ENVIRONMENTAL IMPACT ASSESSMENT FOR PROPOSED BAMBOO MARKET PULP MILL IN FRIENDSHIP, WESTMORELAND

DRAFT FINAL

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Date:	12.12.2022
Prepared by:	Everything Environmental Since 1991
Prepared for:	Bamboo Bioproducts Limited Third floor, 8 Lady Musgrave Road Kingston 5, Jamaica

PROPRIETARY RESTRICTION NOTICE

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ABBREVIATIONS AND ACRONYMS

ADM	Air Dispersion Modelling
ADt	Air-dry metric tonnes
ALARP	As low as reasonably practicable
AMR	Allied Market Research
ARC	Antecedent runoff condition
ASME	American Standards of Mechanical Engineering
BAT	Best Available Techniques or Technology
BBP	Bamboo Bioproducts Limited
BEKP	Bleached Eucalyptus Kraft Paper
BHKP	Bleached Hardwood Kraft Paper
BMP	Biodiversity Management Plan
BOWEC	Building and Operations of Works of Engineering Construction
BSKP	Bleached Softwood Kraft Paper
BSJ	Bureau of Standards Jamaica
CAGR	Compound Annual Growth Rate
CaO	Calcium Oxide or quicklime
$Ca(OH)_2$	Calcium Hydroxide or slaked lime
CBA	Cost benefit analysis
CC	Climate Change
CDM	Clean Development Mechanism
CEDP	Community Engagement and Development Plan
CITIES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CN	Curve Number
CO_2	Carbon dioxide
CoC	Chain of Custody
COD	Chemical oxygen demand
COVID-19	Coronavirus disease 2019
CP	Closure Plan
CVRA	Climate Vulnerability and Risk Assessment
dBA	Decibels
DEM	Digital Elevation Model
DO	Dissolved Oxygen
DOC	Dissolved organic carbon
DTM	Digital Terrain Model
ECF	Elemental Chlorine Free
EgB	Gibraltar-Bonnygate Formation

EHS	Environmental, Health and Safety
EHSG	Environmental, Health and Safety Guidelines
EHSMMP	Environmental, Health and Safety Management and Monitoring Plan
EHU	Environmental Health Unit
EIA	Environmental Impact Assessment
EL	Environmental Licence
EMMP	Environmental Management and Monitoring Plan
ENSO	El Niño Southern Oscillation
EPRP	Emergency Preparedness and Response Plan
EPs	Equator Principles
ESG	Environmental, social and governance
EIA	Environmental Impact Assessment
ESL	Environmental Solutions Limited
ESS	Environmental and Social Standard
EU BAT	European Union Best Available Techniques or Technology
FFG	Functional Feeding Group
FSC	Forest Stewardship Council
ft	Feet
GAP	Good Agricultural Practices
GDP	Gross Domestic Product
GHG	Greenhouse gas
GIIP	Good International Industry Practice
GoJ	Government of Jamaica
H_2S	Hydrogen sulphide
HEART Trust NSTA	Human Employment and Resource Training Trust/National Service Training Agency
HEC-GeoHMS	Geospatial Hydrologic Modelling Extension
HEC-HMS	Hydrologic Engineering Centre – Hydrologic Modelling System
HEC-RAS	Hydrological Engineering Centre – River Analysis System
HFO	Heavy fuel oil
HSG	Hydrologic soil group
IFC	International Finance Corporation
IMP	Impact Management Plan
ISO/IEC	International Organization for Standardization/International Electrotechnical Commission
JCF	Jamaica Constabulary Force
JFB	Jamaica Fire Brigade
JNHT	Jamaica National Heritage Trust
JPS Co.	Jamaica Public Service Company

km	Kilometre
LDA	Local development area
LNG	Liquid Natural Gas
LOI	Letters of intent
m	Metre
MCGES	Ministry of Culture, Gender, Entertainment and Sport
MDGs	Millennium Development Goals
M&E	Monitoring and Evaluation
MEGJC	Ministry of Economic Growth and Job Creation
MGI	Mona GeoInformatics Institute
MICAF	Ministry of Industry, Commerce, Agriculture and Fisheries
Mn	Newport Formation (member of the White Limestone Group)
MOAF	Ministry of Agriculture and Fisheries
MoHW	Ministry of Health and Wellness
MPS	Multi-parameter system
mS/cm	milliSiemens per centimeter
MSD	Midsummer drought
MTS pa	metric tonnes per annum
MW	MegaWatt
Na_2S	Sodium sulphide
Na_2SO_4	Sodium sulphate
NaOH	Sodium hydroxide
NDC	Nationally Determined Contribution
NEPA	National Environment and Planning Agency
NG	Natural Gas
NGO	Non-Government Organisation
NIC	National Irrigation Commission
NOx	Nitrogen oxides
NRCA	Natural Resources Conservation Authority
NSWMA	National Solid Waste Management Authority
NWA	National Works Agency
NWC	National Water Commission
O_2	Oxygen
O_3	Ozone
ODPEM	Office of Disaster Preparedness & Emergency Management
OHSEMP	Occupational Health, Safety and Environment Management Plan
p.a.	per annum
PAJ	Port Authority of Jamaica
P&L	Permit & Licence

PM_{10}	Particulate Matter with a diameter ≤ 10 microns
POC	Particulate organic carbon
ppt	Parts per thousand
PSCS	Pan Caribbean Sugar Company
PVC	Polyvinyl Chloride
Qa	Alluvium
QA	Quality Assurance
QC	Quality Control
SCJH	Sugar Company of Jamaica Holdings Limited
SDC	Social Development Commission
SDGs	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SIA	Social Impact Assessment
SIMP	SIMP- Social Impact Management Plan
SO_2	Sulphur Dioxide
SOx	Sulphur oxides
STATIN	Statistical Institute of Jamaica
TCF	Totally Chlorine Free
The UWI	The University of the West Indies
TMP	Traffic Management Plan
TOC	Total organic carbon
TWA	Time Weighted Average
UNFCCC	United Nations Framework Convention on Climate Change
US-EPA	United States Environmental Protection Agency
VOC	Volatile organic compounds
WHO	World Health Organisation
WMC	Westmoreland Municipal Corporation
WMP	Waste Management Plan
WMU	Watershed Management Unit
WRA	Water Resources Authority

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- Eleanor Jones, MA, OD – Team Leader and Environmental Risk Management Specialist
- Annmarie Goulbourne, MSc – Project Manager, Environmental and Social Specialist
- Rashidah Khan-Haqq, MPhil – Environmental Chemist
- Herona Thompson, MSc – Engineering Geologist and Environment Management Specialist
- Pietra Brown, MA - Climate Vulnerability Specialist
- Kimberley Coore, MPhil – Environmental Analyst and Ecologist
- Jaidene Webster-Jones, BSc – Environmental Chemist
- Shadain Ellis, MSc Candidate – Chemical Analyst
- Raylee Dunkley, PhD Candidate – Chemical Analyst
- Vianzo Rowe – Sampling Technician
- Herbert Thomas – Hydrologist

The views expressed herein are those of the authors and do not necessarily reflect the views of Bamboo Bioproducts Limited.

EXECUTIVE SUMMARY

Bamboo Bioproducts Limited (BBP) proposes to farm bamboo on a large scale in Jamaica in a sustainable and holistic manner. This bamboo will be harvested on a managed and progressive basis, and then processed in a world-class pulp mill using the best available state-of-the-art technology. The bamboo pulp will be sold to multinational corporations that produce consumer tissue and personal hygiene products.

In addition to large-scale farming, BBP proposes to construct and operate the first fully integrated Bamboo Market Pulp Mill in the Western Hemisphere. The pulp mill will be situated on approximately 350 acres of land in Friendship, Westmoreland, following a fully sustainable 'Agro-Ecological-Industrial' model. The proposed mill will have a design capacity to produce 250,000 air-dry metric tonnes per annum of Conventional Baled and Fluff Bamboo Pulp. The proposed mill will use bamboo chips supplied from farms growing the *Bambusa vulgaris* in Jamaica as the raw material to produce the pulp. The mill that will be constructed will follow the typical pulp mill layout and the produced pulp will be exported. To facilitate the logistics of transporting the raw and produced product, to and from the mill for export, enclosed electric-powered trucks will be used. The Project also proposes to have its own high-yield bamboo farms in addition to providing opportunities for contract farming for various local partners. All phases of the project process will adhere to the Forest Stewardship Council (FSC) Chain of Custody Certification.

Following the World Bank's screening and scoping procedure for projects of this nature, this Project has been characterised as a Category A project.[i] The environmental due diligence is also intended to support the appraisal of the proposed BBP investment project being slated for development bank financing, to determine its suitability for financing. For financing, the proposed project will be assessed for the potential environment and social risks, opportunities for introducing enhanced environment and social benefits, the capacity of the Borrower to implement the project in keeping with the World Bank's Performance Requirements, and the wider context of the national legislative and regulatory requirements within which it will operate. Hence, Environmental Solutions Limited (ESL) was contracted by BBP to undertake an Environmental Impact Assessment (EIA). The EIA was conducted in alignment and compliance with the International Finance Corporation's (IFC) Environmental and Social Performance Standards; environmental, social and governance (ESG) factors; the FSC's Performance Standards, Principles and Criteria, and the Equator Principles. Additionally, this EIA report has been prepared in support of the Environmental Permit applications being made by BBP to the National Environment and Planning Agency (NEPA) for the proposed bamboo market pulp mill. This EIA will primarily focus on the proposed pulp mill.

The approach and methodology included a review of the project description and base designs, an assessment of the existing environmental and social conditions, the completion of impact and mitigation assessments, a review of alternatives, the development of a risk assessment, and the development of management and monitoring plans for the environmental and social areas in relation to the project.

[i] Category "A" projects are those with the most significant and mostly permanent environmental and social impacts.

Additionally, a Climate Vulnerability and Risk Assessment (CVRA) was conducted as a requirement for funding.

A summary of the findings based on the report's chapter headings is presented below. They are:

❖ **Project Description**

- The proposed pulp mill site is located in the area of Friendship, Westmoreland on approximately 350 acres of land. Nearby towns and communities include Barham, Friendship Cross, Hertford, Friendship, Petersfield, Frome, Savanna-la-Mar, and Amity.
- The land is currently owned by BBP. It was formerly owned by SCJ Holdings (SCJH) Limited and is currently being harvested for sugarcane production.
- BBP is planning to install a new non-integrated Bleached Kraft Bamboo Pulp Mill for production of fluff and market pulp based on bamboo grown in Jamaica and Belize.
- The bamboo that will be used as the raw material is the *Bambusa vulgaris* or 'Common Bamboo', which is a clumping bamboo commonly found in Jamaica.
- Investigations are currently ongoing to determine the best locations for the potential farms, as well as the best cultivation and harvesting methods and measures for maximised production, with minimal negative environmental impacts.
- BBP intends to use a combination of, BBP-managed Farms, Contracted Independent Private Farmers and Co-operatives Farms in Jamaica to supply the proposed mill with raw material.
- The indicative pulp mill process concept is based on world-class technologies supplied by ANDRITZ, a globally leading supplier of plants, equipment, and services the pulp and paper industry.[ii]
- The level of technology to be used will comply with the European Union's Best Available Techniques (BAT) Guidelines/Reference Document, published in 2015. BBP will also be in compliance with local requirements with respect to legal and regulatory frameworks as well as international requirements for best practice.
- The lifetime expectancy of the proposed mill is 70 years.
- The construction approach to be taken for the proposed pulp mill is the use of modular construction techniques, off-site and off-island, in a controlled factory environment. Modular units/components will be shipped to Jamaica for assembly.
- The Kraft Pulping Process will be used as the production method and the bleaching process is Totally Chlorine Free (TCF).

[ii] ANDRITZ is a globally leading supplier of plants, equipment, and services for hydropower stations, the pulp and paper industry, the metalworking and steel industries, and for solid/liquid separation in the municipal and industrial sectors as well as for animal feed and biomass pelleting. The publicly listed technology Group is headquartered in Graz, Austria and operates more than 280 sites in over 40 countries.

- The net freshwater requirement for the proposed mill will be $20m^3$ per tonne of production and the water will be extracted from the Cabarita River and treated on an onsite water treatment plant at the mill. The Cabarita River borders the north-western end of the proposed site.
- A wastewater treatment facility will also be constructed on the proposed mill site to treat $20m^3$ per tonne of production and will provide a tertiary level of treatment. The Partner of BBP that will Build-Own-Operate the wastewater treatment facility is SUEZ, a group of companies that specialise in circular solutions in water and waste and operates treatment plants internationally and also in Jamaica.
- Information provided thus faron the mill's chemicals, storage of raw materials and chemicals, waste generation and disposal, air emissions, noise emissions, and energy consumption and these can be found in **Chapter 4** and **Appendix H**. Further details will be provided to comply with the European BAT Guidelines and the NEPA requirements.
- The logistics of the transportation of raw and produced materials for the proposed mill and for export will be facilitated by trucking.
- The intention is to commence the proposed mill's operations in Q3 of 2024 once the relevant permits are received.

❖ <u>Description of the Environment</u>

- Surveys and were completed between July 2021 and May 2022 to determine the existing conditions of the environment, as well as the current socioeconomic status of and within the project sphere of influence. The bulk of the socioeconomic surveys was conducted from July to October 2021 and the bulk of the environmental surveys was conducted from November 2021 to May 2022 to capture information in the wet and dry seasons.
- The site climate, topography, geology and soils are suitable for siting the proposed mill.
- The Hydrology Assessment in Section 5.1.5 estimated that the water requirement of the pulp mill is 12% of the reliable combined flows of nearby rivers.
- Additionally, based on the Water Resources Authority's estimated water demand projections the available water resource of the Cabarita River is adequate to address the mill's water demand now and in the future.
- It should also be noted that the New River tributary joins the Cabarita River below the gauging station at Grange, but its flows could not have been included in the calculations for the combined from due to the limited recorded period from its gauging station. However, a test calculation, where the limited records from the New River tributary were included in the combined flows showed that, with the inclusion of the New River flow, the reliable yield of the combined flows could be increased by a further 20%.
- The Hydrology Assessment has also determined from its Flood Risk Assessment through inundation maps for floods with a 10-year, 25-year, 50-year and 100-year event that the depth of

flooding in the affected area reaches up to 1.5 m for a 100-year event. The rest of the development is on high ground and is not impacted by the floodwaters. Recommendations were provided on how to treat areas of the property that could be impacted by floodwaters.

- An assessment of the impact of the proposed pulp mill on the flood risk of the Cabarita River Watershed Management Unit showed that there would be a very marginal increase in the post development flows and will thus have no impact on the resultant flood levels at and downstream of the mill site.
- Based on the results obtained from the two sampling activities, the water quality parameters assessed, where applicable, were compliant with the Draft Jamaica National Ambient Water Quality Standard – Freshwater, 2009. Parameters that were non-compliant, (e.g., sulfate, chloride, magnesium, potassium, etc.) were below the specified requirements. The water would be classified as excellent or of high quality based on the classification limits set by the Water Resources Authority for these parameters where applicable (i.e. sulfate and chloride).
- The particulate matter (PM_{10}) results obtained from the second assessment were compliant with the Natural Resources Conservation Authority's (NRCA) Ambient Air Quality Standards. However, if both sets of data were compared to the Ambient Air Quality Standard, there would be a a general increase seen in the data obtained during the dry season as compared to the wet season. The nitrogen oxides (NOx), the sulphur oxides (SOx) and hydrogen sulphide were undetected during the wet and dry sampling periods when measurements were collected. Given that no acidic gases were detected in the dry season assessment, it can be assumed that the monitoring sites generally had low concentrations of these gases.
- The average noise readings for all the sites that were surveyed were above the NEPA Standard of 55 dBA for residential areas.
- The flora assessment was typical of perennial grasses, riparian vegetation and shrubs/scrubs. The fauna assessment was typical of what is observed along rivers, grasslands and agricultural fields.
- There were no biologically unique landscapes or areas with special conservation status identified within or in the immediate surroundings of the project area.
- A Cabarita River Ecosystem Assessment investigating the aquatic flora and fauna from upstream of the proposed mill to the marine environment was completed. Five sites were investigated along the Cabarita River and all sites except for the site (Site 1) closest to the mouth of the river were indicative of mildly disturbed to undisturbed aquatic environments. Site 1 was greatly lacking in fauna potentially due to inputs from anthropogenic activities upstream. Coupled with the characteristically low velocity of the relatively wide river channel, the resulting impacts that were observed included a change in colour (blackening of the river), pungent sulphuric-based odour, and dark residue when the river water was filtered. Another factor hindering the establishment of freshwater fauna at Site 1 was the influence of the sea. Sections of the river at the mouth were noted as flowing backwards resulting in the increased salinity of the river (as is also indicated by

the considerably high conductivity levels recorded), limiting the establishment of freshwater fauna. Typical brackish water species were also not observed.

- Observations in the Cabarita River Ecosystem Assessment showed that analyses of the pH, conductivity and water temperature were within acceptable ranges and consistent with results from the water quality assessment.
- Observations in the Cabarita River Ecosystem Assessment concluded that the taxon richness and gamma diversity (i.e., the total species diversity along the entire river) were high except at the mouth of the river.
- The Socioeconomic Assessment/Social Impact Assessment (SIA) covered six (6_ communities – Frome, Savanna-la-Mar, Hertford, Petersfield, Friendship and Amity. The assessment covered the following potential social impacts: the project's sphere of influence, land use patterns, population and household demographics, housing, existing infrastructure, economic activities, use of the river in the project, community services, community challenges, cultural heritage and traffic.
- The Public Participation component of the SIA involved interviews with key stakeholders, surveying 102 community members, and the hosting of an Open Day.
- The results of the Public Participation component of the SIA showed that most of the community members surveyed are highly supportive of the project with some concerns regarding how the project is likely to affect them environmentally and socially.
- The following are the top 10 concerns raised by the stakeholders and members surveyed; these concerns related mainly to the social impacts:
  - i. Local Labour Market
  - ii. Lack of Training
  - iii. Farming Contracts
  - iv. Local Government Involvement
  - v. Water Supply
  - vi. Pollution
  - vii. Health
  - viii. Social Nets
  - ix. Road Safety
  - x. Traffic

  Responses were provided by BBP to address these issues.

❖ **<u>Climate Vulnerability and Risk Assessment (CVRA)</u>**

- The CVRA was used to identify and assess the potential Climate Change and associated risks to the proposed mill and its environs, as well as to propose recommendations for the Project's resilience.
- The process included conducting a vulnerability assessment of the mill and 6 nearby communities within the Sphere of Influence (a minimum 2 km Distance from the proposed Project Site). A

vulnerability assessment has three components: a Sensitivity Assessment, an Exposure Assessment, and an Adaptive Capacity Assessment.

- The communities investigated for the Assessments were the same as those in the SIA – Frome, Savanna-la-Mar, Hertford, Friendship, Petersfield and Amity.
- The hazards that were identified for the current and future sensitivity assessments were riverine flooding, pluvial flooding, wind damage, drought/water availability, hurricanes, tropical storms and storm surge. Pluvial flooding and storm surge had the greatest impact on the current and future sensitivities of the areas.
- The communities had varying levels of exposure to the various hazards in the area. A summary is presented in Table EX-1 below.

Table EX-1: Summary of Exposure Assessment

HAZARDS	LOCAL DEVELOPMENT AREAS AND LEVELS OF EXPOSURE					
	Frome	Savanna-la Mar	Friendship	Amity	Hertford	Petersfield
Flooding	Medium	High	High	Low	Low	High
Anthropogenic (human-induced) Fires	High	Medium	High	Low - Medium	Medium	Low
Sea Level Rise	Low	High	Low	Low	Low	Low
Hurricanes/ Tropical Storm Winds	Medium	High	Medium	Medium	High	Medium
Storm Surge	Low	High	Low	Low	Low	Low
Coastal Erosion	Low	High	Low	Low	Low	Low
Landslides	Medium	Low	Medium	Low	Low	Medium
Droughts	Medium	High	Medium	Medium	Medium	Medium

- The overall vulnerability ranking of the six communities is presented in Table EX-2 below.

Table EX-2: Summary of Results from the Vulnerability Assessment

Project Area	Projected Level of Sensitivity/ Susceptibility to Climate-Related Hazards	Future Exposure (with project assets and infrastructure implemented)	Existing Adaptive Capacity	Vulnerability
Friendship & its zone of influence	High	High	Low	High

- The Climate Risk Assessment looked at the following potential risks and hazards: climate variables/ hazards; current and projected stresses from climate change; the likely impacts on the proposed assets/infrastructure/community; the hazard probability; impact risk and mitigation or adaptation measures.
- The climate variables or hazards with the highest risk to the area and infrastructure were storm surge and hurricanes/tropical storms. The hazard with the lowest risk were landslides.

- Recommendations arising from the CVRA that could be used to improve the resilience of the area, project site and its zone of influence included:
  i. The relevant drainage and building codes must be strictly adhered to minimise the impacts as determined by the CVRA.
  ii. The proposed pulp mill operation must have a Disaster Risk Management Plan;
  iii. Consideration must be made for any road cutting or improvement programmes that may be implemented by BBP in light of possible risks associated with flooding;
  iv. Harvesters of the bamboo for the mill should be encouraged to not engage in slash and burn methods as this may exacerbate soil erosion and contribute to flooding;
  v. Liaising with the Meteorological Service of Jamaica and the Port Authority in relation to port facilities/procedures that can impact the exportation of the produced pulp.

❖ **Air Dispersion Modelling (ADM) Assessment**

- The mill will operate using one recovery boiler unit that will provide power to the mill and is the most relevant equipment for the generation of air emissions. The recovery boiler will be fuelled by LNG (temporarily and for cold-starts) and primarily by lignin, a by-product of the bamboo pulping thereafter.

- Dispersion modelling was conducted for emissions of sulphur dioxide (SO_2), nitrogen oxides (as nitrogen dioxide [NO_2]), carbon monoxide (CO), and Particulate Matter 10 microns (PM_{10}) from the proposed facility. The proposed Bamboo Pulp Mill modelled using LNG fuel fired Recovery Boiler, under the worst-case scenario, plus the background concentration, is predicted to meet the Jamaica National Ambient Air Quality Standards (JNAAQS) and guideline concentration.

- The bamboo facility using LNG and lignin was not predicted to have a significant impact on the air shed. However, the results showed that it is important to note as the operations of other operators in the airshed can have an impact on short-term exposures.

❖ **Impacts Identification and Corresponding Mitigation Measures/Positive Enhancements**

- This section of the report was guided by the IFC's Environmental Health and Safety (EHS) Guidelines.

  These included the:
  i. Environmental, Health, and Safety General Guidelines (2007)
  ii. Environmental, Health, and Safety Guidelines – Pulp and Paper Mills (2007)
  iii. Environmental, Health and Safety Guidelines for Perennial Crop Production (2015)

  Other guidelines will be used in the SEA report.

- Impacts and corresponding mitigation measures were identified for the physical, ecological and socioeconomic environments during the site preparation and construction phase and the operations phase of the Project.

- Impacts were identified based on their probability of impact, direction, duration, permanence, magnitude, spatial extent, and residual impact.
- The most significant impacts identified during the proposed mill's construction related to internal migration and population growth; employment opportunities; and squatting. These three also had the highest residual impact after the recommended mitigation measures were implemented. Some recommendation measures for the aforementioned significant impacts included:
    - Considerations for providing housing for migrant workers through collaboration with public and private sector entities such as the NHT, government Ministries, NGO's and private developers;
    - Prioritizing employment of persons who reside in the immediate sphere of influence.
    - Potentially facilitating developers working closely with the local municipal corporations to ensure that the needs of any transient workforce are anticipated and planned for accordingly.
- The most significant impacts identified during the proposed mill's operations included severe weather, wastewater, air emissions, traffic, social infrastructure, and community development. Wastewater discharge and air emissions were identified as those with the highest residual impact after the recommended mitigative measures were implemented. These impacts and mitigation measures are presented in **Chapters 8 and 9**. Examples of the mitigative measures recommended for wastewater, air emissions and community development were:

Wastewater	- Ensure that the operator of the Wastewater Treatment Plant employs technologies which ensure that the treatment plant is effective in properly treating the effluent to meet the required standards. Continuous monitoring of the treated effluent will be used to demonstrate the performance of the plant. - Ensure treated effluent discharge is kept to a minimum through water use planning and recycling, if possible.
Air Emissions	- Project design should incorporate the best available technology to mitigate adverse air emissions (e.g. scrubbers, electrostatic precipitators, etc.) - Develop and implement preventative maintenance schedule for all equipment on site and for the factory.

- Positive enhancements related to improvements in the socioeconomic environment included the provision of jobs, improving economic standards, community development, potential improvement in social services and infrastructure, and improvements in education/training.

❖ <u>Cumulative Impacts</u>

- The cumulative impacts identified were both potentially positive and negative.
- Positive cumulative impacts included economic upliftment and rural development and improvement in social services/infrastructure in rural areas.

- Potentially negative cumulative impacts identified were:
  - The potential impact of the mill's operations on the quality and downstream use of the Cabarita River.
- Based on the results of the ADM Assessment, there is a potential for a cumulative impact on air quality, however, other operators in the airshed could have a more significant short-term impact.

❖ Identification and Analysis of Alternatives

- There were few alternatives identified for the Project. These were:
  i. No Action Alternative
  ii. Alternative site for the pulp mill – would be moved from Jamaica to Belize;
  iii. Alternative site for water and wastewater treatment plants on site;
  iv. Alternative use of the project site;
  v. Alternatives for the project pulping process, equipment and technology.

❖ Risk Assessment

- The risk assessment conducted was based on the type of hazards which were separated as follows: process-related hazards; physical hazards; chemical hazards; and biological hazards. Risks were identified as well as recommended mitigative measures.
- A Risk Assessment Matrix was compiled with the following considerations: likely impacts, probability, impact risk, possible mitigative/risk control measures, as well as the residual probability, the residual impact and the residual risk.
- The areas identified with the highest ranked risks (extreme and high) on the Project were:

Extreme Risks	High Risks
• Injuries and Fatalities from Chemical Hazards • Improper Disposal of Wastewater Resulting in Pollution • Farming an *Bambusa vulgaris*	• Operational and Workplace Hazards • Machinery and Vehicle Hazards • Injuries and Fatalities from falls (working at height) • Electrical Shocks • Injuries and Fatalities from Working in Confined Spaces • Injuries and Fatalities from Fire and Explosion • Fugitive Dust Nuisance and Other Emissions (Air Emissions/Pollution) • Injuries and Fatalities from Corrosive Spillage • Odour Nuisance • Water Quality Pollution • Pollution from the improper disposal of residues and solid waste • Sedimentation from Drainage and Surface Runoff • Greenhouse Gas (GHG) Emissions • Severe Weather Halting Project Activities • Poor Community Health and Safety • Land Clearance during Construction

- The area identified with the highest residual risk following the recommendations of mitigative/risk control measures was severe weather which could halt project activities.

❖ **Environmental, Health and Safety (EHS) Management and Monitoring Plans (EHSMP and EHSMMP)**

- The EHSMP outlines the environmental management, mitigation, monitoring and institutional measures to be taken in conducting the construction and operational activities of the proposed Bamboo Market Pulp Mill in Friendship, Westmoreland.
- The EHSMP and EHSMMP were developed in accordance with the IFC EHS Guidelines (General, Perennial Crop Production, Paper and Pulp Mills) which contain the performance levels and measures that are normally acceptable to the IFC. It is also in compliance with relevant regulations, legislations and policies developed by the Government of Jamaica.
- The EHSMP and EHSMMPs were divided into the construction phase and the operation phase. Both phases contain:
  - Environmental Management and Monitoring Plans (EMMP)
  - Occupational Health, Safety and Environment Management Plans (OHSEMP)
  - Biodiversity Management Plans (BMP)
  - Emergency Preparedness and Response Plans (EPRP)
  - Community Engagement and Development Plans (CEDP)
  - Traffic Management Plan (TMP)
- An additional EHSMP included in the construction phase was the Waste Management Plan (WMP).

❖ **Social Impact Management Plan (SIMP)**

- The SIMP covered four areas in this report and include the Impact Identification and Management, Monitoring and Reporting, the Stakeholder Engagement Strategy and Complaint Resolution. The complete SIMP is presented in **Appendix P**.
- Three (3) action plans were generated for this proposed Project – the Education/Training Action Plan; the Local Economy Action Plan; and the Social Infrastructure Action Plan.
- Each Action Plan includes an Impact Management Plan (IMP), Mitigation and Management Activities, and Indicators for Monitoring and Evaluation (M&E).
- Community investments and partnerships intended to be made in the Project include:
  - A Community Investment Fund (The BBP Community Fund) to channel financial resources into the community;
  - Key Partnerships with Government Agencies and Non-Government Organisations (NGOs) in the local community;
  - Ongoing provision of a Community Liaison Officer to provide information to the public and deal with stakeholder issues and grievances.

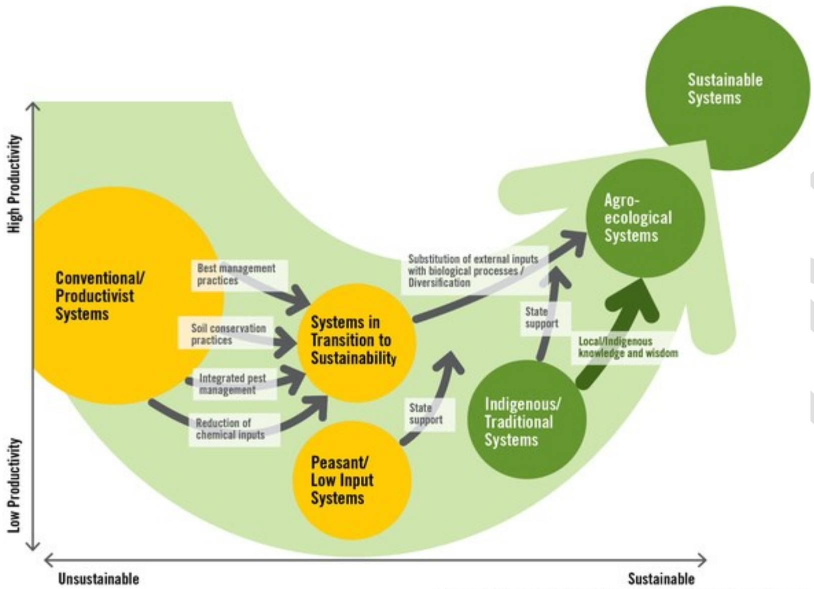
- Annual monitoring reports should be generated as part of the monitoring and evaluation strategy in the SIMP.

In concluding, it is our professional opinion that based on the information provided, once the mitigation measures have been successfully implemented and are within international and local guidelines, the proposed Bamboo Pulp Mill will have minimal to moderate impact on the surrounding physical environment and a positive impact on the social environment.

1 INTRODUCTION

1.1 PROJECT CONCEPT

Bamboo Bioproducts Limited (BBP) proposes to manufacture bamboo pulp in Jamaica in a sustainable and holistic manner. This bamboo will be cultivated in Jamaica and harvested on a managed and progressive basis, and then processed in a world-class pulp mill using state-of-the-art best available technology. The bamboo pulp will be sold to multinational corporations that produce consumer tissue and personal hygiene products.



Source: Latin America and the Caribbean, Summary for Decision Makers, p. 9

The developers propose to construct and operate the first fully integrated Bamboo Market Pulp Mill in the Western Hemisphere that will focus on producing pulp for consumer tissue and personal hygiene products. The pulp mill will be situated on approximately 350 acres of land in Friendship, Westmoreland following a fully sustainable 'Agro-Ecological-Industrial' model. The proposed mill will have a design capacity to produce 250,000 air-dry metric tonnes (ADt) per annum (MTS pa) of Conventional Baled and Fluff Bamboo Pulp. The mill that will be constructed will follow the typical pulp mill layout (Figure 1-1) and the produced pulp will be exported (Figure 1-2). To facilitate the logistics, transporting the produced bamboo pulp from the mill for export, will be done using trucking, with an intention to use electric vehicle trucks.

To support the Project, BBP proposes to have their own high-yield bamboo farms as well as providing opportunities for contract farming for various local partners.

As conceptualised, the Project is expected to:

- Provide consumer tissue and personal hygiene producers with sustainable non-wood fibres from regionally sourced raw material;
- Contribute to the improvement of Jamaica's macro-economic performance and employment opportunities;
- Revitalise local rural communities, by focusing on 5 core principles of community life: ecology and environment; housing; community and well-being; education and training; and business and employment.

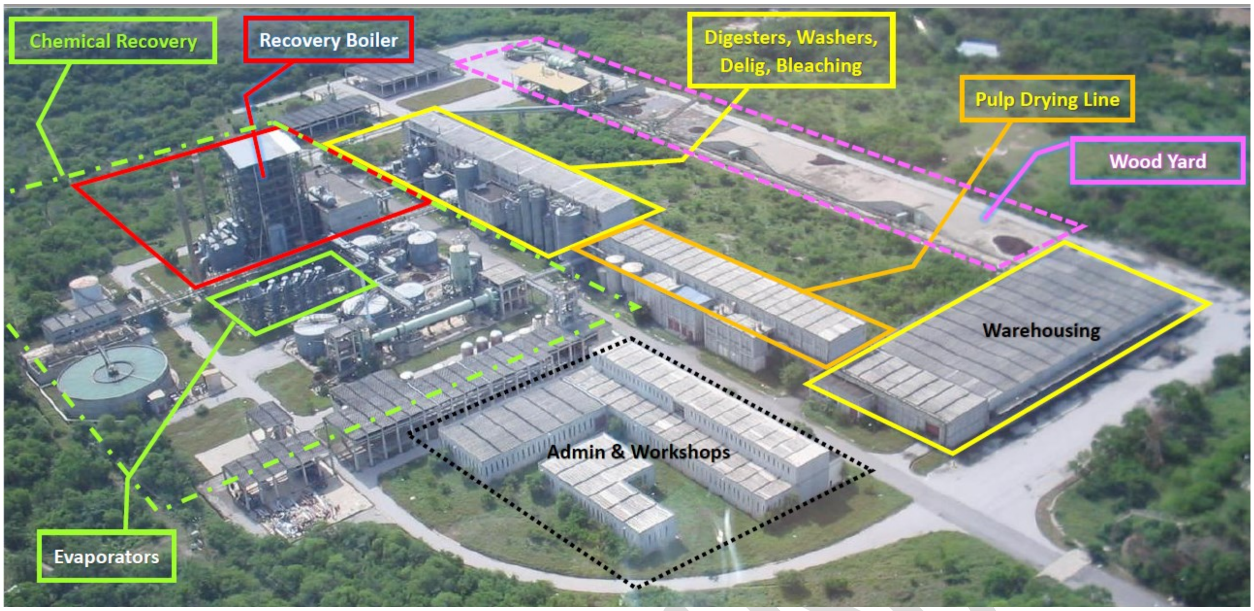


Figure 1-1: Typical Pulp Mill Layout (Source: BBP, 2021)

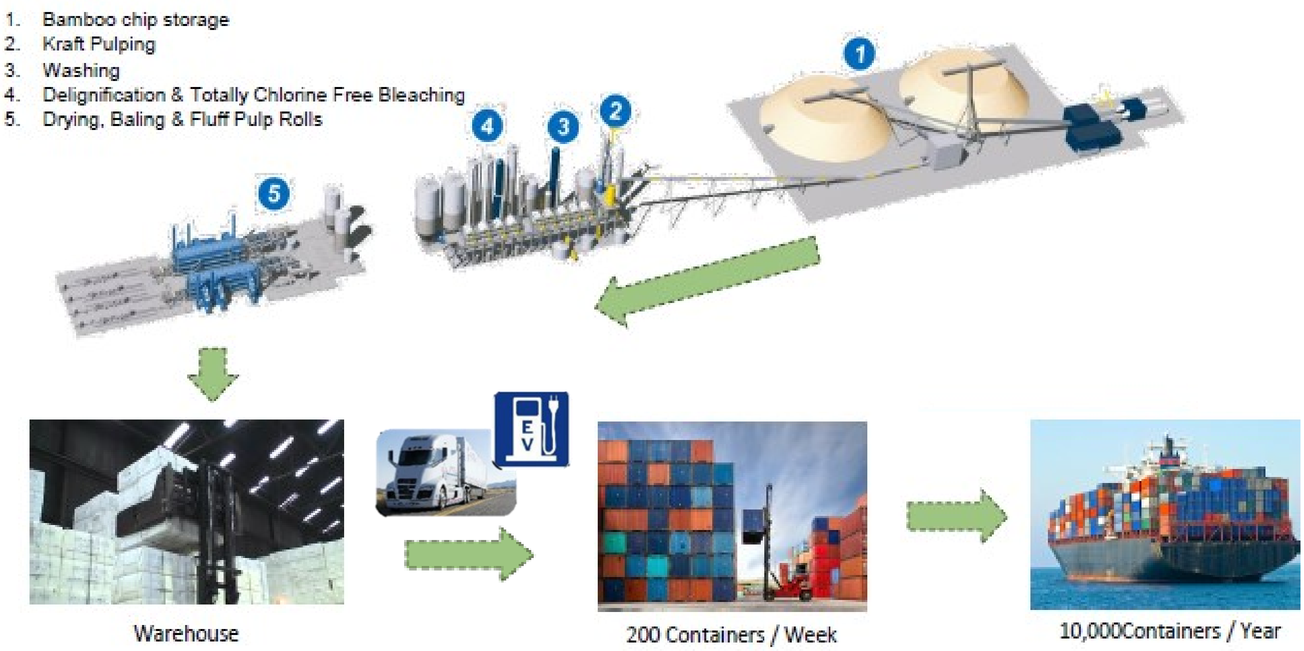


Figure 1-2: Bamboo Fibre Flow Chart (Source: Adapted from BBP, 2021)

The BBP Project Team includes renowned executives in the field of pulp and paper engineering, manufacturing, and marketing supported by a team of local Jamaican experts. The proposed Project involves a capital investment of approximately US$335 million to establish the project with an estimated return on investment of 22% with conservative projections of US$1.8 billion in revenue during the first 10 years.

At the time of this report, there are letters of intent (LOI) in place with leading Consumer Tissue and Personal Hygiene Producers as these companies look to increasingly replace stock consumption with non-wood fibres. Financing is currently under discussion with export credit agencies (UK Export Finance, Finland's Finnvera and SEK) and local financial institutions (National Commercial Bank of Jamaica, Barita, and Delta Capital).

1.2 PROJECT RATIONALE

1.2.1 WOOD PULP MARKET DEMAND AND SUPPLY

The global wood pulp market was valued at $165.3 billion in 2020 according to *Allied Market Research* ("AMR") and is projected to reach $242.1 billion by 2030, with a compound annual growth rate of 3.9% (Figure 1-3). Wood pulp is a renewable raw material that can be used to produce packaging papers, specialty papers, and tissue, among other applications. The wood pulp industry faces contrasting trends according to *RISI Inc.,* with healthy growth in packaging and tissue and continued decline in graphic papers, especially in newsprint and printing paper.

Over the next decade, packaging paper, which accounts for 50% of total volumes, is expected to continue to grow as e-commerce companies drive the transport segment over the foreseeable future. This was also exacerbated by the coronavirus disease (COVID-19), a pandemic commencing March 2020, which resulted in a significant growth in online shopping and delivery, thus increasing the need for packaging and tissue (Freight Investor Services Ltd., 2021). Consumer packaging and tissue products, which represent 20% of total volume, are expected to continue to grow on par with the global Gross Domestic Product (GDP) driven largely by consumer demand for improved hygiene in developing countries and sustainability in developed countries. Graphic papers, which account for 30% of total market volume, will continue its slow decline, thereby contributing to the shutdown of mills or conversion to packaging.

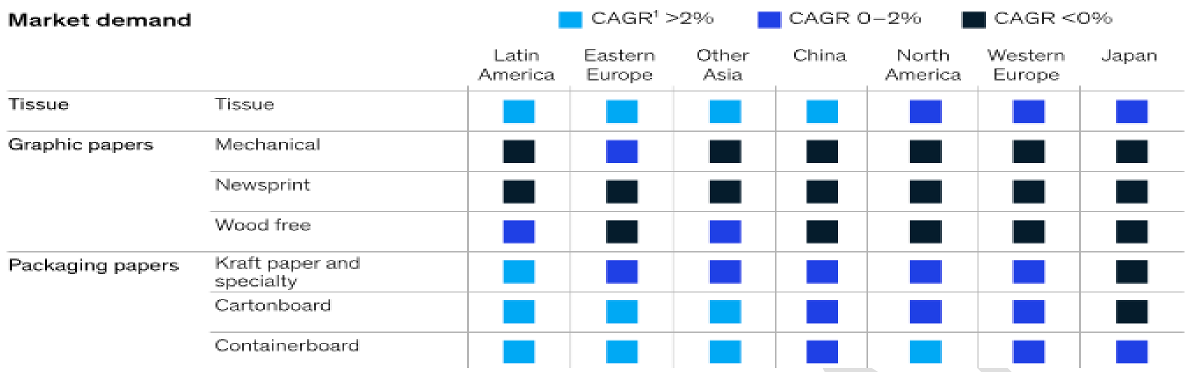


Figure 1-3: Estimated Market Demand of Wood Pulp globally and the Compound Annual Growth Rate (CAGR) (Source: Fastmarkets RISI©)

On the supply side, the bleached chemical pulp market reached 68 million tonnes in 2020, comprising 29 million tonnes for Bleached Softwood Kraft Paper (BSKP) and 39 million tonnes for Bleached Hardwood Kraft Paper (BHKP) (Figure 1-4). Global bleached chemical pulp has increased by 14 million tonnes over the past decade, averaging +2.4% per annum (p.a.), with BSKP expanding by 4 million tonnes (+1.6% p.a.) and BHKP by 11 million tonnes (+3.2% p.a.). The largest bleached softwood pulp producers are the United States, Canada, Finland and Sweden (NOREXECO, 2021). Combined, they account for 75% of production. For bleached hardwood, the largest producer is Brazil with 46% of production (Figure 1-5).

For 2022–2024, *Hawkins Wright Ltd.*[iii] expects capacity expansion to resume with additional capacity mostly of BHKP, or more specifically Bleached Eucalyptus Kraft Paper (BEKP) mills from Chile, Brazil, and Uruguay.

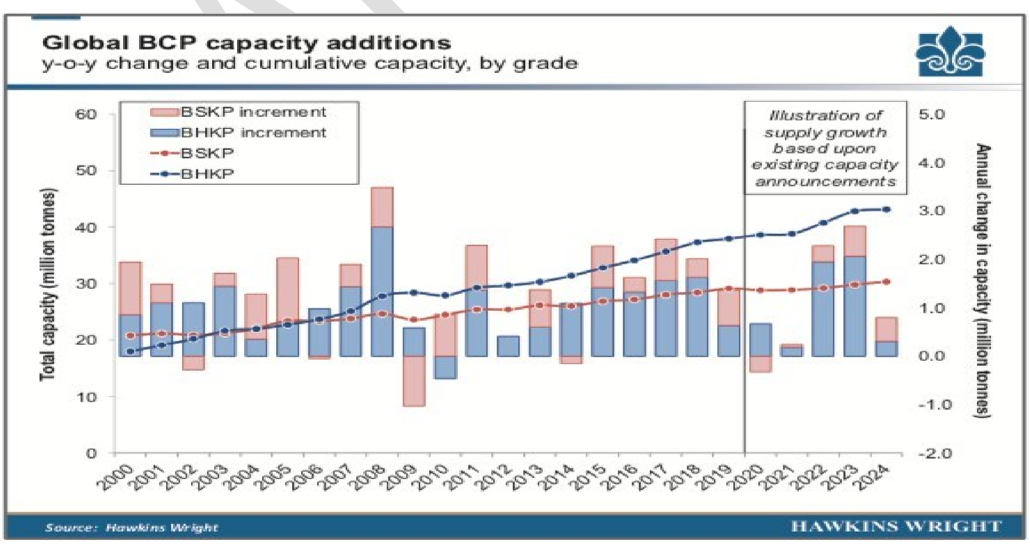


Figure 1-4: Growth in BSKP and BHKP from 2000 to 2020 and Projections up to 2024 (Source: Hawkins Wright Ltd., provided by BBP, 2021)

[iii] Hawkins Wright Ltd. is a market intelligence and analytical consultancy, that has provided over 35 years of experience to the international pulp, paper and biomass industries.

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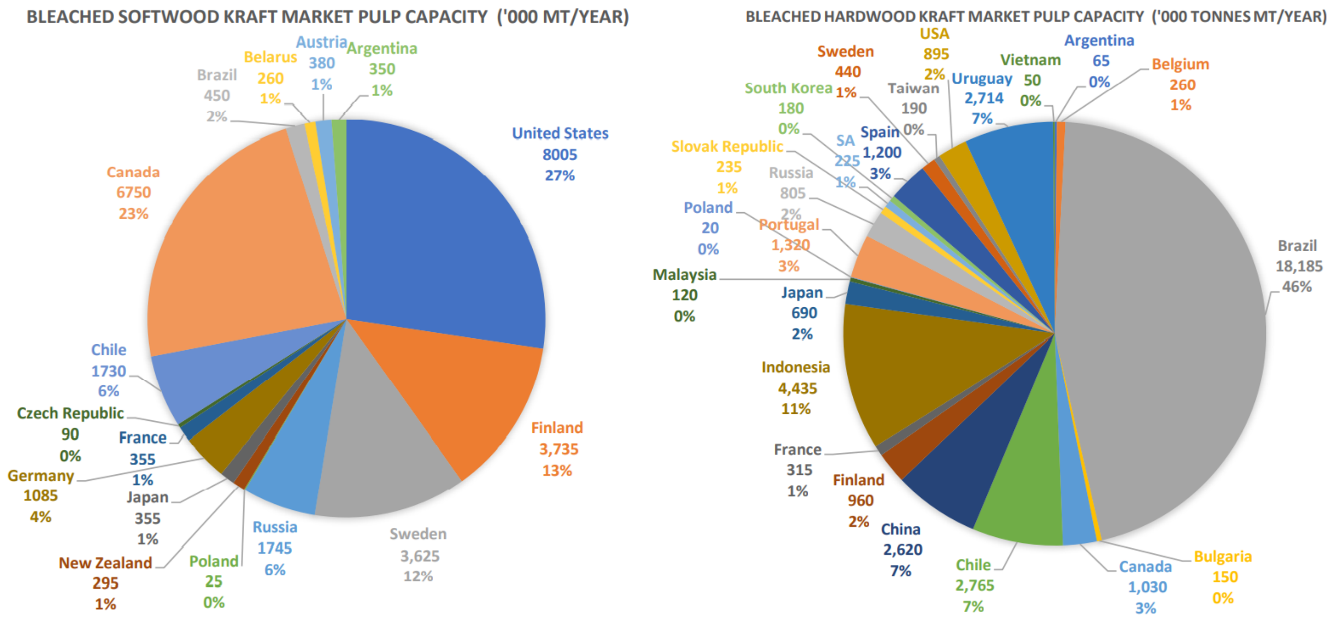


Figure 1-5: Global Producers of BSKP and BSHP (Source: NOREXECO, 2021)

Increasingly, tissue producers are committing to reducing their reliance on virgin forest fibre, promoting sustainable forest management practices, and avoiding purchasing wood sourced from high conservation value forests. As such, non-wood-based tissue products are seen as a viable and attractive alternative in a demanding marketplace. In general, non-wood fibres are obtained from annual plants which are planted and harvested within one growing year, and therefore can provide raw material yield much faster than wood. They can be divided into two categories (Byrd and Hunter, 2013):

1. Agricultural residues: Materials that remain after the principal crop (usually cereal or grain) has been harvested, e.g., rise, wheat straw, corn stalks and sugar cane (bagasse);
2. Fibre crops: Materials that come from crops planted specifically to yield fibre, e.g., industrial hemp, kenaf and bamboo.

Other than bamboo, non-wood fibre sources, including straw, bagasse and kenaf, are not suitable for tissue due to their fibre morphology.

1.3 PURPOSE OF THIS DOCUMENT

The proposed Project is anticipated to have environmental impacts on the development area, with respect to environmental attributes of land, water, air, aesthetics, flora and fauna. In the assessment of the potential environmental impacts, the collection, collation, and interpretation of the data collected from physical, social and ecological investigations are of critical importance. Following the World Bank screening and scoping procedure for projects of this nature, this Project has been characterised as a Category A project. Category "A" projects are those with the most significant and mostly permanent environmental and social impacts.

The environmental due diligence is also intended to support the appraisal of the proposed BBP investment project being reviewed for development bank financing, to determine its suitability for financing. For financing, the proposed project will be assessed for the potential environmental and social risks, opportunities for introducing enhanced environmental and social benefits, the capacity of the Borrower to implement the project in keeping with the bank's Performance Requirements, and within the wider context of the national legislative and regulatory requirements within which it will operate. Hence, Environmental Solutions Ltd. (ESL) was contracted by BBP to undertake an Environmental Impact Assessment (EIA) starting at the Project concept phase, through design and planning. The EIA is expected to focus on issues of potentially significant impact including, but not limited to institutional risks, temporary loss of livelihoods, risks from natural hazards and/or any potential negative impacts to the long-term sustainability of the area. The objective of the EIA procedure is to promote the assessment and uniform observation of the potential environmental and social impacts in planning and decision-making. Another objective of the procedure is to increase the opportunities for the public to receive information, and to contribute opinions to the planning of projects.

The EIA procedure does not make any regulatory decisions concerning the proposed Project or resolve any licensing issues; its objective is to produce information to serve as a basis for regulatory decision-making. The EIA was conducted in alignment and compliance with the International Finance Corporation's (IFC) Environmental and Social Performance Standards, the FSC's Performance Standards, Principles and Criteria, and the Equator Principles. Furthermore, there is a new thrust, where investors are recognising that environmental, social and governance (ESG) factors can play a role in affecting the risk-return characteristics of their investments. Therefore, it is crucial for these ESG factors to be integrated into this EIA as they are the key drivers that will impact the financial performance of the investment and sustainability of the project.

This EIA conforms with the Terms of Reference in **Appendix A** and presents:

- A review of relevant legal and regulatory framework
- The current state of the physical and social environments in and around the proposed Project site
- The potential environmental and social impacts of the proposed Project concept, as well as the significance of these impacts
- Identification of climate change risks, constraints and opportunities
- Measures for preventing and mitigating adverse impacts
- A proposal for the Environmental and Social Management and Monitoring Plan
- The actions taken to facilitate interaction and involvement during the EIA procedure
- Identification of data gaps and additional studies, where needed.

Additionally, this EIA report has been prepared in support of the Environmental Permit (EP) applications being made by BBP to the NEPA for the proposed bamboo market pulp mill. The full environmental permit and applications process, as outlined by NEPA, is presented in **Appendix B**.

1.4 SCOPE OF THIS REPORT

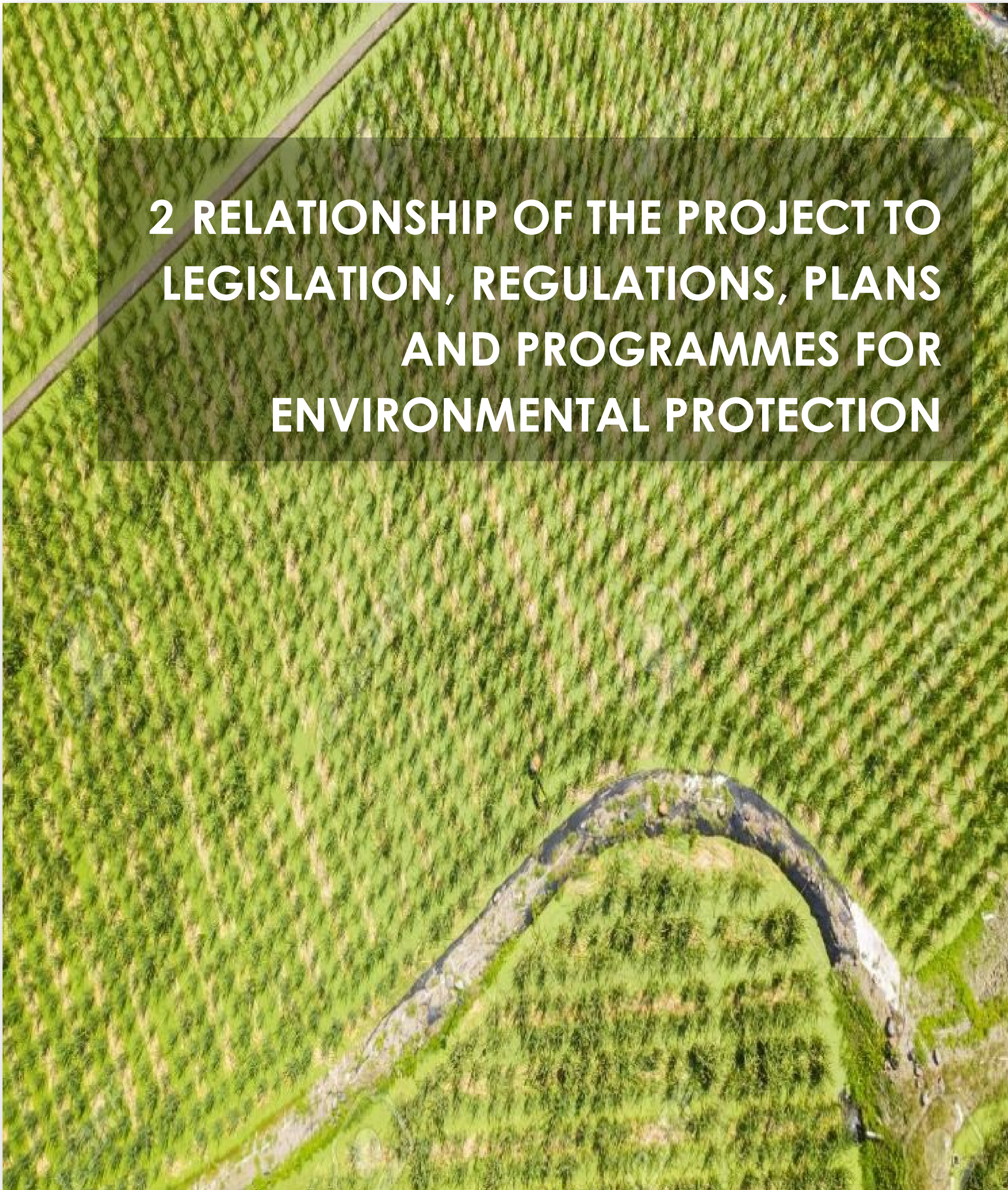
The report will aim to frame the proposed development (site clearance, construction and operation) within the context of the existing conditions at the proposed Pulp Mill Site. It will be based on observations made during the desk review, the site reconnaissance and field visits, expert opinions garnered through our extensive experience and stakeholder consultation. This will include inter alia the surrounding communities, requirements of the local regulatory and other relevant government agencies, international safeguards and guidelines as well as the physical and biological environment. These elements will not only be critical to the permitting process and EIA but should be given due consideration in the design phase of the Project. In this way, mitigation measures for potential risks and impacts to the environmental and social communities will be integrated in the Project from inception/planning.

1.5 ASSUMPTIONS AND LIMITATIONS

The focus of this report is the proposed mill site at Friendship, Westmoreland. The transportation mode and medium of the raw material and product to and from the mill, and plan for the establishment of bamboo plantations will be briefly presented in this report as these have not been finalised and are still in development. A Strategic Environmental Assessment (SEA) of the Plan for the Controlled Cultivation of Bamboo on Former Sugar Cane Lands and idle farmlands across Jamaica will be presented as a separate report.

While this report provides an overview of potential environmental and social concerns, the environmental assessment is limited by the availability, quality, and accuracy of information at the time of this report. The timeframe of data collection and laboratory analyses may also affect the information presented. It is possible that unreported disposal of waste, chemicals or illegal activities impairing the environmental status of the proposed site may have occurred, which could not be identified. The considerations regarding environmental and social risks that are presented in this report are based on the site investigations conducted in from July 2021 to May 2022.

ESL assumes that the records and reports reviewed in the preparation of this report were complete and accurate.



2 RELATIONSHIP OF THE PROJECT TO LEGISLATION, REGULATIONS, PLANS AND PROGRAMMES FOR ENVIRONMENTAL PROTECTION

2.1 KEY INSTITUTIONS AND FUNCTIONS

The following institutions in Table 2-1 have been identified as key implementing agencies relevant to the construction and/or operation of the proposed Project, as well as important aspects of environmental and social management.

Table 2-1: Key Institutions and their Functions

NAME	MAIN FUNCTIONS
National Environment and Planning Agency (NEPA)	NEPA is the main government agency with the primary responsibility of managing the environment. The Agency is responsible for managing all aspects of the Permit & Licence System (P&L) to ensure that all Jamaican facilities (developments), within the prescribed categories, meet required standards to minimise negative environmental effects, including Environmental Impact Assessments (EIA) where appropriate.
Water Resources Authority (WRA)	The Water Resources Authority (WRA), established by the Water Resources Act (1995), is the statutory body of the Government of Jamaica (GoJ) responsible for regulating the abstraction and use of Jamaica's water resources.
Forestry Department	The Forest Act, 1966, established the Forestry Department as the lead government entity responsible for the management of forests located on Crown Lands. The Forestry Department has also been assigned the responsibility for developing and managing the FSC National Standards of Jamaica and acquiring the FSC CoC.
Jamaica National Heritage Trust (JNHT)	The Jamaica National Heritage Trust (JNHT) is an agency under the Ministry of Culture, Gender, Entertainment and Sport (MCGES) with the legal mandate to protect and preserve Jamaica's heritage. The Trust is responsible for the identification, preservation and regulation of delicate national sites and monuments that satisfy the criteria established in the JNHT Act (1958).
Westmoreland Municipal Corporation (WMC)	Their responsibilities include developing, managing and maintaining infrastructure and public facilities such as parochial roads, water supplies, drains and gullies, parks, recreational centres, markets, abattoirs, pounds, cemeteries, transportation centres and public sanitary conveniences.
Ministry of Industry, Commerce, Agriculture and Fisheries (MICAF)	The Ministry of Industry, Commerce, Agriculture and Fisheries (MICAF) has been charged with the responsibility of driving the integration of the production of primary agricultural produce along all the stages of the supply chain through to value added and facilitating full commercialisation of outputs of the agriculture, manufacturing, and service sectors.

NAME	MAIN FUNCTIONS
Ministry of Economic Growth and Job Creation (MEGJC)	The Ministry is charged with drafting the blueprint to drive economic growth and sustainable development in Jamaica. The Ministry has responsibility for seven (7) critical portfolio areas: Land, Environment, Climate Change, Investment, Water and Wastewater, Housing and Works.
National Works Agency (NWA)	NWA is the implementing arm of the MEGJC for major construction works, the main road network and flood control systems.
National Water Commission (NWC)	NWC is charged with the responsibility of being the main provider of potable water supply and the collection, treatment and disposal of wastewater services.
National Solid Waste Management Authority (NSWMA)	The National Solid Waste Management Act (2001) mandates the National Solid Waste Management Authority (NSWMA) to take all necessary steps to execute the management of solid waste in Jamaica.
Social Development Commission (SDC)	The SDC is the principal community organisation agency working with Jamaica's 775 communities.
Office of Disaster Preparedness and Emergency Management (ODPEM)	ODPEM is the permanent disaster preparedness and relief organisation, which is responsible for coordinating, monitoring and educating the nation on disasters and disaster events.
Jamaica Public Service Company (JPS Co)	The JPS Co. is an integrated electric utility company and the sole distributor of electricity in Jamaica.
Jamaica Fire Brigade (JFB)	The Jamaica Fire Brigade is a statutory body within the Office of the Prime Minister – Department of Local Government. The role of the Jamaica Fire Brigade is to protect life and property from fire or other disasters within the Island and its territorial seas.
Jamaica Constabulary Force (JCF)	The JCF is tasked with the maintenance of law and order, the protection of life and property, the prevention and detection of crime, and the preservation of peace.
Port Authority of Jamaica (PAJ)	The PAJ manages port facilities in Jamaica and is a key stakeholder to be engaged in the export of pulp, the importation of construction material and the importation of input materials for the mill process (if required).
Sugar Company of Jamaica Holdings Limited (SCJH)	The SCJH is a wholly owned GoJ land management company which supports Jamaica's developmental objectives. Lands for the proposed mill were leased to the Pan Caribbean Sugar Company Limited however, the land is now owned by BBP. SCJH's current focus under this project is land management.
Environmental Health Unit (EHU), Ministry of Health and Wellness	This unit is under the direction and management of the Health Promotion and Protection Branch. The unit is responsible for managing and providing strategic policy direction for environmental health programmes. The main areas under their management are in Vector Control, Food Safety, Occupational Safety and Health, Port Health and

NAME	MAIN FUNCTIONS
	Quarantine, Building and Subdivision Plans (approving appropriate sewage systems), Water and Wastewater (regulating existing systems), Waste Management (include medical, hazardous and other solid waste, e.g., domestic), Institutional Health and Environmental Sanitation. The service delivery is strongly supported by the National Public Health and Environmental Laboratories.

2.2 LEGISLATION, REGULATION AND POLICY FRAMEWORK

Jamaica has fifty-two (52) statutes that have direct or indirect jurisdiction over matters of the environment, ranging from public health to physical planning and land use. In several instances, there are overlaps and intersections in responsibilities across Ministries. As such, the enactment of the Natural Resources Conservation Authority Act of 1991 (NRCA Act) began the process of rationalisation and prioritisation of these statutes. The Act binds the Crown as well as the people, meaning that enforcement can be applied to public sector entities and private citizens alike.

The following subsections summarise the main legislation, regulations, policies and international treaties that are relevant to the location of the Project Site and the nature of the Project (Table 2-2). It is essential that the Project activities do not violate these statutes. The list is not exhaustive, but represents the critical laws, regulations and policies that must be considered for the Project. Some details on each are presented in **Appendix C** and a full list will be appended to the final full draft of the EIA report.

Table 2-2: Relationship of the proposed Project to the Legislations, Regulations, Plans, Programmes and Policies concerning environmental Protection currently in force

NAME	RELATIONSHIP TO THE PROJECT
Relationship of the Project to the environmental protection legislation and regulations currently in force and under development	
The Natural Resources Conservation Authority (NRCA) Act, 1991	The NRCA Act provides for the management, conservation and protection of the natural resources and is the chief Environmental Act for Jamaica. Communication with NEPA indicated that an EIA is required for this development, as such, this EIA is being done to meet the requirements of this NRCA Act and support permit applications.
The Natural Resources Conservation (Permits and Licences) (Amendment) Regulations, 2015	Under the NRCA Act of 1991, the NRCA is authorised to issue, suspend and revoke permits and licences if facilities are not in compliance with the environmental standards and conditions of approval stipulated. BBP is required to apply for a permit and licences for the following: • Construction and operation of a Market Pulp Mill in Friendship, Westmoreland; • Construction and operation of a power generation plant using renewable energy for use at the Mill; • Construction and operation of water treatment and storage facilities at the Mill; • Licence for the construction and operation of a Wastewater Treatment Plant at the Mill to support the development; • Licence to discharge trade effluent. BBP also intends to use Liquid Natural Gas (LNG) for operations and storage. BBP or their LNG Partner/Provider (to be decided) will also be required to and be responsible for preparing and submitting the necessary Environmental Permit applications for the proposed construction and operation activities.
The Natural Resources Conservation (Wastewater and Sludge) Regulations, 2013	These regulations require that separate licences be acquired to construct, operate and discharge effluent from a Wastewater or Sewage Treatment plant. BBP will require a licence for each activity. Following receipt of a permit, the developer would be required to monitor the effluent quality based on the frequency outlined in the terms and conditions of the licence and submit monitoring reports accordingly.
The Natural Resources Conservation Authority (Air Quality) Regulations, 2006	BBP will be required to employ emission control measures to minimise "stack and fugitive emissions". BBP may be required to obtain an Air Pollutant Discharge Licence.
The Town and Country Planning Act (1999)	The Act establishes area-specific standards for land use, density and zoning. The Act and the Westmoreland Development Order will guide the land use and planning for the Project.

NAME	RELATIONSHIP TO THE PROJECT
Relationship of the Project to the environmental protection legislation and regulations currently in force and under development	
Town and Country Planning (Westmoreland Area) Confirmed Development Order, 2021	The Town and Country Planning Act stipulates the guidance, specifications to be included in development orders and the conditions by which applications will be approved. The Act and the Westmoreland Development Order will guide the land use and planning for the Project. The project is not sited within a designated Local Planning Area but is zoned as *Agricultural Land*. The mill site may need to apply for a "Change of Use" through the Ministry of Agriculture and Fisheries (MOAF), however, as this is an agro industry, this will be clarified. Policies from the Town and Country Planning (Westmoreland Area) Confirmed Development Order, 2021 that apply to the proposed project can be found in **Appendix D**.
The Wild Life Protection Act (1945) *Amended 1991*	This Act is primarily concerned with the protection of specified species of fauna and precludes the hunting of any protected species. The construction and operation phases of the Project will impact biodiversity of the Site and the ecosystem services provided through elements such as vegetation clearance, stack emissions, wastewater discharge, etc.
Factories Act (1943) Amended 2009	This Act makes provision for the registration and supervision of factories, and for the safety of workers employed. It is accompanied by the Factories Regulations (1961), and the Building and Operations of Works of Engineering Construction (BOWEC) Regulations (1968). During construction and operation of the proposed Project, occupational health and safety of workers, visitors and the surrounding community must be paramount to remain compliant with the Act.
Public Health Act (1986) Amended (1996): Subsidiary Legislation on Health and Safety (2013)	The Public Health Regulations 1976 aim at controlling, reducing, removing or preventing air, soil and water pollution in all possible forms. The excavation and construction work and use of heavy machinery and equipment may result in the temporary generation of fugitive dust. Proper care and standard best practices for the construction industry should be applied to minimise public health risks.
The National Solid Waste Management Authority Act (2000)	This Act provides for the regulation and management of solid wastes. Solid waste management will be essential in the construction phase and will require the removal and proper disposal of vegetative matter, soil and construction rubble. The NSWMA should be contacted regarding an approved disposal site.

NAME	RELATIONSHIP TO THE PROJECT
Water Resources Act (1995)	This Act provides for the management, protection and controlled allocation and use of the water resources of Jamaica and provides for water quality control and the establishment and functions of a Water Resources Authority. During construction and operations, the Act, executed through licences and permits granted by the WRA, will guide and monitor the abstraction of water from the Cabarita River, release of effluent into the Cabarita River, water quality of effluent and the controlled area, as well as from any wells if they are drilled and used at the proposed project site in Friendship, Westmoreland.
Watersheds Protection Act (1963)	The proposed Project site falls within the Cabarita River Watershed Management Unit, which encompasses several residential communities that depend on the watershed and its services to maintain their livelihoods.
Relationship of the Project to the environmental protection legislation and regulations currently in force and under development	
Noise Abatement Act (1997)	World Bank guidelines have been adopted by the NEPA and are used for benchmarking purposes along with the draft National Noise Standards that are being prepared. Hence BBP will need to comply in construction and operational phases.
Disaster Risk Management Act (2015)	Given Jamaica's susceptibility to natural hazards and more recently, the outbreak of the coronavirus disease 2019 (COVID-19), BBP should remain cognizant of changes mandated by the Act for business continuity purposes and the safety of all employees.
The Access to Information Act (2002)	All documents pertinent to the EIA process for BBP will be accessible to the general public.
The Plants (Quarantine Act) (1994) and Regulations (1999 and 2005)	The Act makes provision for the effective control of the importation of plants, plant products and articles which pose a threat of introducing into Jamaica any injurious plant pests. This is important as BBP proposes to maintain bamboo farm at multiple sites in Jamaica through various agreements. If BBP needs to import bamboo chips for the pulp mill, from other countries under unusual circumstances, this Act and Regulations will apply.
Jamaica National Heritage Trust Act (1985)	The Act established the Jamaica National Heritage Trust (JNHT) as the agency in charge of the protection of national monuments and national heritage. The JNHT designates what is a national monument which may be located above or below ground and will guide the preservation or removal of any chance finds which may be of historic, architectural, traditional, artistic, aesthetic, scientific or archaeological interest. These chance finds may be encountered during the construction of the proposed site in Friendship, Westmoreland.

NAME	RELATIONSHIP TO THE PROJECT
Relationship of Project to national plans, programmes and policies	
Vision 2030 Jamaica – National Development Plan (2009)	National Outcomes 12, 13 and 15 of the Vision 2030 are integral to this development being proposed. These are as follows: *Outcome 12 and Strategies– Internationally Competitive Industry Structures* • Develop company sophistication and productivity • Develop economic linkages and clusters • Develop economies of scale and scope through collaboration among enterprises in the region • Enhance the framework for competition among enterprises • Promote eco-efficiency and the green economy Related Project Aspects: • The LOI in place with leading Consumer Tissue and Personal Hygiene Producers, as they look to increasingly replace stock consumption with non-wood fibres *Outcome 13 and Strategies – Sustainable Management and Use of Environmental and Natural Resources* • Integrate environmental issues in economic and social decision-making policies and processes • Develop and implement mechanisms for biodiversity conservation and ecosystems management • Develop efficient and effective governance structures for environmental management • Manage all forms of waste effectively Related Project Aspects: • The Project concept is based on the first and last strategies and is an excellent illustration of environmental underpinning in agro-ecological industrial models and design. • BBP Project design has integrated a recovery boiler to supplement power and maximise energy efficiency. • BBP intends to use electric-powered trucks to transport material from the mill to the port. They will be powered by surplus electricity produced from the proposed mill. • The proposed outcome is the establishment of a cottage industry in local rural communities utilising bamboo by-products as straws, stirrers, etc.

<table>
<tr><th>NAME</th><th>RELATIONSHIP TO THE PROJECT</th></tr>
<tr><td></td><td>Outcome 15 and Strategies – Sustainable Urban and Rural Development
• Create a comprehensive and efficient planning system
• Create an appropriate framework for sustainability planning
• Create sustainable urban centres, including urban renewal and upgrading
• Create vibrant and diversified rural areas
• Ensure safe, sanitary and affordable shelter for all
Related Project Aspects:
• All aspects of this development are geared towards sustainable rural development.</td></tr>
<tr><td>Climate Change Policy Framework for Jamaica (2015; Updated 2021)</td><td>The updated Policy Framework is in alignment with the Paris Agreement under the UN Framework Convention on Climate Change. Under the new Policy Framework, the project satisfies components under Goal 2 and Goal 3 of the Policy Framework. They are:
• Goal 2: Pursuit of low carbon development and enhancement of access to and mobilisation of climate finance
2.1 Mitigation: Reduce Jamaica's overall GHG emissions in support of low carbon development.
• Goal 3: Promotion of public education and awareness raising, research and technology transfer towards ambitious climate action
3.1 Technology Transfer: Promote the transfer of environmentally sound technologies for mitigating and adapting to climate change with other countries and international organisations and among the public sector, private sector entities, financial institutions, non-governmental organisations (NGOs) and research/education institutions
The implementation of the mill using the most modern technology to develop a sustainable pulp, the use of electric-powered vehicles and the sustainable production of energy at the mill using a bi-product of the raw material supports responsible climate action.</td></tr>
<tr><td>Update of Nationally Determined Contribution (NDC) of Jamaica to the United Nations Framework Convention on Climate Change (UNFCCC), (2020)</td><td>The Project contributes to plans in the expansion of agroforestry under its commitment concerning the agricultural sector. The Project also contributes to projects that aid in the reduction of greenhouse gas (GHG) emissions, carbon sequestration and enhanced climate resilience which will also be assisted by the introduction of new technology in the manufacturing sector. The Project also aligns with the GoJ's intention to increase the use of renewable energy technologies, such as biodigestors, and LNG as a substitute for heavy fuel oil (HFO).</td></tr>
</table>

NAME	RELATIONSHIP TO THE PROJECT
The National Land Policy (1997)	The goals and objectives of this Policy are to ensure the sustainable, productive and equitable development, use and management of the country's natural resources. Chapter 3 of the National Land Policy includes increasing the utilisation of arable lands, rural development and the protection of watershed and fragile areas and crop and production, all relevant to the construction and operation of the proposed Project.
Jamaica National Physical Plan (1978–1998)	In general terms, the objectives of the proposed Project align with those of the National Physical Plan.
DRAFT Agricultural Land Utilisation Policy (2013)	This policy guides the proper administration and management of land for sustainable use that will foster agricultural growth, encourage opportunities for investment and income generation, satisfy the demand for lands for agricultural production, regenerate livelihoods for farming communities, and promote overall economic development of the country. This Project fulfils the goals of the policy.
The National Water Sector Policy and Implementation Plan (2019)	The goal of the Policy is to ensure that Jamaica's water resources are effectively managed so as to provide for our nation's social, economic and environmental well-being, now and in the future. The objectives of the policy that apply to this Project are: i. To protect watershed areas, ecosystems, catchments and networks, and promote effective programmes for water conservation and protection; ii. To allow for private sector participation in the water sector; iii. To effectively manage water supply in Utility and Non-Utility Service Areas by ensuring equitable sharing of the water resources in the twenty-six (26) Watershed Management Units (WMUs); iv. To increase resilience to climatic shocks, such as drought; v. To encourage rainwater harvesting, both as a primary source of access and as a drought management mechanism; vi. To ensure effective management of wastewater; vii. To ensure effective flood water control.

NAME	RELATIONSHIP TO THE PROJECT
Relationship of Project to national plans, programmes and policies	
National Seed Policy and Action Plan (2015–2025)	The policy focuses on the development of a seed system that ensures the availability of high-quality seed which is accessible to end users. Seed within the context of this policy means parts of agricultural, forestry and horticultural plants intended for sowing or planting purposes. As BBP intends to establish and/or encourage the development of nurseries and seed distribution, this is relevant to the project.
JCP 8: 2021 Jamaican Standard Code of Practice for Bamboo Plantation (2021)	Currently, a voluntary code is in development that is primarily geared towards the nursery and plantation practices for *Bambusa vulgaris*, the most common bamboo growing in Jamaica.
Protection of Plant Genetic Resources for Food and Agriculture Act (2013)	The Act is designed to provide for the protection of Jamaica's plant genetic resources for food and agriculture and for connected matters. This is relevant for the establishment of Bamboo Plantations that will supply the mill.
National Plant Health Policy (2011)	The policy aims to establish a coordinated, sustainable and internationally compliant plant health system that enhances Jamaica's plant health status, thus fostering consumer, plant and environmental health and food security.
DRAFT Occupational Health and Safety Act (2017)	This is a balanced framework to secure the safety and health of workers and prevent accidents and injuries to health during the construction and operational phases of the Project.
The Tree Preservation Order	This Order falls under the Tree Preservation Act. The Order provides for the protection of all trees from destruction or mutilation of any kind, except with the express permission of the local planning authority under the National Land Policy (1996). This will be required if any tress need to be removed from the site during construction.
Forest Policy for Jamaica (2016)	This Policy is geared to promoting sustainable management of Jamaica's forest resources. It governs all forests in Jamaica whether owned by the State or by private interests. Its scope covers land with reforestation potential and forests in urban settings and addresses national priorities as well as international obligations and commitments relating to climate change, biodiversity conservation, and the sustainable use of wetlands. The designated mill site is not within any forests designated by the Forestry Department. However, this Policy will assist in the Project from the growth, management and provision of the raw material (raw bamboo) for the mill.

NAME	RELATIONSHIP TO THE PROJECT
Jamaica's National Energy Policy 2009-2030	The goals of The National Energy Policy include the development of renewable energy sources such as solar, wind, hydropower and biofuels with the target of increasing the percentage of renewables in the energy mix to 20% by 2030 as well as to improve energy conservation and efficiency. The Policy has 5 supporting policies. This overall Policy applies to the mill, primarily through the generation of energy from a recovery boiler and the potential to sell the excess to the grid and to power electric trucks. The supporting Policies that would apply based on the Project are: • The National Energy Conservation and Efficiency Policy 2010 – 2030: This Policy seeks to increase efficiency in the generation, transmission and distribution of electricity, in the use of energy in multiple sectors, particularly in the industrial sector. This Sub-Policy also facilitates Jamaica's participation in the Clean Development Mechanism (CDM) by including a policy action to develop a framework to capitalise on the opportunities offered by the carbon market under the CDM for efficiency and conservation projects; • The Biofuels Policy 2010 – 2030: This Policy provides a framework for the development of the biofuels sector with specific focus on bioethanol from sugar cane, electricity power cogeneration using bagasse and biodiesel primarily from crops. This would apply as the bi-product of the bamboo will be used to generate power in the recovery boiler.
The Emissions Policy Framework for Jamaica (2021)	The Goal of the Policy is to provide effective and coordinated systems for the reduction of emissions from key pollutant sources and maintenance of good air quality throughout Jamaica. The Policy will seek to address, inter alia, the management of emissions from the following sources: • Industrial processes, e.g., power generation; • Land, air and sea transportation; • Waste disposal and treatment; • Land use and biomass burning; • Agricultural by-products; and • Residential and commercial sources. Sources that would be managed under this project are those of industrial processes, waste disposal and treatment, and agricultural by-products.

Other legislation identified upon completion of this report and which will be included in an updated draft of the EIA is the dated Agriculture Produce Act (1926) as well as the need for the newly developed Agricultural Land Utilization Policy to be made operational through the development of an Action Plan.

2.3 RELEVANT INTERNATIONAL TREATIES AND PROTOCOLS

Table 2-3 presents the International Treaties and Conventions that Jamaica has signed to that are of relevance to the proposed Project.

Table 2-3: Relevant International Treaties and Protocols

NAME OF TREATY/ CONVENTION	DATE OF RATIFICATION	REMARKS
Convention concerning the Protection of the World Cultural and Natural Heritage	June 14, 1983	
United Nations Framework Convention on Climate Change	January 6, 1995	
Kyoto Protocol on the United Nations Framework Convention on Climate Change	June 26, 1999	Ratified on June 28, 1999
Paris Agreement under the United Nations Framework Convention on Climate Change	April 11, 2017	Signed April 22, 2016
United Nations Sustainable Development Goals	September 25, 2015	
Convention on Biological Diversity	January 6, 1995	
Cartagena Protocol on Biosafety to the Convention on Biological Diversity	September 25, 2012	Signed June 4, 2001
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	June 22, 1997	

Other international treaties to be considered in the proposed project include:

- **International Treaty on Plant Genetic Resources for Food and Agriculture** – The objectives of this Treaty are the conservation and sustainable use of plant genetic resources for food and agriculture and the fair and equitable sharing of the benefits arising out of their use, in harmony with the Convention on Biological Diversity, for sustainable agriculture and food security.
- **The 2030 Agenda** – The 2030 Agenda is a Global Pact unanimously agreed to by the 193 Member States of the United Nations to take bold and transformative steps to shift the world on to a sustainable and resilient path, while leaving no one behind. The 17 Sustainable Development Goals (SDGs) and 169 targets of this Agenda, which is the successor to the Millennium Development Goals (MDGs), build on existing global agreements.
- **Global Good Agricultural Practices** – Good agricultural practices are "practices that address environmental, economic and social sustainability for on-farm processes, and result in safe and quality food and non-food agricultural products". Good agricultural practices (GAP), codes, standards, and

regulations are guidelines which have been developed in recent years by the food industry, producers' organisations, governments, and NGOs, aiming to codify agricultural practices at the farm level for a range of commodities.

- **FSC Chain of Custody** – FSC CoC Certification ensures that FSC materials and products have been checked at every stage of processing, so customers purchasing products sold with FSC claims can be confident that they are genuinely FSC certified.

2.4 EQUATOR PRINCIPLES

The Equator Principles (EPs) are a credit risk management framework for determining, assessing and managing environmental and social risk in Project Finance transactions. Project Finance is often used to fund the development and construction of major infrastructure and industrial projects. The EPs are 10 principles adopted by financial institutions and are applied where total project capital costs exceed US$10 million. The EPs are primarily intended to provide a minimum standard for due diligence to support responsible risk decision-making.[iv] Their objective is to promote sustainable environmental and social performance which can lead to improved financial, environmental, and social outcomes. The EPs are based on the International Finance Corporation Performance Standards on Social and Environmental Sustainability and on the World Bank Group Environmental, Health, and Safety (EHS) Guidelines.

2.5 WORLD BANK GROUP ENVIRONMENTAL, HEALTH AND SAFETY GUIDELINES

2.5.1 WORLD BANK ENVIRONMENTAL AND SOCIAL FRAMEWORK

Protecting the people and the environment are at the centre of World Bank funded programmes. It is a necessary pillar to achieve the World Bank's goals to end extreme poverty and promote shared prosperity. The World Bank seeks to minimise and mitigate any harm to people and the environment through the application of several social and environmental standards. These standards include an assessment and management of environmental and social risks and impacts. The Environmental and Social Standard 1 (ESS1) is the *Assessment and Management of Environmental and Social Risks and Impacts*. It applies to all projects for which World Bank Investment Project Financing is sought. ESS1 establishes the importance of the following guidelines:

a. The Borrower's existing environmental and social framework in addressing the risks and impacts of the project;

b. An integrated environmental and social assessment to identify the risks and impacts of a project;

c. Effective community engagement through disclosure of project-related information, consultation and effective feedback; and

[iv] From the July 2020 Equator Principles – EP4.

d. Management of environmental and social risks and impacts by the Borrower throughout the life of the project.

The Bank requires that all environmental and social risks and impacts of the project be addressed as part of the environmental and social assessment conducted in accordance with ESS1. The other Standards, ESS2-10, set out the obligations of the Borrower in identifying and addressing environmental and social risks and impacts that may require special focus. These Standards establish objectives and requirements to avoid, minimise, and, where residual risks and impacts remain, to compensate for or offset such risks and impacts.

- The Bank will only support projects that are consistent with, and within the boundaries of its Articles of Agreement and are expected to meet the requirements of the ESSs in a manner and within a timeframe acceptable to the Bank.
- The Framework also includes non-mandatory guidance and information tools to assist borrowers in implementing the Standards, bank staff in conducting due diligence and implementation support, and stakeholders in enhancing transparency and sharing good practice.

The Jamaica EIA process has been strongly influenced by the original World Bank Guidelines on EIAs. Protecting the people and the environment are at the centre of World Bank funded programmes. It is a necessary pillar to achieve the World Bank's goals to end extreme poverty and promote shared prosperity. The World Bank seeks to minimise and mitigate any harm to people and the environment through the application of several social and environmental standards. These standards include an assessment and management of environmental and social risks and impacts.

The environmental and social risks and impacts which the Bank will consider in its due diligence are project-related and include the following:

Environmental and social risks and impacts, including

i. Those identified in the World Bank Group Environmental, Health and Safety Guidelines (EHSG);

ii. Those related to community safety;

iii. Those related to climate change and other trans-boundary or global impacts;

iv. Any material threat to the protection, conservation, maintenance and rehabilitation of natural habitats and biodiversity; and

Those related to the use of living natural resources, such as fisheries and forests.

2.5.2 ENVIRONMENTAL, HEALTH AND SAFETY (EHS) GUIDELINES

Borrowers and projects of World Bank funding are required to comply with the World Bank Group EHS Guidelines. The EHS Guidelines are technical reference documents with general and industry-specific statements of Good International Industry Practice (GIIP). The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable cost. The EHS Guidelines that will apply to this entire project include:

i. Environmental, Health, and Safety General Guidelines (2007)
ii. Environmental, Health, and Safety Guidelines – Pulp and Paper Mills (2007)
iii. Environmental, Health and Safety Guidelines for Perennial Crop Production (2015)
iv. Environmental, Health, and Safety Guidelines for Forest Harvesting Operations (2016)

Guidelines are provided for the following pollution factors (see relevant sections of the International Finance Corporation's (IFC) Environmental, Health and Safety Guidelines – Paper and Pulp Mills, 2007) in Figure 2-1.

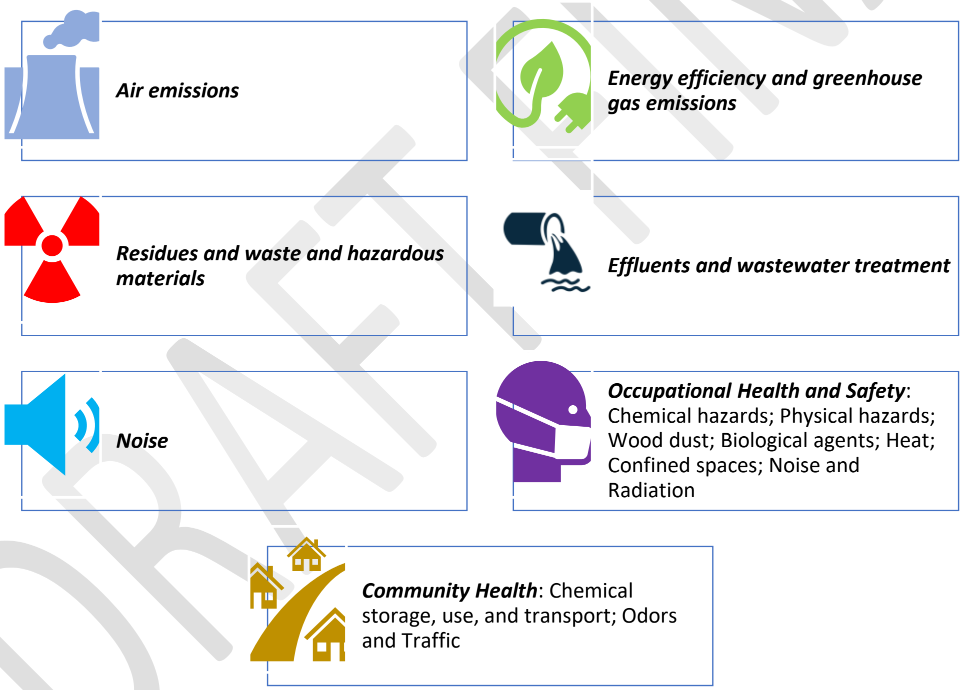


Figure 2-1: Pollution factors represented in the IFC's Environmental, Health and Safety Guidelines for Paper and Pulp Mills.

2.6 IFC PERFORMANCE STANDARDS ON SOCIAL AND ENVIRONMENTAL SUSTAINABILITY

The IFC is a member of the World Bank Group and is focused exclusively on the private sector in developing countries. These Performance Standards are essential documents to help the World Bank Group and its clients manage and improve their social and environmental performance through an outcomes-based approach. The Performance Standards also provide a solid base from which clients may increase the sustainability of their business operations. The seven (7) Performance Standards shown in are applicable to the proposed Project.

1. Social and Environmental Assessment and Management System
2. Labour and Working Conditions
3. Resource Efficiency and Pollution Prevention
4. Community Health, Safety and Security
5. Land Acquisition and Involuntary Settlement
6. Biodiversity Conservation and Sustainable Natural Resource Management
7. Indigenous Peoples *(not applicable to proposed Project)*
8. Cultural Heritage

Figure 2-2: Performance Standards that apply to this project.

IFC's Sustainability Framework articulates the Corporation's strategic commitment to sustainable development and is an integral part of IFC's approach to risk management. The Sustainability Framework comprises IFC's Policy and Performance Standards on Environmental and Social Sustainability, and IFC's Access to Information Policy. The Policy on Environmental and Social Sustainability describes IFC's commitments, roles, and responsibilities related to environmental and social sustainability.

2.7 FSC PRINCIPLES AND CRITERIA

The FSC has developed a set of ten principles and 70 criteria that apply to FSC-certified forests around the world. The ten principles are represented in Figure 2-3. This Project aims to receive FSC Chain-of-Custody Certification, and as such must also meet these criteria.

1. Compliance with Laws
2. Workers' Rights and Employment Conditions
3. Indigenous Peoples' rights (not applicable)
4. Community Relations
5. Benefits from the Forest
6. Environmental Values and Impacts
7. Management Planning
8. Monitoring and Assessment
9. High Conservation Values
10. Implementation of Management Activities

Figure 2-3: Ten principles from the FSC that apply to this project.

2.8 WORLD BANK'S ENVIRONMENT, SOCIAL AND GOVERNANCE ISSUES

Integrated in the project and this EIA is the evaluation of the project based on the World Banks' Environment, Social and Governance (ESG) issues. Some key ESG risks integrated in the proposed project are as follows:

ENVIRONMENTAL	SOCIAL	GOVERNANCE
• Climate mitigation/adaptation strategy – » Exposure to and preparedness for natural disasters (physical risk); » Climate transition (renewable energy supply and reduced dependence on fossil fuels) • Energy efficiency and security • Air pollution prevention, mitigation and management • Carbon footprint • Water pollution prevention, mitigation and management • Waste generation and recycling	• Social and rural development • Human rights adherence • Human capital development and contribution to the labour market • Gender equality • Non-Discriminatory	• Meeting legal and regulatory requirements

2.9 GAPS

One gap that exists between the Jamaican legislation/policies and the IFC Performance Standards relates to stakeholder consultation. Stakeholder consultation is a requirement in the EIA process for NEPA. However, outside of this, there are no other specific requirements for public consultations when a project is being undertaken. Nonetheless, stakeholder consultations are considered a key success factor for development projects and have therefore been utilised for this consultancy as further elaborated in the sections below.

2.10 LICENCES AND PERMITS RELEVANT TO THE PROJECT

The following sections outline the probable relevant licences and permits that are relevant to the proposed Project. The names of the licences and permits printed below are the official names; some components within the official name, may not apply to the Project. This is not intended to be prescriptive but is based on the Project concept as presented in the Project Brief submitted to NEPA (submitted March 25, 2020; revised April 21, 2020).

2.10.1 ENVIRONMENTAL LICENCES (EL)

Environmental Licences that could be relevant to the Project include:

- Construction of wastewater treatment plant(s);
- Operation of wastewater treatment plant(s). This licence is renewed every 5 years;
- Discharge of treated sewage effluent into the environment. This licence is renewed every 5 years;
- Discharge of trade effluent into the environment. This licence is renewed every 5 years;
- Air Pollution Discharge Licence.

2.10.2 ENVIRONMENTAL PERMITS (EP)

Environmental Permits that could be relevant to the Project include:

- Construction and operation of facilities for the manufacturing and processing of pulp, paper and wood;
- Construction and operation of water treatment and storage facilities, including desalination plants and water supply plants;
- Construction or installation and operation of pipelines of 20m or more in length for the transmission of noxious, explosive, flammable and or toxic material;
- Construction and operation of power generation plants of 1MW or above using hydrocarbon fuels;
- Modification of waterways for the transfer of water resources or river training works;
- Well drilling for water abstraction.

2.10.3 WATER ABSTRACTION AND USAGE LICENCES

Water Abstraction and Usage Licences that could be relevant to the Project include:

- WRA Permit for Abstraction of water from river(s) if this is decided. This is renewed every 5 years;
- WRA Permit for well drilling if this is decided.

3 METHODOLOGY AND APPROACH

3.1 GENERAL APPROACH

The general approach to the EIA is in keeping with best practice and the Terms of Reference from the NEPA as indicated in **Appendix A.** The process is presented in Figure 3-1.

Figure 3-1: Methodology of the EIA

The screening and scoping were completed prior to the EIA. The base case design will be presented as the Project Description in **Chapter 4**. The subsequent sections will describe the surveys to determine the existing environmental and social conditions and the methodology for the impact and mitigation assessments.

3.2 EXISTING ENVIRONMENTAL CONDITIONS

The compilation of information about existing environmental conditions and the assessment of key issues to help inform development decisions was the first step in executing the assessment. Team meetings were used to discuss the progress of investigations and analyses and to facilitate integration of data toward an understanding of the systems at work in both the natural and built environment.

The team of consultants conducted preliminary site investigations together to determine the dominant environmental issues relevant to the proposed development, the critical elements for analysis, and the issues to be highlighted for the design and planning process. Detailed field surveys to gather primary data on the proposed Project, within a 2 km sphere of influence and in areas of interest, were subsequently conducted. Other proposed developments and surrounding land use were also reviewed in the context of compatibility with the proposed Project including potential positive, negative, and cumulative impacts.

Field investigations were conducted to capture information pertaining to the existing conditions of the environment and socioeconomic status in the proposed project sphere of influence and within other areas of interest. Data was collected during both the wet and dry seasons in Jamaica.

A site reconnaissance was conducted in March 2021 while field investigations were conducted between July 2021 and May 2022. Field investigations for the Physical and Ecological Assessments to determine the environmental attributes during the wet season were conducted in November 2021. Investigations were also conducted between February and May 2022 to determine the existing environmental attributes during the dry season. A summary of the assessments conducted are outlined in Table 3-1.[v] Social Surveys were conducted in July and October 2021. Section 3.2 describes in detail the approach for the physical, biological, and socioeconomic environment.

[v] Observations from the field investigation in March 2021 were used to generate the Site Reconnaissance Report for comparative purposes in this EIA report.

Table 3-1: Summary of Physical, Ecological and Socioeconomic Investigations for the Proposed Project Site in Friendship, Westmoreland (October–May 2022)

ATTRIBUTE	PARAMETERS	DATA POINTS	SAMPLING PERIOD
Water quality	Physical, Chemical and Bacteriological Parameters	Eight (8) sampling stations	One sampling period on November 2, 2021
		Twelve (12) sampling points	One sampling period on March 29, 2022
Ambient Air Quality	Respirable particulates (PM_{10}), hydrogen sulphide (H_2S), nitrogen oxides (NOx) and sulphur oxides (SOx)	Seven (7) sampling stations	PM_{10} and H_2S measurements collected during one 24-hr sampling period in November 2021 between 1:00 p.m. on November 2, 2022, to 5:00 p.m. on November 3, 2021. NO_x and SO_x measurements were collected during another 24-hr sampling period between 1:30 p.m. on November 25, 2021 and 1:30 p.m. on November 26, 2021.
		Seven (7) sampling stations	PM_{10}, NO_x, H_2S and SO_x measurements were collected during one 24-hr sampling period between 2:00 p.m. on March 31, 2022, and 2:00 p.m. on April 1, 2022.
Noise levels	Noise levels in dBA	Seven (7) sampling stations	Two 3-minute assessments at each site over a 2-day sampling period in November 2021
		Seven (7) sampling stations	One 3-minute assessment at each site in May 2022
Geology and Soils	Geological history, type of soils in and around the proposed site, soil profile and characteristics, geotechnical hazards	N/A	N/A
Hydrology (surface and ground)	Drainage area and pattern, nature of streams, aquifer characteristics, flooding hazards	N/A	N/A
Climate	Wind, Rainfall, Temperature and Humidity	N/A	N/A
Ecology	Existing flora and fauna (incl. bats)	2 km sphere of influence	Daytime and nocturnal surveys during November 2021 and February 2022

ATTRIBUTE	PARAMETERS	DATA POINTS	SAMPLING PERIOD
Socioeconomic aspects (incl. public participation)	Demographic and socioeconomic characteristics, cultural heritage, social services, physical and public infrastructure, social amenities, planned works, labour & working conditions and issues regarding land acquisition	Individual surveys (102) and targeted stakeholder groups	Based on data published by the Statistical Institute of Jamaica (STATIN), SDC and other sources Individual surveys conducted in select communities in July 2021 Focus groups and meetings with key stakeholders held in July 2021 Open-day forum held in October 2021
Land Use	Land use of different categories around the proposed site	NA	Based on the Town and Country Planning (Westmoreland) Confirmed Development Order, 2021

3.2.1 PHYSICAL ASSESSMENT

This assessment comprised an evaluation of the current climate, topography, land use, site history, geology and soils, hydrology and drainage, air quality, noise quality, water quality, ecology and socio-economic environment that could potentially be affected by the proposed development. Data was collected in both the wet and dry season and assessed where possible. The source-pathway-receptor model was also used to assess the pollution risk. This model is used in the industry to identify the potential causes and sources of pollution, how the pollution can travel through the environment (pathway), and who and what (physical, human and environmental receptors) can be affected. The information from the model was used to inform **Chapters 8–12** of the report which relate to the identification of impacts and mitigation measures, risk assessment and EHS management and monitoring plans.

3.2.1.1 Topography

The approach included a review of relevant literature, and analysis of topographic maps and satellite imagery of the area. Maps used included:

- The 1:50,000 Topographic Map Series, Sheet 5
- Google Earth Satellite Imagery from January 2001 to 8 November 2021.

3.2.1.2 Geology and Soils

The approach included a review of relevant literature, and analysis of topographic, geological and soil maps for the area and findings from the geotechnical investigation report conducted. Maps used included:

- The 1:50,000 Geological Map Series, Sheet 5
- The 1:50,000 Topographic Map Series, Sheet 5
- Hydrostratigraphy and Geological Features Map of the Location, Water Resources Authority, 2021
- Soil Map of the Location, Water Resources Authority, 2021
- Soil Internal Drainage Map, Water Resources Authority, 2021.

3.2.1.2.1 Assessment of potential Geotechnical Hazards

The approach included a review of the relevant literature, as well as a review of topographic and satellite imagery to determine a history or features that indicate the area is at risk of geotechnical hazards such as sinkholes, seismic risk, settlement/heave, landslides, and other hazards. Information from a geotechnical investigation report will be used to verify the information.

3.2.1.3 Hydrology and Drainage

The hydrological and drainage analyses included the following activities:

i. Description of the hydrology and hydrogeology of project site and surroundings including mapping of existing surface waterways within and near the site and downstream of the site;
ii. Use of data from nearby wells, the WRA hydrostratigraphy maps and geotechnical investigations to examine sub-surface conditions (soil type, depth to ground water, ground water quality, etc.) and any effects on ground water due to additional pumping water-well post-development, effects on infiltration and percolation, and effects on surface and ground water quality;
iii. Conducting a natural hazard risk assessment as it relates to flooding and stormwater runoff using a cross-section survey data of main channels identified in the area for the Hydraulic Analysis;
iv. Conducting a hydrologic impact assessment of proposed development on the watershed including assessment on water quality;
v. Assessing the cumulative impacts; and
vi. Identification of mitigation measures (hard and soft) to prevent any negative impacts from the development on the water resources of the watershed.

The subsequent Sections elaborate on key aspects of this analysis.

3.2.1.3.1 Watershed Demarcation

The determination of the watershed boundary impacting the proposed Project area is an essential starting point for the hydrological analyses, as it provides the basis for water resource assessment, protection, management, and modelling. Watershed definition was done by terrain processing using ArcGIS Software along with a suitable Digital Elevation Model (DEM). The Watershed was demarcated using the Geospatial Hydrologic Modelling Extension (HEC-GeoHMS) developed by the US Army Corps of Engineers Hydrologic Engineering Center, a geospatial hydrology toolkit (an ArcView extension) and a 28m x 28m DEM of the area. The terrain pre-processing components are depicted in Figure 3-2.

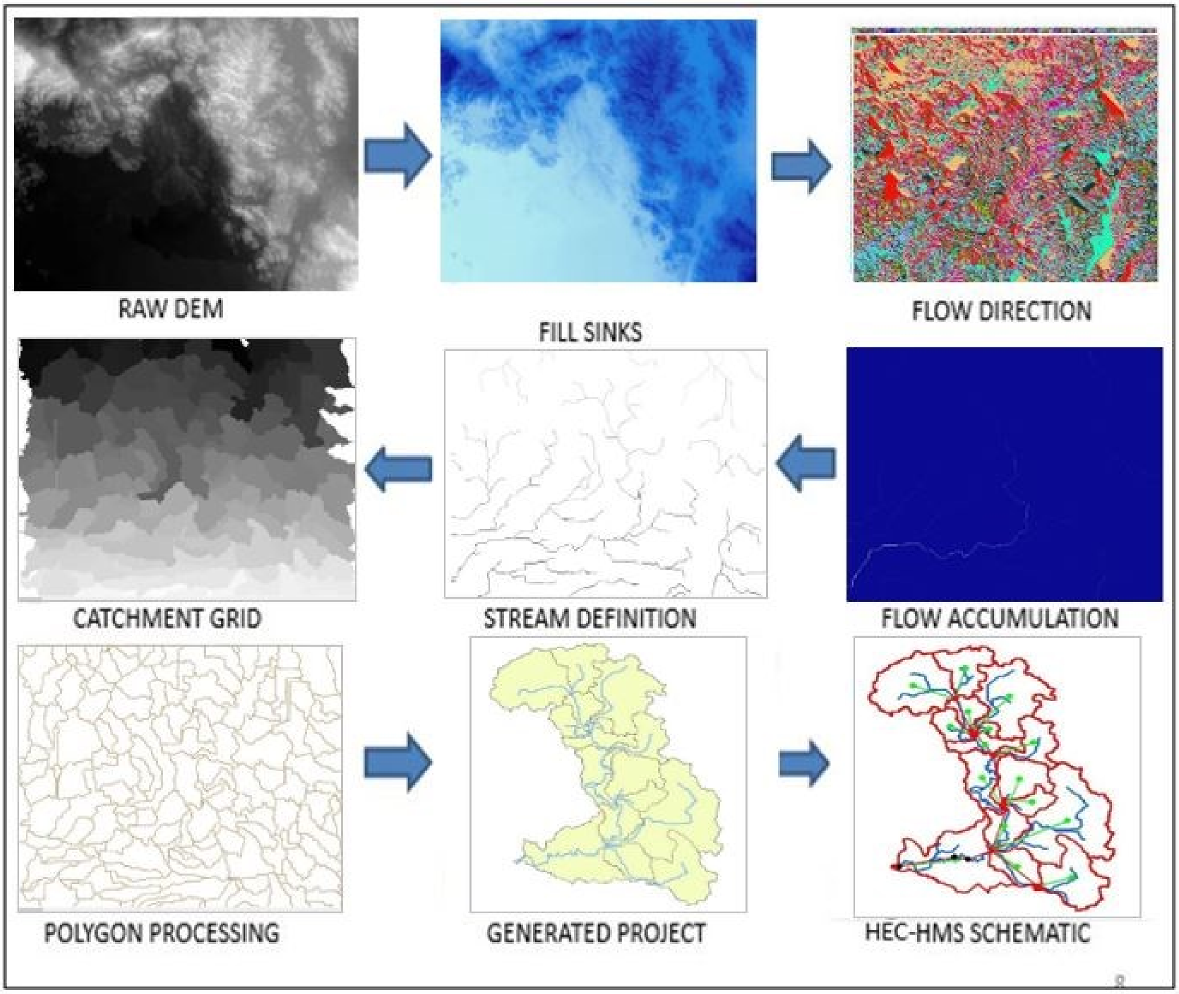


Figure 3-2: ArcMap Terrain Pre-processing Components of the Cabarita River Watershed above Barton Bridge

As shown, the process involved first the filling of the sinks in the DEM, followed by the estimation of the flow direction and flow accumulation, the definition of the stream flow path and catchment grid. From this grid, the Watershed and Sub-basins were demarcated.

3.2.1.3.2 Hydrologic Analysis

The pre- and post-development conditions of the proposed mill area and environs were simulated and presented in 10-, 25-, 50-, and 100-year (T-yr) flow hydrographs using the HEC-HMS model. The process involved:

i. Data collection: streamflow, average stream velocity, rainfall and other climatological data, soil information, land use and an assessment of how this impacts the watershed;
ii. The development of hydrologic and meteorologic models;
iii. The calibration/verification of the hydrologic model; and
iv. Running rainfall-runoff simulations.

The designated flood flows were determined by hydrologic (rainfall to runoff) modelling to facilitate the pre- and post-development assessment and to simulate the corresponding peak flows. The simulated pre- and post-flood flows were routed through the relevant reaches of the river to determine the extent of inundation by the various flood magnitudes. The simulation of the designated return period rainfall was done using the HEC-HMS model. Peak flows were simulated from these rainfalls using GeoHEC-RAS model. A digital terrain model (DTM) of 1m x 1m was used to refine the assessment and simulate flows at specified locations.

3.2.1.3.3 Investigation on the potential for Groundwater Usage in the Project

There is a potential that groundwater resources may be used in the project, hence an examination into the potential for usage of this source was necessary. The approach for this investigation involved the use of data from nearby wells, from WRA hydrostratigraphy maps and the geotechnical investigation to examine:

i. Sub-surface conditions (soil type, depth to ground water, ground water quality, etc.);
ii. Any effects on ground water due to additional pumping water-well post-development;
iii. Effects on infiltration and percolation; and
iv. Effects on surface and ground water quality.

3.2.1.3.4 Water Availability to meet Project Demand

The water resources were determined from desktop evaluation of the surface and ground water data available for the development be done:

- Wells in the area were identified and their yields investigated;
- Stream flow data was analysed to determine the reliability of flows; Rainfall data was collected and analysed to characterise the rainfall over the area.

Given the water requirements of the proposed Project, the adequacy of the existing resource potential can be determined.

3.2.1.3.5 Assessment of potential Flood Hazard

A hydraulic analysis was conducted to determine the risk of flooding. This included:

i. A field reconnaissance conducted on April 08, 2021 in a section of the Cabarita River between Barham and Friendship and the land south of that section of the river;
ii. Conducting an elevation survey using cross-section elevation data derived from the digital terrain model (DTM) provided by drone technology;
iii. Simulating flood levels using the Hydrological Engineering Centre – River Analysis System (HEC-RAS) 6.1 model.

3.2.1.4 Climate

The methodology and approach for assessing the climate of the area was determined through review of data from the Meteorological Service of Jamaica and other published literature. Climate change projections from State of the Jamaican Climate, 2015 prepared by the Climate Studies Group at The University of the West Indies (The UWI) were also reviewed. Information on the climate will be used in **Chapters 5, 6 and 12**.

3.2.1.5 Air, Noise and Water Quality

An assessment of the physical environment was conducted in the Friendship community of Westmoreland to determine the direct and indirect project-related risks and impacts related to water, wastewater, air and noise. Sampling and assessments were done within the proposed site for the Bamboo Bioproducts Pulp Mill and at any potential receptors to site activities. Several water quality sampling sites were taken from the Cabarita River and some of its tributaries, where possible, as well as a canal along the Hertford to Flowerhill Road. Noise and air assessments included sites along the Hertford to Flowerhill Road, the Truro Gate to Locust Tree Road and along roadways within the Friendship community.

The environmental assessment included the quantification of particulate matter (PM_{10}), NO_x, SO_x, as well as H_2S levels, noise surveys and water quality assessments for several physical, chemical, and microbiological parameters.

3.2.1.5.1 Quality Assurance

For all water samples, a quality assurance (QA) and quality control (QC) plan involving all aspects of the proposed project, was instituted. This QA/QC plan forms an essential first step in generating data of the highest quality and reliability. The programme was comprised of the care and calibration of field equipment, as well as the collection and preservation of samples. Information on the description, location and GPS co-ordinates of all water samples was all documented, along with the ambient conditions at the time of collection or at the beginning of the sampling exercise. The results of these can be found in **Appendix M.**

The quality control procedures used in the laboratory for the analyses of water samples included the testing of blanks, reference standards and duplicates, as well as the utilisation of verified standard analytical methods. In all cases, appropriate CoC records were prepared and maintained for analytical samples. All containers were properly labelled, individually packaged, stored, and transported in a cooler maintained at the appropriate temperature.

Where parameters were not analysed in-house, labs with similar QA/QC programmes were used and were also monitored to ensure that data of the highest quality was received.

For the air quality assessment and noise survey, all equipment was calibrated prior to use and where applicable, field blanks were used for quality control purposes. Monitoring devices were placed away from any known sources of pollutants to prevent bias in the data collected.

Detailed observations were made at all sampling stations which were georeferenced for traceability and for all monitoring requirements. These detailed observations can be found in **Appendix J.**

3.2.1.5.2 Water Quality

Water quality assessments were conducted to determine the existing quality of the Cabarita River prior to the mill's development. These assessments were also used to identify and assess impacts to the waterway and any environmental receptors that would most likely be impacted. Eight (8) grab water samples were collected during the wet season assessment and twelve (12) grab water samples during the dry season. The parameters analysed are found in Table 3-2.

Table 3-2: Parameters analysed for the Water Quality Assessment Exercise

pH (pH units)	**Dissolved Oxygen (mg O_2/L)**
Conductivity (mS/cm)	**Salinity (ppt)**
Total Dissolved Solids (mg/L)	**Biochemical Oxygen Demand (mg O_2/L)**
Chemical Oxygen Demand (mg O_2/L)	**Total Suspended Solids (mg/L)**
Total Alkalinity (mg $CaCO_3$/L)	**Total Hardness (mg $CaCO_3$/L)**
Phenol (mg C_6H_5OH/ L)	**Chloride (mg Cl^-/L)**
Total Nitrogen (mg N/ L)	**Total Phosphorous (mg P/L)**
Fats, Oil & Grease (mg/L)	**Nitrate (mg NO_3^-/L)**
Orthophosphates (mg PO_4^{3-}/L)	**Sulphate (mg SO_4^{2-}/L)**
Faecal Coliform (MPN/100ml)	***E. coli* (MPN/100ml)**
Calcium (µg Ca/L)	**Magnesium (µg Mg/ L)**
Silica (µg SiO4/L)	**Zinc (µg Zn/ L)**
Copper (µg Cu/ L)	**Arsenic (µg As/ L)**
Mercury (µg Hg/ L)	**Chromium (µg Cr/ L)**
Manganese (µg Mn/ L)	**Sodium (µg Na/ L)**
Lead (µg Pb/ L)	**Iron (µg Fe/ L)**
Dissolved Organic Carbon (mg C/ L)	**Potassium (mg K/L)**
Pesticides (µg/L)	**Total Organic Carbon (mg C/ L)**

The water quality assessment had the following major objectives:

- Assess the current water quality of the Cabarita River;
- Assess land use practices and their impacts on the aquatic environment prior to the mill's development;
- Make recommendations for the monitoring and management of water resources based on the proposed activities.

Water quality sampling was done for selected points along the Cabarita River located within, upstream (before the proposed site) and downstream (after the proposed site) of the proposed project boundary. Sampling was also done at selected tributaries of the Cabarita River to quantify their potential impacts on the main stream of the Cabarita River. However, samples were not collected from the Roaring River tributary during the wet season assessment due to the inclement weather faced during the latter part of the sampling exercise. Nonetheless, the sample taken at WQ3 (identified in Figure 3-3) should capture any potential impacts coming from the Roaring River and the tributary of the Cabarita River captured at the WQ1 sampling site. The Roaring River tributary was sampled during the dry season assessment. All water sampling locations visited during the wet season and dry season are presented in Figure 3-3 and Figure 3-4.

Plans were made to collect groundwater samples from the Blue Castle and Acton House wells, which were within the closest proximity to the site. These wells were outside of the 2 km radius. However, information gathered during the assessment indicated that the Blue Castle well was not operational and the WRA indicated that the well was blocked. The team was not able to contact the owner of the privately-owned Acton House well or access the property during the assessment. It is recommended that, where possible, these and any future wells be monitored as a part of future environmental management plans.

Sampling Methodology

Field observations and *in situ* measurements were made with respect to smell, colour, pH, dissolved oxygen, salinity, conductivity, total dissolved solids, and temperature at each site. Salinity, temperature, conductivity, total dissolved solids and dissolved oxygen were measured using a YSI ProPlus Model Multi-parameter system (MPS). All samples collected were kept between 0 – 4°C and transported to the International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) 17025 accredited Quality and Environmental Health Laboratory at Environmental Solutions for analysis bearing in mind the analysis hold time for each test parameter.

Water quality results were compared to the Jamaica's National Resource and Conservation Authority's (NRCA) Ambient (Fresh) Water Quality Guidelines as well as the IFC Environmental, Health and Safety Guidelines for Pulp and Paper Mills.

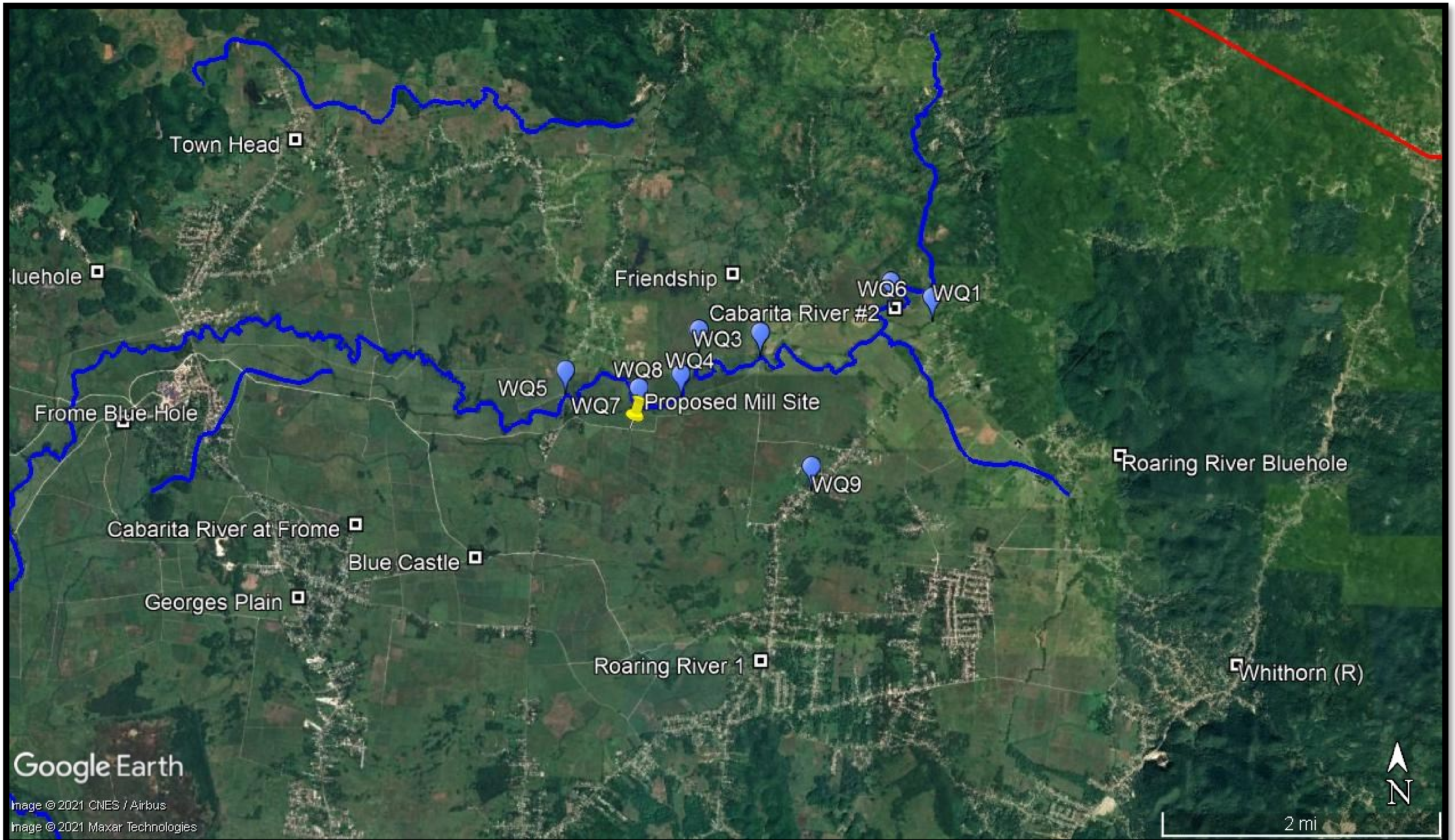


Figure 3-3: Water Quality Sampling Sites (November 2021)

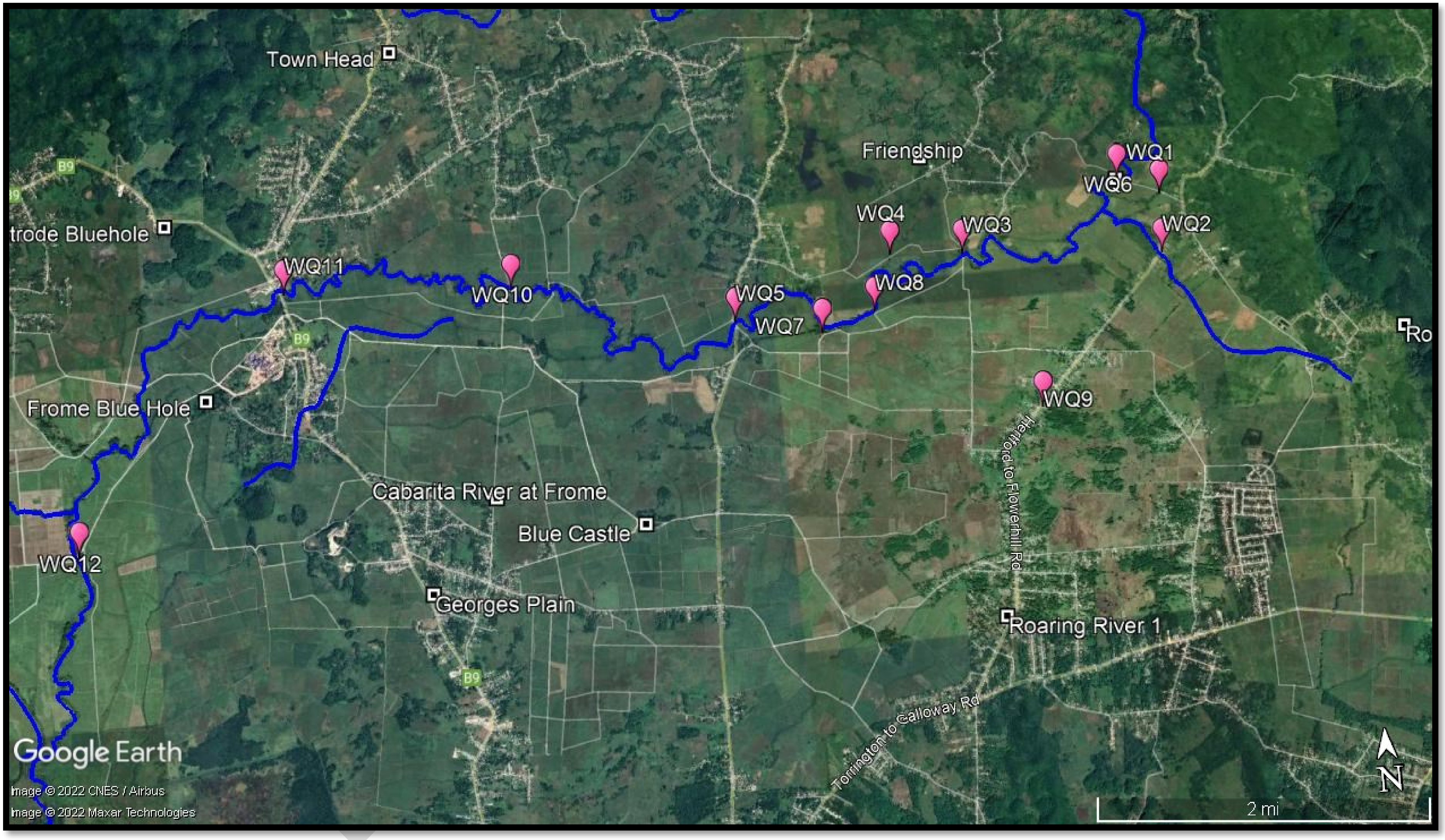


Figure 3-4: Water Quality Sampling Sites (March 2022)

3.2.1.5.3 Air Quality

Two air quality assessments were conducted in the wet and dry season. An Air Dispersion Modelling (ADM) Assessment was also conducted, as requested by NEPA. The methodology of the air quality assessment is presented below, and the methodology of the ADM assessment is presented in Section 3.4.

The objective of the air quality investigation was to determine, as best as possible, the concentrations of respirable particulates (PM_{10}), hydrogen sulphide (H_2S), nitrogen oxides (NO_x) and sulphur oxides (SO_x) levels in the proposed project area based on the assessments conducted in both the wet and dry seasons. Air quality measurements were taken at seven (7) sites along main routes leading to and from the proposed project site, and in the surrounding communities. Sites likely to be most affected by changes in air quality, for example, those areas with high human populations (e.g., schools, health centres, town squares) were considered for this exercise as these sites were determined to be some of the most sensitive receptors.

The information on the sampling equipment used to collect air quality information is provided in **Appendix M.**

Particulate Matter

Particulate matter is the term given to small solid or liquid particles suspended in either a gas or liquid medium. The size of these suspended particles not only determines the lifespan of the particles within the atmosphere, but also the possible fate if inhaled by individuals. The size range of greatest concern to human health lies between 0.1–10µm; these are referred to as respirable particulates (PM_{10}). Effects of the exposure of PM_{10} on human health include, but are not limited to, adverse impacts to the respiratory system, damage to lung tissue, cancer, and premature death. The extent of these effects will be influenced by the age and health of the affected individuals, as well as the period of exposure.

To minimise the potential impact of particulate matter on the health of people and the environment, the United States Environmental Protection Agency (US-EPA) and the National Environment and Planning Agency (NEPA) have published national air quality standards which state that the maximum daily concentration should not exceed 150 $\mu g/m^3$.

Particulate matter was measured using calibrated air pumps (with flow rates between 2-15L/min), attached to pre-weighed Polyvinyl Chloride (PVC) filters. The pumps were calibrated before use with a factory calibrated primary flow meter from Bios International Corporation. In the field, the pumps were placed at the approximate respiratory height of the individual/s for a 24 (± 4-hour) period. After the 24-hour sampling period, the pumps were collected, and the filters returned to the laboratory where they were stabilised and weighed to determine a Time Weighted Average (TWA) value for the particulates. Information on the equipment used can be found in **Appendix M.**

The placement of the pumps varied based on the type of information to be collected. Some pumps were placed in locations to capture the direct exposure to individuals, while others were placed to capture the population/general exposure. An increase in vehicular activities is expected due to the operations of the mill. Sensitive receptors such as schools and residential areas which are normally along roadways were therefore assessed to determine any impact on daily lives due to the activities of the mill's operations. Other sampling sites such as roof tops were used to gather data on background levels of some air pollutants as well as along areas which are deemed to be in the sphere of influence of the mill's operations.

The results at the end of the sampling period were compared to the National Environment and Planning Agency's (NEPA) and the US EPA's Ambient Air Quality Standards.

H_2S, NO_x and SO_x

Hydrogen sulphide, nitrogen oxides and sulphur oxides were measured using passive samplers. The samplers were generally placed at approximate respiratory height for a 24-hour (± 4-hour) period. After the 24-hour sampling period, the samples were collected, placed in their respective storage containers, and returned to the laboratory for analysis.

3.2.1.5.4 Noise Quality

Noise measurements were collected from seven (7) sites in the proposed project area. These were along main routes leading to and from the proposed project site, and in the surrounding communities. Sites likely to be most affected by changes in noise quality, for example, those areas with high human populations (e.g., schools, health centres, town squares) were considered for this exercise as these sites were determined to be some of the most sensitive receptors.

Noise measurements were taken using a calibrated Quest SoundPro SE/DL series sound level meter, which conforms to the IEC 616721-1-2002 Class 2, Sound Level Meter Type 2, ANSI S1.4 – 1983 (R2001) Octave Band &1/3 Octave Band Filter Class 1, IEC 61260:2001 Octave Band & 1/3 Octave Band Filter Class 1, ANSI S1-11-2004 and ANSI S1.43 -1997 (R2002) Type 2 standards. The average noise level readings were taken over 3-minute intervals and recorded in decibels (dBA). Wind direction and any unusual local noise sources were documented at each sampling location. In addition, before and after the survey, the instrument was checked with a calibrator, which is pre-calibrated at the factory. The results at the end of the sampling period were compared with the NEPA Standard of 55dBA for residential areas. No night-time assessments were collected. More information on the equipment can be found in **Appendix M.**

Table 3-3 presents the distribution of tests for the noise and air quality assessments collected, while Figure 3-5 and Figure 3-6 show the monitoring locations for air quality and noise assessments.

Table 3-3: Distribution of Tests for Air Quality and Noise, 2021

LOCATION	NOISE	PM_{10}	NO_x	SO_x	H_2S
Site 1	✓	✓	✓	✓	✓
Site 2	✓	✓	✓	✓	✓
Site 3	✓	✓	✓	✓	✓
Site 4	✓	✓	✓	✓	✓
Site 5	✓	✓			
Site 6	✓	✓			
Site 7	✓	✓	✓	✓	✓

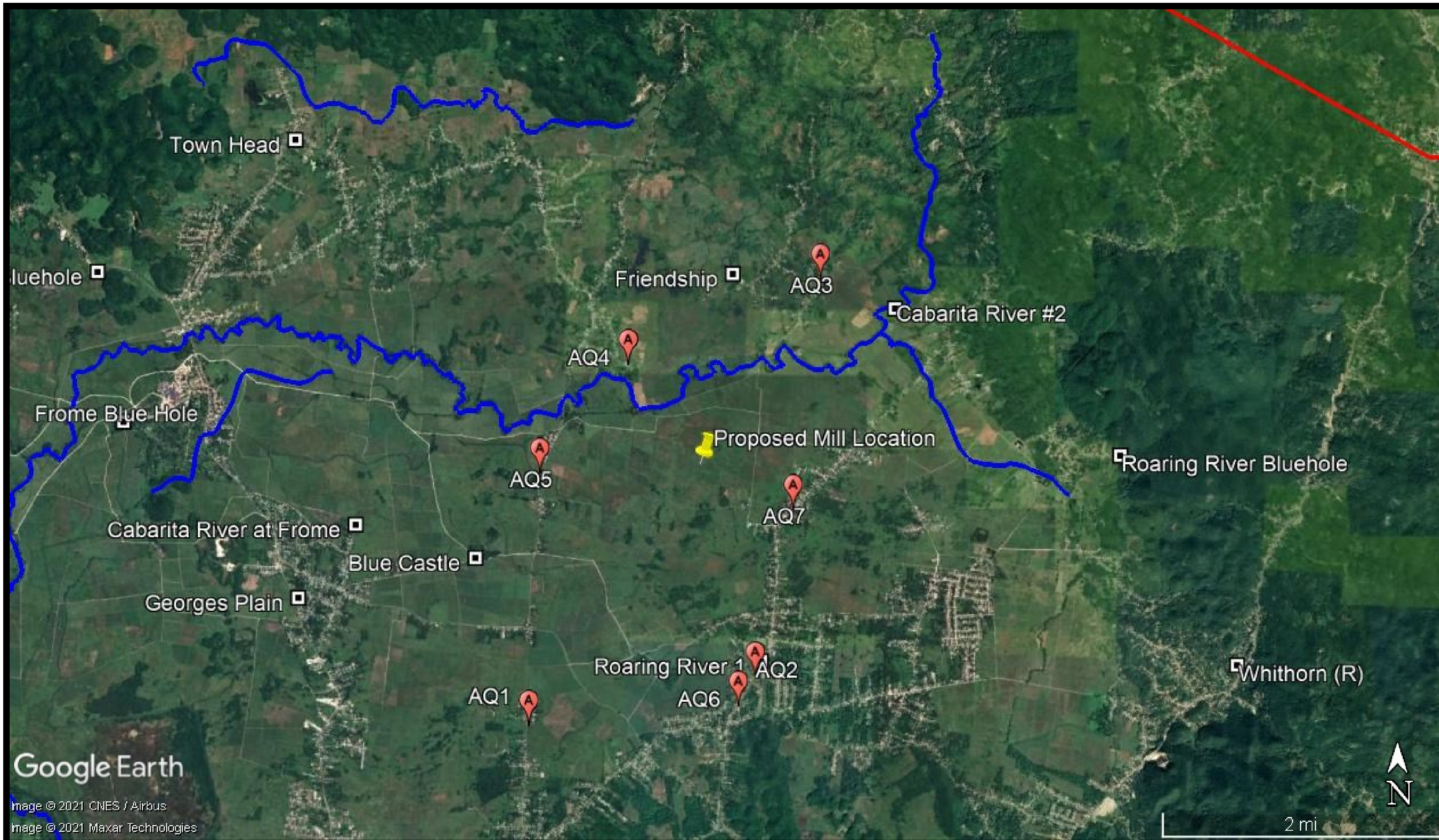


Figure 3-5: Air Monitoring and Noise Survey Sites (November 2021)

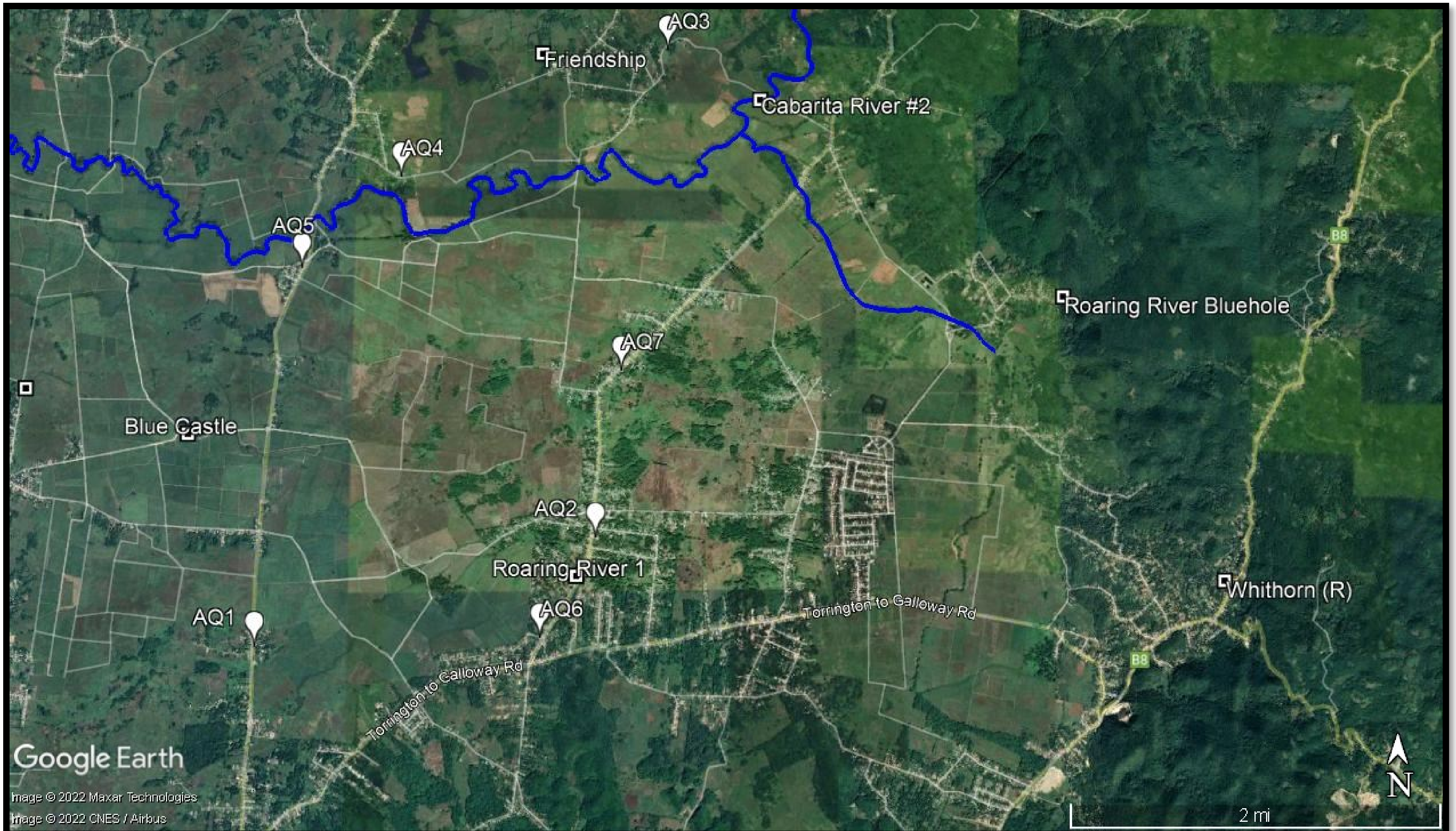


Figure 3-6: Air Monitoring (March 2022) and Noise Survey Sites (May 2022)

3.2.2 ECOLOGICAL ASSESSMENT

The proposed Project site consists of a large expanse of cane fields bordered by residential communities and the Cabarita River. Two assessments were conducted – a General Assessment of the area during the wet and dry season and a Freshwater Ecology Assessment of the Cabarita River. The approach for this assessment included a review of the relevant literature and site assessments. Site assessments conducted on November 4–5, 2021 and in late February 2022 were geared to achieve the following:

i. Perform ecological surveys during the wet and dry season for plant species and vegetation mapping (with emphasis being placed on rare, endemic, threatened, protected, endangered, invasive, and economically important species found);
ii. Perform ecological surveys during the wet and dry season for animal species including birds, mammals, fish, amphibians, reptiles, invertebrates, and general wildlife (with emphasis being placed on rare, endemic, threatened, protected, endangered, invasive, and economically important species found);
iii. Identify areas that may potentially be affected by the proposed development;
iv. Provide an assessment of potential effects (direct and indirect) on ecological receptors and nature conservation interests on and around the site including habitat loss, habitat change, ecosystem function, faunal mortality due to vegetation clearance, and secondary effects from changes in air quality, disturbance and displacement due to vegetation clearing, noise, vibration, lights, and human presence, as well as the introduction of invasive alien species.

A flora and fauna assessment will be presented in this report. The flora assessment included a series of walkthroughs in all the vegetation types present within the study area. The survey was conducted during the daytime. All plant species encountered were recorded and separated into Riparian Vegetation and Perennial Grasses and Scrubs/Shrubs. For each species, the name, perceived dominance and its growth form were noted. The dominance was graded using the DAFOR scale (i.e., D= dominant, A= abundant, F= frequent, O= occasional and R= rare) as indicated in Table 3-4.

Table 3-4: DAFOR Scale used to categorise the Fauna in the Study Area

SCALE	TOTAL NUMBERS OBSERVED DURING THE SURVEY
Dominant	≥ 20
Abundant	15 – 19
Frequent	10 – 14
Occasional	5- 9
Rare	< 4

The common names of most of the species sighted were assigned in-situ. In the case of unknown species, voucher specimens were collected to be identified at The University of the West Indies (The UWI) Herbarium. All plants were identified to the species level by examining morphological features such as leaf arrangement, leaf pattern, and pattern of branching and morphology of floral and fruiting structure in conjunction with the use of Adam's (1972) *Flowering Plants of Jamaica* and preserved reference specimens of the herbarium.

The fauna assessment was typical of what is observed along rivers, grasslands and agricultural fields. Surveys were conducted during the day and at night-time to capture nocturnal fauna. Groups of animals identified included birds, dragonflies, butterflies, insects, snails, bats and fish.

3.2.2.1 Cabarita River Freshwater Ecology Assessment

Five sites along the Cabarita River were selected for the Freshwater Ecology Assessment of the Cabarita River, prioritising areas within the 2 km circle of influence of the proposed bamboo pulp mill. The following physical and chemical parameters recorded were at each site:

i. Channel width – measured from bank to bank;
ii. Flow rate – measured with a flow meter;
iii. Discharge – calculated from channel width and flow rate;
iv. Canopy cover – estimated as percentage coverage of overhanging vegetation across the channel width; and
v. Aquatic parameters:
   - pH, conductivity (µS cm^{-1}) and water temperature (°C) – measured with a Hanna Instruments multiparameter meter.

The aquatic invertebrate assessment was adapted from the Protocol Manual from the Ontario Benthic Biomonitoring Network (Jones et al. 2007), used in environmental impact assessments. Invertebrates were collected by kick net and from submerged rocks and vegetation until a minimum of 100 individuals were obtained. Each specimen was placed in 95% ethanol for preservation. The first 100 invertebrates within each sample were randomly selected and classified to the lowest taxonomic level possible. Each taxon was classified into a functional feeding group (FFG) according to Ramírez and Gutiérrez-Fonseca (2014).

Calculations used in the assessment were the Alpha and Gamma Diversity and the Beta Diversity.

i. Alpha and Gamma Diversity – Simpson's Index

The Simpson's Index was used as a measure of alpha and gamma biodiversity for each site and for the entire river. The formula for the Simpson's Index is as follows:

$$1 - [\Sigma(p^2)]$$

p – the proportional abundance of a taxon at a site.

Values for Simpson's Index range from 0 (very low diversity) to 1 (very high diversity).

ii. Beta Diversity – Sørensen Pairwise Dissimilarity

The Sørensen Pairwise Dissimilarity (β) was used to compare differences in invertebrates among sites (beta diversity):

$$\frac{\mathrm{b}+\mathrm{c}}{(2\mathrm{a}+\mathrm{b}+\mathrm{c})}$$

a – the number of taxa shared between two sites

b – the number of taxa only in the first site

c – the number of taxa only in the second site

Values for the Sorenson Pairwise Dissimilarity range from 0 (identical invertebrate communities) to 1 (completely dissimilar invertebrate communities).

Additional biodiversity surveys may be required and can occur following the EIA and prior to construction.

3.2.3 SOCIOECONOMIC ASSESSMENT

The socioeconomic assessment began with a desk review which focused on identifying the existing social, historical, cultural, economic and environmental context of local development areas (LDAs) prior to the project's implementation. The LDAs investigated were Hertford, Friendship, Amity, Frome, Petersfield and Savanna-la-mar in Westmoreland. Data was collected from internal BBP documents, online maps, newspaper articles, the websites/social media platforms of different public and civil society organisations in each LDA among others.

The report, named the ***Community & Needs Assessment Report***, generated by Leap Co. was submitted to BBP in April 2021. The report presented the sites' cultural heritage, social services, physical infrastructure, labour and working conditions, and issues regarding land acquisition. Based on these preliminary findings, implications for BBP's operations and role in targeted communities were clearly outlined.

The identification of social impacts was in general guided by IFC Performance Standard 1 Requirements: Assessment and Management of Social Risks, Impacts and Opportunities.

Following the initial report, several stakeholder meetings were held, and surveys were completed by 102 individuals from the six LDAs. As the Social Impact Assessments were conducted during the COVID-19 pandemic, many surveys were held virtually via video conferencing. Fortunately, some face-to-face consultations were able to take place in Westmoreland in the form of the General Parish Stakeholder Meeting and with the Westmoreland Chamber of Commerce. Stakeholder meetings were held in July 2021 with the political representatives, general parish stakeholders and agricultural stakeholders and community members. The 102 individual community members were surveyed between July 8 and July 10, 2021. The purpose of these consultations was to provide additional insights about community needs and implications for the company in each LDA. It also helped to fill gaps in knowledge which remained after the completion of the desk review. The report's findings and recommendations were then published in a ***Community Consultation Report*** produced in September 2021. Findings of the second report were disclosed among stakeholders at an in-person event on October 23, 2021, held at the Frome Technical High School (Plate 3-1). Feedback from the in-person meeting and additional recommendations were published in a ***Social Impact Assessment (SIA) Study Report*** produced in November 2021. The aforementioned reports published by Leap Co. can be found in **Appendix O** and **Appendix P.**

The second set of stakeholder feedback, along with additional research conducted on the affected population, was used to inform the Social Impact Management Plan (SIMP). This plan will guide BBP in mitigating the negative effects that the mill's construction and eventual operations may have on the economic activities, social amenities and environment of the sites. It will also guide BBP's activities in an endeavour to intentionally improve life in affected communities. The SIMP was being developed at the time of this report. Other submissions required for the socioeconomic assessment include the final submission and acceptance of the SIMP and organising a final presentation to the community which was carried out by ESL at a public hearing alongside the EIA in January 2022.

Plate 3-1: Photos from Meeting held at the Frome Technical High School. Pictured L-R: BBP Agronomist, Mr. Hormilson Cruz Rios; CEO of BBP Mr. David Stedeford answering questions from the public (October 23, 2021)

3.2.3.1 Archaeology/Heritage

A site assessment, the social impact assessment report, preliminary information from the Jamaica National Heritage Trust (JNHT), the National Library's Special Collections Department, and other existing reports were consulted to determine whether any notable heritage or archaeological elements were present in the vicinity of the Project Area. Several reports and maps were found and utilised in the assessment; however, ESL has not yet received a response from the JNHT regarding the need for a full Archaeological Impact Assessment. However, should this be required, BBP will undertake as needed.

3.3 CLIMATE VULNERABILITY AND RISK ASSESSMENT

The Climate Vulnerability and Risk Assessment (CVRA) was conducted to identify and assess potential risks from Climate Change (CC) and its related natural hazards to:

- The establishment of the proposed bamboo pulp mill site in Friendship, Westmoreland, and the surrounding communities;
- The need to increase the understanding of the risks and propose recommendations to increase the project’s resilience.

Figure 3-7 presents a summary process flow of the CVRA. The CVRA is presented in **Chapter 6**. The CVRA will also be confirmed with guidance provided by the Equator Principles.

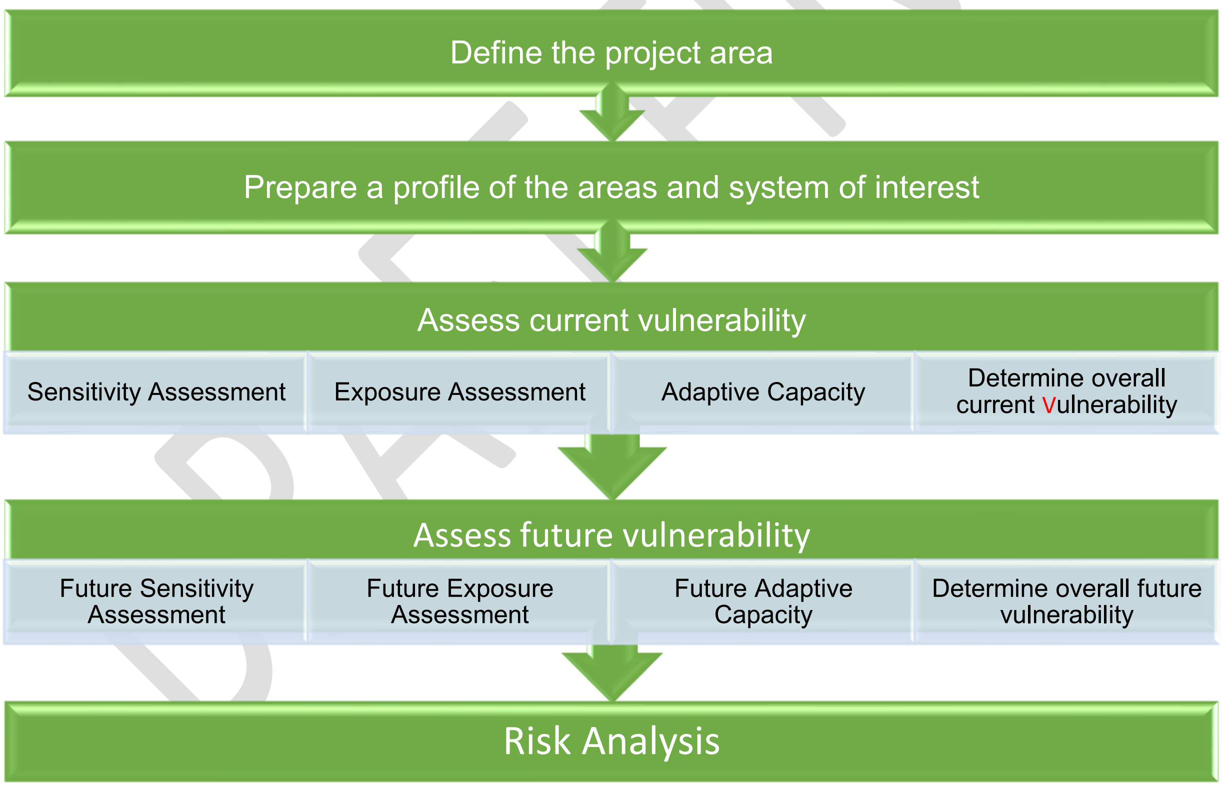


Figure 3-7: Process Flow of the CVRA

3.4 AIR DISPERSION MODELLING ASSESSMENT

An Air Dispersion Modelling (ADM) Assessment was conducted to estimate the impact of air emissions from the proposed Bamboo Pulp Mill on the ambient air quality in and around the project site. The ADM Assessment was requested by NEPA for this facility and the findings are presented in **Chapter 7**.

The assessment was done in accordance with the Natural Resources Conservation Authority's Ambient Air Quality Guideline Document, 2006 and the United States Environmental Protection Agency's (USEPA) Guidelines on Air Quality Modelling. This assessment was done using AERMOD version 9.6.1. The USEPA model 12060 of the AERMOD/AERMET air dispersion model was used to determine the pollutant fallout concentrations.

Emission rate input files for sources at the facility were gathered from the European Union Best Available Techniques (EU BAT) reference document[vi] and proposed fuel quality. The proposed liquified natural gas (LNG) fired emission rates were determined using EU BAT emission data for the proposed recovery boiler. Land use and terrain effects were all included as part of the model. These were obtained from *Lakes Environmental Software* pre-processed terrain data and onsite information gathered from assessment conducted by RGS Engineering Limited at the proposed location. A cumulative impact study was conducted considering all major and significant sources within the 20km model domain. Source generation data for the cumulative impact study was gathered from the National Environment and Planning Agency (NEPA). Meteorological data used to input into AERMET files was gathered from MM5 pre-processed modelling data for a 5-year period provided by *Lakes Environmental Software.*

Once the MM5 pre-processing was completed, the MM5 output file was converted into a format recognised by the AERMET model (meteorological pre-processor for the AERMOD model). The final output was generated by creating a pseudo meteorological station at the specified site location. A receptor grid was determined for the purpose of completing the model, in essence, creating the modelling domain. A multi-tier grid system that included 4,719 receptors was input into the model domain as follows:

- Two-tiered grid covering the entire domain: tier 1 with a spacing of 500m, covering a distance of 10km, while tier 2 has a spacing of 100m covering a distance of 15km;
- 2490 Fence line grid receptors – 100m from the fence line with a 25m spacing;
- 15 Discrete Receptors located in residential and commercial communities.

Detailed information on the inputs and results of this assessment can be found in **Chapter 7**.

3.5 IMPACT ASSESSMENT, MITIGATION MEASURES AND MANAGEMENT PLANS

3.5.1 IMPACT ASSESSMENT

Following the various environmental and social assessments, several impacts were identified that were associated with the proposed project design developed by BBP, the potential site preparation and construction information provided and the eventual operational conditions. These impacts were assessed

[vi] Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board. Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control). Updated in 2015.

with respect to their probability, magnitude, duration, direction, permanence, spatial extent and residual impact:

- Probability defines the likelihood of occurrence;
- Magnitude defines an impact as minor, moderate, major or significant;
- Duration defines whether an impact is a short-term, long-term, intermittent or continuous;
- Direction defines whether the impact is positive or negative;
- Permanence defines an impact as reversible or irreversible;
- Spatial extent defines if the impact is confined to a local area, regional area or is of a national extent;
- Residual impact defines the associated impact remaining after the implementation of mitigation measures (minor, moderate, major or significant).

Impacts were identified based on the factors in Table 3-5.

Table 3-5: Impact Assessment Criteria

IMPACT ASSESSMENT CHARACTERISTICS	
Probability of Impacts	
Rank	**Definition**
Rare	Impact which is rare
Unlikely	Impact which is unlikely to occur
Possible	Impact which may occur
Likely	Impact which is likely to occur
Almost Certain	Impact which is almost certain to occur
Magnitude of Impacts	
Rank	**Definition**
Minor	The environmental and/or social conditions will be affected, but the impact is small enough that it is unlikely to be of concern to the government, communities, and organisations.
Moderate	An impact of moderate significance is one within accepted limits and standards. The emphasis for moderate impacts is on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable (ALARP).
Major	A major impact is one where there will be a large change to communities or the natural environment. The aim of this report is to identify ways to prevent or mitigate these large impacts. At times this is not possible, and it is up to the regulator to decide if this is acceptable when considering the benefits of the Project.
Significant	A significant impact is one where there will be a large change within and beyond the immediate communities or the natural environment. This may also include impacts that can themselves result in other negative impacts and, in some cases, be irreversible. The aim of this report is to identify ways to prevent or mitigate these large impacts. At times this is not possible, and it is up to the regulator to decide if this is acceptable when considering the benefits of the Project.
Direction of Impact	
Rank	**Definition**
Positive	Impacts of the project on the environment and vice versa are likely to be good.

IMPACT ASSESSMENT CHARACTERISTICS	
Negative	Impacts of the project on the environment and vice versa are likely to be bad.
Impact Duration	
Rank	**Definition**
Short term	Occurring infrequently or during 0–5 years of the Project
Medium term	Occurring frequently during 5–15 years of the Project
Long term	Occurring frequently during the Project's lifetime
Permanence of Impacts	
Rank	**Definition**
Reversible	Effects which are reversible and diminish when activities cease or over time.
Irreversible	Effects which are not reversible and do not diminish even if the activity ceases to occur, and do not diminish with time.
Cumulative	Effects of an action are added to or interact with other effects in a particular place and within a particular time.
Spatial Extent of Impact	
Rank	**Definition**
Local	Potential impacts are restricted to the project area of influence.
Regional	Potential impacts affect the local and parish level.
National	Potential impacts extend to the national level.
Residual Impact	
Rank	**Definition**
Minor	The environmental and/or social conditions will be affected, but the impact is small enough that it is unlikely to be of concern to the government, communities, and organisations.
Moderate	An impact of moderate significance is one within accepted limits and standards. The emphasis for moderate impacts is on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable (ALARP).
Major	A major impact is one where there will be a large change to communities or the natural environment. The aim of this report is to identify ways to prevent or mitigate these large impacts. At times this is not possible, and it is up to the regulator to decide if this is acceptable when considering the benefits of the Project.
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3.5.2 MITIGATION MEASURES, RISK MATRIX AND THE MANAGEMENT AND MONITORING PLAN

Appropriate mitigation measures were then recommended to address all the negative impacts. These mitigative measures were developed based on the Hierarchy of Control which is a system used to control risks in a workplace (Figure 3-8).

Figure 3-8: Hierarchy of Controls used to guide mitigative measures that can be taken in the project. Source: https://www.hseblog.com/general-hierarchy-of-control-measures/

These mitigative measures and results were compiled in a risk matrix which also presented the potential residual probability, residual impact and residual risk that may arise once potential mitigative and risk control measures are implemented. Additionally, the results of both the impact assessment, mitigation measures and risk assessments were used to develop management action plans to minimise the negative impacts identified. These management plans were separated into two documents – the Environmental, Health and Safety Management and Monitoring Plan (EHSP) and the Social Impact Management Plan (SIMP). The EHSP has the following subsections:

- Introduction
    - Objectives of the EHSP
    - Scope of the EHSP
    - Structure of the EHSP
- Identification of Proposed Mitigation Measures
    - Construction Phase
    - Operations Phase
- The EHS Management and Monitoring Plan

  - Air Quality Management Plan
  - Noise Management Plan
  - Water Quality Management Plan
  - Flora and Fauna Management Plan
  - Waste Management Plan
  - Health and Safety Management Plan
  - Emergency Response Plan
  - Consultation Plan and Grievance Mechanism
  - Social Impact Management Plan
  - Summary of Monitoring Frequency
  - Cost Estimates

The SIMP, commencing at Section 13.6, was extracted from the complete SIMP Report in **Appendix P**. The SIMP has the following subsections:

- Introduction
  - Objectives of the SIMP
  - Scope and Structure of the SIMP
  - Structure of the SIMP
- Identification of Proposed Mitigation Measures and Relevant Environmental Management Plans
- The SIMP
  - Education/Training Action Plan
  - Local Economy Action Plan
  - Social Infrastructure Action Plan
- Community Investment and Partnerships
  - Key Partnerships
- Monitoring and Reporting
  - Monitoring and Evaluation
  - Reporting
- Stakeholder Engagement Strategy
  - Engagement Principles and Strategy
  - Stakeholder Engagement Mechanisms
  - Community Engagement Evaluation
- Complaint Resolution
  - Instructions for Completion Annual Monitoring Reports

3.6 ASSUMPTIONS AND LIMITATIONS

The available environmental and social data and the assessment of impacts always involve assumptions and generalisations. Furthermore, the available technical and engineering data for the proposed Project is preliminary at this stage. Lack of sufficient data may cause uncertainty in the assessment of some of the potential impacts. During the assessment of the proposed Project, the potential uncertainty factors were identified as comprehensively as possible and their impact on the reliability of impact assessments has been considered.

3.7 DATA GAPS AND RECOMMENDED INVESTIGATIONS

In light of the above, and the proposed site for construction and operation of the proposed Project, the following investigations are recommended to ensure a more comprehensive conclusion on the feasibility and environmental impacts of the Project can be drawn:

- **Cost benefit analysis** (CBA) –The proposed Project is anticipated to have significant positive social and economic costs at the local, regional and national levels. A CBA can be used to analyse the Project options and their anticipated costs (including Project components, technologies, layout and location) and compare with the ranging environmental and social costs.
- **Archaeological Impact Assessment** – A site assessment was conducted and information was collected during the social impact assessment. Preliminary information from the Jamaica National Heritage Trust (JNHT) and the National Library's Special Collections Department was received, however, they are being consulted to determine whether any notable heritage or archaeological elements were present in the vicinity of the Project Area. Several reports and maps were found and utilised in the assessment; however, ESL has not yet received a response from the JNHT regarding the need for a full Archaeological Impact Assessment. However, should this be required, BBP will undertake as needed.
- **Strategic Environmental Assessment (SEA)** – The proposed project may also lead to the development of farm sites to supply the pulp mill with raw material. The locations of the farm sites have not been finalised to date. Test plots are currently underway to determine the best local conditions, equipment, materials, chemicals and growing conditions to establish the *Bambusa vulgaris*, as a commercial/cultivated crop. A SEA can be conducted to evaluate the individual and wholistic risks of the respective farm sites. The findings from the SEA can be used to guide the development a Farming Management Plan for the project.

4 PROJECT DESCRIPTION

4.1 PROPOSED PROJECT SITE AND SITUATION

According to NEPA and NRCA, this project is classified in the environmental permit application process as the Manufacturing of Paper, Pulp & Wood.

BBP intends to establish a fully sustainable 'Agro-Ecological-Industrial' model in the manufacturing of bamboo pulp in Jamaica. The project design has sought to conform to a holistic model as well as the demand for more sustainable and climate change reducing material and the growth in green business. Figure 4-1 presents a summary of the holistic model that guides the proposed project and Figure 4-2 presents the product life cycle from cultivation to the end product.

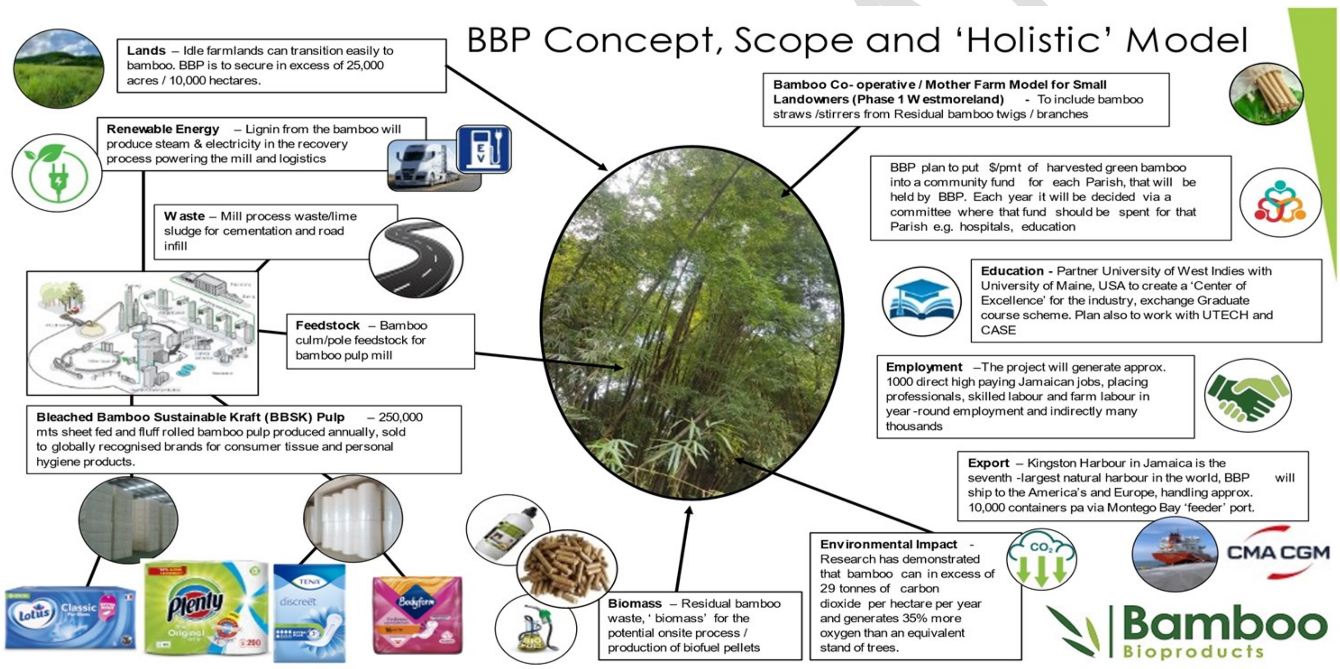

Figure 4-1: The holistic Model guiding this Project (Source: BBP, 2022)

Figure 4-2: Product Life Cycle for the project. (Source: BBP, 2022)

4.1.1 SITE OF THE PULP MILL

The proposed project site is on the Friendship Estate in Friendship P.O.,[vii] Westmoreland (18°17'15.52"N 78° 5'27.64"W), which is, in straight-line distances, approximately 27 km southeast of Montego Bay, the capital of St. James and approximately 7.7 km northeast of Savanna-la-Mar, the capital of Westmoreland (Figure 4-3). The proposed site is approximately 5.9 km east of the Frome Sugar Factory and 6.1 km northwest of the Paradise Park Solar Farm. The entire property for the Pulp Mill is approximately 350 acres (~1.42 km^2) as seen in Figure 4-4.The immediate vicinity of the site is surrounded by lands previously used for sugar cane cultivation, three settlements – Barham in the west, Friendship Cross to the east, and Hertford to the southeast. The Cabarita River is found to the north. Photographs of the proposed mill site and surrounding areas are presented in Plate 4-1.

[vii] There are variations among government agencies in relation to the actual siting of the proposed mill, whether based on community, electoral division, constituency, etc. The general area of Friendship will be indicated as the mill location.

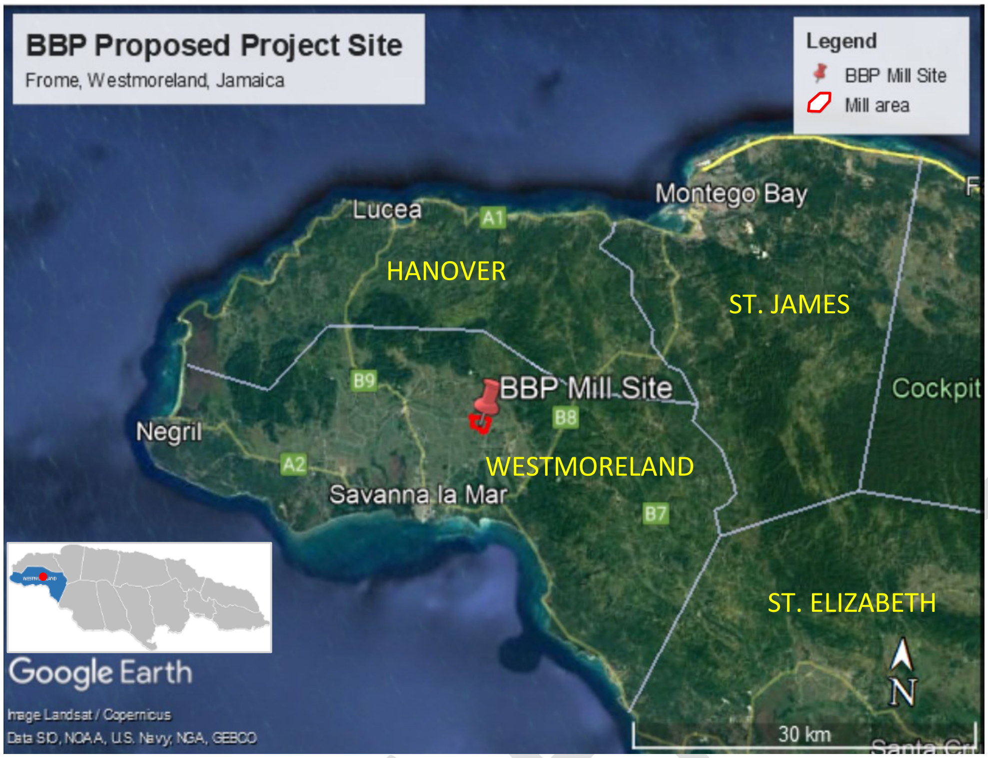

Figure 4-3: Satellite Map of the Project Site in relation to the other Parishes and major Towns/Cities (Source: Adapted from Google Earth Pro, 2021)

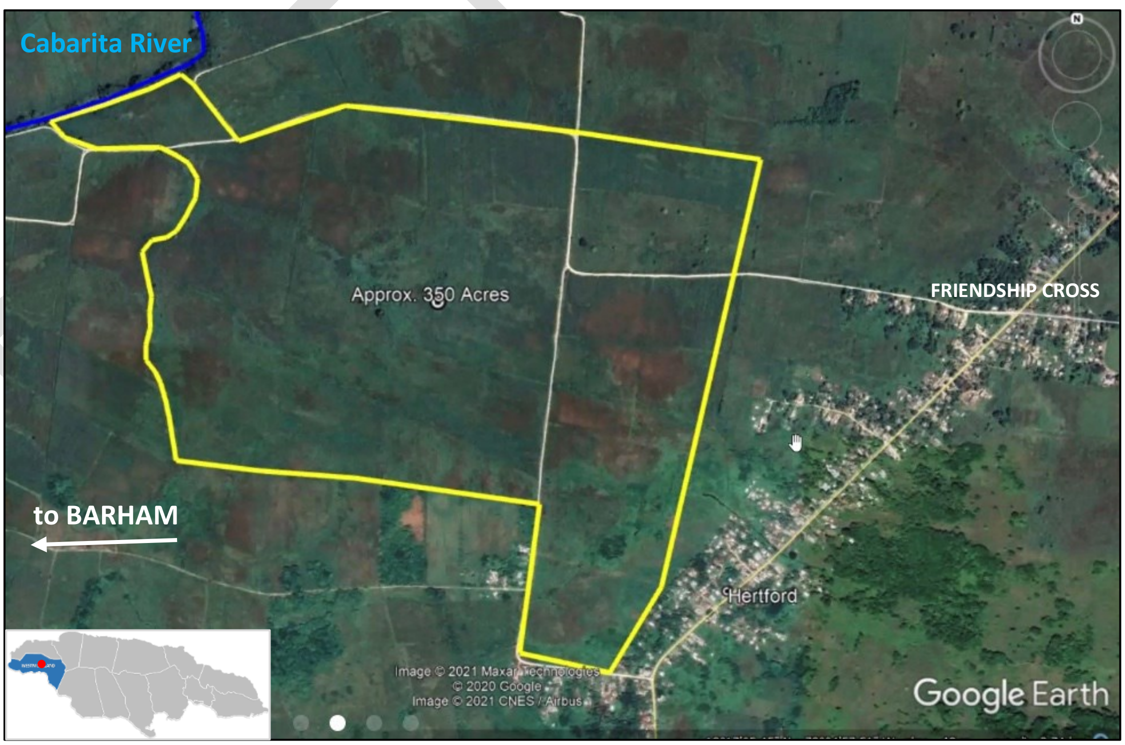

Figure 4-4: Proposed Mill Site Area (Source: BBP, 2021)

Plate 4-1: Images from proposed Project Site and immediate surrounding Areas in Friendship, Westmoreland (March 2021 and October 2021)

Jamaica and this area in Westmoreland were selected for this project based on unique factors such as:

i. Jamaica's geographical location and port facilities which support the logistics for transferring the pulp to markets in North America, South America and Europe;
ii. The Bamboo, known as the *Bambusa vulgaris* or "common bamboo", is the preferred species for paper/tissue and thrives in Jamaica;[viii]
iii. The presence of large areas and concentrations of bamboo across Jamaica;
iv. Jamaica's long tradition of farming and agricultural production;
v. Idle sugar cane farmlands can transition easily to bamboo which thrives in Jamaica
vi. Jamaica has strong infrastructure to support its production;
vii. The proposed mill site has, from preliminary results, many benefits: area large enough to site and operate a mill, relatively flat land, limited hazard risk, and the potential of surrounding lands to be used as bamboo plantations (helping to reduce transportation);
viii. The surrounding areas and communities have the sufficient infrastructure and human resources to support the mill;
ix. The presence of an existing water supply, all year long in acceptable quantity and quality;
x. Existing transportation facilities and ease of accessibility to nearby ports or possibilities to create them at a reasonable cost.

4.1.1.1 Land Ownership

The proposed project site is owned by BBP. Formerly, it was leased by the Pan Caribbean Sugar Company Limited (PCSC), however they released the land back SCJ Holdings Limited (SCJH). On August 16, 2021, the GoJ received Cabinet approval for sale of land in Friendship, Westmoreland for the proposed Bamboo Pulp Mill Site (ESL Meeting, September 2021) and BBP purchased the land from SCJH.

4.1.1.2 Access to the Site

The Site is located within an area where it is able to access 'Class A, Class B and Class C' type roads. It is easily connected to the Port of Montego Bay in the North Coast via a 44.8 km road (mostly Class A) with an estimated driving time of 1 hour and 2 minutes. The mill is also accessible to the main port of Jamaica in the Capital of Kingston via roads and the South Coast highway spanning 196 km with an estimated driving time of 3 hours and 27 minutes. However, this time may be reduced once the extension of the South Coast highway is completed in 2023.[ix]

[viii] Jamaica's Global Forest Resource Assessments have shown that areas with bamboo have significantly increased in area from 1990 to 2020.
[ix] "$17.4 Billion Set Aside For Southern Coastal Highway Improvement Project" taken from https://jis.gov.jm/17-4-billion-set-aside-for-southern-coastal-highway-improvement-project/

4.1.2 RAW MATERIAL - BAMBOO FARMS

In addition to the construction and operation of a pulp mill, BBP intends to secure 25,000 acres of land in Jamaica to set up bamboo farms and nurseries that will supply the raw material for the mill. As at the date of this report, the locations for the bamboo plantations are still being finalised and agreements are being made with government agencies and local partners for the acquisition, leasing or partnerships in establishing and managing these plantations. Currently, BBP is having discussions with the SCJH to convert idle sugar can lands (already disturbed ecological sites) into bamboo farms. Bamboo Test Plots are currently being undergone on sugar lands in Westmoreland to determine the best conditions and requirements to develop bamboo plantations in Jamaica. The type of bamboo that will be grown on the farms is *Bambusa vulgaris*. The bamboo farming and farms will be addressed in a different scope of work.

No bamboo will be planted on the proposed pulp mill site. It is intended that all the bamboo required for the mill will be grown and harvested in Jamaica. If, under unusual/ unforeseen circumstances BBP needed to import *B. vulgaris* chips, then the applicable Jamaican regulatory requirements including phytosanitary considerations would be applied. These regulations include the Agricultural Produce Act 1926 and the Plants (Quarantine) Act, 1993 through the Plant Quarantine Produce Inspection Branch of the Ministry of Agriculture and Fisheries.

Currently, BBP has two methods to supply the pulp mill with the feedstock required as indicated in Figure 4-5.

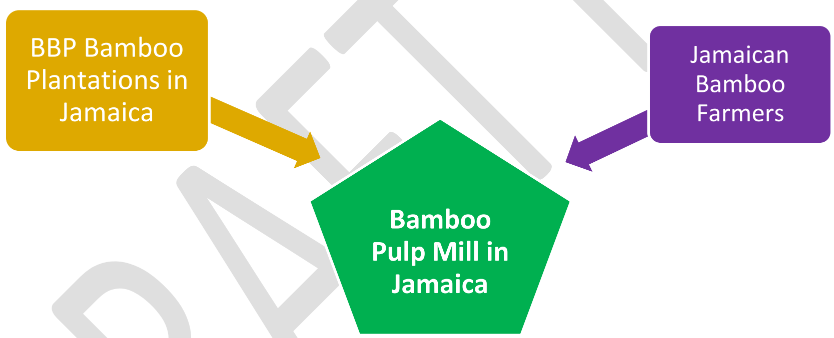

Figure 4-5: Methods being used to supply the proposed Bamboo Pulp Mill in Friendship, Westmoreland

BBP intends to secure as much land as possible from discussions with SCJH, but also plans to lease land from other land owners as well as contract farmers to cultivate bamboo. A draft list of the distribution of the locations of potential farms sites is presented in Figure 4-6. The negotiations for all these options are currently ongoing and have not been finalised. The Bamboo Plantations will have a Farm Management Plan as required. If Contract Farmers are utilised, they would be required to cultivate bamboo according to the published JCP 8: 2021 Jamaican Standard Code of Practice for Bamboo Plantation (2021) developed by the Bureau of Standards (BSJ).

DRAFT

BBP Bamboo Farm Lands (final audit pre contract)

	Land Owner	**Parish**	(estimate) **Acres**
1	Sugar Company Jamaica	Westmoreland, Clarendon, St Thomas, St Elizabeth	15,000
2	Seprod	St Thomas	3,064
3	Golden Grove	Portland	2,000
		BBP Managed Farms	**20,064**

	Land Owner	**Parish**	**Acres**
1	Confidential	Westmoreland, Hanover	2,000
2	Confidential	Westmoreland	1,118
3	Confidential	St. Catherine	1,250
4	Confidential	St Elizabeth	1,372
		Privately Managed Farms	**5,740**
		Total Bamboo Farms Acreage	**25,804**

Figure 4-6: Draft list of the potential locations of farm sites under negotiations (Source: BBP, 2022)

The focus of this EIA is on the Bamboo Pulp Mill and as such the farming component is being dealt with holistically and separately as mentioned above. Details on the bamboo farms, their location, requirements and methods of cultivation and harvesting will be provided in the SEA to be submitted to NEPA once the selection of farm sites has been finalised. Further reference to farm sites in the document will relate to the interconnectedness with the mill operations.

4.1.3 LOGISTICAL PLAN FOR THE PROJECT

As BBP seeks to establish a fully sustainable 'Agro-Ecological-Industrial' model, an efficient logistical plan is necessary for the farming and production of bamboo pulp in Jamaica. This comprises the modes of transporting the raw material from farm sites to the pulp mill, and the product from the pulp mill for export. The means and mode of transportation are currently under development, however, as at the date of this report, BBP intends to primarily use a trucking system. BBP is also exploring the option of developing a barging system; however, the latter is conceptual. Any transportation of raw material over water will conform with local regulations and approval from the Port Authority of Jamaica (which has been consulted on all matters concerning water transport associated with the project). A Transport Management Plan is to be developed once the logistical plan has been finalised. The logistical programme is as follows. The barging programme entails:

i. Establishing a Programme that utilises the Port of Montego Bay as the main cargo. This programme involves a collection facility/site and the onsite storage of raw bamboo at the port;
ii. The procurement and use of electric-powered trucks to transport the bleached bamboo pulp from the proposed mill in Friendship, Westmoreland to the Port of Montego Bay in St. James. It is estimated that this will result in the transit of 30 of 40 containers (60–80 trucks on return trip), per day from the proposed pulp mill to the Port of Montego Bay. Approximately 50 to 80 trucks, ingress and egress, providing bamboo chips from across Jamaica to the proposed mill. The number, weight and specifications of the electric-powered trucks to be used will be provided once finalised;
iii. The establishment of a facility where the electric-powered trucks will be kept when not in use (Lorry Park). The location of the Lorry Park is to be identified, but it is expected that it will be located in close proximity to the Port of Montego Bay;
iv. The allowance of contracted farmers to deliver bamboo to the proposed pulp mill using trucks via an established entrance.

Once the logistical plans have been finalised, a Transportation Management Plan will be developed and submitted to the relevant authorities. Additionally, BBP will procure the relevant local licences and permits required.

4.2 WHY BAMBOO?

Bamboo is a widely distributed and fast-growing gramineous plant. According to The International Bamboo and Rattan Organisation (INBAR):[10]

> ***"Bamboo and rattan are astounding resources with unique potential to combat poverty and natural resource challenges. They grow locally to some of the world's poorest communities in the tropics and subtropics, and have many uses, providing a vast range of sustainable products, livelihood options and ecosystem services. If we can harness the potential of bamboo and rattan, the Global South will be closer to achieving its ambitious development, climate and environmental aims, including the Sustainable Development Goals, green growth, REDD+ targets, the Paris Agreement commitments, and the Aichi Biodiversity Targets."***

Of the approximately 1,500 species of bamboo, some can grow up to heights of 30m and can sometimes be as much as 20cm in diameter. Bamboo can grow as much as 100 centimetres in 24 hours, depending on soil quality and other factors, which speaks to its significant renewable and sustainable nature. In Jamaica, at least six bamboo species are present with *Bambusa vulgaris* being the prevalent bamboo species.[11] The bamboo forest coverage in the island was estimated to be at approximately 116,890 ha in 2020 according to the 2020 Forest Resource Assessment Reclassification.[12]

Globally, bamboo is emerging as an important raw material for Paper, Consumer Tissue and Personal Hygiene products as a sustainable non wood pulp. A strong international demand for the replacement of traditional tree-based fibres has produced a growing need for the creation of a bamboo sector within wood-based product industries. Bamboo is classified as a grass and for paper pulping purposes it is considered an annual plant. One major advantage is that bamboo species yield a wide variety of fibre properties and there is an opportunity to produce a paper product with both strength and smoothness/softness using one raw material, similar to wood. The physical and chemical characteristics of bamboo fibres allows for them to be used for a much wider variety of tissue and paper products than most other grass pulps. Only bamboo satisfies the requirements for tensile and softness. Furthermore, its tissue technical properties are similar to paper grades made from softwood. Pulping conditions are also very similar to eucalyptus. Hence, bamboo is an excellent alternative to hardwood pulp.

Additionally, an important aspect of bamboo is its appeal to farmers/growers. Rather than having to wait 60–70 years for other hardwoods and softwoods to reach a suitable maturing for pulping, farmers planting bamboo can have an annual food crop (shoots) and fibre crop each year after a 3-year induction period, and they would only have to replant the crop every 20–35 years. Although it is often characterised as an invasive, bamboo is easily contained with well-known, international best practices and techniques, and it can be eliminated from a growing plot by intensive mechanical ploughing.

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[10] INBAR is a multilateral development organisation that promotes environmentally sustainable development using bamboo and rattan.
[11] Country Profile: Jamaica. Source: https://www.inbar.int/country/jamaica/#2
[12] Source: FAO, 2020

Another important aspect of bamboo is that it provides many benefits to the environment and can contribute to mitigating climate change. This is very relevant at this time as upon the conclusion of the 2021 United Nations Climate Change Conference – COP26 (November 12, 2021), it was presented that the private sector is driving the progress in reducing GHG emissions.[13] The range of environmental and climate change benefits the plant provides are found in Figure 4-7 below.

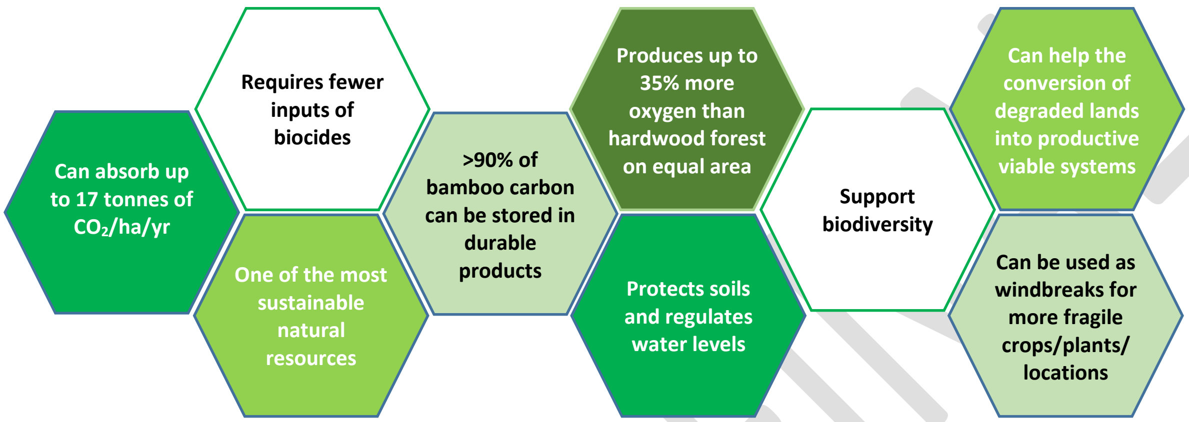


Figure 4-7: Benefits of using Bamboo in the Project

As indicated, bamboo has a high potential to act as a carbon sink. A comparison of the carbon sink properties of bamboo and a pine tree is presented in Section 10.4.

In recent years, new technologies have been developed to overcome the disadvantage of bamboo as a pulping raw material (e.g., silicon removal), and to improve the quality of bamboo pulp products. Bamboo can also produce a vast range of sustainable goods, employment opportunities, and ecosystem services.

According to the Global Forestry Report – Bamboo in Jamaica is recognised for its usefulness in the protection of soil and water and Social Services (FAO, 2020). Bamboo is used most often for temporary construction and is being promoted for use as raw material for utensils, handicrafts and construction.

4.2.1 *BAMBUSA VULGARIS* OR "COMMON BAMBOO"

BBP proposes to cultivate *Bambusa vulgaris*, an open-clumping, sympodial[14] bamboo species (Figure 4-8 and Figure 4-9). It is classified as a perennial grass/sedge that can grow to 20 m tall and 4–10 cm in diameter, with an internode length of 45 cm. This species is the most widely cultivated bamboo throughout the tropics and subtropics, including Jamaica, but is also found spontaneously or naturalised on riverbanks, roadsides, wastelands, and forest edges, secondary forests and disturbed sites, generally in the low altitudes.

[13] Why It Feels So Hard to Understand What Really Happened at COP26. Source: New York Times, 2021. https://time.com/6120266/cop26-takeaways/

[14] Sympodial (Clumping): Sympodial or clumping bamboos are those that do not spread and form tight clumps which only slowly expand in diameter each year.

It grows best under humid conditions but can tolerate unfavourable conditions, for example, drought (Ohrnberger, 1999). Though adaptable to a wide range of soils, common bamboo grows more vigorously on moist soils, for example, sandy loams to loamy clay alluvial soil (Tripathi, 2008). This species grows best in areas with annual rainfall ranging from 1500 to 3800 mm. However, *B. vulgaris* can thrive under a wide range of moisture and soil conditions.

Figure 4-8: Image of Bambusa vulgaris as it occurs in Forests (Source: Smithsonian Institution, Pedro Acevedo-Rodriguez n.d.)

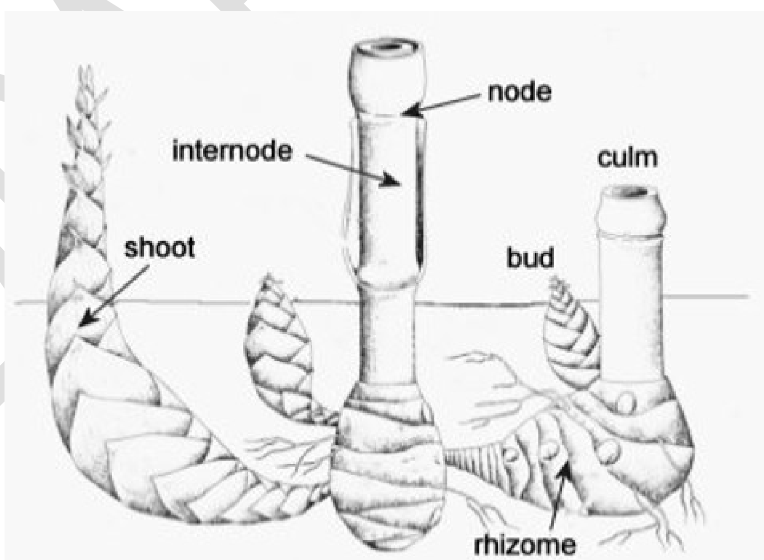


Figure 4-9: Growth Structure of sympodial (clumping) Bamboo

In Jamaica, the *Bambusa vulgaris* is listed as an *Invasive Alien Species*, with a high rate of growth; effective mitigation measures must be in place to prevent it from establishing outside of the designated farm area (once finalised) and displacing native vegetation. An *Invasive Alien Species* is defined by the Forestry Department as a deliberately or accidentally introduced species to an area different from its native range. The Forestry Department, through its Forestry Stewardship Council DRAFT Interim National Standard of Jamaica (2022), shall only use alien species when knowledge and/or experience have shown that any invasive impacts can be controlled.

B. vulgaris grows forming extensive monospecific stands which outcompete native vegetation by shading native plants and monopolising resources (Blundell et al., 2003). This species also represents a serious environmental concern because it has the potential to invade native forests moving along riparian zones (Okutomi et al., 1996). It also disrupts the successional process in disturbed areas, secondary forests, and forest edges in coastal and riparian forests (Blundell et al., 2003).

In Jamaica, *B. vulgaris* has colonised many streams that intersect roads and formed monocultures in some riparian areas (Blundell et al., 2003; Kairo et al., 2003). A study performed in riparian areas of the Luquillo Mountains (Puerto Rico), showed that introduced bamboos may affect native stream macro-invertebrates through alteration of food resources and habitat typically provided by leaf inputs from native, mixed-species riparian forests. This study showed that alien bamboo leaf fall exceeds that of native mixed forests, and where bamboo occurs in riparian zones, bamboo leaves undergo rapid leaching of elements during aquatic decay (O'Connor et al., 2000).

The International Bamboo and Rattan Organization (INBAR) has conducted research into the management of invasive species and has concluded that there is information accessible to knowledge resources to effectively manage the species. There are a number of easy ways to reduce the risks of bamboo invasion through the implementation of preventative measures, assessing the risks of introducing bamboo species, enacting legislation and regulations to restrict the planting and use of certain species of bamboo and effective management strategies. The BSJ has also published the *JCP 8: 2021 Jamaican Standard Code of Practice for Bamboo Plantation* (2021) to guide the preparation and management of bamboo plantations in Jamaica.

In the *JCP 8: 2021 Jamaican Standard Code of Practice for Bamboo Plantation* (2021), recommendations are provided for the cultivation and harvesting of all types of bamboo found in Jamaica. These recommendations are found in **Appendix F**. Once the farm sites have been finalised and the trial tests on farming methods and the physical, mechanical and chemical requirements have been also finalised, this may be provided in the SEA to be submitted to NEPA.

4.3 SOCIAL INCLUSION IN THE PROJECT

BBP will seek to facilitate social inclusion in the project. Potential options for social inclusion are presented below.

Community Cooperatives

BBP will have their own high yield bamboo farms in Jamaica (see example in Figure 4-10) but could provide opportunities for contract farming for various local partners, as well as support and technology to partners to ensure the required targets are met (Figure 4-11). Payments will be backed by long-term contracts. To guarantee income so farmers can better plan and manage their farms, it is planned that partner farms will be paid quarterly on an agreed contract basis. Additionally, as mentioned above, if Contract Farmers are utilised, they would be required to cultivate and harvest bamboo according to the *JCP 8: 2021 Jamaican Standard Code of Practice for Bamboo Plantation* published by the BSJ and the relevant international guidelines and certification (FSC

Certification) for the project. It should be noted that the development of bamboo plantations will only be used to farm a minimal amount of bamboo based on the mill requirements.

Figure 4-10: Image of a typical Bamboo Farm

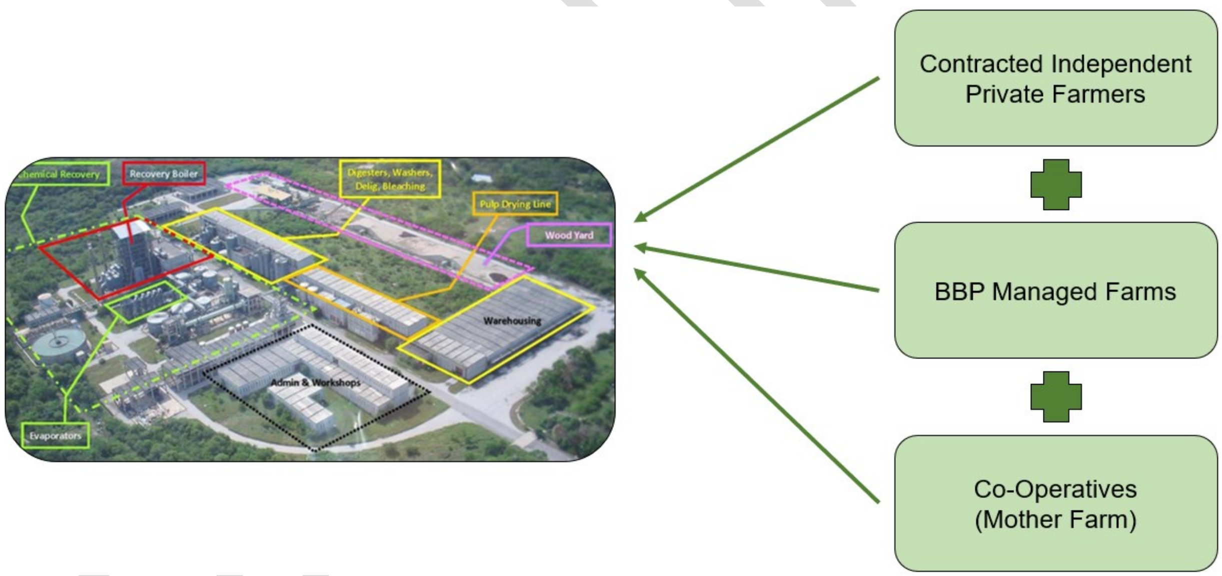


Figure 4-11: Preliminary concept of how BBP will work with other Farmers to supply the proposed Project

The formal organisation of community effort under community cooperatives could, with consultative guidance, organise the harvesting of bamboo for the mill. BBP is currently working with GoJ agencies, for the establishment and management of small-scale, independent farmers and relevant support which may be provided.

Cottage Industry

BBP proposes to, under the guidance of their community development team, could establish cottage industries from bamboo by-products to aid in revitalising local rural communities and as a measure for social inclusion. The upper part of the bamboo culms can be used to make bamboo reusable or single use straws (Figure 4-12:), utensils, and twizzle sticks. While this could typically be used as biofuel, this will be used as a way of giving back to the community and promoting entrepreneurship.

Figure 4-12: Example of Bamboo Straws – of the Items proposed to be produced from By-products

4.4 INTERNATIONAL CERTIFICATION FOR THE PROJECT

Forest Stewardship Council (FSC) Chain of Custody Certification

FSC Chain of Custody Certification ensures that FSC materials and products have been checked at every stage of processing, so customers purchasing products sold with FSC claims can be confident that they are genuinely FSC certified. The certification:

- Provides credible assurance for products with environmentally and socially responsible sources to access the market;
- Verifies that FSC-certified material has been identified and separated from non-certified and non-controlled material as it makes its way along the supply chain, from the forest to the market;
- Provides third-party assurance for projects made of or containing forest-based materials from sustainable sources.

BBP is in the process of acquiring the FSC Chain of Custody Certification to minimise environmental and social risks of the project activities and increase sustainability value of the tonne. Jamaica's Forestry Department is the responsible agency for developing and managing the FSC National Standards of Jamaica. The Forestry Department has developed an interim standard with the FSC guidelines that is currently being reviewed by the FSC for finalisation.

4.5 PULP MILL

BBP is planning to install a new non-integrated Bleached Kraft Bamboo Pulp Mill for production of fluff and market pulp based on bamboo, as *Bambusa vulgaris*, grown in Jamaica.[15] A diagram of the intended product transformation is seen in Figure 4-13. The indicative pulp mill process concept is based on world-class technologies supplied by ANDRITZ,[16] their experience in providing efficient and sustainable pulp and paper technologies, plus the exploratory laboratory studies conducted exclusively for BBP with the specific bamboo raw material (as sent to Valmet and ANDRITZ laboratories). The level of technology that will be used will comply with the European Best Available Techniques (BAT) Guidelines/Reference Document, published in 2015. It should be noted that local conditions such as the local legal and regulatory framework, environmental limitations, energy prices etc., will influence the final concept and design. The lifetime expectancy of the proposed mill is 70 years.

Figure 4-13: Flow from the raw Material to the final Product expected from the Mill Operations (Source: BBP, 2021)

The proposed Project will have a design capacity to produce 250,000 ADt MTS pa of Conventional and Fluff Bamboo Pulp. All the pulp will be dried and produced as bales and reels which will be transported to the Port of Montego Bay for export. At full capacity, the Project is expected to have an ingress and egress of approximately 50–80 trucks per day providing bamboo chips from plantations across Jamaica and approximately 30–40 trucks (1-way trip) transiting between the proposed mill and the Port of Montego Bay. BBP is in current ongoing negotiations with global tissue producers, which collectively sell 10 million tons per annum of finished products and purchase circa 5 million tons per annum in market pulp. In line with increasing sustainability value, a prominent tissue producer has a goal to reduce by 50% by 2025 the company's consumption of 800,000 tons of hardwood pulp from natural forests. They intend to balance this using non-wood fibres, such as bamboo, and this would be subject to availability of suitable "non-wood fibre". BBP intends to ship the product to buyers in mostly Europe, followed by North America and South America.

Bamboo Bioproducts Limited also proposes to have high-yield bamboo farms in Jamaica providing the raw material for the mill. The planned works include the construction and operation of a new pulp mill for production

[15] A non-integrated mill according to the European BAT Guidelines (2015) and this project is a pulp mill that produces market pulp and does not run a paper machine.
[16] Andritz is the leading global developer and supplier of technologies, automation and services for the pulp, paper and energy industries. Source: https://www.andritz.com/pulp-and-paper-en

of fluff and market pulp based on bamboo in Jamaica. Associated works will include the improvement roadways leading to the proposed Project mill site;

4.5.1 CONSTRUCTION OF THE PULP MILL

Traditionally, pulp mills are constructed in a site fabricated fashion – meaning that almost all parts of the process equipment are shipped to site and then assembled, piped, tested and commissioned onsite. The approach that will be taken by BBP is to build the new Pulp Mill in Westmoreland using modular construction techniques off-site, in a controlled factory environment for the delivery of a complete pulp manufacturing system.

This modular approach features key aspects which will result in:

- Superior design at reduced costs
- Maintaining Project construction timetables
- Increased safety
- Reduced construction environmental impact
- Minimisation of remote site access and severe site weather constraints
- Reduced field time and construction costs
- Reduction of site waste
- Improvement in construction quality due to controlled environment
- Extensive factory acceptance testing (FAT) prior to arrival on site
- Overall reduced capital expenses (CAPEX)
- Ongoing reduced operating expenses (OPEX)

Typical module types envisaged for BBP's proposed pulp mill include:

- Truck-able modules
- Pipe rack modules
- Skid-mounted equipment modules
- Hybrid modules (partially completed in the shop and fully assembled in the field)

The largest equipment items – for example, the Recovery Boiler – are simply too big to be modularised and be transportable to an inland site. However, the modular construction approach will still be applied to the ancillary equipment associated with the Recovery Boiler process "island".

4.5.1.1 Benefits of the Construction Method

Engineering Cost Savings

The modular design will be optimised by BBP's Engineering, Procurement and Construction contractor working with the OEM vendor(s) to offer the optimum understanding of each specific process within every module. For example, a properly engineered and optimised module may be built with 250mm pipe, while the same process in a site fabricated design would typically use larger pipe such as 350–400mms diameter. This overly conservative approach in traditional site fabrication adds cost with no performance gains over modular construction. The expense for larger pipes, welding, inspection, pipe fittings, and associated valves necessary with a site fabricated unit is not required in modular construction. When repeated across all aspects of the mill's construction, this reduces the overall installed cost of the project.

Improved Safety

Modular construction improves overall plant safety in several ways:

- Modular construction takes place in a controlled factory environment with inherently lower risk levels compared to a site fabrication environment;
- Modules are tested as complete assemblies versus individual components—which leads to fewer operational risks and a more efficient (faster) start-up—before becoming integrated with the overall pulp mill unit, and rigorously verified using Smart 3D engineering modelling and process simulation software. Every conceivable operating mode is analysed and the design optimised to accommodate all modes of operation. This improves the reliability of the operating units to ensure:
    - No leaks at joints
    - Maintenance of personnel safety when removing control valves during commissioning or maintenance
    - The correct pipe anchoring systems are used to allow for movement of the piping during different plant operations.

By automating every module's operation (as well as the overall plant) – not just of day-to-day activities, but also abnormal or infrequently used modes – operators have more time to focus on monitoring and maintaining the rest of the mill processes.

Enhanced Performance Leads to Improved OPEX and CAPEX

Improved efficiency of operation combined with higher reliability results in mill operating expenditure (OPEX) that is typically lower than comparable site fabricated plants. This prolonged operational stability allows for improvements in the plant's overall yield rate and productivity. With increased availability and improved operating stability over longer periods of time, upsets are reduced. This leads to increased product capacity as more of a desired product is produced on the first pass, reducing the need to recycle product, and allowing the facility to process additional raw material (bamboo). Safety—coupled with enhanced performance through greater availability, improved yield rate, and reduced upsets—leads to reduced plant OPEX over the lifetime of the pulp mill.

Overall capital costs, CAPEX, can also be reduced significantly by the use of modular construction techniques. This is simply because it is far more efficient to build modules in a controlled factory environment than on site in a natural environment. Site fabrication labour costs are always higher than factory fabrication labour costs (within a given country). In addition, modular construction means:

- Higher quality assembly and fabrication;
- Welding, pipe-fitting and other fabrication processes are performed under ideal conditions;
- Highly trained and experienced assembly and fabrication technicians are already employed by the modular system provider (BBP's EPC contractor) ensuring consistent work and worker availability.

Modular construction methodology therefore provides better security for maintaining Project costs and timelines.

Reduced Construction Environmental Impact

Minimising site fabrication by use of modular construction techniques also minimises the environmental impact at the construction site in every respect, particularly on the host communities for example,

- Fewer site workers and their impact on site and local host communities
- Reduced impact on overall site emissions during construction
- Less traffic accessing the site
- Reduced noise levels
- Better air quality (less site traffic results in reduced dust and fumes; reduced need for site welding and grinding generates lower particulates, fumes and waste).

4.5.2 THE MILL LAYOUT AND COMPONENTS

The pulp mill that is being designed for the project conforms with the Kraft Pulping Process. This Section will describe the components of the mill, while Sections 4.5.2-4.5.4 will describe the mill layout in relation to the Kraft Pulping Process. Figure 4-14 shows a typical layout of a Kraft Pulp Mill, while Figure 4-15 shows the conceptual layout of the proposed pulp mill in Friendship, Westmoreland. A more detailed drawing of the mill's layout is presented in **Appendix G**.

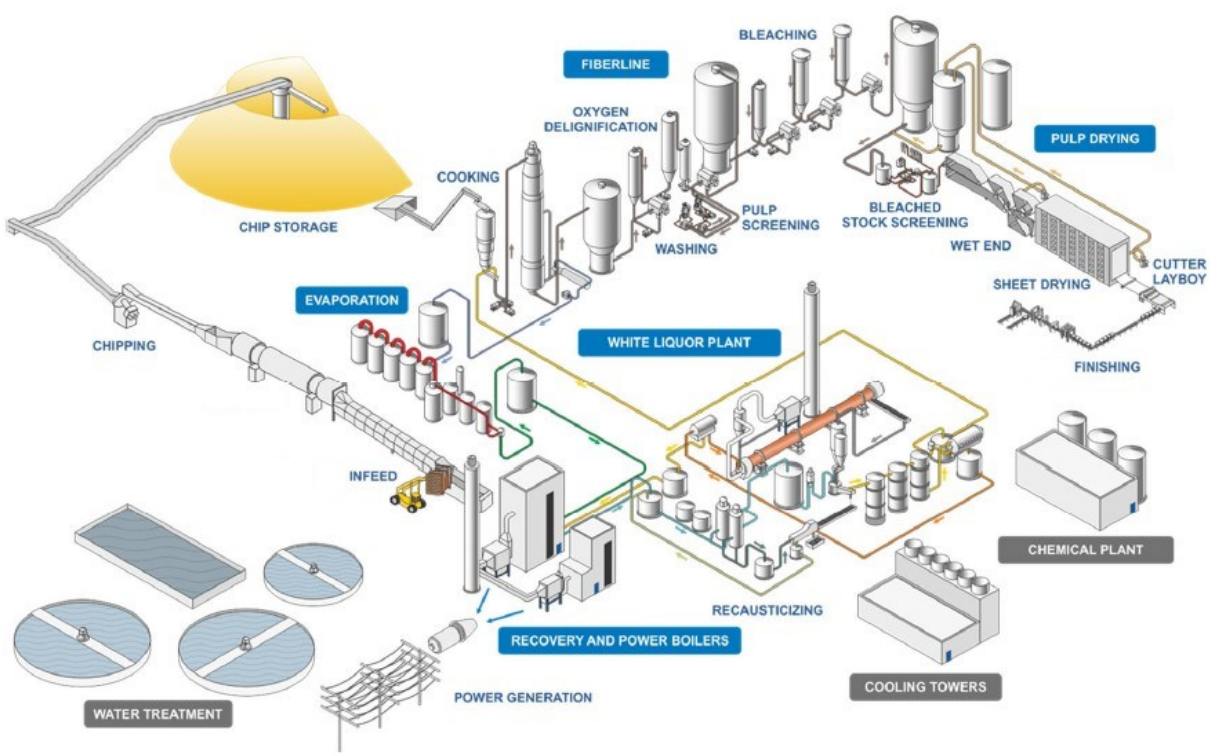


Figure 4-14: Typical Layout of the Kraft Pulp Mill in relation to the Processes identified in Plate 4-16 (Source: BBP, 2021)

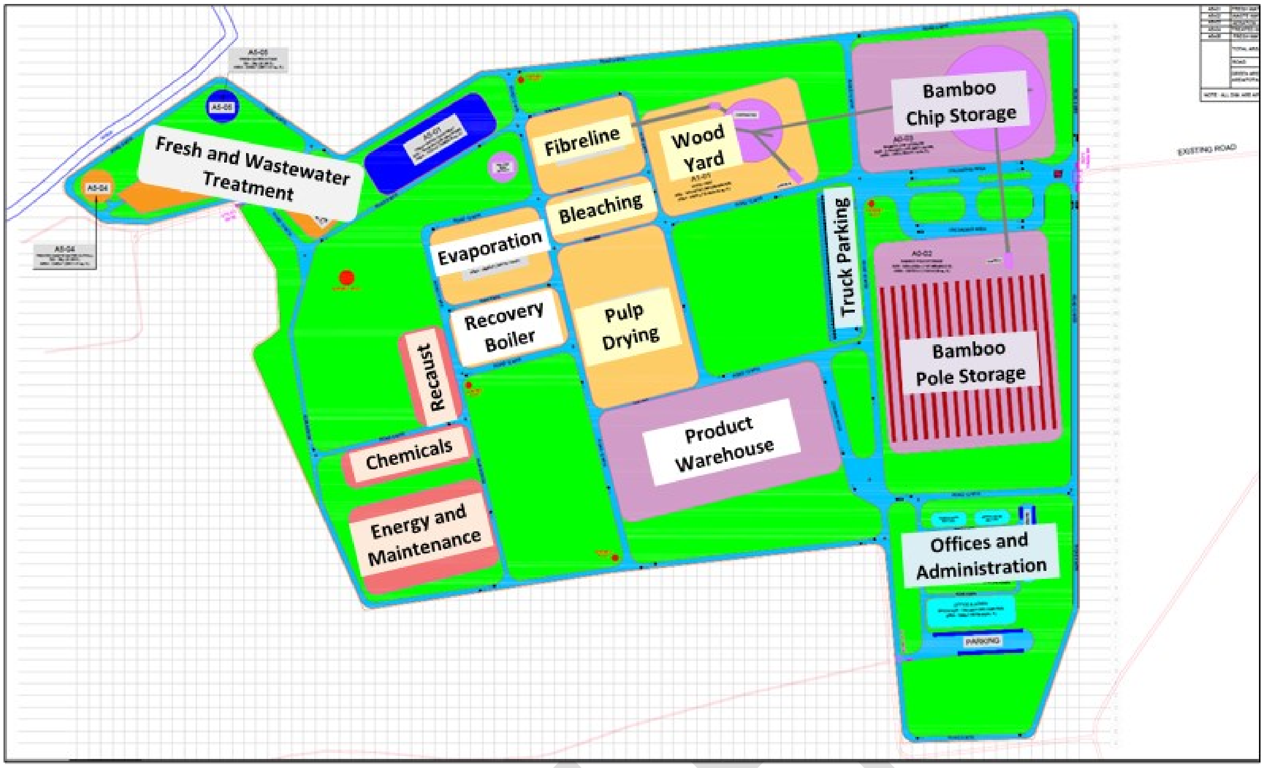


*Figure 4-15: Proposed Mill Conceptual Layout (Source: BBP, 2022). *Note: "Recaust" represents the Recausticizing Plant. A more detailed drawing of the mill's layout is presented in Appendix G.*

As seen in Figure 4-15, the pulp mill will include areas for:

1. Bamboo Chip Handling and Storage
2. Wood Yard
3. Fibreline
4. Bleaching Plant
5. Pulp Drying Plant
6. Evaporation Plant
7. Recovery Boiler
8. Recausticizing Plant
9. Water and Wastewater Treatment Plants
10. Chemical Storage
11. Energy and Maintenance Building
12. Product Warehouse
13. Offices and Administrative Buildings

4.5.3 THE MILL OPERATIONS

It is expected that the pulp mill will operate for 24/7 for 350 days per year.

4.5.4 KRAFT PULPING PROCESS

Kraft pulping (Cheremisinoff and Rosenfeld, 2010) is the most common form of chemical pulping used by 80% of the total chemical pulping industry. The Kraft pulping process relevant to this project has four main steps: raw material preparation, pulp manufacturing, chemical recovery, and pulp bleaching. Figure 4-16 shows a simplified overview of the Kraft pulping process.

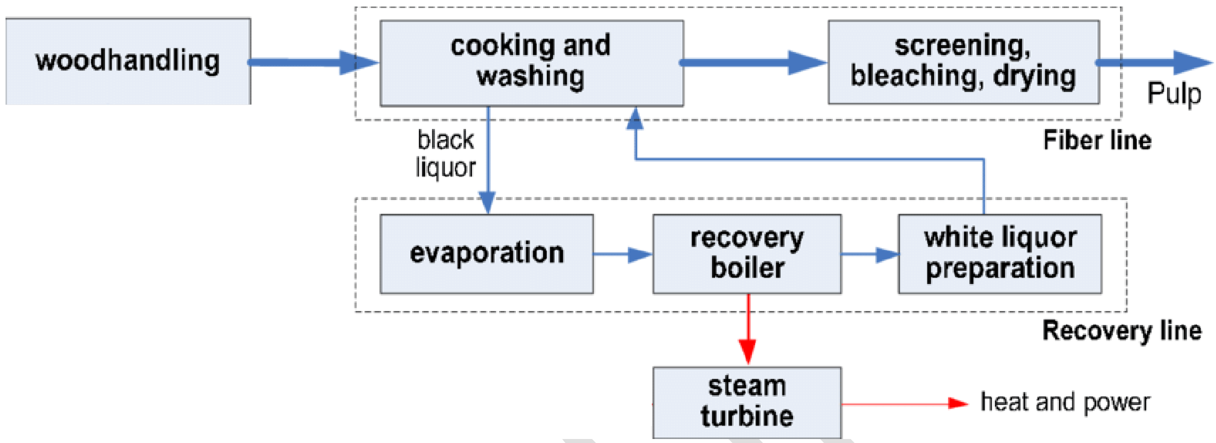


Figure 4-16: Simplified Diagram of the Kraft Pulping Process modified for this project (Adapted from: Hamaguchi et al., 2012)

As seen in Figure 4-16 in dotted lines, the kraft pulping process has two main parts:

i. **The PULP LINE** (**The Fibreline**) – Wood Handling, Cooking and Washing, Screening, Bleaching and Drying

ii. **The CHEMICAL RECOVERY/RECOVERY LINE** – Evaporation, Recovery Boiler, Recausticizing (White Liquor)

The machines and equipment for the Kraft Process of the pulp mill will be supplied by ANDRITZ.

4.5.4.1 The Pulp Line/Fibreline

In relation to Figure 4-16, the process commences with the wood handling which will occur in the Bamboo Chip Handling and Storage and Wood Yard (Figure 4-15). Once bamboo (B. vulgaris) culms are transported to the mill they will be chipped to a nominal length of 25 mm in a chipper. These chips are then stored; screened for thickness, size and uniformity and are then washed before being cooked in the Fibreline. The physical pulping of the wood chips is done in digester systems in the Fibreline area.

Kraft pulping involves the digesting of wood/non-wood chips at elevated temperature and pressure in "white liquor". White liquor is a water solution of sodium sulphide (Na_2S) and sodium hydroxide (NaOH). The white liquor chemically dissolves the lignin that binds the cellulose fibres together in the wood/non-wood. Bamboo, the raw material for this project, is categorised as a non-wood fibre. Non-wood chips typically cook more readily than wood chips, hence, in the cooking process, Kraft cooking may use reduced Na_2S. Additionally, the spent liquors usually have lower concentrations of dissolved organics and process chemicals compared with the typical chemical pulping of wood.

In the cooking process there are two common types of digester systems, batch and continuous digestor systems. This project will use a Continuous Digester System. The Continuous Digester System/cooking process involves the continuous processing of material from feed to discharge.

Advantages of using the Continuous Digester include:

a) For large-scale cooking equipment, the construction, and operation of continuous digester are less costly;
b) High pulp yield and less area occupied;
c) Less energy consumption, peak load avoided;
d) Less labour required – Compared to the highly automated batch cooking equipment, the batch digester and continuous digester are the same;
e) Uniformity of pulp cooking is better than batch cooking.

The cooking will be based on a three-row digester proceeded by a TurboFeed chip feed and black liquor treatment with Reboiler. The ANDRITZ Lo-Solids cooking will be used where the primary objective is to minimise the concentration of dissolved organics throughout the bulk phase of delignification while maintaining, as with other forms of modified cooking, an "even" alkali profile, minimal cooking temperatures, and minimal concentrations of dissolved lignin at the end of the cook.

Advantages of this method and equipment include:

a) Increased pulp strength;
b) Decreased cooking chemical requirements;
c) Decreased bleaching chemical requirements; and
d) Multiple extractions and multiple diluent additions resulting in significant improvement the in overall operation.

Once cooking is complete, the contents of the digester are moved to an atmospheric tank, usually referred to as a blow tank. The entire contents of the blow tank are sent to pulp washers. The pulp washers separate the pulp from the spent cooking liquor. At this stage, the pulp is called brown stock while the spent cooking liquor and the pulp wash water are combined to form a weak "black liquor".

The brown stock then proceeds through various stages of washing and eventually bleaching to create a product that meets desired levels of brightness, strength and purity. Bleaching occurs in the Fibreline. There are two main types of bleaching used in the industry – Elemental Chlorine Free (ECF) and Totally Chlorine Free (TCF). In ECF bleaching, the chemicals used include chlorine dioxide, alkali for the extraction of dissolved lignin, and peroxide and oxygen for the reinforcement of the extraction stages. In TCF bleaching, the chemicals used are oxygen (O_2), ozone (O_3) or peracetic acid, and hydrogen peroxide with alkali from the lignin extraction. TCF bleaching is the more environmentally safe option, as the elimination of chlorine removes the production of toxic chlorinated organic compounds, which can negatively impact human health and cause environmental damage. In this project, the bleaching process is Totally Chlorine Free (TCF).

The finished product will be available as conventional standard pulp bales and/or fluff pulp in reels after going through the Drying Plant where the pulp is dewatered, dried, baled and reeled. The fluff pulp in this form is suitable for the manufacturing of personal hygiene products.

4.5.4.2 The Chemical Recovery Process

A benefit of the Kraft process is that it is designed to recover the cooking chemicals and heat. The black liquor that is formed is concentrated in a multiple-effect evaporator system to about 55% solids. This will be done in the Evaporation area as seen on Figure 4-15. The black liquor is then further concentrated to about 65% solids. The strong black liquor is then sent to the Recovery Boiler (see Figure 4-15). BBP proposes to use an ANDRITZ HERB™ Recovery Boiler in the process and it will have three main functions:

i. Recovery of inorganic pulping chemicals
ii. Incineration of the dissolved organic material and the recovery of the energy content as process steam and electrical power
iii. Prevention and control of pollution (a significant reduction of the wastewater load discharged to the wastewater treatment plant and an extensive reduction of emissions to air)

In the Recovery Boiler, the combustion of the organics dissolved in the black liquor provides the energy for the pulping process and for converting sodium sulphate (Na_2SO_4) to sodium sulphide (Na_2S). This chemical conversion and fuel value of recoverable black liquor is normally enough to make kraft pulp mills more than self-sufficient in heat and electrical energy. There will also be an auxiliary boiler to support the Recovery Boiler. This auxiliary boiler will be used to provide start-up steaming capacity as well as emergency and maintenance in the process; it will use LNG as its fuel when required for usage.

The inorganic chemicals present in the black liquor collect as a molten smelt at the bottom of the Recovery Boiler. This smelt is dissolved in water to form green liquor, which is transferred to a Recausticizing tank, where quicklime (calcium oxide, CaO) is added to convert the solution back to white liquor for return to the digester system. A lime mud precipitates from the tank. The lime mud, which is composed primarily of Calcium Carbonate ($CaCO_3$) with some calcium silicates present, precipitates from the tank, as shown in the equation in Figure 4-17 below.

$$\text{Green Liquor} + \text{Lime} = \text{Lime Mud} + \text{White Liquor}$$

$$Na_2CO_3 + H_2O + CaO = CaCO_3 + 2NaOH$$

$$\text{Sodium Carbonate} + \text{Water} + \text{Calcium Oxide} = \text{Calcium Carbonate} + \text{Sodium Hydroxide}$$

Figure 4-17: Simple Recausticizing Equation

A lime kiln will not be used in this process as bamboo has a high silica content, which typically creates problems with silica glazing, making it impossible to operate a lime kiln. The cooking liquor will be based on fresh quicklime bought from external suppliers. The produced lime mud will be temporarily stored in an appropriate area and may be used outside the mill, and investigations are underway as to its usage either as part of raw material in the cement industry or as soil improvement material (both fertilizers and/or correction of densities).

Figure 4-16 shows a simplified generic overview of the Kraft pulping process, while

Figure 4-18 displays the inputs and outputs for the production of Kraft Pulp. Based on the explanation of the Kraft pulping process and Figures 4-16 to 4-18, the conceptual layout of the proposed pulp mill in Friendship, Westmoreland (Figure 4-15) can be understood from the information provided. Further information on the mill processes, quality parameters in development, and information on the Kraft process is found in **Appendix H.**

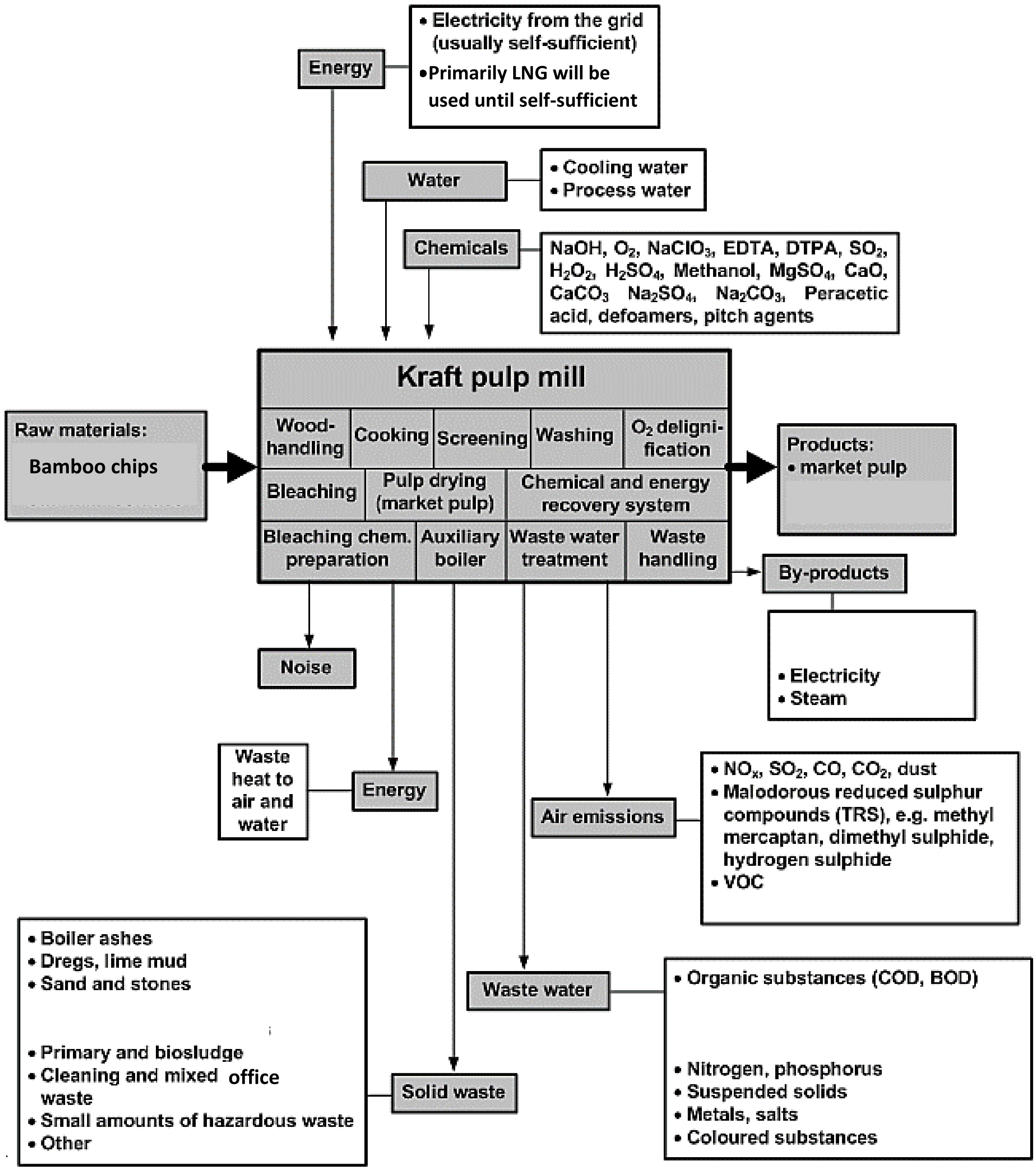


Figure 4-18: Typical Inputs and Outputs of a Kraft Pulp Mill modified for this Project (Source: Adapted from: European BAT Guidelines, 2015)

The predicted performances (**quality parameters**) of the different departments are an indication to what can become guarantees at a later stage. Final designs have not yet been developed and as such, the quality performances outlined below are still being refined. More detailed information on the quality parameters can be found in **Appendix H.** The next Sections (4.6–4.11) will describe certain factors that must be considered before assessing the environmental and social impacts and for licensing and permitting purposes.

4.6 WATER SUPPLY AND CONSUMPTION

The net freshwater requirement for the proposed Project will be 20m^3 per tonne of production (5,284 US gallons). No water abstraction system (surface or groundwater) currently exists at the proposed site. Water for the mill will primarily be extracted from the Cabarita River at the intake location seen in Figure 4-15. There is a potential to drill, extract and use groundwater for the recovery boiler, however, this option has not been finalised. BBP will apply for all the requisite licences once the plans have been finalised.

According to the European BAT Guidelines, water quality requirements for pulp mills vary based on the use, product quality and production processes employed. The main impurities of the raw water that need to be removed, if present, are:

i. Colour – natural brownish or yellowish colour;
ii. Turbidity – small particles of suspended organic and inorganic substances;
iii. Hardness – dissolved calcium and magnesium salts; and
iv. Iron and manganese.

Processes that could occur during treatment, once licences are approved include:

- Filtration to remove sediments and suspended solids;
- Reverse osmosis to create potable water, where needed, for administrative services and other areas linked to the investment;
- Treating water if abstracted from a drilled well.

BBP will provide additional information about the proposed water extraction and treatment, including the equipment.

4.7 WASTEWATER TREATMENT FACILITY

The proposed Project will require the construction of a wastewater treatment facility seen in Figure 4-15. The facility will have a capacity to treat 20m^3 of trade effluent per tonne production and will provide a tertiary level of treatment. The JAD2001 coordinates for the planned location of the single mill WWTP discharge point to the Cabarita River will be: 633696.2, 682690.31 (Figure 4-19).

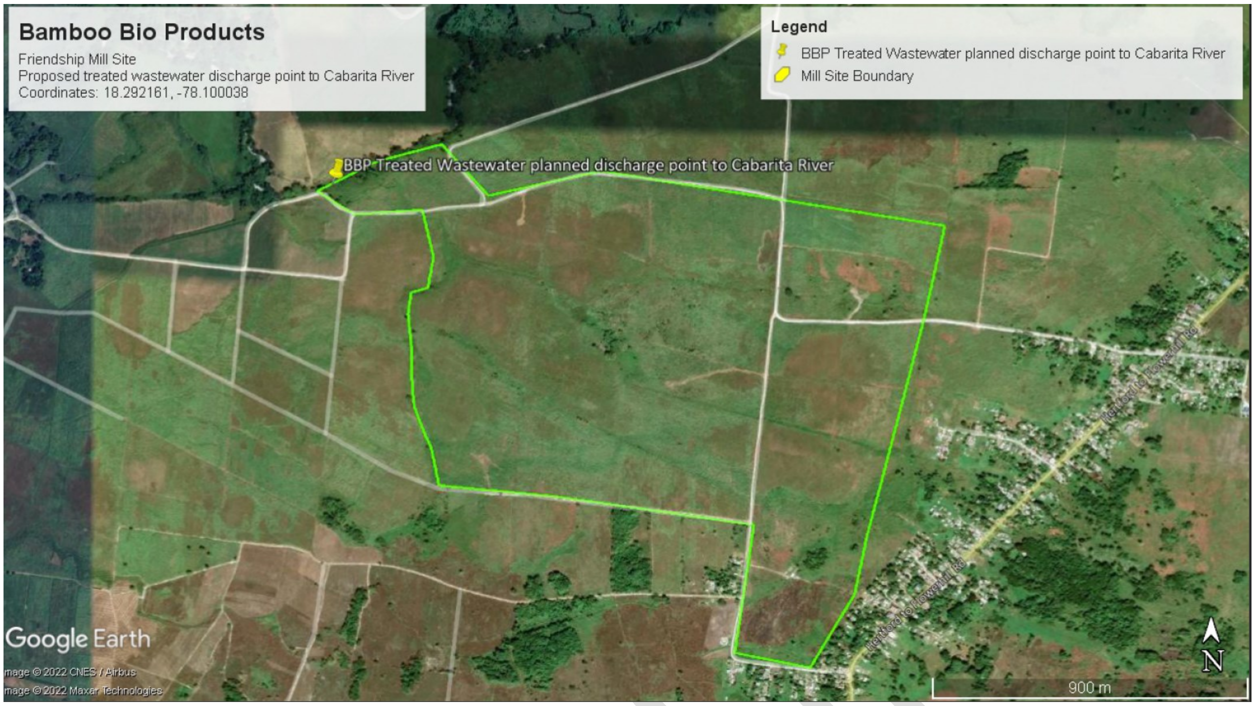


Figure 4-19: Proposed outlet for the WWTP (Source: BBP, 2022)

The treated wastewater discharge will be tailored to conform with the European BAT Guidelines for Kraft pulp mills. These are effluent flows of <18 m^3/ADt and COD in effluent <30 kg COD/ADt. Additionally, BBP will comply with the NEPA Trade Effluent Standards and IFC Effluent Guidelines for Pulp and Paper Facilities—Fibre Preparation, Non-Wood (see **Appendix E**).

The Bamboo Bioproducts (BBP) market pulp mill planned for construction will use a standard, modern form of the well-established bleached Kraft pulping process to create its product, namely: Bleached Bamboo Sustainable Kraft (BBSK) Pulp. The manufacturing process design features maximum practicable internal recycling to minimise the process wastewater flow to be treated by a state-of-the-art dedicated Wastewater Treatment Plant (WWTP). In addition to the application of AMT (Accepted Modern Technology) and BPEM (Best Practice Environmental Management) principles, BAT (Best Available Technology) will be applied throughout the manufacturing process and the WWTP operations.

The WWTP is designed to produce effluent which complies with all NEPA standards for the discharge of trade effluent, as well as related standards from the International Finance Corporation (IFC), and the European Union (EU). More information on the WWTP being designed for the mill is found in **Appendix I**.

The core business of BBP is the production of high value BBSK market pulp for export from Jamaica to primarily Europe and North America. However, BBP recognises that wastewater treatment is not a core business or competence of BBP. Therefore, BBP intends to contract or partner with a recognised water industry specialist having the necessary competence, experience, and support structure to properly design, build, maintain and operate the WWTP at the mill under long-term contract to BBP. The WWTP partner selected by BBP is SUEZ.

SUEZ as a Build-Own-Operate (BOO) Partner to BBP

SUEZ offers long-term, full-service contracts with Build-Own-Operate (BOO) contracts, designed to allow SUEZ to assist BBP with all key water operations. SUEZ makes a life cycle commitment to ensure that the required quantity and quality of product water is delivered. SUEZ provides this assurance by drawing on deep expertise and reliability as a manufacturer of equipment and chemical technologies used in hundreds of SUEZ BOO projects globally. With flexible durations and robust proven technologies, SUEZ ensures that the quantity and quality of water needed is safely and reliably delivered. A SUEZ BOO also provides customers with additional assurance. If for some reason the BOO Partner is not able to deliver the results needed, SUEZ will use the world's largest mobile fleet to ensure contract compliance.

SUEZ currently owns and operates hundreds of industrial and municipal plants processing more than 60,000 m^3/hr [(360 millions of gallons per day (MGD)] of water or wastewater around the world, including Jamaica. Focused on the power/steam generation, refining, chemical processing, steel, microelectronics, desalination, and pulp and paper industries, SUEZ provides operations and maintenance services for customers with water processing needs ranging from 10 to 20,000 m^3/hr (44–88,000 GPM).

SUEZ also has the ability to process water from nearly any source, including rivers, boreholes/wells, lakes, and industrial processes. SUEZ treats these water sources to produce water for boiler feed, semi-conductor manufacture, food process, drinking purposes, industrial processes, and other applications.

SUEZ employs numerous field service representatives (FSRs) globally. These hands-on technical experts provide local service and support. SUEZ can provide a dedicated service technician at every customer site as part of the commitment to exceed the highest EHS standards and oversee a successful worry-free operation.

Mill Design Principles in relation to WWTP

In relation to wastewater from the process operations entering the WWTP, the BBP mill process design incorporates the following best practice principles for Kraft pulp mills:

- Systems for collection and recycling of accidental discharges of spills from the process water;
- Sufficient and balanced volumes of pulp storage, broke storage[17] and white water storage tanks to avoid or reduce processed water discharges;
- Recycling of wastewater, with simultaneous recovery of fibres;
- Separation of contaminated and non-contaminated (clean) wastewaters with collection and reuse of clean non-contact cooling waters and sealing waters;
- Oxygen delignification ahead of the bleach plant;
- Efficient washing of the pulp ahead of bleaching;
- Use of elemental chlorine free (ECF) bleaching or total chlorine free (TCF) bleaching;
- Maximisation of knot removal;
- Collection and recycling of spent cooking liquor spills;
- Stripping and reuse of evaporation and digester condensates.

[17] "Broke" is the standard pulp and paper industry term used to describe 'scrap' or sub-standard production. All broke (i.e. all sub-standard production) is repulped (using only water) and 100% recycled and reprocessed in the mill.

4.7.1 WWTP PROCESS DESCRIPTION

The BBP pulp mill site at Friendship will be based on strict segregation of all three (3) fundamental wastewater sources:

i. Trade effluent/processed wastewater (including from all bunded areas where any spillage may occur) will be collected from all process units 'islands' and piped directly to a dedicated wastewater treatment plant at the lower elevation of the site, thus enabling gravity drainage;

ii. Sanitary (grey and black) water from site facilities (offices, washrooms, canteen, etc.) will be piped through a dedicated system to a modern modular sewage treatment unit specified and designed to meet all NEPA discharge requirements. Treated water will be discharged to the Cabarita River;

iii. Rain/storm water will be collected via a dedicated system of channels, gullies and pipes, incorporating oil and grease traps where necessary, and collected in an equalisation/surge pond or tank. Some rainwater will be pumped back to the mill process fresh water supply to supplement river and ground water supplies. Surplus rainwater will flow into the Cabarita River.

All three types of wastewater will be fully treated before any is discharged to the Cabarita River.

4.7.1.1 Trade Effluent Process Description

In order to employ BAT and meet NEPA, EU and IFC discharge standards for treated wastewater, the BBP WWTP designed and operated by SUEZ will feature three (3) stages of treatment. The process that will be utilised was determined based on assessments conducted by the design engineers. The process features are:

i. All processed wastewater streams will be completely segregated from the dedicated site's sanitary (grey and black) water system and the separate rain/storm water system;

ii. Process wastewater streams flow by gravity to an equalisation tank with suitable retention capacity to allow a significant reduction in flow and composition variability as well as pH and temperature ahead of Stage I of the treatment system;

iii. Stage I treatment comprises a clarifier using either sedimentation-flocculation or dissolved air flotation (DAF) to separate suspended matter (primarily cellulose fibres and fines) and return them to the pulp mill for reprocessing. This reduces initial total suspended solids (TSS) loading and recovers useful fibre. Clarified water is pumped to Stage II:

iv. Stage II is an activated sludge aeration tank in which activated sludge from Stage III is recirculated back to initiate aerobic processes;

v. Stage III is a Membrane Bio Reactor (MBR) based on SUEZ LEAPmbr ZeeWeed technology. Sludge from the MBR will be recirculated to Stage II, with surplus sludge being dewatered by a belt press. The primary purpose of this technology is to simultaneously reduce TSS, biochemical oxygen demand (BOD), and chemical oxygen demand (COD) levels down to the required standards;

vi. Clean wastewater will be discharged back to the Cabarita River via a break tank in which continuous quality monitoring and recording will take place.

The processes for treating the process wastewater are represented in Figure 4-20.

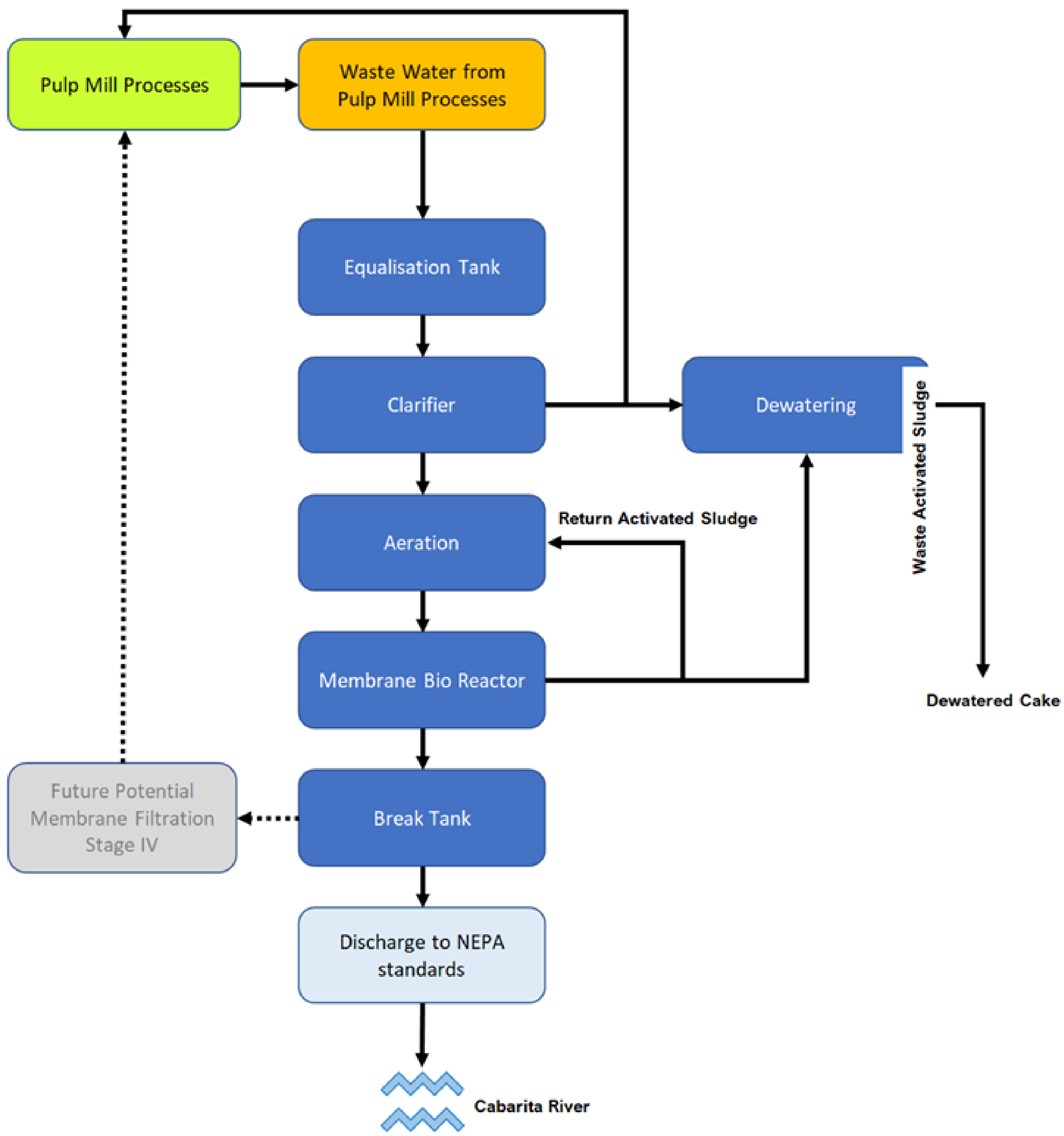


Figure 4-20: BBP WWTP Schematic (Source: BBP, 2022)

The key treatment technology of the BBP WWTP process is the Membrane Bio Reactor (MBR) as seen in the last stage of Figure 4-20. The ZeeWeed MBR system comprises two major functions: a biological reactor; and an ultrafiltration system which separates biological solids from the final effluent. Microorganisms such as faecal coliform and other pathogenic organisms will be removed in the MBR. Its reinforced hollow-fibre membranes and unique design achieve superior effluent quality while reducing energy consumption with an increasing membrane lifespan (Figure 4-21). Advanced COD, colour and lignin removal are be achieved by the addition of inorganic and organic Suez coagulants. More information on the system can be found in **Appendix I**.

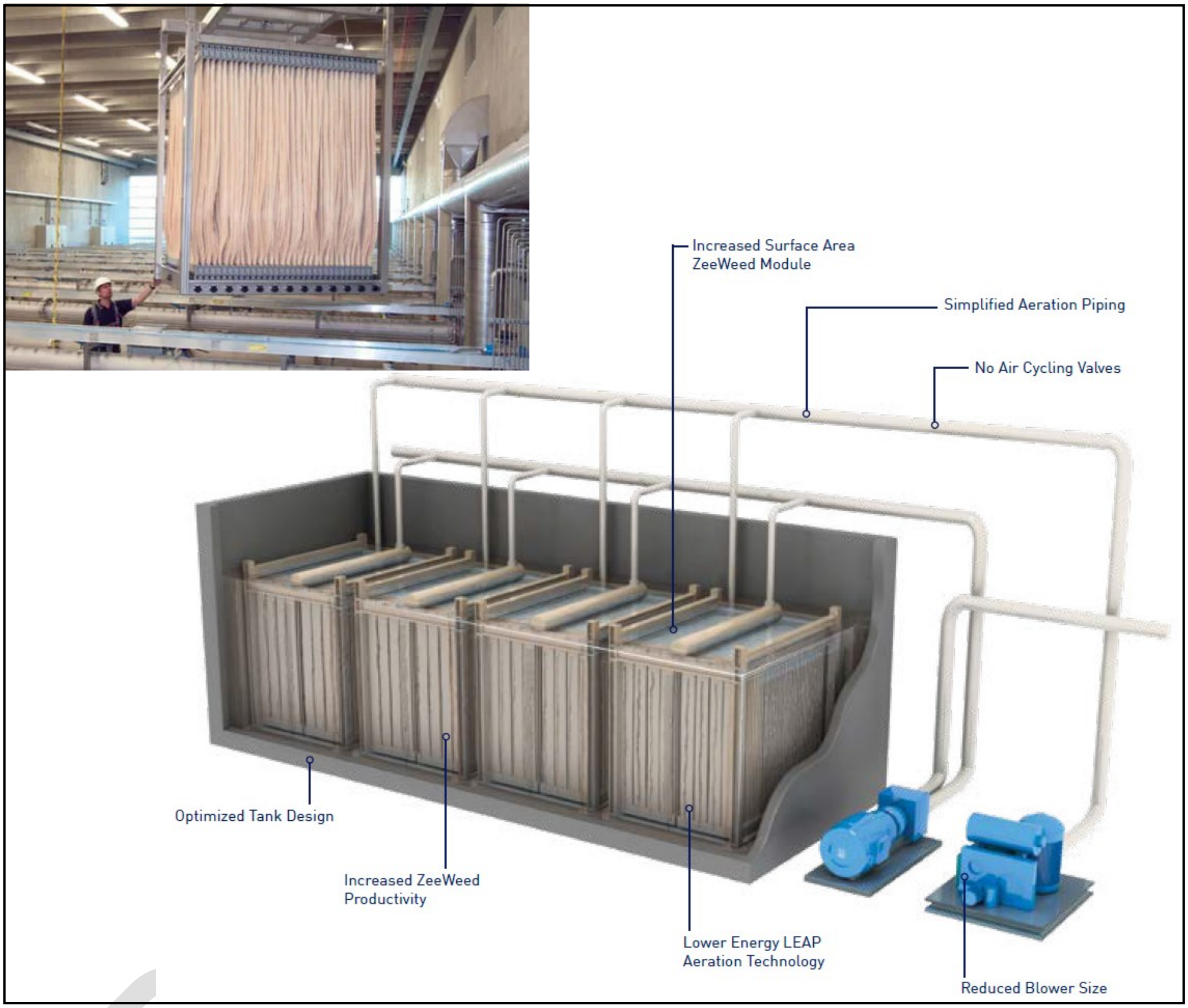


*Figure 4-21: **ZeeWeed MBR Cassette to be used at the pulp mill.**[18]*

The type of WWTP plant that will be supplied by SUEZ is a Z-MOD* S (AG) packaged plants. Features provided in the base system of the WWTP include:

- ZeeWeed* 500 reinforced ultrafiltration membranes produce superior effluent quality while operating in a high solid wastewater environment
- Complete systems incorporate screening, biological equipment, filtration equipment, and disinfection
- Epoxy coated carbon steel tank with anoxic chamber with mixing, aerobic chamber with diffusers and membrane chambers

[18] LEAPmbr ZeeWeed reference video: https://www.youtube.com/watch?v=Qy5dmgFwufQ

- Aeration blowers, permeate pumps, back pulse pumps, back pulse tank, control panel, recirculation pump, GE Fanuc PLC, and HMI interface mounted on the equipment skid
- Plant start-up and operator training

Table 4-1 below shows the data sheet for the water treatment system being designed for the Pulp Mill.

Table 4-1: Data sheet for the Z-MOD S4 System of the Water Treatment Solution SUEZ is designing for use at the Pulp Mill

	Value	Unit
Design Flow Rates		
Average Flow	20,000	gpd
Peak Flow	40,000	gpd
Permeate Discharge Design		
Design Flow Rate	15	gpm
Max TDH Required	6.7	psig
Available TDH	22	psig
Discharge Pressure	15.3	psig
Standard Equipment		
Blowers for Process & Membrane Aeration	2	
Aerobic Diffusers	1 Lot	
Anoxic Mixing	1 Lot	
Membrane Modules	4	
Recirculation Pumps	2	
Permeate Pumps	2	
Backpulse Pumps	2	
Backpulse Tank	1	
Control Panel	1	
PLC	1	
HMI	1	
Biological Tank	1	
Equipment Skid	1	
Biological Footprint		
Membrane & Biological Tank Diameter	12	ft
Maximum Length Per Tank	47	ft
Minimum Tank Length (with Membranes)	16	ft
Typical Number of Tanks	1	#
Typical Total Tank Length	20-30	ft
Required Height to Hoist Hook for Membrane Removal	TBD	ft
All information is provided based on typical characteristics and may vary depending influent characteristics		
Low Strength Wastewater is 250 mg/L BOD, 250 mg/L TSS, 45 mg/L TKN		
High Strength Wastewater is 500 mg/L BOD, 500 mg/L TSS, 90 mg/L TKN		

4.7.1.2 Process Data

Projected WWTP influent flow rates from BBP pulp mill individual process island operations is presented in Table 4-2. Figure 4-22 presents the estimated effluent flow rate based on the mill's processes.

Table 4-2: Projects WWTP influent flows at the BBP pulp mill based on the individual process island operations. *Note: BSW represents Brownstock Washing.

Effluent flow	l/s	m3/adt	temp, °C
Chip handling	15	1,6	35
Cooking	0	0,0	0
BSW	81	8,9	55
Drying	7	0,7	0
Evaporation	0	0,0	0
Recovery Boiler	0	0,0	0
Causticizing (WLP)	11	1,2	38
Total process	114	12,5	48
Other (Cooling tower purge, demin plant, chemical plant, water treatment)	28	3,0	
Effluent Steady State Total = 15,5 m3/ADt			

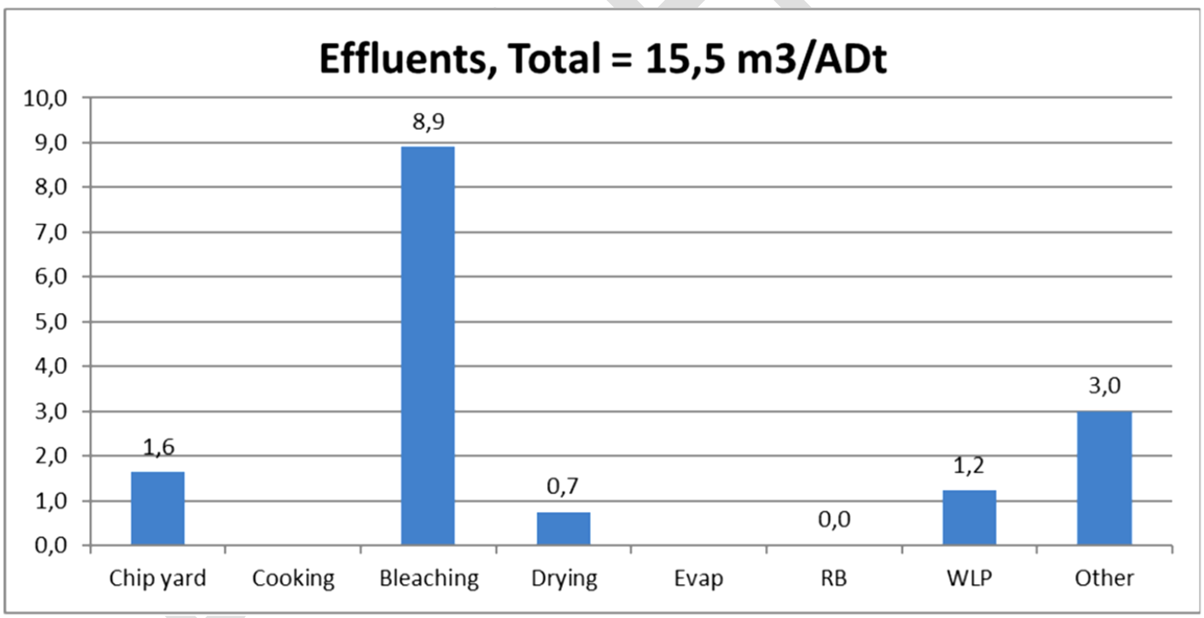


Figure 4-22: Estimates of the effluents that will be produced based on the individual pulp mill processes. Note: RB represents the Recovery Boiler and WLP is the Recausticizing Plant.

The data above (Table 4-2 and Figure 4-22) are for steady-state, normal operations. For process upset conditions and other operational excursions, the WWTP will be designed to handle and process flow rates equivalent or up to 20 m^3/ADt.

4.7.2 TRADE EFFLUENT DISCHARGE STANDARDS

BBP has the objective of meeting all relevant local and international standards for discharge from the new pulp mill. Table 4-3 shows current NEPA, IFC and EU standards for treated water discharges from bleached Kraft pulp mills, with the BBP target values (monthly average).

Table 4-3: Wastewater Discharge Targets compared to local and international Standards

Values have been converted from mg/l to kg/ADt for direct comparison

			Local and International Standards and Guidelines		
Water emissions	**Unit**	**BBP target**	**NEPA**	**IFC**	**EU BAT**
Flow	m^3/ADt	<20	N/A	50	20 - 50
AOX	kg/ADt	0	N/A	0.25	0 – 0.2
COD	kg/ADt	<10	2.0 (<100 mg/l)	20	7 - 20
TOC	kg/ADt	<3.5	N/A	N/A	N/A
BOD	kg/ADt	<0.5	0.6 (<30 mg/l)	1.0 (BOD_5)	
TSS	kg/ADt	<0.5	1.0 (<50 mg/l)	1.5	0.3 - 1.5
Ntot	kg/ADt	<0.1	0.2 (<10 mg/l)	0.2	0.05 - 0.25
Ptot	kg/ADt	<0.02	0.1 (<5 mg/l)	0.03	0.01 – 0.03
Temperature	°C	amb +/-2	amb +/-2	N/A	N/A
pH	pH units	6.5 - 8.5	6.5 - 8.5	N/A	N/A

Acronyms:
ADt (Air-dried metrid tonne of production – containing standard 10% moisture content);
amb (ambient); AOX (adsorbable organic halides); COD (chemical oxygen demand);
TOC (total organic carbon); BOD (biological oxygen demand);
BOD_5 (five-day biochemical oxygen demand); TSS (total suspended solids); Ntot (Total nitrogen);
Ptot (Total phosphorus)

4.8 WASTE GENERATION AND DISPOSAL

4.8.1 SOLID WASTE

Information on the waste to be generated will be provided by BBP once finalised. Preliminary information shows that the largest solid waste component will be “lime mud cake”. It will be primarily dewatered Calcium Carbonate (at about 55% dryness) and it is intended that this “lime mud cake” could be used by the cement industry as a raw material and could also be used for road construction as binder/filler material. Similarly, small quantities of fly ash generated from the recovery boiler’s electrostatic precipitator could be used as a road construction filler and/or as a soil conditioner. BBP plans on using water treatment technologies that minimise (or eliminate) generation of bio-sludge as a waste product. Small quantities of sand, green liquor “dregs” (calcium sulphate and carbonate) deposits from the Recausticizing process, and general mill and office waste materials will be disposed of using licensed and approved waste handling contractors. It is also expected that the WWTP will generate dewatered sludge from their processes which BBP intends to utilise sustainably. More information on the management of sludge and its sustainable usage in the project can be found in Section 13.2.

In the interim, the general waste of a typical Kraft pulp mill, as identified by the European BAT Guidelines, are presented in Table 4-4 below.

Table 4-4: Compilation of Tables that provide the average Types, Composition and Concentrations of Waste typically produced by a Kraft Pulp Mill (Source: Extracted directly from the European BAT Guidelines, 2015)

Average waste generation in kraft pulp mills in kg dry solids/ADt

Type of waste	kg dry solids/ADt of pulp
Waste water treatment sludge	10
Wood ash	9 (*)
Other ashes	14 (*)
Fibre	5
Wood waste	6
Dregs, grits and green liquor sludge	10 – 20
Lime enriched with non-process elements	10 – 20
Hazardous waste	0.2
Total	**60 – 80**

NB:
'Wood ash' is fly ash and dust from the incineration of wood material (e.g. from the bark boiler).
'Other ashes' are ashes from fuels used in energy production other than wood and black liquor.
(*) Values for ash/ADt are higher if additional biomass from external sources is used as complementary fuel.
'Wood waste' is bark, chips, sawdust, wooden packages, etc.
Source: [Finnish BAT Report, 1996], with changes proposed by experts from the TWG.

Average composition of green liquor sludge with different amounts of lime mud

Lime mud (%)	Dry solids (%)	Ash (%)	Organic content (%)	Tot-N g/kg DS	Tot-P g/kg DS	Tot S g/kg DS
<2	45	62	20	0.4	0.6	23
75	59	62	6.5	<0.4	2.8	6.3

Average metal concentrations in green liquor sludge with different amounts of lime mud

Lime mud (%)	Ba	Cd	Co	Cr	Cu	Hg	Ni	Pb	Sr	Zn
<2	430	16	9.2	75	90	0.07	60	18	330	2 300
75	310	11	5.3	85	96	<0.10	29	11	290	1 000

NB: All values expressed as mg/kg dry material.

The plans for the disposal of waste are currently under development. According to Figure 4-15, no area has been designated as a facility to store waste or for waste disposal. Information on the types of waste to be generated, their storage and disposal will be provided by BBP. The disposal of waste will conform with local and best practice guidelines.

4.8.2 SEWAGE EFFLUENT

Sewage generated on site will be treated by an entirely separate dedicated modular sewage treatment unit from the WWTP to be supplied and operated by SUEZ. This stand-alone sewage treatment will utilise a Membrane Bio Reactor (MBR) technology to simultaneously reduce TSS, biochemical oxygen demand (BOD), and chemical oxygen demand (COD) levels down to the required standards. The process will also remove faecal coliform. This sewage treatment unit is currently being designed and will comply with local regulations as indicated in Table 4-5 below.

Table 4-5: NEPA Sewage Effluent Standards

PARAMETER	EFFLUENT LIMIT
BOD_5	20 mg/l
TSS	20 mg/l
Total Nitrogen	10 mg/l
Phosphates	4 mg/l
COD	100 mg/l
pH	6-9
Faecal Coliform	200 MPN/100 ml
Residual Chlorine	1.5 mg/l

4.9 CHEMICALS TO BE USED AT THE PROPOSED PULP MILL

As indicated in

Figure 4-18, there is a range of chemicals used for the operation of a Kraft pulp mill. A provisional list of the chemicals that will be used for pulping and treatment at the proposed mill are presented in Table 4-6. Table 4-7 lists the draft concentrations and temperatures for some of the primary chemicals to be used at the proposed site.

Table 4-6: Provisional List of Chemicals to be used at the proposed Pulp Mill in Friendship, Westmoreland (updated October 2021) (Source: BBP, 2021)

	Chemical Name	Formula	Common Name	State	Comment
	BULK/COMMODITY				
Primary Pulping Chemicals	Sodium Hydroxide	$NaOH$	Caustic Soda	Solid	
	Sodium Sulphide	Na_2S		Solid	Often sold as hydrate
	Sodium Sulphate	Na_2SO_4		Solid	
	Magnesium Sulphate	$MgSO_4$		Solid	Delignification
	Sulphuric Acid	H_2SO_4		Liquid	
	Hydrogen Peroxide (aqueous)	H_2O_2		min 50% conc liquid but not exceeding 68%	Above 68% conc, H2O2 is unstable
	Calcium Oxide OR Calcium Hydroxide	CaO/ $Ca(OH)_2$	Lime	Solid	Ideally, from local cement works
	Oxygen	O_2	Liquid Oxygen	Liquid	Ideally, on site liquefaction
	Ozone	O_3		Gas	Manufactured by mill on site

	Chemical Name	Formula	Common Name	State	Comment
	One or more of Peroxyacids family	$R.CO_3H$	Peracids, e.g., Paracetic Acid	Liquid	Delignification & bleaching
	Ethylene.diamine.tetra.acetic acid	$C_{10}H_{16}N_2O_8$	EDTA	Solid or liquid (in solution)	Chelating agent
	SPECIALISED				
Secondary Treatment Chemicals	Coagulents		Aluminium Sulphate, Polyaluminium Chloride, ferric sulfate	Liquid	Water treatment
	Polymers: Acrylamides, Epichlorohydrin		Coagulent aids	Liquid	Water treatment
	Biocides		Slimicides	Liquids	Process water treatment
	Oxygen scavengers				Boiler feedwater treatment
	Scale preventers				Boiler feedwater treatment
	pH control alkalis				Boiler feedwater treatment
	Sludge conditioners				Boiler feedwater treatment
	Anti-foamers		Defoamers		Water foam prevention
	Various chemicals used for multi-stage wastewater treatment (yet to be specified)		Includes nutrients (for activated sludge) + various others, depending on final technology choices		Wastewater Treatment

Table 4-7: List of Chemicals, Concentrations and Temperatures to be used in the Fibreline for the proposed Pulp Mill in Friendship, Westmoreland (Source: Technical Specifications of the proposed Mill, BBP, 2021)

CHEMICALS	VALUE
NaOH - **concentration, min.** - **temperature** - **pressure at the battery limit (min)**	 30% 25˚C 4 bar (g)
H_2SO_4 - **concentration, min.** - **temperature, min.**	 98% 25˚C
Oxygen - **concentration, min.** - **temperature**	 92% 14 bar(g)
H_2O_2 - **concentration, min.** - **temperature** - **pressure at the battery limit (min)**	 27.5% 25˚C 14 bar (g)
Ozone (O_3) - **concentration, min.** - **temperature** - **pressure at the battery limit (min)**	 12.5 % 20˚C 12 bar (g)
Talc - **concentration, min.** - **temperature**	 9% 20-30˚C
DTPA **(diethylenetriaminepentaacetic acid)** - **concentration, min.**	 99%

Information regarding the full list of the type, concentrations and areas of use of the chemicals will be provided by BBP.

4.10 STORAGE OF RAW MATERIALS AND CHEMICALS

The storage of materials component of the mill is currently under development. According to Figure 4-15, two areas have been designated for the storage of the raw bamboo before they are chipped. This area was designated to act as a barrier (noise and aesthetics) to separate the full operation of the mill from the nearby communities along the Hertford to Flowerhill Road. Bamboo culms will be stored in horizontal piles and measures will be taken to ensure that the stored culms do not become breeding grounds for mosquitoes. More information on the storage of this raw material will be provided by BBP.

Also, according to Figure 4-15, there is an area on the proposed mill layout designated for 'Chemicals'. Information regarding the full list of the type of chemicals and their estimated storage times will be provided by BBP. The storage and disposal of raw materials and chemicals will conform with local and international best practice guidelines. All chemical storage and usage areas will be provided with compliant bunded controlled containments to prevent spills entering the environment.

4.11 AIR EMISSIONS

The proposed pulp mill intends to follow the European BAT Guidelines (Suhr et. al. 2015). For information purposes, Figure 4-23 indicates the potential emissions that could be released at each stage of a Kraft pulp mill process. However, in this project there will not be any Bark boiler, Lime Reburning or emissions from these equipment as seen in Figure 4-23.

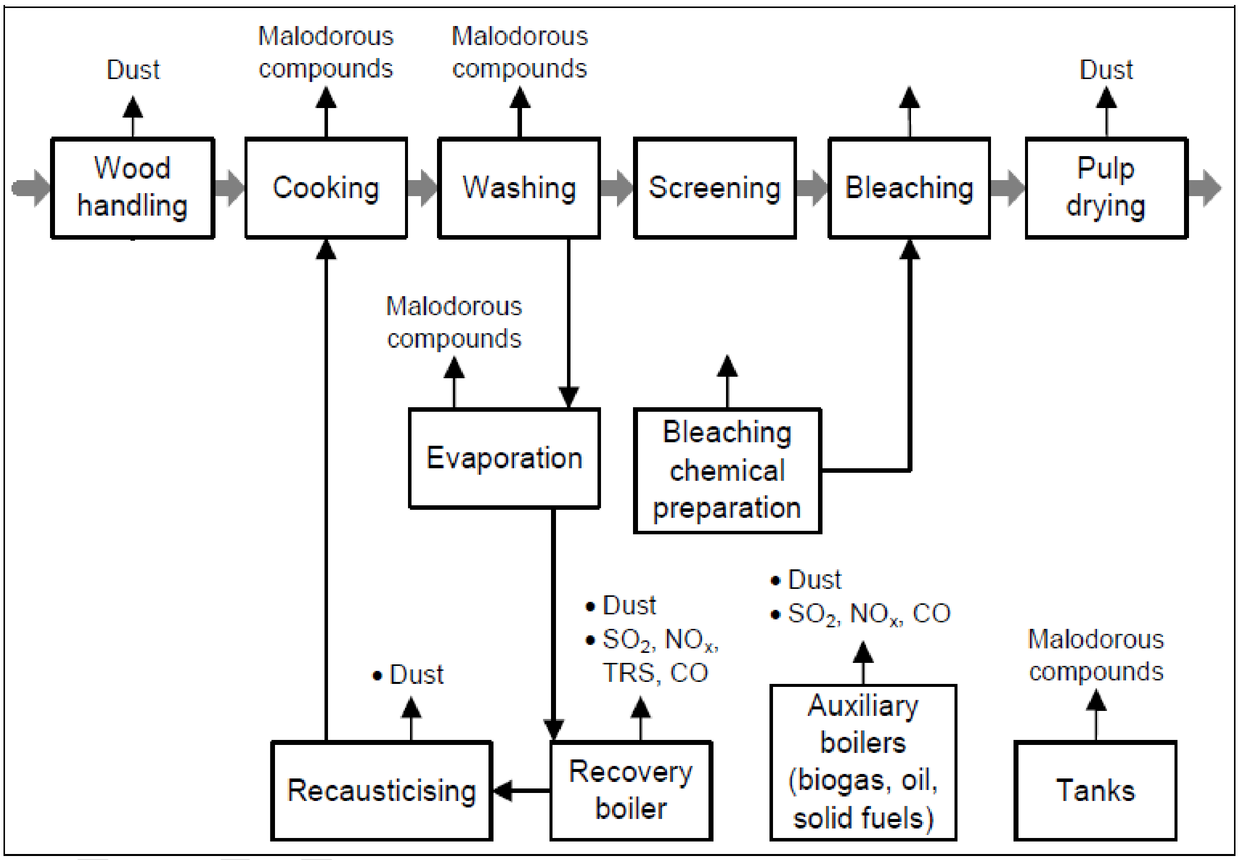


Figure 4-23: Air Pollutants typically released at each Stage of the Kraft Pulping Process at a Mill, with Considerations made for the BBP Pulp Mill processes and TCF Bleaching (Adapted from: European BAT Guidelines, 2015)

Information has been provided by ANDRITZ on the expected emissions based on the preliminary mill design. This information is presented in Table 4-8.

Table 4-8: Expected Emissions from the proposed Project Pulp Mill (Source: ANDRITZ, 2020). There is a possibility that updated designed emissions may have reduced TRS.

Expected emissions to air from the recovery boiler at maximum continuous black liquor firing rate 1270 tDS/d.

Emissions			Note
TRS -content in flue gases The average TRS content (defined as H_2S) in the dry flue gases, corrected to 6 % O_2, and 70-100% black liquor firing capacity will not exceed	mg/m^{3}n	5	According to BAT
NO_x - content in flue gases The average NO_x content (defined as NO_2) in the dry flue gases, corrected to 6 % O_2 • Black liquor N-content by weight max. N=0.15 %	mg/m^{3}n	200	According to BAT
SO2-content in flue gases The average SO_2 content in the dry flue gases, corrected to 6% O_2, black liquor S/(Na_2+K_2) mole ratio being maximum 32% will not exceed the following:	mg/m^{3}n	50	According to BAT
Dust in flue gas The average dust content in dry flue gases after the electrostatic precipitator, corrected to 6 % O_2, will not exceed the following:	mg/m^{3}n	200	According to BAT

Recent information provided by BBP indicated that the designs are being explored to further reduce some of the emissions in Table 4-8, namely the non-condensable gases from the process. Non-condensable gases (NCGs) are usually referred to as Total Reduced Sulfur compounds (TRS) or Dilute Vent Gases and are by-products of the kraft pulp process.[xix] These gases, mostly sulfurous, are extremely malodorous and flammable. The TRS in the bamboo pulp mill process are generated in pulp digesters where the bamboo chips are cooked in the Kraft liquor as well as they can be generated in direct contact evaporators, in recovery boilers. The TRS gases involved are hydrogen sulfide (H_2S), methyl mercaptan (CH_3SH), dimethyl sulfide (CH_3SCH_3) and dimethyl disulfide (CH_3SSCH_3).[xx] The TRS gases that are emitted from digesters, evaporators, turpentine systems, strippers, brownstock washers and liquor storage tanks will be collected and burnt in the Recovery Boiler.

Other NCGs outside of TSR include volatile organic compounds which will be produced from the stripping process in the Chemical Recovery process.[xxi] In the bamboo pulp mill process the NCGs that will be

[xix] Monitoring Non-condensible Gases (TRS) in Pulp Mills taken from https://www.controlinstruments.com/documents/monitoring-non-condensable-gases-trs-kraft-pulp-mills#:~:text=Non%2Dcondensable%20gases%2C%20usually%20referred,are%20extremely%20malodorous%20and%20flammable

[xx] Lin, B. Collecting and burning noncondensible gases taken from https://www.tappi.org/content/events/08kros/manuscripts/3-6.pdf

[xxi] Siddiqui, N.A., Ziauddin, A., 2011. Emission of non-condensable gases from a pulp and paper mill - a case study. J. Ind. Pollut. Control 27, 93–96. Suhr, M., Klein, G., Kourti, I., Gonzalo, M.R., Santonja, G.G., Roudier, S., Sancho, L.D., 2015. Best available techniques (BAT) - reference document for the production of pulp, paper and board. Eur. Comm. 1–906.

produced are the dilute NCGs (DNCG) and concentrated NCGs (CNCG). The DNCG will be collected during the cooking process and at the Evaporation Plant. The CNCG will be collected in the Evaporation Plant. The non-condensable gases produced in the pulp mill processes are cooled and are then sent to the Recovery Boiler where they will be incinerated and oxidised.

From the Recovery Boiler which is the furnace in the process, outputs from this process include air emissions and fly ash, the latter which will be recycled within the chemical recovery system. All emissions from the boiler will be scrubbed (using spray tower and electrostatic precipitator) and should conform with local and international guidelines, with the stricter guidelines taking precedence.

4.12 NOISE EMISSIONS

Information will be provided by BBP to ESL, once the proposed mill designs are finalised. However, in the preliminary technical specifications noise insulation was mentioned to be used at the proposed mill. BBP intends to design the site layout in order to position the potentially noisiest manufacturing areas furthest away from existing local habitation in order to minimise and mitigate noise pollution to local residents.

Sources of noise will be distributed along the production chain from the receipt of the raw material (wood chips) to the shipping of the pulp. The number of external noise sources of a non-integrated pulp mill such as BBP is typically around 80–100 items. The major ones are process and machine room ventilation and vacuum pump exhausts. The most significant sources of permanent noise according to the European BAT Guidelines are:

i. Equipment for mechanical treatment such as wood drums, refiners, grinders, etc.;
ii. Cutting of wood before debarking for the mechanical pulp mill;
iii. Transport of media in pipelines and other systems such as conveyors without optimal dimensions;
iv. Temporary steam blowing during process disturbances;
v. Hydraulic units;
vi. Fans, for example, for heat recovery of paper machines;
vii. Motors, compressors;
viii. Compressors of the cooling machines;
ix. Trucks for loading and unloading;
x. All transport in and near the mill site including railways;
xi. Cleaning of process equipment such as lime silos with a vacuum tube to a tank truck.

BBP will comply with local regulations regarding the noise levels generated. The final noise control targets required will determine the scope and costs of sound attenuation, along with plant layout considerations. BBP has specified for noise control designs be a requirement for the detailed design of the mill as it can result in considerable cost reductions and compliance with best practice. Additionally, depending on specific noise level requirements, absorptive silencers, resonators or enclosures can be used. Active Noise Control is yet another method of noise reduction that can be applied, if necessary, especially at the lower frequencies.

4.13 ENERGY CONSUMPTION

In a pulp mill, heat and electrical energy are used. Heat energy is consumed for heating fluids, water evaporation, and to either accelerate or control chemical reactions. Electrical energy is mostly consumed for the transportation of materials through pumping (>50%). BBP will provide ESL with information regarding the energy balances for the proposed pulp mill and quality performances. In the interim, for the information purposes of NEPA, generalities about Kraft pulp mills according to the European BAT Guidelines are being presented below.

Generally, as indicated in the European BAT Guidelines and the EHS Guidelines – Paper and Pulp Mills (World Bank Group, 2007), the manufacturing of bleached Kraft pulp consumes about 10–14 GJ/ADt of heat energy, excluding steam for the production of electrical power. The consumption of electrical energy is 600–800 kWh/ADt, including the drying of pulp. The drying of pulp consumes 25% of the heat energy and 15–20% of the electrical energy. A typical energy balance for a Kraft pulp mill is presented in Table 4-9. The proposed pulp mill will be more than self-sufficient and will generate surplus power which is intended to be used to fuel the 'electric-powered' trucks in the logistics chain or sold to the local provider, the JPS Co., for profit. Generally, modern pulp mills are energy self-sufficient by burning 50% of the raw material composition (lignin) in the recovery boiler (strong black liquor), using bark/bamboo culms as fuel, and the generation of secondary energy from different process steps that can be recovered as warm and hot water (40–80 °C). Through production and the recovery boiler, preliminary estimates show that the proposed mill could produce approximately 30 Mwe of power whilst consuming less than 27 Mwe. The mill will not need to vent excess steam in any eventuality. Any excess steam will be condensed, not vented.

Fossil fuels, such as LNG in this project, are mainly used as support fuel, in the lime kiln (not in this project) and in the treatment of malodorous gas. The proposed mill will be supplied with LNG, from a supplier to be determined. Information on the LNG demand and storage on site will be provided by BBP once finalised.

Table 4-9: The Energy Balance for a typical modern Kraft Pulp Mill (Source: European BAT Guidelines, 2015)

Mill type	Units	Non-integrated bark-fired pulp mill
Heat generation		
Black liquor	GJ/t pulp	18.0
Bark and wood waste	GJ/t pulp	4.2
Heat consumption		
Pulp mill process	GJ/t pulp	11.0
Paper mill process	GJ/t paper	-
Back-pressure power	GJ/t pulp	3.0
Condensing power	GJ/t pulp	8.2
Power generation		
Back-pressure power	kWh/t pulp	820
Condensing power	kWh/t pulp	800
Total	kWh/t pulp	1 620
Power consumption		
Pulp mill process	kWh/t pulp	700
Paper process	kWh/t paper	-
Power to grid	kWh/t pulp	920
Source: J.Suutela, Pöyry Finland Oy		

The proposed process is assumed to be highly efficient from an energy production perspective. Information that will be provided by BBP at a later date includes:

- The total installed electrical power;
- The total indicated power consumption for the proposed Project;
- An estimate of the power to be produced from the recovery boiler; preliminary estimates are approximately 30 Mwe;
- How excess energy produced will be used, outside of charging electric-powered trucks;
- Information on the LNG power facility that will be set up. It is assumed that LNG will not be bought on a regular basis; it will be bought and stored, used when needed, and restocked when necessary. Also, information will be provided on the infrastructure required to complete the LNG system and the distribution of natural gas (NG) to the proposed Project successfully, including storage tanks and re-gas/processing system;
- The amount of LNG to be supplied per day and the amount of fuel be stored on the proposed mill site.

Information on an LNG installation, activities and processes will be provided below. Figure 4-24 shows a proposed schematic of an LNG installation.

Figure 4-24: Proposed Schematic of LNG/NG Installation using an Example in Jamaica

4.13.1 LIQUEFIED NATURAL GAS (LNG) STORAGE AND NATURAL GAS (NG) DISTRIBUTION

The main activities related to the installation of the LNG Facility are:

- Site clearance
- Foundation preparation and Excavation
  - Steel work/Formwork setup
  - Concrete pouring and curing
  - Pipe lying
  - Pipe testing
- Installation of equipment
  - Fabrication of parts outside of Jamaica
  - Shipment to Jamaica
  - Transportation of parts from port to site
  - Assembly on site
  - Installation
  - Commissioning
- Operation

Impoundment Area and Bund Wall

The LNG Provider is advised to construct an impoundment area and bund wall compliant with United States' National Fire Protection Agency (NFPA) "59(A)", the national guideline for the handling and storage of LNG. The impoundment area will be sized to hold at least 110% of the total volume of a tank, as well as all the liquid piping and components. Rainwater and related substances may be pumped out using a water pump. Under no circumstance will any LNG be allowed to escape this containment.

Storage Tanks

The LNG Provider should provide double-walled construction LNG tanks, with special insulation properties designed to keep the liquid cold. They will be compliant with the American Standards of Mechanical Engineering (ASME) Pressure Vessel code. The storage tanks will be permanently anchored into the foundation, which will be designed, approved and completed by Jamaican professional engineering firms licensed in Jamaica. Tanks will be refilled by delivery of over-the-road tankers (see **Refill Delivery**).

The number of tanks, the amount of LNG to be stored, the sizing of tanks, the exact placement, and other related factors are still to be determined.

Refill Delivery

Portable LNG-transport tanks will be used to deliver LNG to the proposed site. The location where they will be filled is to be determined. However, from this location (filling station), they will be trucked to the proposed project site. Once onsite, the delivery tank will be connected to the system using a flexible steel hose. The number of site delivery trips to supply the required ~3,800L of LNG per day is yet to be determined.

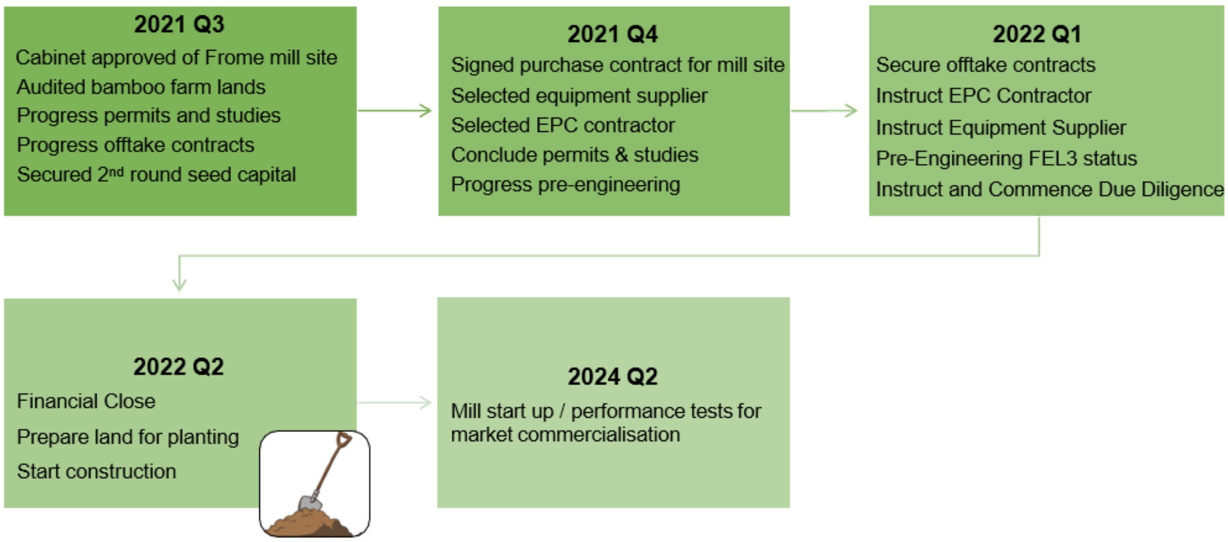
Processing System (Regasification)

Liquid from the storage tanks will be discharged to an LNG Processing System in a controlled and automated manner. There, it will be converted back to its natural state, a gaseous vapour, using vaporisers which will be supplied by the LNG Provider. [*In short, LNG is converted back to its natural state simply by allowing it to warm up*]. The Natural Gas itself will be sent to the Power Generation Units, which will consume the natural gas with engines and produce electric power. A computer system will continuously monitor the process conditions of all equipment, flow, and surrounding areas: temperatures, pressures, flow rates, supply power, and so on. All process functions are automatic and controlled by the computer system using a telemetry system. When the engines do not need to consume gas, gas will not flow.

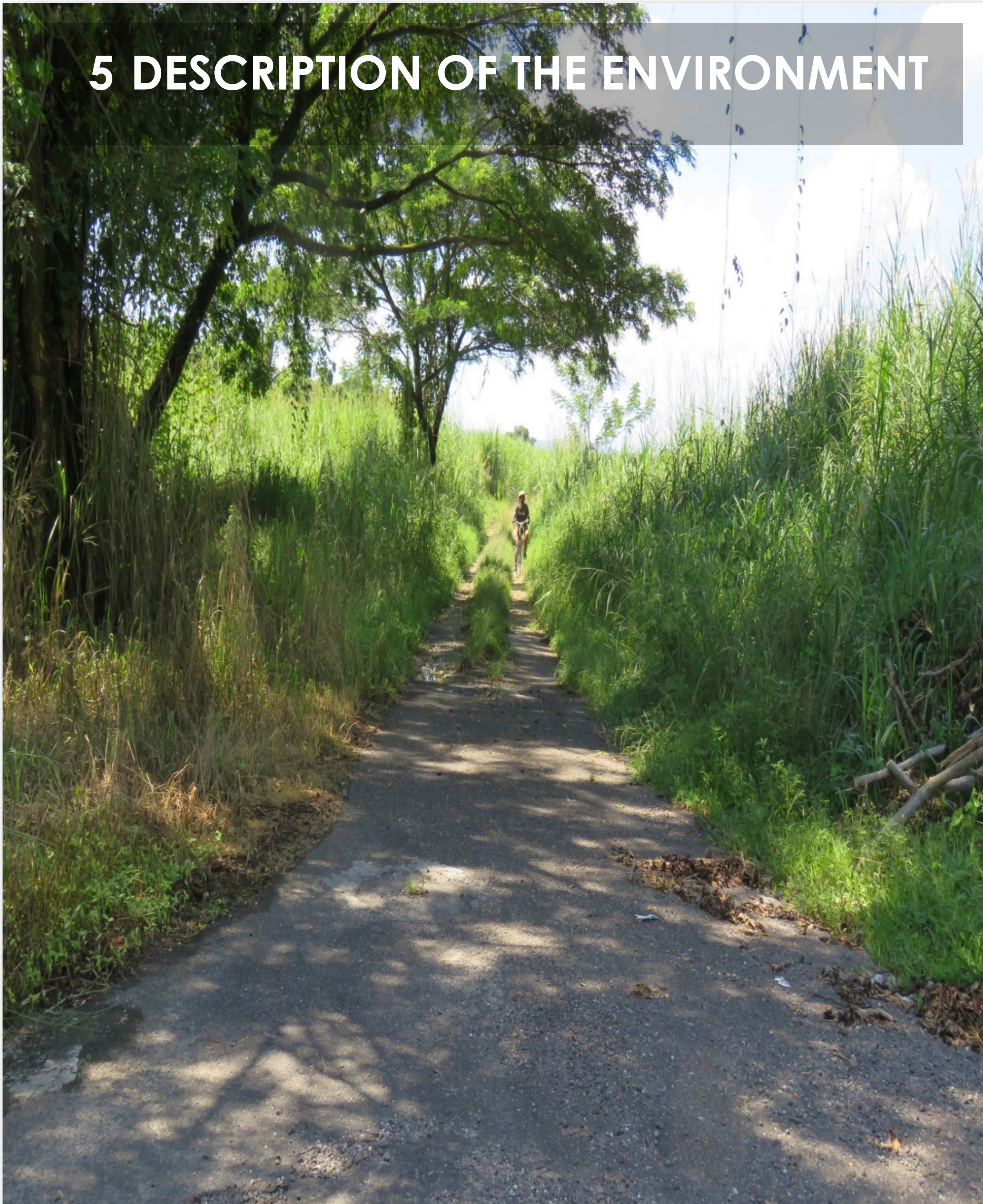
The LNG Provider will need to apply for all the requisite environmental permits and/or licences as required to fulfil their obligations to supply fuel to the proposed LNG facility.

4.14 PROJECT TIMELINES

It is proposed that the Project will take 24 months to build and be completed. It is estimated that construction will commence in Q1 of 2023 with operations commencing by Q2 2024 seen below (BBP, 2021).



5 DESCRIPTION OF THE ENVIRONMENT



5.1 PHYSICAL ENVIRONMENT

5.1.1 CLIMATE

5.1.1.1 Background

This section of the report will present Jamaica and the project area's existing climate. Future climate scenarios and projections will be presented in **Chapter 6**.

Jamaica's climate is mainly sub-tropical or tropical maritime, with the Northeast Trade Winds and the island's orographic features, (mainly the eastern Blue and John Crow Mountains and the Central Ridge of mountains and hills) characterised as the most important broad-scale climatic influences. Other influences include the warm waters of the Caribbean Sea; the synoptic weather systems, for example, the Azores-Bermuda high-pressure system; surface, mid and upper-level troughs; frontal systems; easterly waves; tropical depressions; tropical storms; hurricanes; and infrequently, the inter-tropical convergence zone. Diurnal solar patterns, clouds and rainfall are the dominant meteorological variables that influence the meso-scale fluctuations of temperature, humidity, visible and ultraviolet (UV) light, and evaporation.

A summary of Jamaica's climate is presented in Table 5-1. The climatology establishes the baseline to which future change is added to produce a future climate scenario.

Table 5-1: Summary of Jamaica's Climate[xxii]

CLIMATE VARIABLE	DESCRIPTION
Temperature	Variations in surface temperature is due largely to the variation in solar insolation. Jamaica's temperature is unimodal with peak temperatures occurring during the summer months from June to September and coolest temperatures occurring from December through March: • Mean temperature values range between approximately 24°C and 27°C; • The mean maximum (daytime) temperatures can go as high as 33°C during the warmest months for some locations; • Mean minimum (night-time) temperatures can be as low as 19°C during the coolest months.
Rainfall	Jamaica has a bimodal pattern of rainfall: • The dry season is December–March where the long-term average rarely exceeds 100 mm; • The rainy season spans April–November. This can be divided into an early rainfall season (April–June) and a late rainfall season (September–November); • A mid-summer minimum in July (termed the midsummer drought or MSD) separates the early and late wet seasons; • The most rainfall for the island is during the late rainfall season, with May and October being the rainiest months, while February and March are the driest months of the year; • Significant year-to-year variability due to the influence of phenomenon like the El Niño Southern Oscillation (ENSO).

[xxii] The climatology and historical trends presented are based on multiple sources of data such as:
- Temperature- Monthly data for stations across the island with less than 20% missing data and reporting between 1971–2015;
- Rainfall- Monthly data for stations across the island with less than 20% missing data and reporting between 1971–2015.

CLIMATE VARIABLE	DESCRIPTION
Storms and Hurricanes	The North Atlantic hurricane season runs from June 1 to November 30. This coincides with the period when the Caribbean Sea is most conducive to convective activity and with Jamaica's rainfall season. Mid-August to late October is the peak of the North Atlantic season. However, hurricanes may occur at any time during the season. The ENSO phenomenon also plays a significant role in modulating hurricane activity in the North Atlantic from year to year. During an El Niño phenomena, fewer Atlantic hurricanes are formed. The opposite is true for La Niña phenomena. The ENSO leads to regular fluctuations on a 5 to 7-year timeframe.
Storm Surges	Due to its low-lying nature, the town of Savanna-la-Mar is extremely vulnerable to storm surges and other hurricane-related damages.
Wind	Winds in Jamaica are a combination of the prevailing winds, sea breezes and mountain and valley winds which arise because of heating and cooling in valleys. Winds are strongest in Portland, St. Thomas, Manchester and St. Elizabeth.
Solar Radiation	Solar radiation data from 12 stations throughout Jamaica from 1978 to 1987 suggest a peak in solar radiation in June–July and a minimum in January. Highest irradiation occurs on the flat coastal plains, while the smallest amounts occur in eastern Jamaica over high mountain regions.
Relative Humidity, Sunshine Hours and Evaporation	Data is limited to Norman Manley and Sangster International Airports. There is no significant variation in relative humidity. Average humidity at the airport stations is higher during morning hours, ranging from 72–80%, and lower in the afternoon at 59–65%. This could be due to afternoon showers. Sunshine hours vary little throughout the year, ranging between seven and nine hours per day. There are more sunlight hours in the dry season and fewer in the main rainy season, with this being directly related to cloudiness. Evaporation tends to be a function of both temperatures and available moisture. For both stations, the values peak during the months approaching July (month with the highest mean temperatures), following the onset of the rainy season (May).

Source: The State of the Jamaican Climate, 2015 (Smith Warner International Report, 2021)

The climate of the proposed mill area will be discussed in Section 5.1.1.2 below.

5.1.1.2 Temperature and Humidity

As reported in the 2021 Bamboo Site Reconnaissance Report, the climate at the proposed mill site, Friendship, like the rest of Jamaica, is subtropical with gentle to moderate north-easterly prevailing winds and average daily temperatures varying from 24.9°C in February to about 28.0°C in August (see Figure 5-1) (ESL, 2021). Humidity ranges from 70% to 84% with significant diurnal variation resulting in high morning humidity and significantly lower humidity in the afternoon.

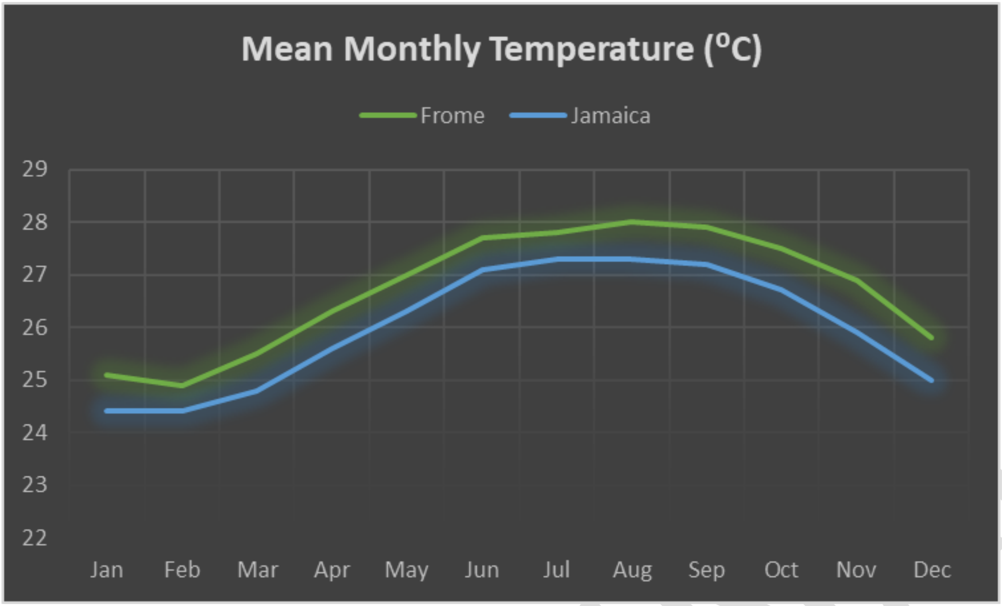


Figure 5-1: Mean monthly Temperature (°C) received in Westmoreland (calculated by averaging Rainfall from all Stations in the Parish from 1971–2000) vs Jamaica (Source: Meteorological Service Jamaica)

5.1.1.3 Rainfall

The proposed project site is located within the western Rainfall Zone 3 of Jamaica's four (4) rainfall zones (Figure 5-2). In Zone 3, the rainfall peaks in May and September to October and has the least pronounced mid-summer rainfall minimum. Also, compared to the other rainfall zones, Zone 3 also shows least variability from month to month and receives the most rainfall of all zones except the East (Zone 2) which can be seen in Figure 5-3 and Table 5-2 (Climate Studies Group, Mona (CSGM) 2017). Westmoreland's rainfall tends to have a wet August to October period with long-term (1971–2000) mean annual rainfall just over 2000 mm (Figure 5-3). The 30-year monthly mean rainfall ranges between 70 mm (minimum) to 274 mm (maximum).

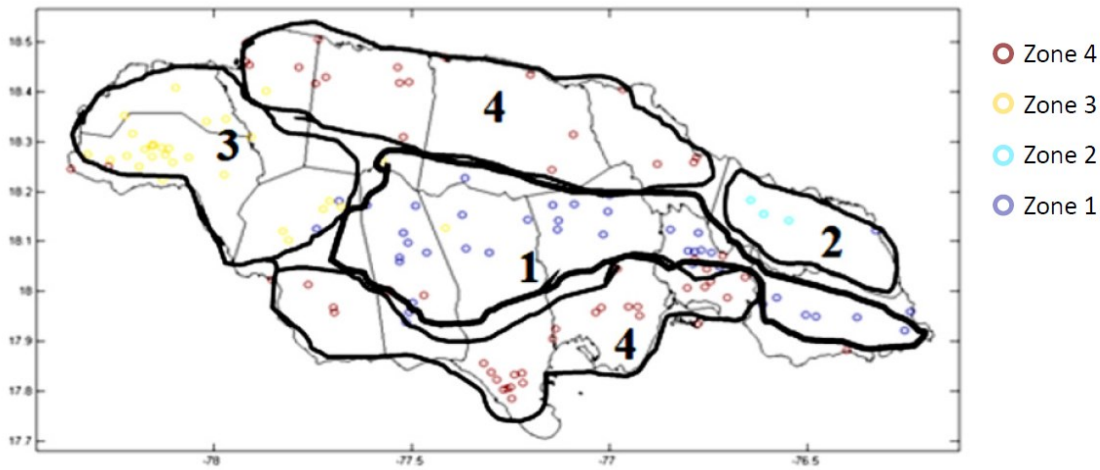


Figure 5-2: The 4 Rainfall Zones in Jamaica. The bold black Lines are rough Delineations of the 4 Zones (Source: CSGM, 2017)

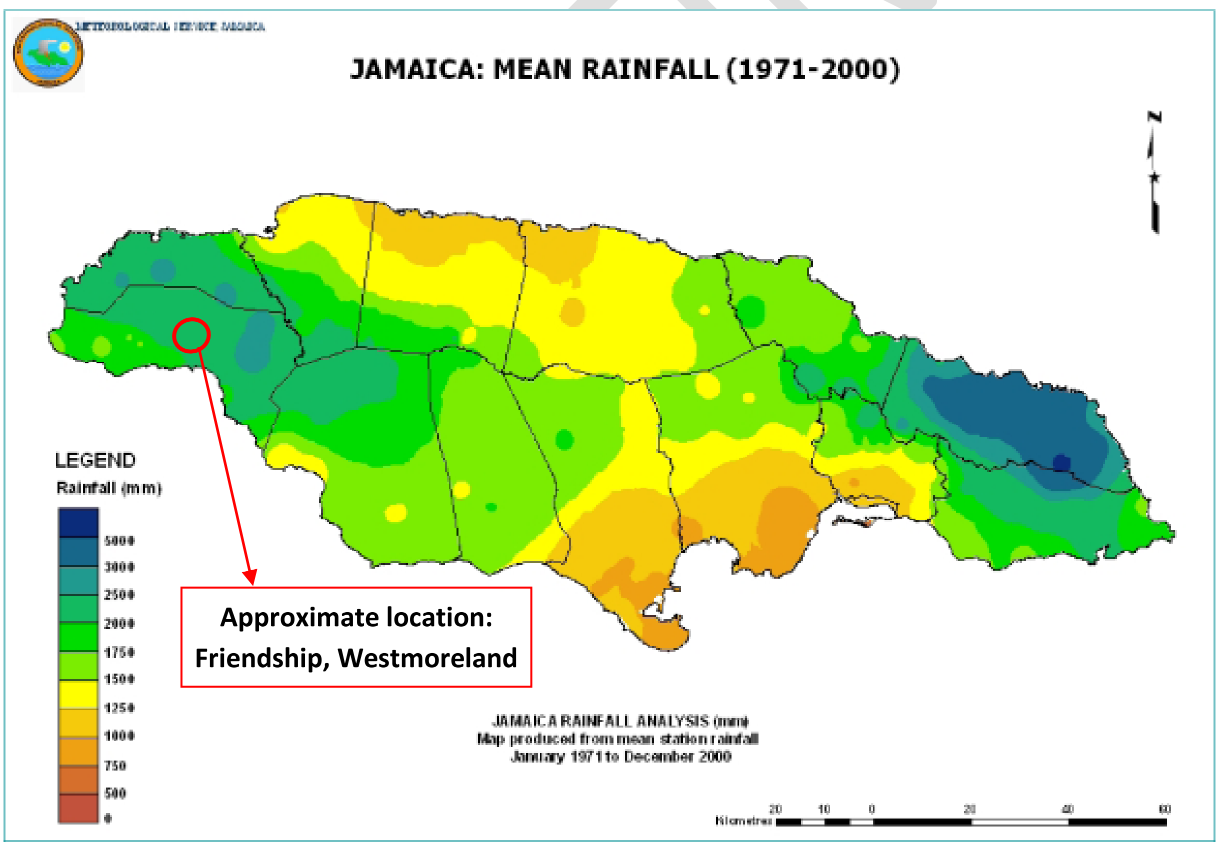


Figure 5-3: Distribution of Mean Annual Rainfall for Jamaica (in millimetres) for the Period of 1971–2000 (Source: Meteorological Service of Jamaica)

Table 5-2: Average annual Rainfall Values (in millimetres) over the Period 1981–2010 for the four Rainfall Zones compared to the all-island Average. Zone 3 is outlined in red.

MONTH	ZONE 1	ZONE 2	ZONE 3	ZONE 4	COUNTRY
January	121.41	380.12	155.02	83.66	105.63
February	122.32	255.93	178.29	79.76	81.00
March	124.44	247.81	167.26	82.51	90.78
April	166.09	367.56	181.19	105.52	122.50
May	215.35	356.92	237.49	143.39	240.53
June	144.60	195.58	193.85	92.89	140.16
July	166.60	241.27	212.72	112.42	124.78
August	193.00	274.76	237.09	116.74	165.23
September	259.98	274.04	254.63	165.89	207.28
October	226.18	359.04	254.02	149.36	236.16
November	189.88	475.26	191.29	135.18	173.85
December	149.15	392.95	166.25	98.41	112.68

Source: State of the Jamaican Climate 2015 (CSGM, 2017).

The nearest weather station to the proposed project site is Frome. This weather station is approximately 6.5km from the proposed project site. As seen in Table 5-3 below from 1996–2016, there has been seasonal variation in atmospheric temperatures that are consistent with the rest of the island.

In assessing the rainfall data, it is also important to investigate the dry periods as observed in Table 5-2. The maps in Figure 5-4 and Figure 5-5 illustrate the Standard Precipitation Index (SPI) for a dry period (December–January 2021) and a wet period (July to August) using data calculated from the 125+ weather stations.

Table 5-3: Mean Temperature Climatologies for nine meteorological Sites across Jamaica with Data averaged over varying Periods for each Station. Units (°C). Frome is highlighted in a red box.

Station	Years Averaged	Altitude (metres)	Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
			Lat (°N)	Long (°W)												
Bodles	1987-2015	36.0	17.93	77.14	24.8	24.9	25.3	26.2	26.9	27.7	27.8	28.0	27.8	27.4	26.2	25.8
Discovery Bay Marine Laboratory	1992-2009	10.0	18.47	77.42	24.8	24.8	25.0	26.0	26.6	27.4	27.6	26.8	27.8	27.3	26.4	24.5
Duckenfield	2000-2015	17.0	17.92	76.26	24.8	24.9	25.1	25.8	26.6	27.5	27.7	27.7	27.3	26.8	26.2	25.5
Frome	1996-2016	20.0	18.29	78.15	25.1	24.9	25.5	26.3	27.0	27.7	27.8	28.0	27.9	27.5	26.9	25.8
Norman Manley	1992-2015	2.7	17.93	76.78	27.0	26.9	27.1	27.8	28.5	29.3	29.5	29.5	29.3	28.7	28.2	27.4
Mason River	1978-2015	703.0	18.20	77.26	21.0	20.7	21.3	21.8	22.3	23.1	23.3	23.5	23.0	23.1	22.3	21.7
Passley Gardens	2000-2015	36.0	18.20	76.49	24.7	24.7	25.0	25.8	26.6	27.5	27.6	27.7	27.5	27.0	25.9	25.5
Sangster	1992-2015	9.0	18.50	77.92	25.9	25.9	26.4	27.3	27.9	28.7	29.0	29.1	28.7	28.2	27.5	26.5
Worthy Park	1973-2015	374.0	18.14	77.15	21.7	21.9	22.5	23.4	24.3	24.9	25.0	25.1	25.1	24.6	23.6	22.4
Jamaica					24.4	24.4	24.8	25.6	26.3	27.1	27.3	27.3	27.2	26.7	25.9	25.0

Source: Meteorological Service of Jamaica as seen in State of the Jamaican Climate 2015 (CSGM, 2017).

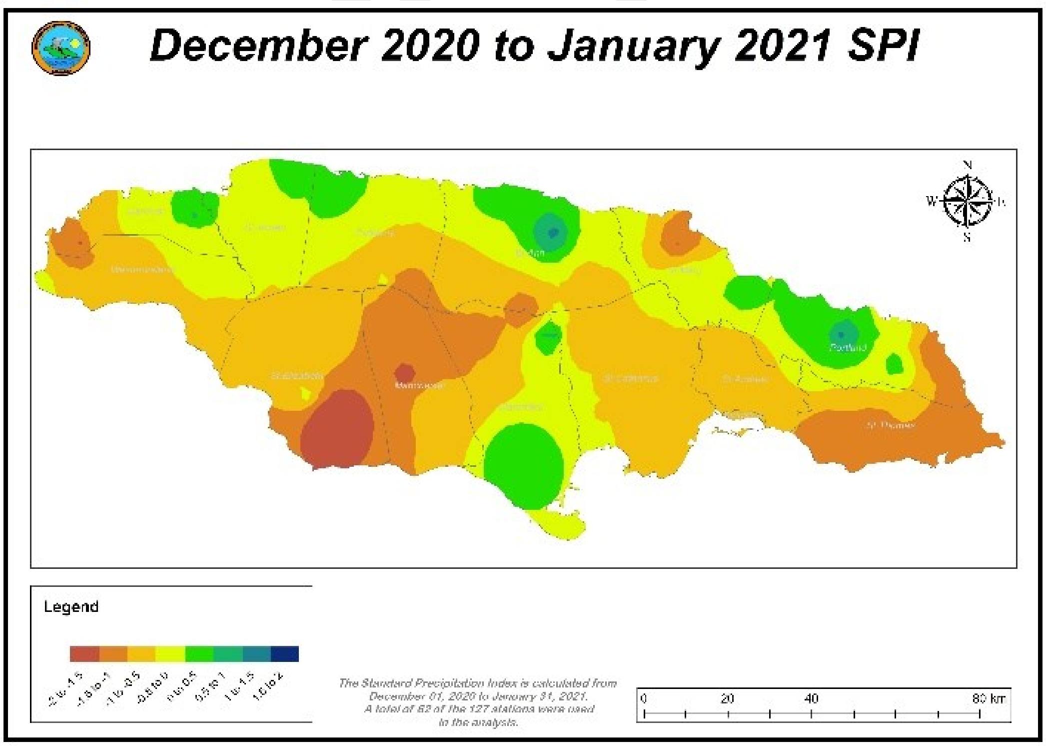


Figure 5-4: Rainfall Distribution for the usually dry Period (December–January 2021) (Source: Meteorological Office of Jamaica)

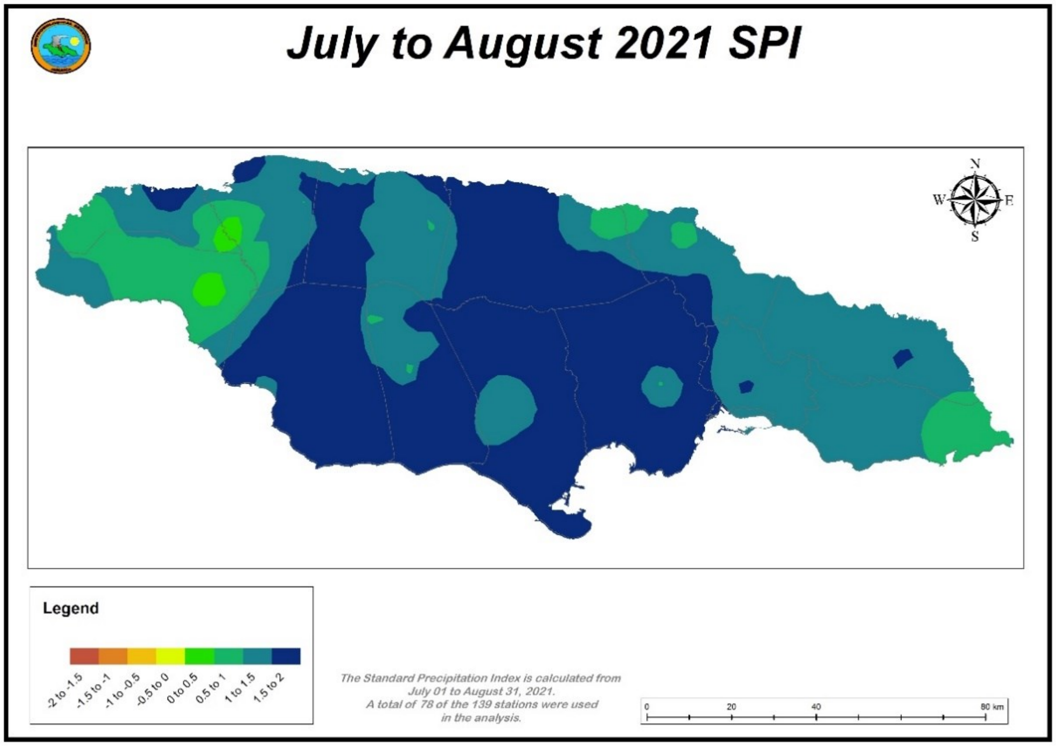


Figure 5-5: Rainfall Distribution for the usually wet Period (July to August 2021) (Source: Meteorological Office of Jamaica)

5.1.1.4 Winds

Winds are affected by the Northeast trades combined with the sea breeze resulting in an east north easterly wind with wind speeds ranging between 2.61–6.95 m/s. The prevailing wind direction in the project area is from the northeast. According to the map on the variation of wind speeds across Jamaica, the proposed area receives some of the lowest wind velocities in the island (Figure 5-6).

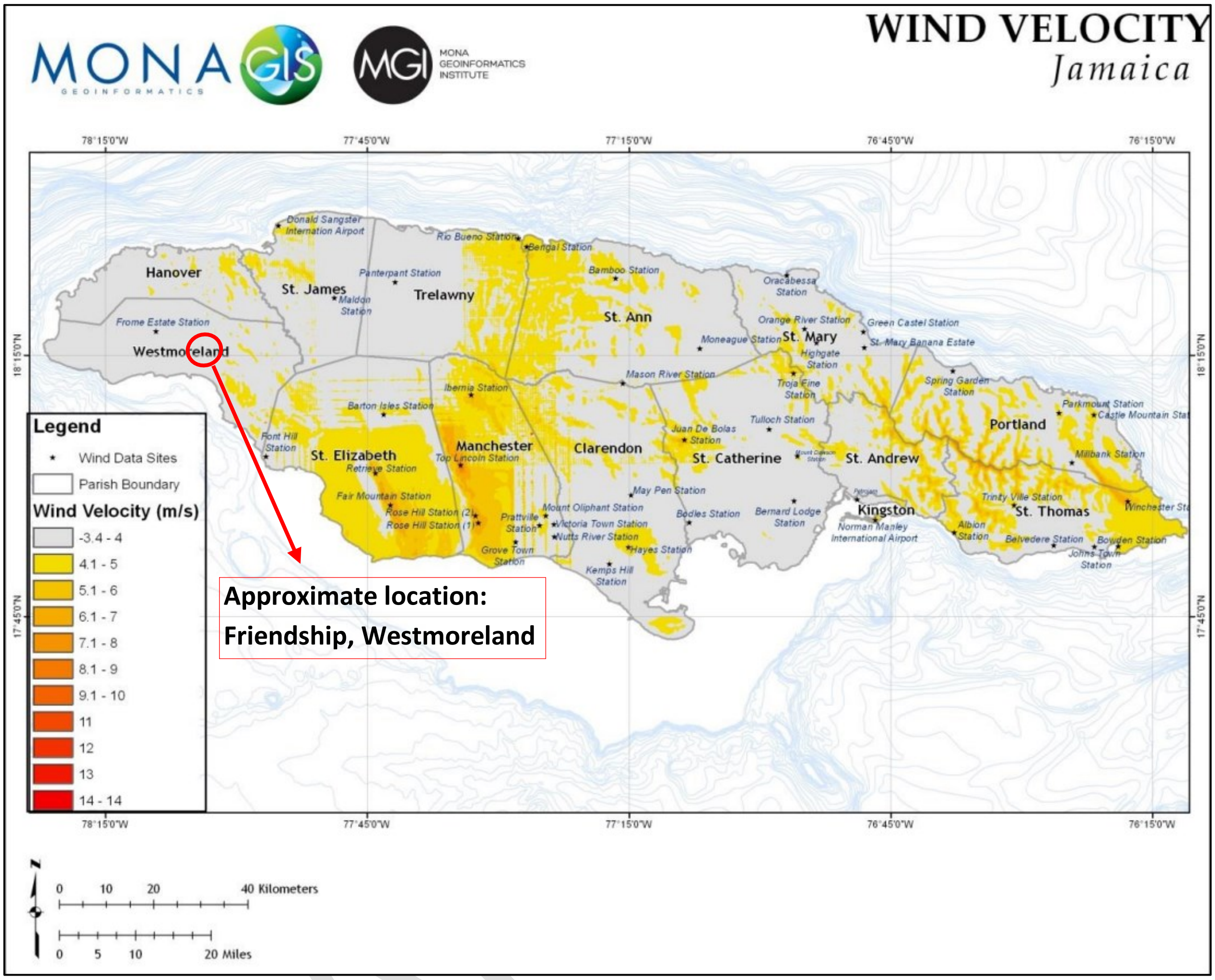


Figure 5-6: Variation of Wind Speeds across Jamaica (Source: Mona GeoInformatics Institute (MGI))

During the Hurricane Season each year extreme weather conditions can be expected. These systems generate intense rainfall of long durations and high velocity winds. Significant flash flooding is likely to occur during these periods, and the Office of Disaster Preparedness and Emergency Management (ODPEM) has listed Westmoreland as a flood-prone area. The impacts from flooding and high velocity winds can pose significant risks to the project infrastructure, investments, the business continuity and human life. Standards for drainage and building codes must be strictly adhered to and relevant climate change scenarios considered.

5.1.2 CLIMATE CHANGE PROJECTIONS

The effects of climate variability and change are of major significance to Jamaica's population, economy, and the future state of its natural environment. Major threats include:

- A rise in sea level by between 0.18 and 0.59m to the year 2100
- Increases in the frequency of storms (and possibly hurricanes)
- Increases in the severity of storms and storm surges
- Increases in prolonged periods of drought
- Increases in short duration, high intensity rainfall that can cause severe localised flooding
- Increases in health epidemics, due to the transmission of vector-borne and water-related diseases as a result of an increase in floods and the removal of natural barriers such as mangroves and forests.

Box 1 below provides a summary of the Climate Change projections for the study area. The CVRA will be discussed in **Chapter 6**.

Box 1- SUMMARY CLIMATE PROJECTIONS

Using the Regional Climate Model (RCM) projections for Zone 3 for mean, minimum and maximum temperature, all time slices show an **increase in temperature.**

Rainfall

There will be a **reduction in rainfall** from the 2030s (-10 to 34.37) onwards and an increase in the range of variability up until the end of century where RCM models predict a percentage change in rainfall from -13.23% to 6.09% between 2081 and 2100. This variability and uncertainty in rainfall is different to other sections of the island which are expected to experience a decline in rainfall across all timescales. Historically, Westmoreland shows the least variability between rainy and dry seasons.

Sea Level Rise

It is projected that sea level will rise between 0.18 and 0.59m by 2100. According to the 2015 State of the Jamaican Climate Report, 90% of Jamaica's Gross Domestic Product is earned along the coastal zone. Twenty-five percent (25%) of the population, banks, commercial centres, tourist facilities and ports are all located within the coastal zone. Negril which is a major economic zone in the parish of Westmoreland spans 408km^2 of coastline and is flat and its economy is dominated by coastal tourism and fishing. As such, increases in sea level may result in displacement of fishers' landing sites, economic disruption within the tourism sector and threatens to remove a key historical and cultural space for residents.

Hurricanes

According to the RCP 4.5 model, it is projected that there will be more Category 5 hurricanes. Jamaica's location within the path of the Atlantic Hurricane Belt makes it vulnerable to the passage of tropical storms. Most of these storms approach the island from the south. This increases the risk of Westmoreland to more high velocity wind speeds and heavy rainfall. This will increase the incidence of storm surges and coastal inland flooding which poses significant risk to communities and commercial interests (businesses, tourist facilities) located along the coastline. This may lead to flooding on the farm.

Storm Surges

Storm Surges result from tropical storms and those are projected to increase. Increased incidence of sea level rise and storm surges will lead to the displacement of 25% of Jamaicans living in coastal areas. Furthermore, it is likely that critical economic infrastructure along the coast will be extremely affected by this phenomena. This has significant consequences for the communities, but also for Savanna-la-Mar.

5.1.3 TOPOGRAPHY, LAND USE AND SITE HISTORY

5.1.3.1 General Topography

The proposed mill site sits on gently sloping plain between the city of Savanna-la-Mar in the south, the Friendship Mountain to the east and Flower Hill in the North (Figure 5-7). The project site is located on land approximately 30–47 m above sea level from the boundary with the Cabarita River in the northwest, to the upper eastern boundary of the site. The surrounding hills are defined by karstic topography. From the site visit, conducted on October 23, 2021, it was identified that the property is undulating but generally sloping to the NW towards the Cabarita River.

The transportation route from the proposed mill site to the Port of Montego Bay is indicated as the B8 road in Figure 5-7, which is a Class A road that connects the mill site from the community of Galloway (south of Withorn in Figure 5-7) to Reading. This road traverses through the mountains from between the Friendship and Cornwall Mountains to Reading, near Montego Bay.

Figure 5-7: Google Earth Satellite Imagery showing the Topography at and around the proposed Site (Source: Google Earth Pro, 2021)

5.1.3.2 Land Use and Site History

It is proposed that the bamboo market pulp mill will be constructed on 350 acres (~1.42 km^2) of land in Friendship, Westmoreland (Figure 4-4). The site is currently in use for sugar cane production and actively being farmed for sugar cane; some areas of the property are in ruinate. The proposed mill site is bound to the north by the Cabarita River, and along the east and southeast by the communities of Amity, Moram, Bath and Hertford, and on the west by sugar lands.

The majority of the lands surrounding the proposed mill site have previously been used for the farming of sugar cane, whilst many of the sugar lands within Friendship and Frome now remain idle. There is a road network that leads to the proposed mill site by way of a secondary road (B9) from which residential community roads and farm roads branch. This secondary road connects to the A2 road that connects towns along the south coast. There are also secondary roads that lead from the site, through the hinterlands to the parish of Hanover.

Historically, the proposed project area comprises sugar cane lands used to supply the Frome Sugar Factory. The Frome Sugar Factory in Westmoreland, built in 1938, is considered as the beginning of large-scale sugar cane production in Jamaica, with the growth of farms throughout the island and an increase in production. Rice was once grown in the marshlands of the area; however, sugar cane has been the primary crop for over 60 years.

5.1.4 GEOLOGY AND SOILS

The proposed site and surrounding areas comprise mostly Alluvium plains with zones of limestone bedrock that define the highlands or elevated areas within the plains (Figure 5-8). The Alluvium (Qa) is described as an outwash of silts, sand and gravels derived largely from the erosion of the limestone hills to the northeast and northwest. The alluvium deposits occupy the courses of the river (Cabarita River) and drainage lines that crisscross the site and are known to be thicker in depressions and thin towards the higher elevations. The Qa overlies members of the White Limestone and Yellow Limestone Groups.

A review of the 1:50,000 Geological Sheet 05 (Savanna-La-Mar) indicated that the site is underlain by limestones of the Newport Formation (Mn). The Newport Formation comprises weak to moderately weak chalky limestone and is a member of the White Limestone Group. The Mn is faulted against the Gibraltar – Bonny Gate Formation (Egb) to form the northern and eastern parts of Negril Hill. The Middle Eocene to Miocene Egb of the White Limestone Group is described as a fine-grained, soft to moderately hard planktonic micrite that was deposited in deep waters.

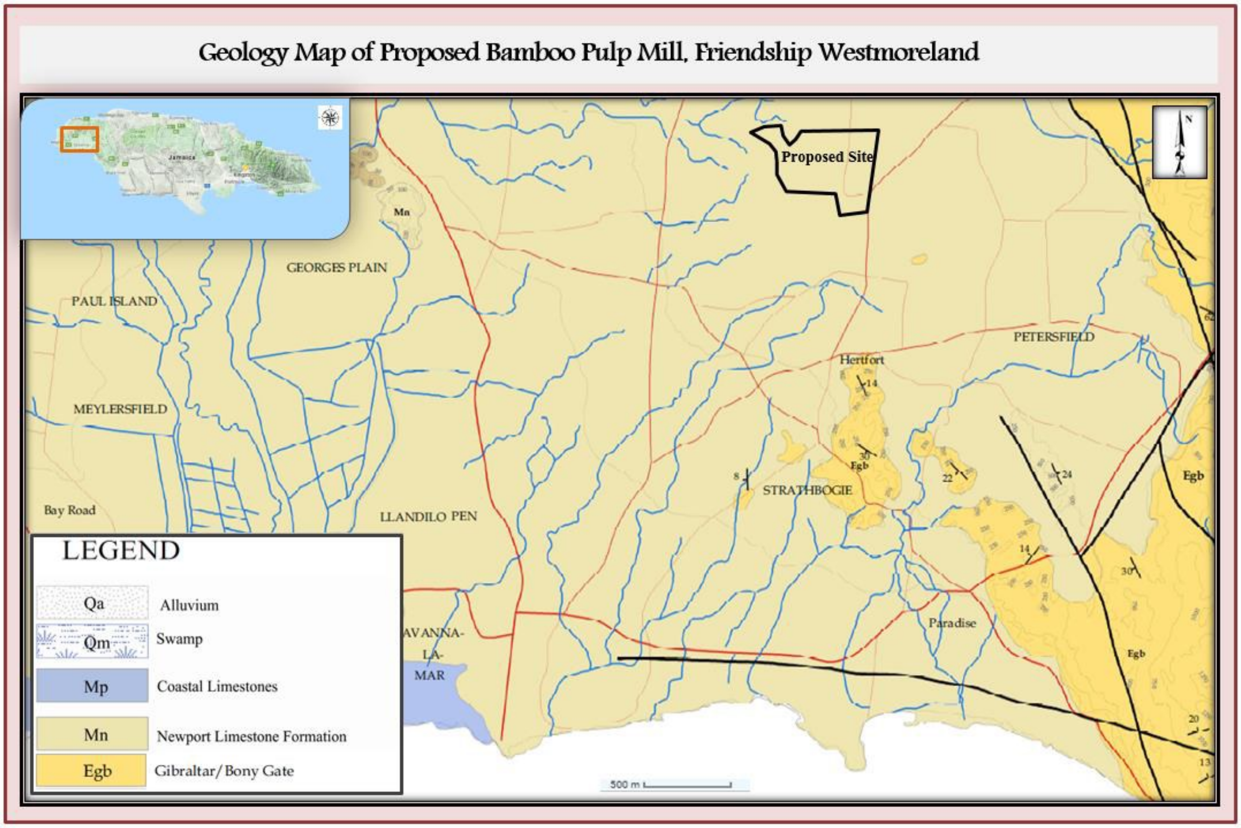


Figure 5-8: Geological Map of the Proposed Study Area (Source: Adapted from Mines and Geology, 2008)

No caves or sinkholes were noted on site during the site reconnaissance or site visit; however, the Jamaica Caves Association has indicated that there are four mapped caves within a 3.2 km straight line distance from the proposed project site (see Figure 5-13).

The soil textures in the project site are largely clay and clay loam followed by sandy loam and stony loam overlying the Alluvium (Figure 5-9). The clay and clay loam have very slow rates of infiltration and internal percolation (slow internal drainage) potential, giving rise to surface drainage (the Cabarita River and waterways). In the literature, the sandy and stony loam are designated as Soil class 77 – the Bonny Gate Stony Loam. This soil type has very rapid internal drainage properties, with implications for very low surface runoff potential and lack significant surface drainage features.

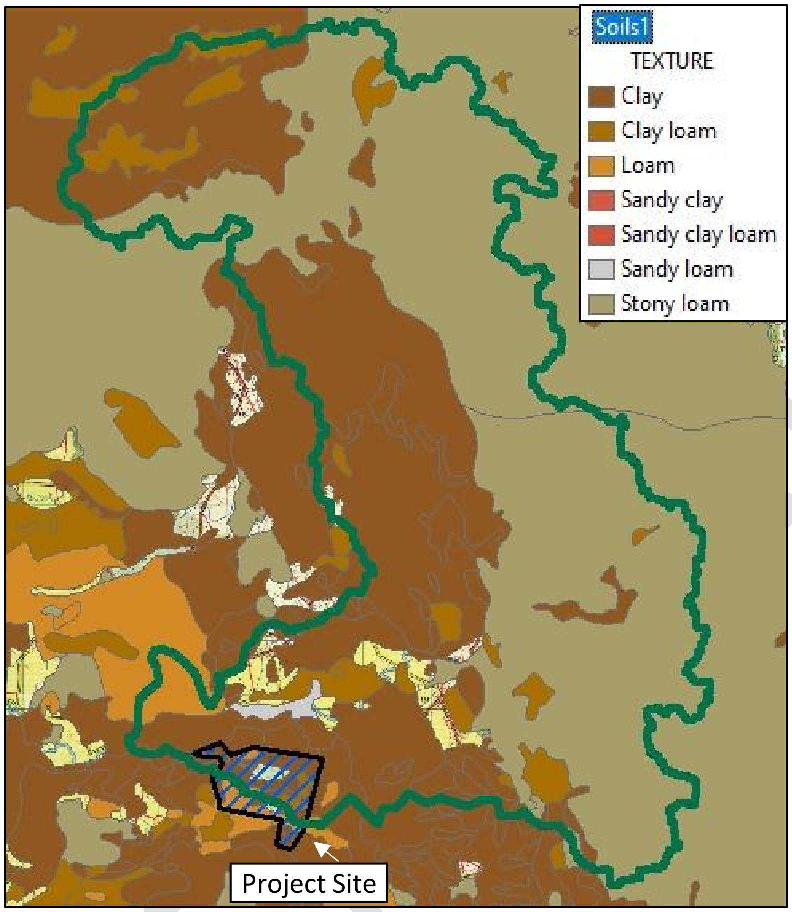


Figure 5-9: Soil Map of the Area with the Project Site indicated in black, and the Cabarita Watershed indicated in a green Outline (Source: Clipped from the Soil Map of Jamaica obtained from the Water Resources Authority (WRA) Jamaica)

5.1.4.1 Geotechnical Investigation

A geotechnical investigation was conducted in March 2022 to determine the geotechnical characteristics of the rock/soil on the site, ascertain presence of groundwater, and evaluate engineering parameters that should be used to assist in the foundation design of the structures. Six (6) boreholes and two (2) percolation holes were drilled and tested to determine the geotechnical characteristics and engineering parameters.

Exposed outcrops of the Newport Formation were limited to occasional exposures at ground level which were found to be generally hard, representing a case-hardened cap rock. An upper surficial layer of topsoil consisting of Brown Sandy Silts and Clays drapes the underlying limestone material. Subsurface investigations showed that the site comprises a combination of fine-grained calcareous SILT and CLAY, as well as coarse grained calcareous SAND and GRAVEL underlain by weak to moderately strong LIMESTONE material. Fine-grained SILT and CLAY were commonly encountered at shallow foundation depth where it drapes the underlying coarse-grained calcareous SAND, GRAVEL and LIMESTONE material.

5.1.4.2 Seismic Risk

The site is not located within close proximity to a fault (Figure 5-8). However, the hills and mountains that border the site, especially those largely located 5–10 km southeast of the site display extension faults, with fault trends mainly in three directions (E–W and NW–SE). Faults trending in the NW–SE direction are the most recent, regarded as having been initiated in the Mid-Tertiary with subsequent movement until relatively recent geologic time. These faults are therefore relatively young, and do not appear to be seismically active, nonetheless, they do represent a zone of weakness along which displacements can be induced and minor tremors may occur. In addition, minor faults are also responsible for increased jointing and fracturing of rocks. A few earthquakes with magnitudes between 2.7 and 3.2 on the Richter Scale were recorded between 1998 and 2010 (Figure 5-10).

Within Jamaica the most active earthquake zone comprises the faults associated with the Blue Mountains Block in Eastern Jamaica. Figure 5-10 shows most earthquakes occur in the eastern part of the island in the Blue Mountains Block with a few in Westmoreland (MGI & Earthquake Unit, UWI, 2011). A relatively recent vulnerability assessment map, presented in Figure 5-11, represents a 100-year return period earthquake of Magnitude VIII that originated from within the Blue Mountains Block. If such an event were to occur, the proposed site may experience shaking at a magnitude IV on the Modified Mercalli Intensity Scale. According to Table 5-4, the potential magnitude from the modelling in Figure 5-11 would result in light shaking with a peak acceleration of 2.8 % g and a peak velocity of 1.4 cm/s.

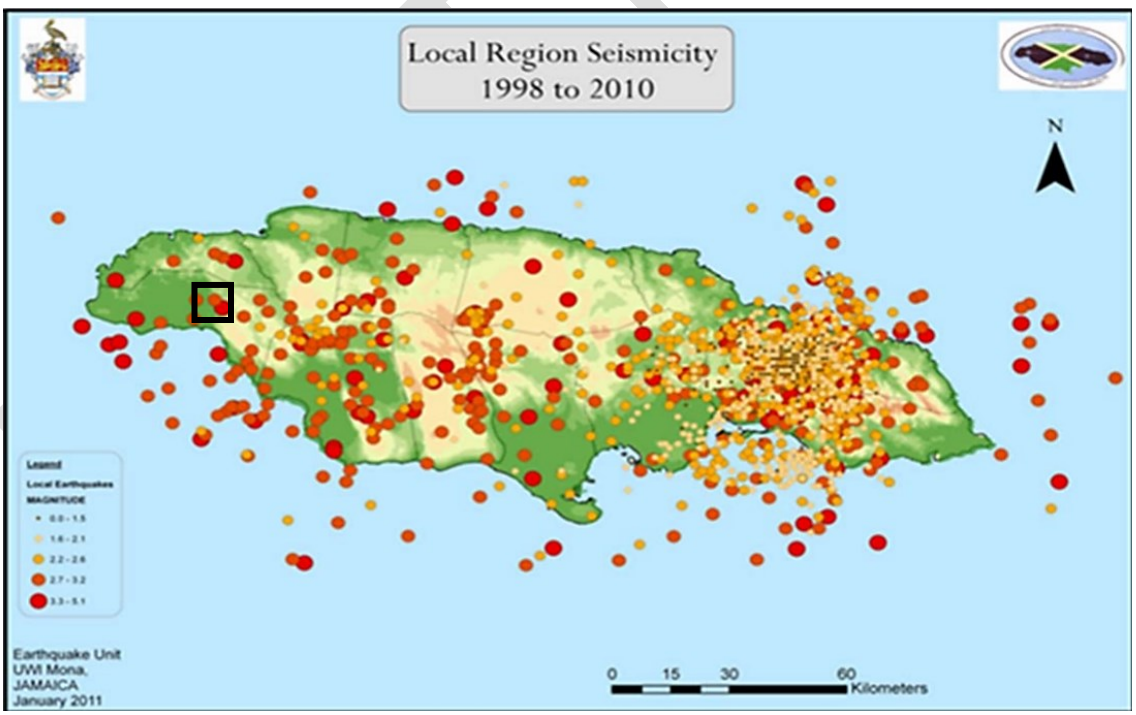


Figure 5-10: Jamaica Seismicity 1998–2010 (Source: Earthquake Unit, UWI, 2011).*[xxiii] *Project Site indicated within the black Box. Local Earthquake Magnitudes within the Study Area range from 2.7 to 5.1.

[xxiii] https://ggim.un.org/meetings/2013-Chengdu/documents/01_Chengdu%20Presentation_2013%20_Revised.pdf

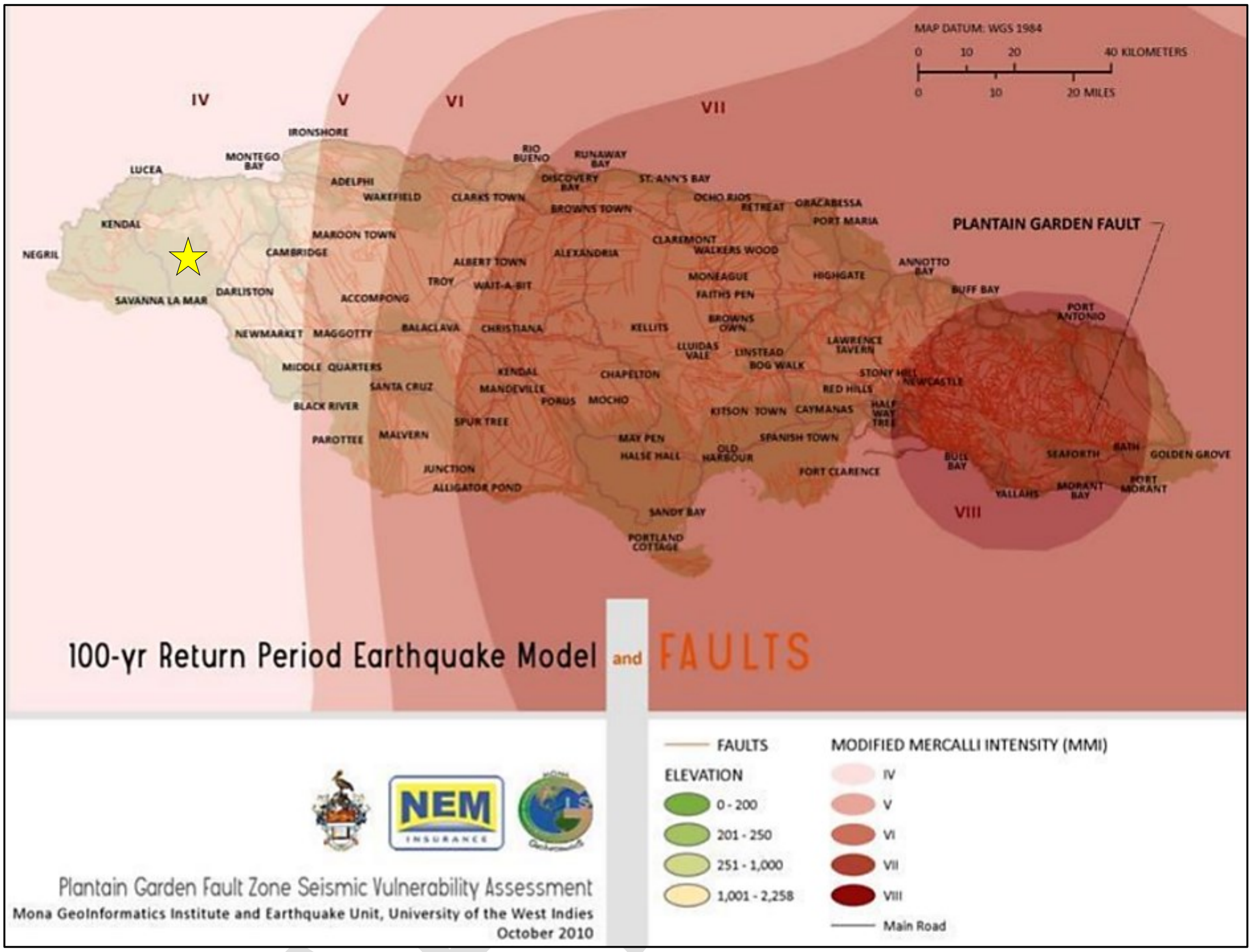


Figure 5-11: Modelled Intensity for 100-year Return Period Earthquakes of Magnitude VIII from within the Blue Mountains Block (MGI & Earthquake Unit, UWI, 2010). Project Site indicated with a yellow Star.

Table 5-4: Relationship between Earthquake Intensity (as the MMI = maximum modified Mercalli Intensity), Peak Acceleration and Velocity, Shaking and potential Damage

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Source: Calais, 2013

5.1.4.3 Landslide Risk

The topography of the site is generally flat with a low gradient and is therefore not expected to be affected by landslides. However, the karstic hills surrounding the northern and eastern sections of the site are susceptible to landslides and rockfalls due to the steep slopes and limestone geology. This can potentially impact the route to transport the pulp to the Port of Montego Bay via the route of Galloway to Ramble.

5.1.5 HYDROLOGY AND DRAINAGE

5.1.5.1 Hydrogeology and Hydrostratigraphy

The proposed project site is bordered to the north by the Cabarita River. The Cabarita River is a 39.7m long second order perennial river originating in Grange, Hanover and flows in a south westerly direction to Savanna-la-Mar and emptying in the Caribbean Sea. In addition to wells and springs in the general area, it is one of the main surface water sources directly or indirectly used for public water supply in the parish of Westmoreland. It was estimated in 2010 that about 45% of the parish's population received potable water and sewerage services via the NWC.[xxiv] The river also has other domestic, recreational and livelihood uses.

According to the WRA, the project site is located within the Cabarita River Hydrologic Basin in the southwest of Jamaica. For local water management purposes, the Cabarita River Hydrologic Basin has been divided into four Watershed Management Units (WMU) and the project site is found within the Cabarita River WMU and the Cabarita River sub-WMU (Figure 5-12). The water resources in the Cabarita River WMU comprise groundwater from limestone aquifers and surface water from the rivers and springs that drain all the sub-WMUs in the Cabarita River WMU.

The Cabarita River emerges at the foot of the Cash and Patty Hills at near 400m elevation and meanders over 22 km to the outlet of the sub-watershed at Barham. The primary drainage direction is to the south to Savanna-la-Mar via the Cabarita River which drains the WMUs of the southern section of the Lucea River and Great River. The major tributaries of the Cabarita River are the Roaring River, the New River and Mayfield River upgradient of the mill site. The Mill Site sub-watershed has river flow gauges operated by the Water Resources Authority at the locations shown in Figure 5-12 and Figure 5-13.

[xxiv] National Water Commission (NWC) Jamaica-Draft Westmoreland Water Supply Plans

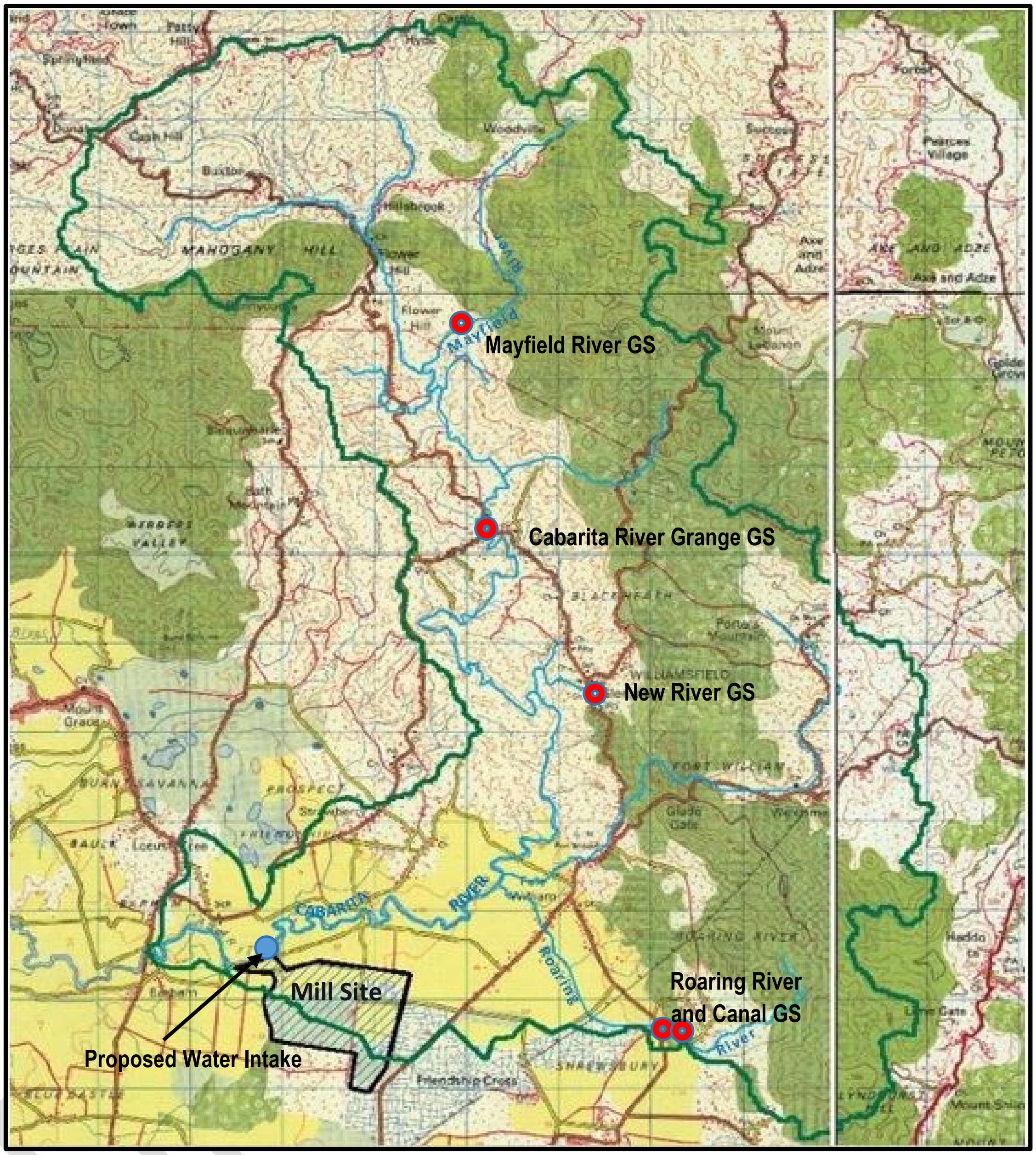


Figure 5-12: Bamboo (Friendship, Westmoreland) Mill Site Watershed. WRA Gauge Stations represented by red Circles

As shown in Figure 5-13, the mill site is located on the Alluvium Aquiclude with pockets of overlain unconfined Alluvium Aquifers. To the north of the site is the Basal Aquiclude and to the east, the Limestone Aquifer which is highly fractured with several faults and caves. There are no wells located in the watershed above the mill site. Wells are, however, located downstream of the site in the pockets of Alluvium Aquifer. The aquifer is semi-confined.

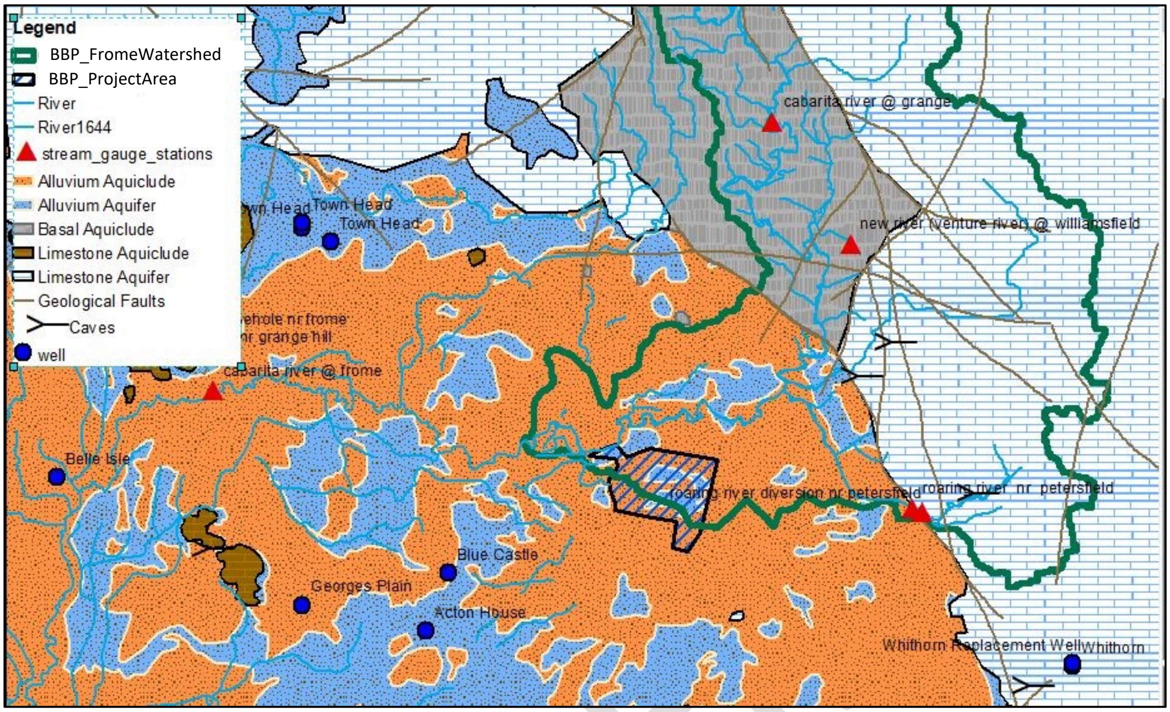


Figure 5-13: Map showing Hydrostratigraphy and Geologic Features of the Project Site and Watershed Environs (Data source: WRA)

5.1.5.2 Examination of the Sub-Surface Conditions

Figure 5-14 shows an overlay on the Geology map sheet of the wells from the WRA database that are located down gradient of the mill site. These wells could possibly be vulnerable to any spill of contaminants from the site. The overlying Alluvium (Qa) is a combination of aquiclude and aquifer material.

The closest well to the mill site is the Blue Castle Well, located 2.4 km southwest of the site. This well was drilled to a depth of 33.3 m (110 ft) in the limestone aquifer having a rest water level of 10.9 m (36 ft). This well is currently blocked. The lithology of the well from the ground surface was clay and stone (0–18 ft) followed by soft limestone (8 ft thick) and hard limestone (84 ft thick).[xxv] Groundwater flows in southerly and westerly directions. The closest National Water Commission source is the Petersfield Spring located 2.9 km southeast of the site.

The static groundwater levels in the wells at Georges Plain and Blue Castle were extrapolated to estimate the levels in the limestone aquifer over the section A – A' (in Figure 5-14). The alluvium over the limestone in this section being principally aquiclude material may offer some level of protection to the aquifer. The soft underlying limestone could also be of low permeability and offer additional protection. However, several pockets of aquifer material are present in the alluvium (as shown above in Figure 5-13) and these may facilitate movement of any spilled contaminants to the limestone.

[xxv] Information on lithology sourced from the WRA Web-Map

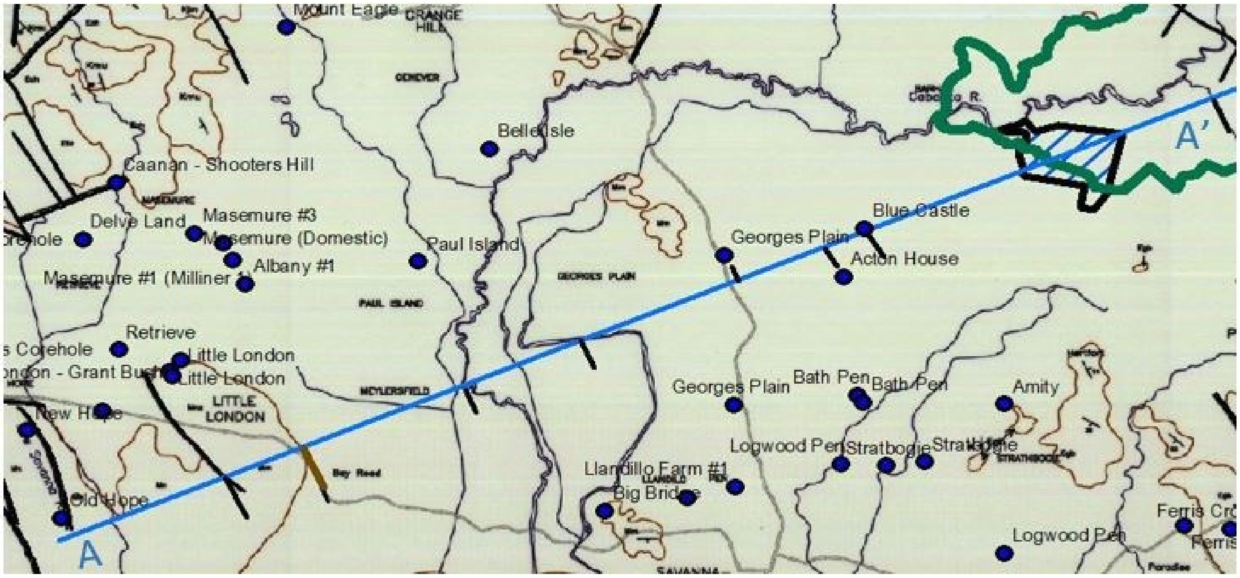


Figure 5-14: Map showing Wells SW of the Mill Site (Data source: WRA)

5.1.5.3 Results from the Geotechnical Investigation

Groundwater was detected in five of the six boreholes and one of the percolation holes drilled during the geotechnical investigation. Groundwater levels ranged from 0.68 m (2.25 ft) to 1.35 m (4.5 ft) on the site. Groundwater is at its highest elevation of 0.68 m (2.25 ft) on the north-eastern section of the project site while not present on the south-eastern section. Based on well data from the WRA, the static groundwater measured at the Blue Castle well located 2.4 km southwest of the project site is 10.9 m (36 ft). It therefore implies that the natural groundwater table is at a much greater depth, given that the site is further north and upgradient of the well. It was therefore deduced that the very high groundwater levels encountered at the Bamboo Pulp Mill Site can be considered as perched groundwater which is a saturated zone above the regional water table, separated by an impermeable zone.

The percolation rate recorded for the soil is limited to the north-western section of the property near to the wastewater and freshwater treatment systems. The percolation rate of 11min/inch was recorded which indicates that the soil has good absorption property. However, where there is discharge from wastewater systems, which are likely to contain pollutants, then this must be treated to the tertiary level to prevent/minimise contamination at discharge points. This is especially important since the Cabarita River is close to the north-western section of the property.

5.1.5.4 HAZARD VULNERABILITY OF WATERSHED

As shown in Figure 5-13, the Project watershed is the upgradient section of the Cabarita River WMU that is characterised by high flooding potential. As shown in Figure 5-15, the project site is not located within an area of high flood potential. However, communities on and surrounding the project area, such as

Frome, Friendship and Petersfield, have been declared flood-prone areas by the ODPEM.[xxvi] The proposed project could possibly increase the flooding risk. Given the shallow root structure of bamboos, the growing of these plants tends to aggravate the land slippage potential and consequently, may increase in the sedimentation rates, decrease the conveyance of the channels, and further aggravate the flooding potential.

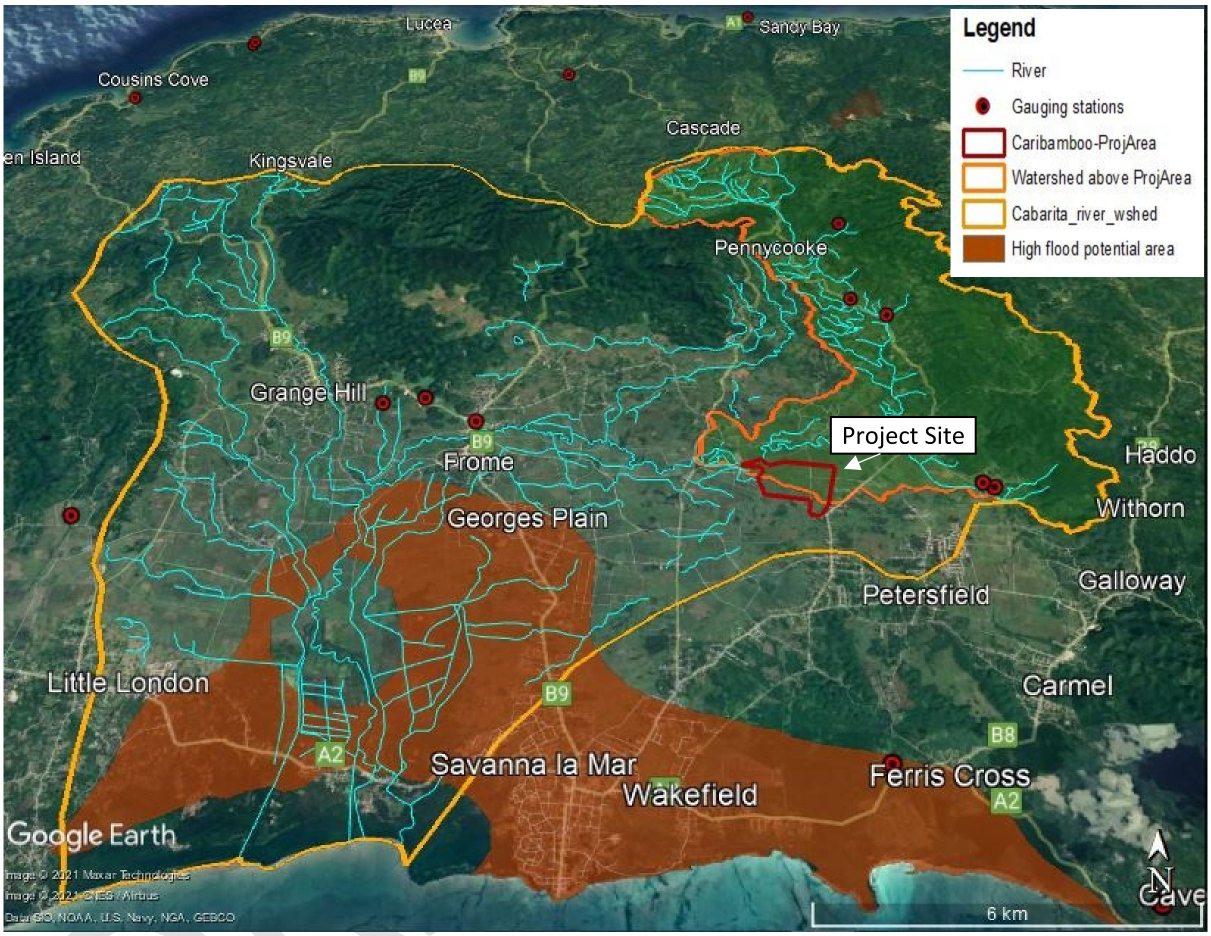


Figure 5-15: Location of Areas with a high Potential for Flooding within the Cabarita River sub-WMU and with respect to the Location of the proposed Project Site

5.1.5.5 Flood Risk Assessment

The major flood impact envisaged is the inundation of the project site given its location in what appears to be the flood plain of the river (Figure 5-15). As stated previously, the area downstream of the project site that is at high risk of flooding may be further impacted; this must therefore be assessed.

The flood inundation assessment was done for the 10-, 25-, 50- and 100-year events. The designated flood flows were determined by hydrologic (rainfall to runoff) modelling, to facilitate a pre- and post-

xxvi https://www.jamentrust.org/wp-content/uploads/2016/03/final_submission_to_infrastruture_development_ctte_re_disaster_risk_legislation_May_2014.pdf development assessment. The simulated pre- and post-flood flows were then routed through the relevant reaches of the river to determine the extent of the inundation by the various flood magnitudes. Hydrological and hydraulic analyses were conducted to determine the flood risk. Details of the methodology and the complete hydrological assessment report can be found in **Appendix N.**

5.1.5.6 Hydrological Engineering Centre – River Analysis System (HEC-RAS) Flood Level Simulation

The simulation of the T-yr flow hydrographs for the pre- and post-development conditions of the project area and its environs was done using the HEC-HMS (Hydrologic Engineering Centre - Hydrologic Modelling System) model. The HEC-HMS model schematic for the "BBP-Friendship Watershed" is shown in Figure 5-16.

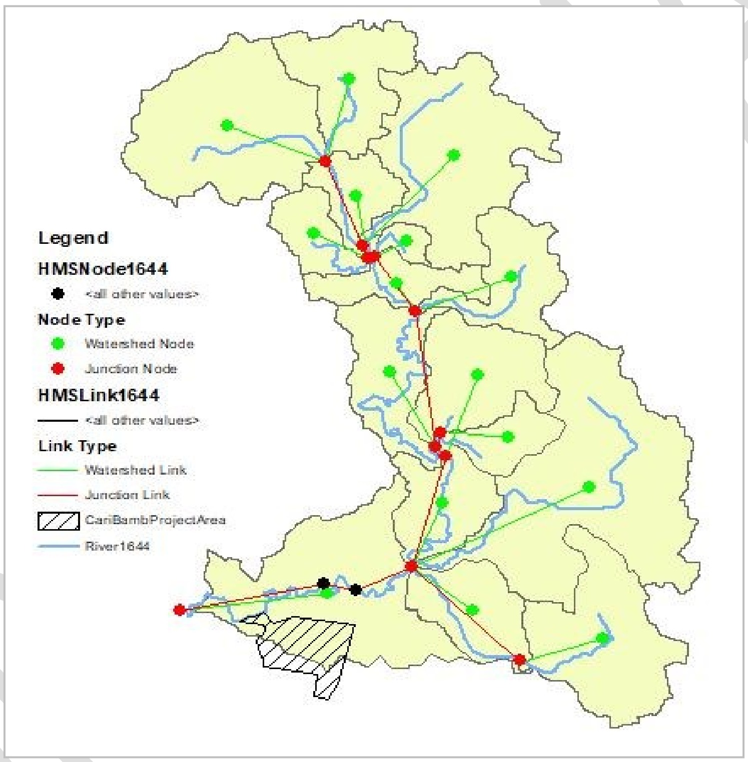


Figure 5-16: HEC-HMS model Schematic for the proposed Project Site within the Cabarita River sub-WMU which will be called the "BBP-Friendship Watershed" in the Analyses

As part of the hydrologic analyses, a DTM was used as a base to generate a profile of cross-section (A-B) passing through the proposed development in Figure 5-17. This cross-section indicates that most of the development site is on high ground and only a small section of the mill site will be impacted by flooding. The elevations range between 36m and 40m above mean sea level (AMSL) or depths of 5.8m to 9.2m above the left bank of the Cabarita River channel of approximately 30.2m AMSL. The area that would potentially be impacted by flooding is the area where the freshwater intake, aerobic lagoon, and water treatment plant are located as depicted in Figure 4-15. The results of the extent of the inundation based on the analyses are presented in Figure 5-18. These inundation maps shows that the depth of flooding in the affected area reaches up to 1.5 m for the 100-year event. The rest of the development is on high ground and is not impacted by the floodwaters. Details of the methodology and the complete hydrological assessment report can be found in **Appendix N.**

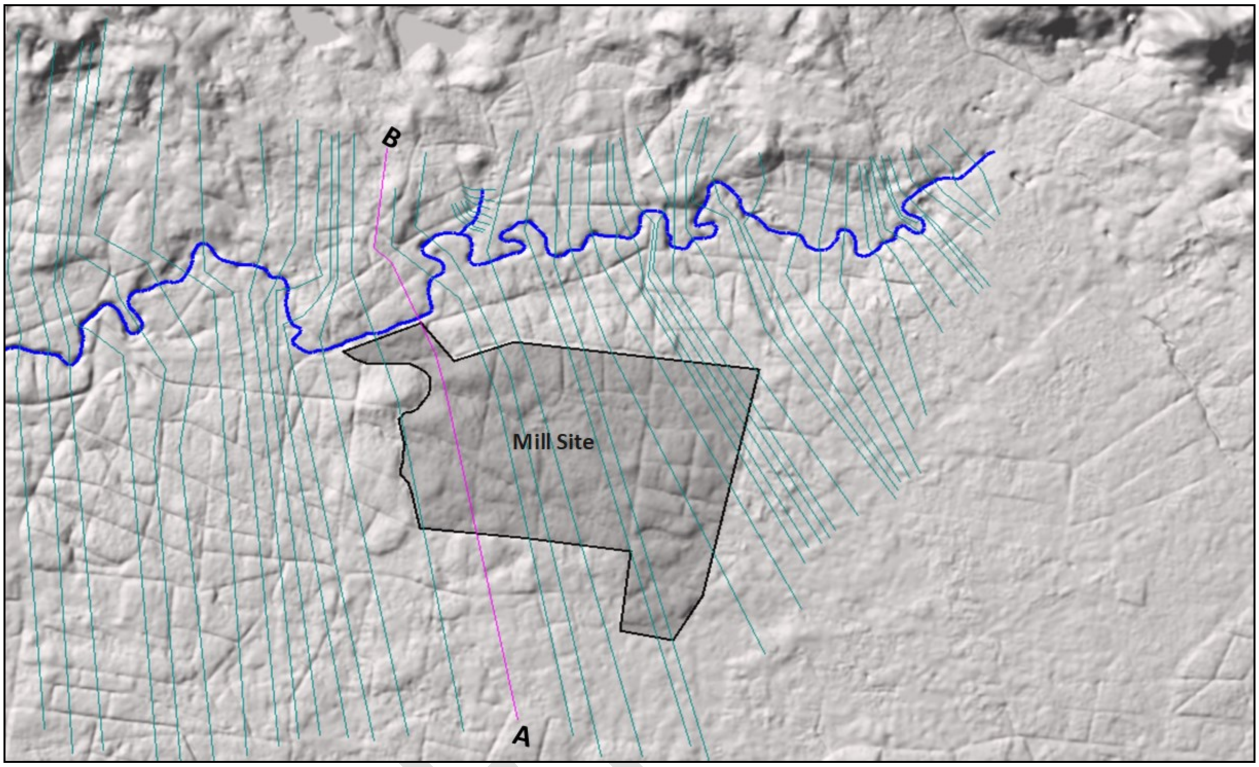


Figure 5-17: DTM showing the Cross-section Locations in the Cabarita River's Designated Reach

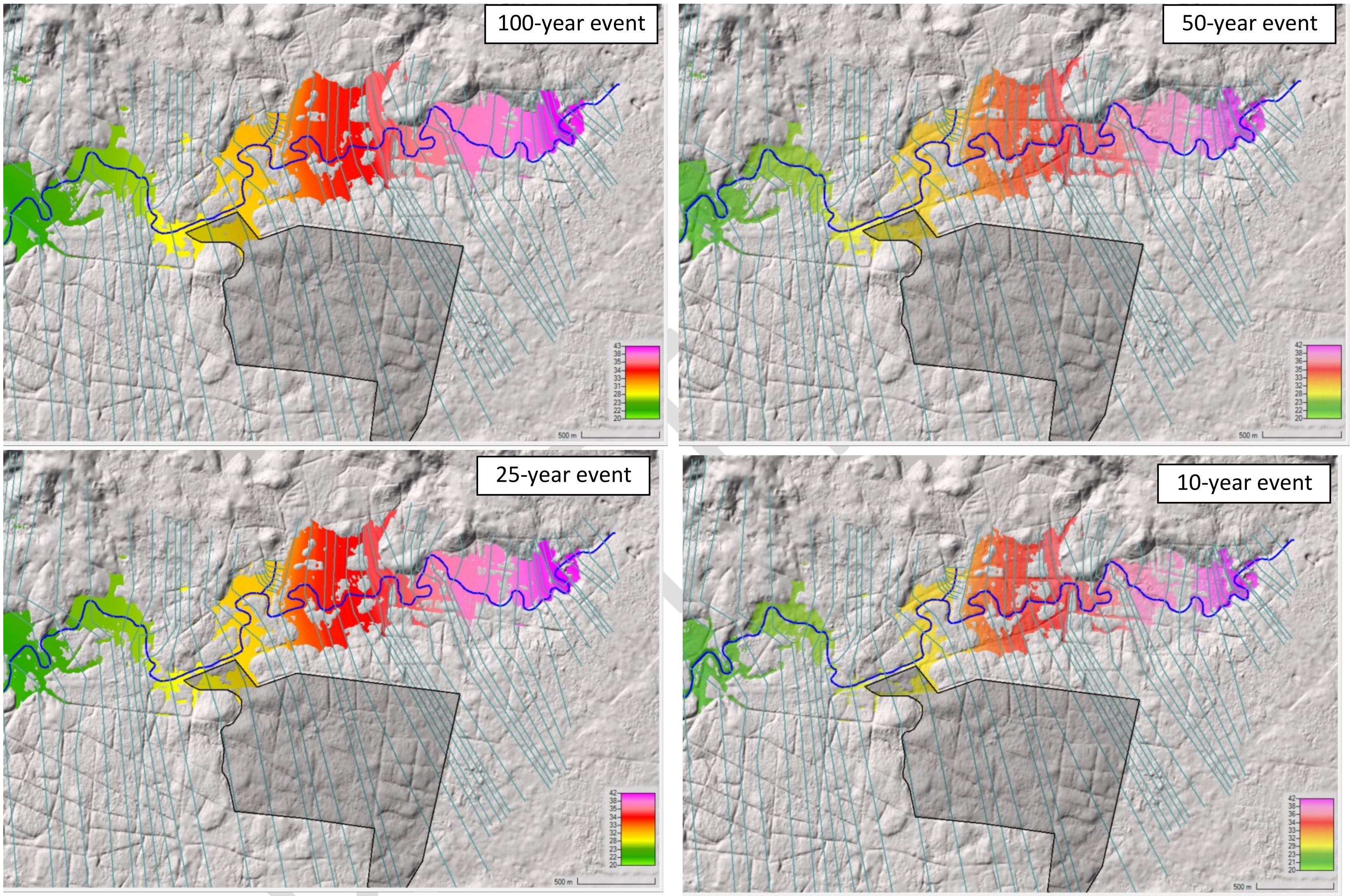


Figure 5-18: Flood Inundation Extents analysed for 10-, 25-, 50- and 100-year Events

5.1.5.7 Potential Water Sources/Available Water

5.1.5.8 Surface water reliability assessment

The reliable flow of a river at a particular location is defined as the flow that is equalled or exceeded for 95% of the time. This is estimated statistically, using the flow duration analysis method. The accuracy/reliability of the estimate is dependent on the length of the record which should be at least 10 years of continuous daily flow data. The reliability of the flows in the vicinity of the intake structure of the pulp mill site is based on the analysis of the combined flows for the Cabarita River at Grange and the residual Roaring River flows recorded at the Petersfield gauging station. For the Cabarita River, the data covers 54 years of data over the period 1968–2021 as shown in Figure 5-19 below. The average flow is 1.62 cumecs (139,968 m^3/day), ranging from 50.09 cumecs to 0.02 cumecs or (4,327,776 m^3/day to 1,728 m^3/day).

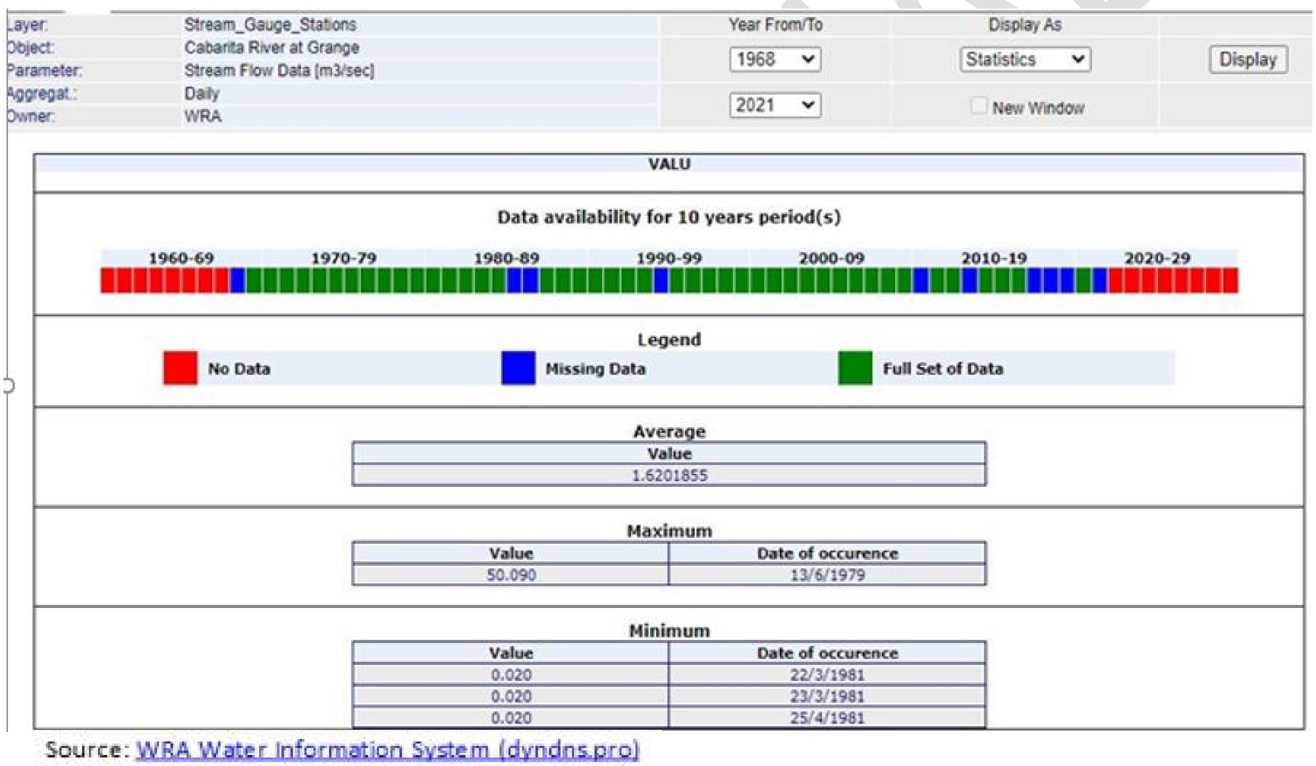


Figure 5-19: Flow Statistics of the Cabarita River at Grange (Source: WRA)

For the Roaring River, the data covers 57 years of data over the period 1965–2021 as shown in Figure 5-20 below. The average flow is 4.45 cumecs (384,480 m^3/day), ranging from 24.93 cumecs to 0.03 cumecs or (2,153,952 m^3/day to 2,592 m^3/day).

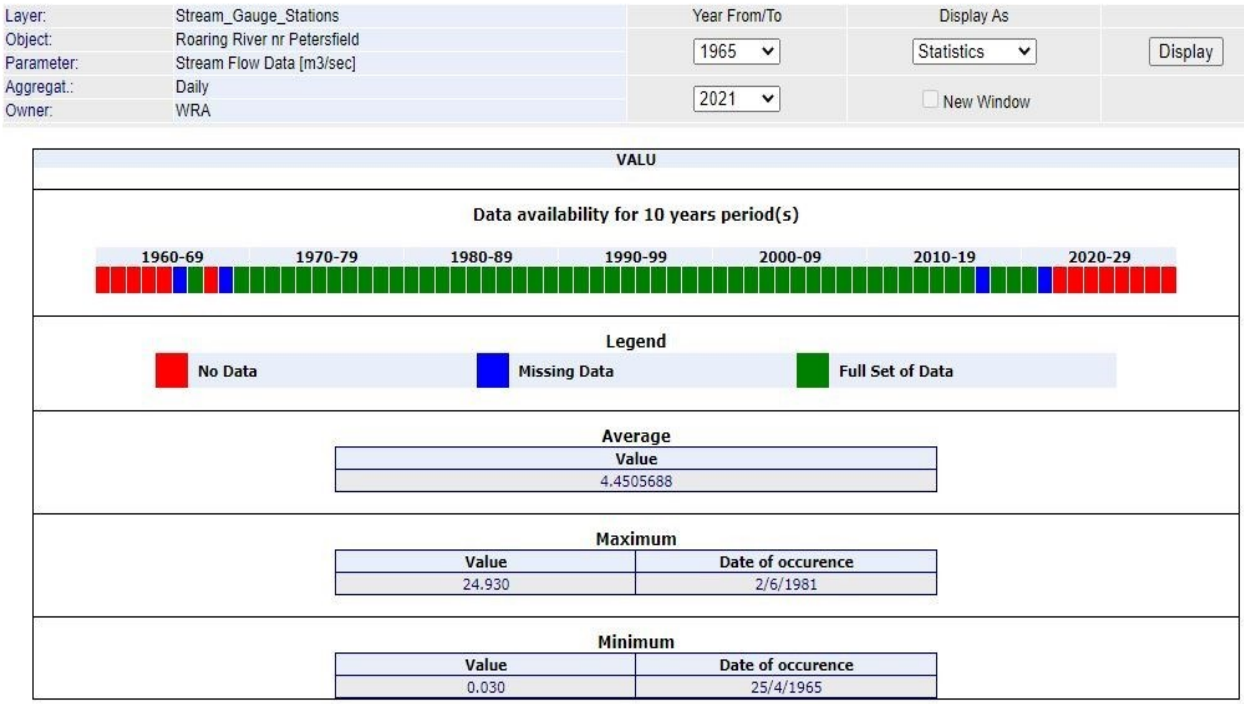


Figure 5-20: Flow Statistics of the Roaring River near Petersfield (Source: WRA)

For the period between 1968 and 2021, where flow data were available for both stations, the daily mean flows were added to form a series of combined flows, representing the flow in proximity to the pulp mill site. The combined flows were statistically analysed to develop the flow duration curve shown in Figure 5-21.

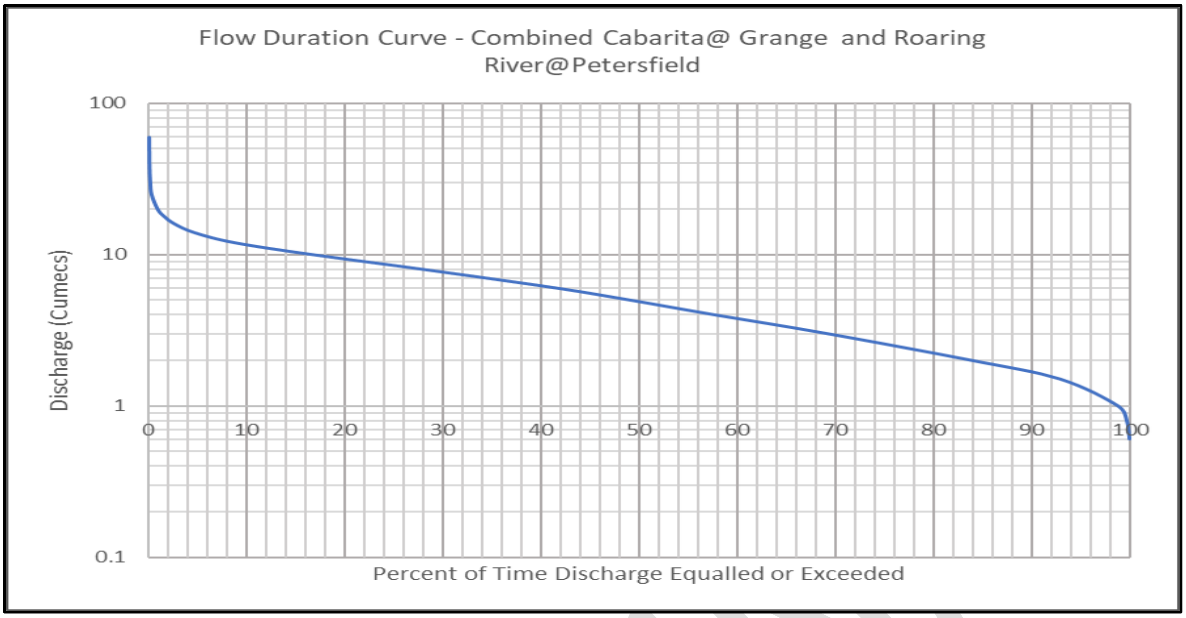


Figure 5-21: Flow Duration Curve – Combined Cabarita River at Grange and Roaring River at Petersfield

From the graphs above, the reliable yield (Q95) of combined flow is 1.4 cumecs or (120,960 m^3/day). The requirement of the pulp mill being 14,200 cumecs is therefore 12% of the reliable combined flows.

It should also be noted that the New River tributary joins the Cabarita River below the gauging station at Grange and its flows should have been included in the combined flows. However, the period of record of the New River gauging station was too short for it to be included. A comparison of the New River and the combined flows for the period of the New River data set shows that the New River flow is approximately 20% of the combined flows. Hence, the reliable yield of the combined flows could be increased by a further 20% (i.e., 145,152 m^3/day).

The WRA has confirmed that the estimated municipal water demand for the Cabarita WMU in 2020 was 5.52 million cubic meters (MCM) per year or 15,123 m^3/day, while for 2080, it would be 6.14 MCM or 16,822 m^3/day. The estimated irrigation demand is 10.7 MCM for 2020 or 29,315 m^3/day and 0 for 2080 based on the projected decline in irrigation demand. Although this demand will be significantly increased by the requirements of the pulp mill, the available resource is adequate to address this demand now and in the future.

5.1.5.9 Groundwater reliability assessment

This was not calculated as there is no intention to extract groundwater as a primary means of utilising water for the mill.

5.1.5.10 Water Demand Projections

The daily water requirement for the project from the Cabarita River is estimated at 14,200 m^3/day (3.75 million US gals/day or 3.12 million gallons/day), based on a daily pulp production rate of 710 tonnes and estimated water requirement of 20 m^3/day per tonne.

As shown in Figure 5-12, the intake of the water from the Cabarita River to the project site is located below its confluence with Roaring River. The Roaring River flows at the Petersfield gauging station are regulated by the National Water Commission (NWC) diversion canal located approximately 100 m upstream. The flow at the Petersfield gauging station therefore represents the residual flows after the NWC's abstraction.

According to the International Plant Protection Convention (IPPC), the best world references of water consumption in projects of this nature are in the range of 30 m^3/ADt – 50 m^3/ADt (Luciano Oliveira, 2017). According to the European BAT Reference Document for the Production of Pulp, Paper and Board used in the European Union, the volume of water consumption for bleached Kraft pulp mills varies between 20 and 90 m3/ADt (Suhr et al., 2015).[xxvii] BBP estimates a net freshwater requirement for the Project of 20m^3 per tonne of production, in keeping with the lowest water consumption from the European BAT Guidelines. BBP intends to use the Cabarita River as the major freshwater intake and discharge point for the mill operations with an option to use groundwater to supply the boiler feed. In applying the design capacity to the production projections, it is estimated that the water demand for a 250,000 ADt pa Mill would be 5.0 MCM pa [(250,000 ADt pa) x (20 m^3/ADt)].

5.1.5.11 Impact of Proposed Development on Watershed

5.1.5.12 Flooding Impact

The major factor impacting the post development runoff is the permeable areas of the watershed that would become impervious by the changing land use. The mill site (1.55km^2) occupies a very small part of the Cabarita River Watershed (63.4km^2) above the mill site, approximately 2.4%. Assuming a worst-case scenario where the entire mill site would be made impervious, the portions of the subbasin (Sb) it occupies were determined and modelled as impervious areas. Hence, the Subbasins, which occupied Sb15 and Sb12 shown in Figure 5-22, had the impervious percent of their areas changed from the predevelopment values of 27% to 42% for Sb15 and 0% to 10% for Sb12. The resulting post development flow increase for the 100-year floods were insignificant as expected and are as follows:

Subbasin	Pre-Dev 100-yr flow	Post-Dev 100-yr flow	Increase
Sb12	33.5 cumecs	33.8 cumecs	0.3 cumecs
Sb15	43.1 cumecs	43.5 cumecs	0.4 cumecs
Outlet	241.1	241.3	0.2 cumecs

[xxvii] Volume determined from the European Integrated Pollution Prevention and Control Bureau (EIPPCB) questionnaires from 2007/2009 and update of figures from 2010 in the BAT report. This volume is based off the assumption that the volume of water used is closely linked to the wastewater load discharged from the mill.

Hence, there will be a very marginal increase in the post development flows and will thus have no impact on the resultant flood levels at and downstream of the mill site.

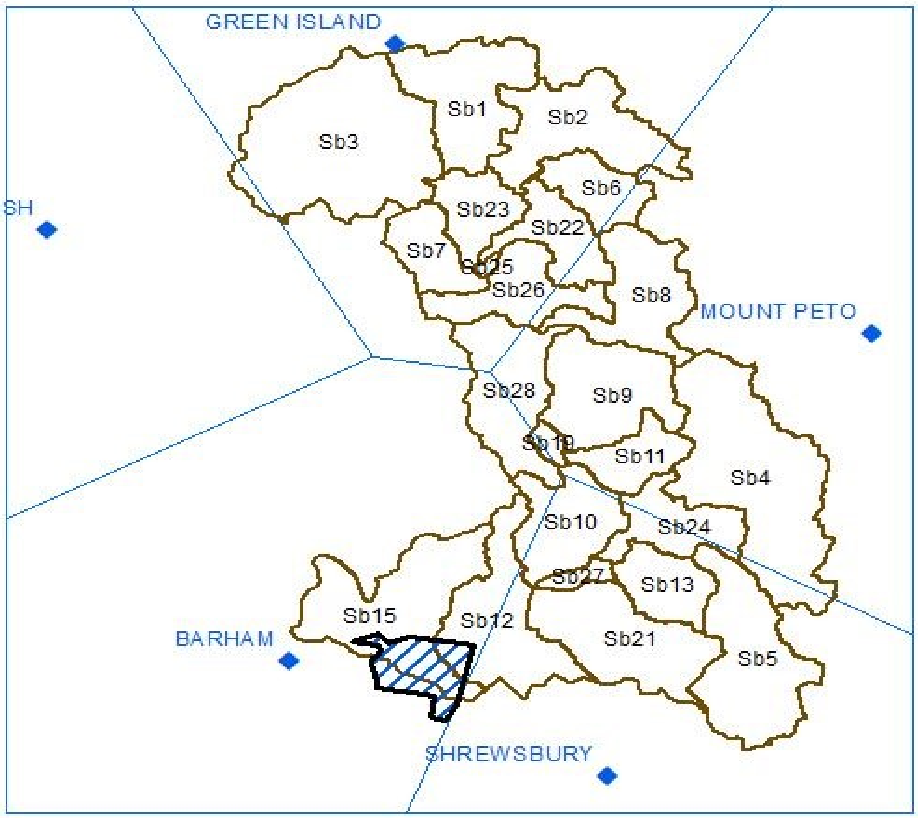


Figure 5-22: Rainfall Station Thiessen Polygons for Mill Site

5.1.5.13 Surface and Groundwater Quality Impact

In the assessment of the impact of the mill process during the operation phase, a knowledge of the process is very essential. Singh et al. (2019) identifies five basic processing steps, each step of which can be carried out by a variety of methods and each releasing wastewater to the final effluent. These are summarised as follows:

i. ***Debarking,*** where the plant fibre is converted into chips and the bark removed. Raw materials include hard wood, softwood, and agro-residues, which transfer to water tannins, resin, acids, and other substances present in the bark;

ii. ***Pulping*** turns the chips into pulp by removing the lignin and hemicellulose content from the raw material, which results in a cellulose rich pulp. Pulping can be done by different methods, such as mechanical, semi-chemical, kraft, sulphite pulping, and other pulping process;

iii. ***Bleaching*** is engaged to meet the desired colour dictated by product standards. Several bleaching agents, including chlorine, chlorine dioxide, hydrogen peroxide, ozone, etc. may be used either singly or in combination. In this step, lignin, phenols, resin acids, and other compounds get chlorinated and transformed into extremely toxic xenobiotics;

iv. ***Washing*** removes the bleaching agents from the pulp. Generally, an alkali caustic soda is used to extract colour and bleaching agents from the pulp and hence, this process is also known as the alkali extraction stage;

v. ***Paper and paper*** products are finally produced by mixing the washed pulp with appropriate fillers (clay, titanium dioxide and calcium carbonate) and sizing agents like rosin and starch.

Surface and ground water quality deterioration is a possible impact of the effluent discharge associated with the mill. The constituents of the effluent include:

- Suspended solids which consume oxygen when decaying;
- Organic matter which also uses oxygen in water;
- Nutrients such as Phosphorous and Nitrogen which trigger algae bloom;
- Toxins associated with the chemical compound found in pulp and paper mill.

According to Singh et al. (2019), the effluent is mostly degrading products of lignin, cellulose, hemicellulose, and wood extractives. The lignin degradation includes compounds such as monomeric phenols, enol ethers, mercaptides, stilbene, quinone derivatives, chlorinated phenols, acetic acid, formic acid, acetaldehyde, methanol, furfural, and methyl glyoxal. The effluent also includes over 300 organochlorine and other unidentified compounds, some of which are extremely toxic and persistent.[xxviii]

The Kraft pulping method generates significant amounts of solid, liquid and gaseous emissions, requiring treatment before release into the environment. Some inorganic solid wastes are of particular concern due to the high quantities generated, which are landfilled: green liquor dregs; slaker grits; lime mud; and boiler fly ash.

As shown in Figure 5-13, the Alluvium (Qa) over the limestone in the vicinity of the mill site is principally aquiclude material. This will offer some level of protection to the aquifer. The soft underlying limestone could also be of low permeability and thus offer additional protection to the Egb limestone. The presence of several pockets of aquifer material in the Alluvium under the mill site may, however, facilitate the movements of any spilled contaminants to the limestone.

It is therefore recommended that in addition to the preventive spill measures to be employed, there should be a programme of quarterly water quality monitoring of selected down gradient wells, as part of the milling operations.

[xxviii] The chlorinated organic compounds are formed during chlorine bleaching stage of paper production; however, the Bamboo Bioproducts Ltd. mill will not be using chlorine bleaching as stated (ESL, 2020).

5.1.6 WATER QUALITY

Water samples were collected from various points along the Cabarita River, tributaries to the Cabarita River, as well as a canal located along the 'Hertford to Flowerhill' Road. The water quality sampling locations for the wet season assessment and the dry season assessment are identified in Figure 5-23 and Figure 5-24 respectively. The descriptions of the water quality sampling locations are presented in **Appendix J**.

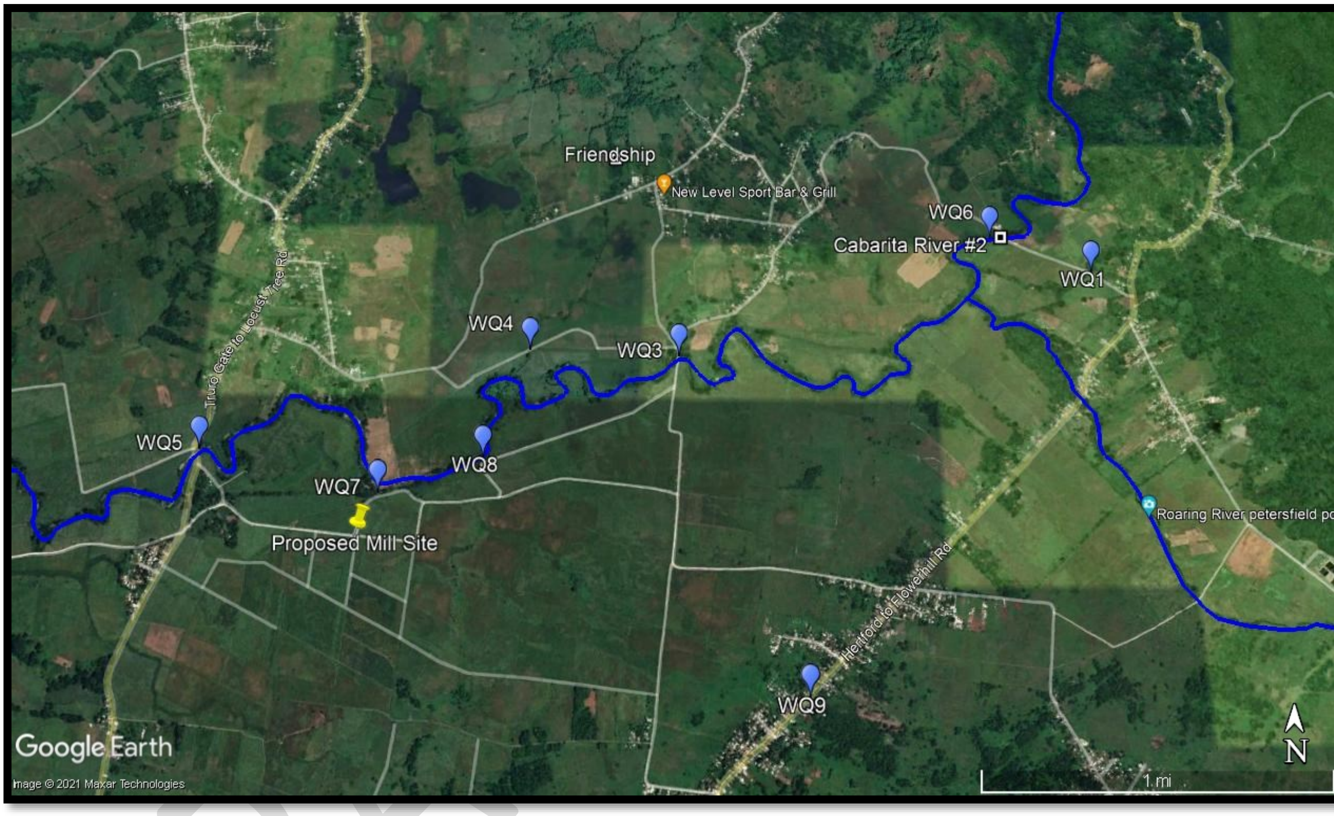


Figure 5-23: Water Quality Sampling Points (November 2021)

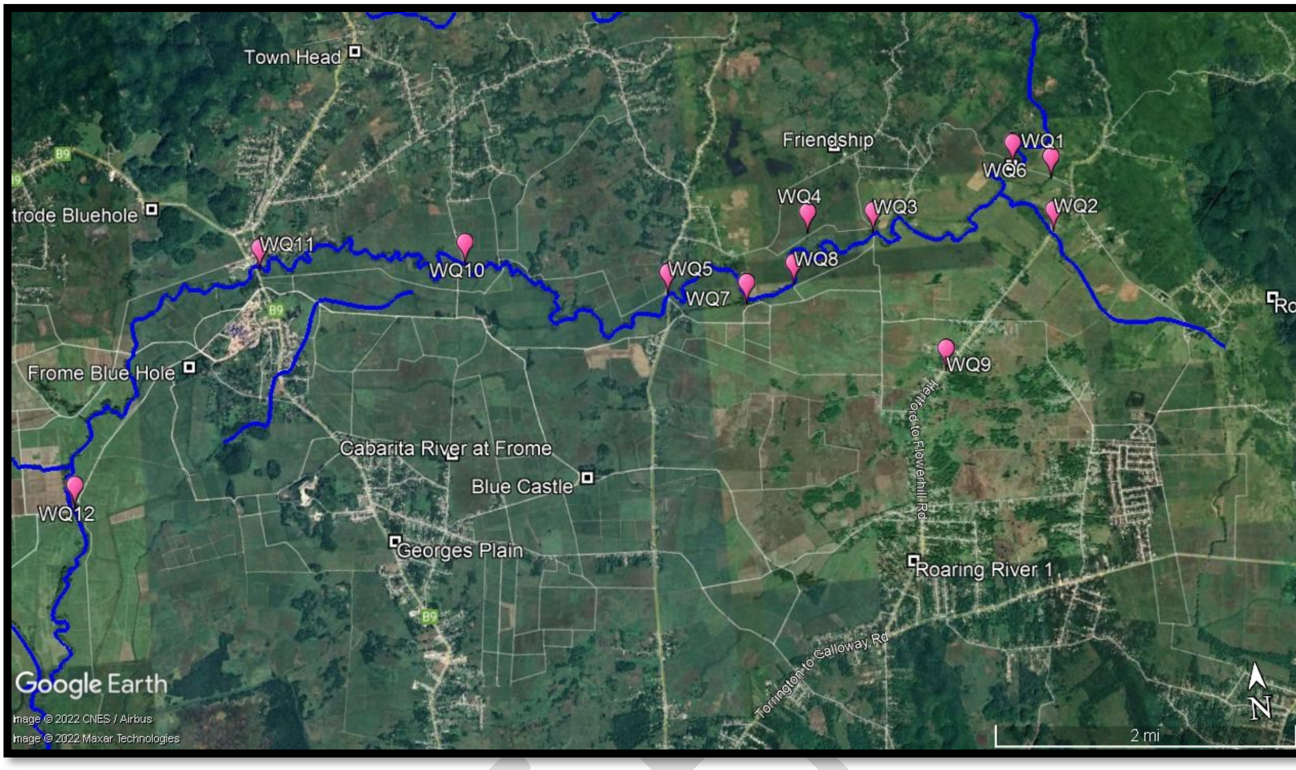


Figure 5-24: Water Quality Sampling Points (March 2022)

5.1.6.1 Wet Season Assessment

The results of the water quality exercise for the wet season assessment indicated that the quality of the water was generally similar across the investigated areas except for the samples collected at sites WQ4 (a tributary) and WQ9 (a canal). All of the aggregate properties (see Table 5-5), with the exception of pH, for the samples collected at WQ9 were outliers or suspected outliers of the data pool. The values obtained for conductivity, salinity and total dissolved solids (TDS) measurements (parameters which account for the dissolved ions in solution (e.g., Na^+, Cl^-, OH^-, CO_3^- etc.) for WQ4 were also outliers of the data pool. This suggests that there is either a difference in source of and/or inputs to these two water bodies when compared to the other sampling locations.

Table 5-5: Description of Water Quality based on Aggregate Properties (November 2021)

PARAMETERS (units)	WQ1	WQ3	WQ4	WQ5	WQ6	WQ7	WQ8	WQ9
pH (pH units)	7.47 @ 24.6 °C	7.65 @ 24.8 °C	7.26 @ 25.6 °C	7.80 @ 25.2 °C	7.94 @ 24.5 °C	7.76 @ 25.0 °C	7.75 @ 25.0°C	6.78@ 26.3°C
DO (mg O_2/L)	7.36 @ 24.6 °C	7.48 @ 24.8 °C	6.17 @ 25.6 °C	6.21 @ 25.2 °C	7.69 @ 24.5 °C	7.45 @ 25.0 °C	6.73 @ 25.0°C	2.82@ 26.3°C
Conductivity (mS/cm)	0.337@ 24.6 °C	0.325 @ 24.8°C	0.201 @ 25.6 °C	0.325 @ 25.2°C	0.291 @ 24.5 °C	0.325 @ 25.0 °C	0.324 @ 25.0°C	0.442@ 26.3°C
Salinity (ppt)	0.16@ 24.6 °C	0.15@ 24.8°C	0.09@ 25.6 °C	0.15 @ 23.4 °C	0.14 @ 24.5 °C	0.15 @ 25.0 °C	0.15 @ 25.0°C	0.21@ 26.3°C
TDS (mg/L)	221.00 @ 24.6 °C	211.90 @ 24.8 °C	128.70 @ 25.6 °C	210.6 @ 25.2 °C	190.45 @ 24.5°C	211.25 @ 25.0 °C	210.69 @ 25.0°C	280.8@ 26.3°C

Although not designated as statistical outliers of the complete data set, the pH, salinity, TDS and conductivity seen at sites WQ1 and WQ6, differed slightly from those samples collected from the major water body (i.e., WQ3, WQ5, WQ7 and WQ8). WQ6, the sampling point most upstream of the proposed project location, was observed to have a higher pH (7.94) and lower conductivity, TDS and salinity (0.291 $mScm^{-1}$, 190.45 mgL^{-1}, 0.14 ppt) when compared to the other samples taken from along the Cabarita River. WQ1, a tributary of the Cabarita River, was observed to have a lower pH (7.47) and a higher conductivity, salinity and TDS (0.337 $mScm^{-1}$, 221.00 mgL^{-1}, 0.16 ppt), compared to WQ6 and the other samples collected along the Cabarita River. This may be an indication that the tributaries of the river, above the WQ3 sampling point, may contribute to the variance observed between the average pH (7.74), conductivity (0.325 $mScm^{-1}$), and subsequent TDS and salinity values observed at the sampling points downstream of where the tributaries enter the main Cabarita River. However, the effect and extent of these tributaries' influence on the river quality would have to be confirmed through additional sampling and monitoring exercises.

Despite the variance in the quality of the water seen across the different tributaries and locations along the Cabarita River, all the water quality points sampled were within the specifications of the Draft Jamaica National Ambient Water Quality Standard – Freshwater, 2009 (see Table 5-6) for their aggregate properties (where applicable); this is an indication that the water was of good quality and was not showing signs of any significant impacts from anthropogenic activities during this sampling activity.

Table 5-6: Jamaica National Ambient Water Quality Standards – Freshwater, 2009 (NEPA)

Parameters (units)	Standard Range
Total Dissolved Solids (mg/L)	120.0 – 300
pH (pH units)	7.00 – 8.40
Conductivity (mS/cm)	150.0 – 600

Although no standard exists for salinity, it is a function derived from conductivity. Therefore, it can be assumed that once the conductivity of the water quality point is within the specifications of the reported standard, then the salinity of that point would also be typical of a freshwater in the Jamaican context. Freshwaters are typically characterised as having salinities of less than 0.5 ppt.

Dissolved oxygen (DO) is an important indicator of the quality of water as it is a necessity for the biological and chemical processes of both plants and animals. A healthy water body is generally characterised as one that contains a dissolved oxygen concentration of between 80 and 120%.[xxix] At 25°C, the solubility of oxygen in freshwater at 100% saturation is approximately 8.4 mgO_2/L.[xxx] Hence, the DO concentration of these water bodies was expected to be >6.7 mgO_2/L. All the water samples collected had dissolved oxygen concentrations greater than 6.7 mgO_2/L, with the exception of the samples collected at WQ4, WQ5 and WQ9. As mentioned before, WQ9 was collected from a drain/canal along the 'Hertford to Flowerhill' Road. The low DO concentration seen at this sampling point may be due to the fact that the water here was slow moving – not encouraging the aeration of the water body, warmer than the other sampling points, and shallow and also containing a lot of plant material. The canal was also noted to be an earthen canal. Similarly, the sample point collected at WQ4 may have had a lower DO content than the other sampling points as it was a heavily vegetated area and slower moving than the other sampling points collected along the river. Although the main water body was characterised a fast-flowing water body, the water sample at WQ5 was collected in an area where the velocity of the water was slower due to the depth of the water.

Total nitrogen, phenol, zinc, copper, arsenic, mercury, chromium, lead, fats, oil and grease (FOG), and pesticides were undetected at all locations suggesting that the water samples collected and the water upstream of the various sampling points were free from any major anthropogenic pollutants at the time of sampling and will not be discussed any further (see Table 5-7). Small amounts of iron and manganese were detected in all water samples. Both manganese and iron are essential micronutrients for plant and animal growth and health. In typical freshwaters, manganese levels generally do not exceed 200 µg/L,[xxxi] while iron concentrations generally do not exceed 1 mg/L.[xxxii] Both the iron and manganese concentrations obtained at all sites were below these levels further underscoring the point that the water body appeared to be free from any major anthropogenic sources at the time of sampling.

Total organic carbon (TOC) is the sum of dissolved organic carbon (DOC) and particulate organic carbon (POC) in a water body. Based on the data obtained, it can be assumed that the TOC present in all water bodies comprised mainly DOC. DOC is the fraction of TOC that can pass through a 0.45-micron filter and can originate from natural sources such as detritus and primary producers, which may be a possible reason the DOC and TOC were both highest at WQ9 and WQ4 as these were the most densely vegetated areas. It has been noted that for healthy lakes and rivers worldwide, the TOC and DOC mean concentrations were typically below 5 mgO_2/L.[xxxiii] All water samples were below this level cementing the point that the

[xxix] https://www.enr.gov.nt.ca/sites/enr/files/dissolved_oxygen.pdf
[xxx] http://www.state.ky.us/nrepc/water/ramp/rmdo2.htm
[xxxi] https://www.who.int/water_sanitation_health/dwq/chemicals/manganese.pdf
[xxxii] https://www.lenntech.com/periodic/water/iron/iron-and-water.htm
[xxxiii] https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/approved-wqgs/organic-carbon-tech.pdf

samples collected were of good quality as it relates to freshwater bodies at the time of sampling. Similarly, the chemical oxygen demand (COD) obtained for each water sample was relatively low. Chemical oxygen demand (COD) encapsulates those species within a water body that could possibly use oxygen in the presence of a strong chemical oxidant. The COD of a natural water system gives information on how much oxygen is required for the oxidation of waste to carbon dioxide and water, with all organic matter in the sample being converted to carbon dioxide. COD concentrations are generally ≤20 mgO_2/L in unpolluted surface water samples.[xxxiv] All water samples collected were less than this value indicating the general good quality of the water bodies from which the samples were taken. Furthermore, all BOD values were determined to be within the specifications (0.8-1.7 mgO_2/L) of the Jamaica National Ambient Water Quality Standards – Freshwater (see Table 5-9).

[xxxiv] S.K. Jain, V.P. Singh, Water Resources Systems Planning and Management in Developments in Water Science, 2003

Table 5-7: Description of Water Quality Parameters (November 2021)

PARAMETERS (units)	WQ1	WQ3	WQ4	WQ5	WQ6	WQ7	WQ8	WQ9
Nitrate (mg NO_3^-)	<1.3	1.3	2.0	1.8	1.8	1.3	1.8	2.6
Nitrate as Nitrogen (mg NO_3^-–N/L)	<0.3	0.3	0.4	0.4	0.4	0.3	0.4	0.6
Orthophosphate (mg PO_4^{3-}/L)	0.10	0.08	0.05	0.09	0.14	0.11	0.10	0.02
Sulfate (mg SO_4^{2-}/L)	2	2	2	2	2	2	2	2
Faecal Coliform (MPN/100mL)	1600	220	240	920	>1600	920	540	920
E.coli (MPN/100mL)	540	170	240	170	>1600	350	350	350
COD (mg O_2/L)	3	5	6	10	6	6	10	8
TSS (mg/L)	3.1	3.9	1.7	5.5	2.7	4.8	6.0	<1.6
Chloride (mg Cl^-/L)	3.5	3.2	3.2	3.2	4.1	3.1	3.2	5.6
Total Nitrogen (mg N/L)	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2
Total Phosphorus (mg P/L)	0.04	0.04	0.02	0.04	0.02	0.04	0.06	<0.02
BOD (mg O_2/L)	0.7	0.9	1.0	1.4	0.8	1.0	1.3	1.1
Total Alkalinity (mg $CaCO_3$/L)	185.3	180.4	103.7	183.6	163.7	180.8	184.3	250.6
Total Hardness (mg $CaCO_3$/L)	219.8	193.2	108.6	210.5	175.10	208.10	201.1	281.4
Phenol (mg C_6H_5OH)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

PARAMETERS (units)	WQ1	WQ3	WQ4	WQ5	WQ6	WQ7	WQ8	WQ9
Fats, Oil & Grease (mg/L)	<1	<1	<1	<1	<1	<1	<1	<1
Calcium (mg Ca/L)	73.9	71.8	36.3	71.9	61.2	70.8	70.8	99.8
Magnesium (mg Mg/ L)	2.02	2.33	2.15	2.35	2.57	2.30	2.32	1.65
Silicon (mg Si/L)	4.13	5.00	6.07	5.15	5.23	4.97	5.05	3.09
Zinc (µg Zn/ L)	<11.0	<11.0	<11.0	<11.0	<11.0	<11.0	<11.0	<11.0
Copper (µg Cu/ L)	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
Arsenic (µg As/ L)	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4
Mercury (µg Hg/ L)	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090
Chromium (µg Cr/ L)	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
Manganese (µg Mn/ L)	5.8	10.2	29.4	14.1	5.1	11.2	13.1	10.3
Sodium (mg Na/ L)	2.56	2.69	5.66	2.75	3.47	2.74	2.69	2.23
Lead (µg Pb/ L)	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6
Iron (µg Fe/ L)	140	245	529	343	192	265	310	109
Pesticide Screen (ppb)	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
DOC (mg C/ L)	0.64	0.80	1.90	1.20	0.98	1.20	1.00	3.10
TOC (mg C/ L)	0.69	0.86	2.10	0.86	0.75	1.00	1.10	3.20

Jamaican surface waters are naturally hard due to the prevalence of limestone (accounting for over 70% of the island's geological makeup). All the water quality sites sampled, except for WQ4, were characterised as hard to very hard waters (see Table 5-8) and fell within the specified range of the Jamaica National Ambient Water Quality Standards – Freshwater (see Table 5-9).

Table 5-8: Water Hardness Scale[xxxv]

Concentration (ppm)	Hardness Rating
< 61	Soft
61 – 120	Moderately hard
121-180	Hard
> 180	Very hard

Table 5-9: Jamaica National Ambient Water Quality Standards – Freshwater, 2009 (NEPA)

Parameters (units)	Standard Range
Calcium (mg Ca/L)	40.0 – 101.0
Chloride (mg Cl^-/L)	5.0 – 20.0
Magnesium (mg Mg/L)	3.6 - 27.0
Nitrate (mg NO_3^-/L)	0.1 – 7.5
Phosphate (mg PO_4^{3-}/L)	0.01 – 0.8
Sodium (mg Na/L)	4.5 – 12.0
Sulfate (mg SO_4^{2-}/L)	3.0 – 10.0
Hardness (mg $CaCO_3$/L)	127.0 – 381.0
Biochemical Oxygen Demand (mg O_2/L)	0.8 – 1.7

WQ4 appears to originate from a basal aquiclude, which may account for the hardness seen at this location in comparison to the other sampling points (see Figure 5-27). The other sampling locations, except for WQ9, were taken from areas along the Cabarita River or tributaries of the Cabarita River that had reaches in limestone aquifers or both basal aquicludes and limestone aquifers. Figure 5-26 highlights the clusters of data observed when some of the parameters associated with total dissolved solids were compared. WQ4 is identified within the red oval (Figure 5-26), WQ9 is identified within the green oval and all other locations in the purple oval. Given the nature of the limestone aquifers, water moving through the limestone bedrock is expected to have a high level of dissolved solids due to dissolution of limestone rock minerals. This would also impact the pH of the water, making it more basic. Trends in total alkalinity and total hardness, which are both linked to the concentration of rock salt ions (e.g., calcium, magnesium

[xxxv] sam.usace.army.mil/Portals/46/docs/military/engineering/docs/WRA/Jamaica/Jamaica WRA - English.pdf

and sodium) will be similar. This trend was seen as depicted in Figure 5-25 where the water quality sampling points are plotted in sequential order (i.e., the first data point is WQ1, and the last data point is WQ9).

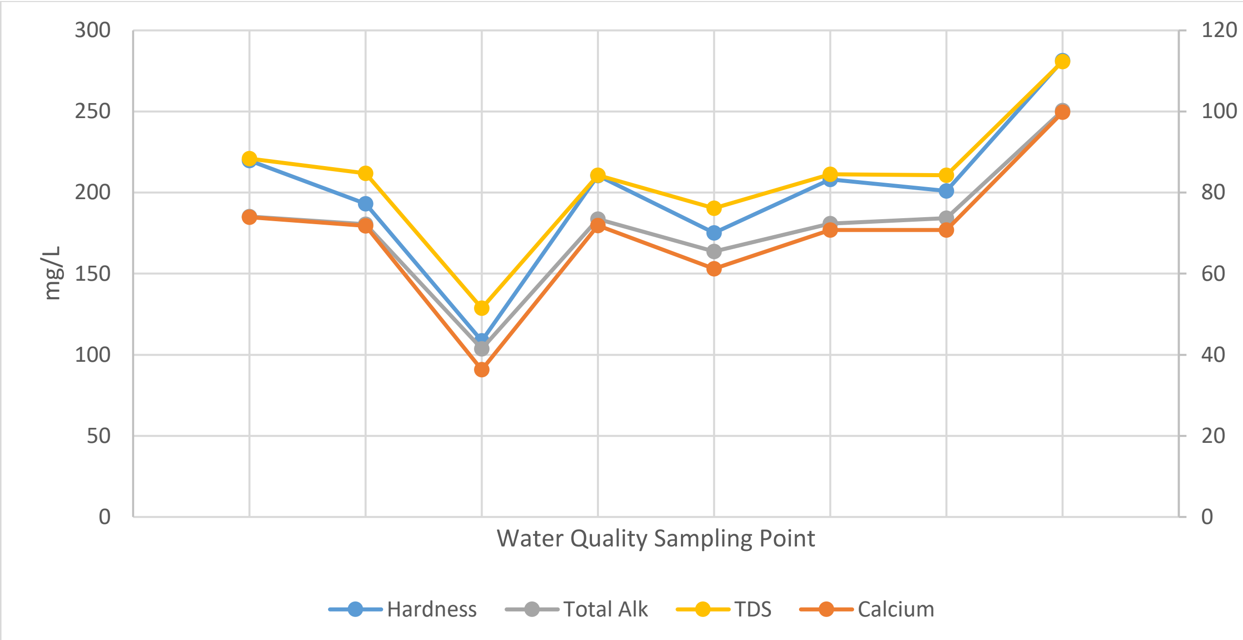


Figure 5-25: Trends in Data between Hardness, Alkalinity, TDS and Calcium (November, 2021)

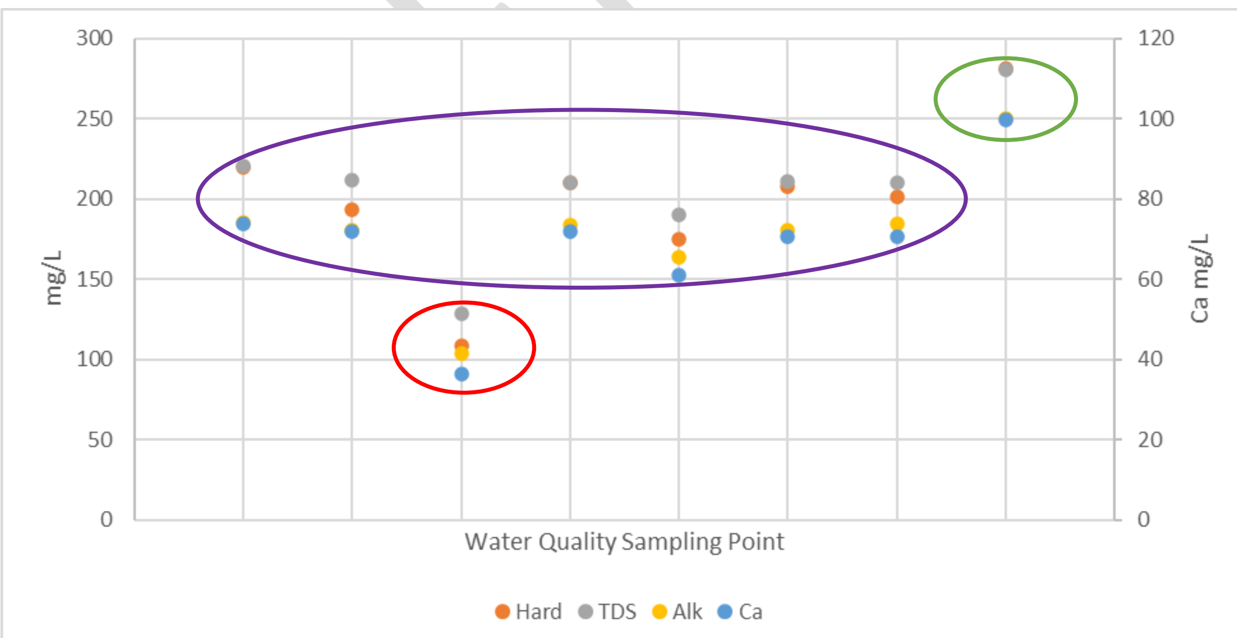


Figure 5-26: Cluster Points indicating Trends in Data between Hardness, Alkalinity, TDS and Calcium from various Sources

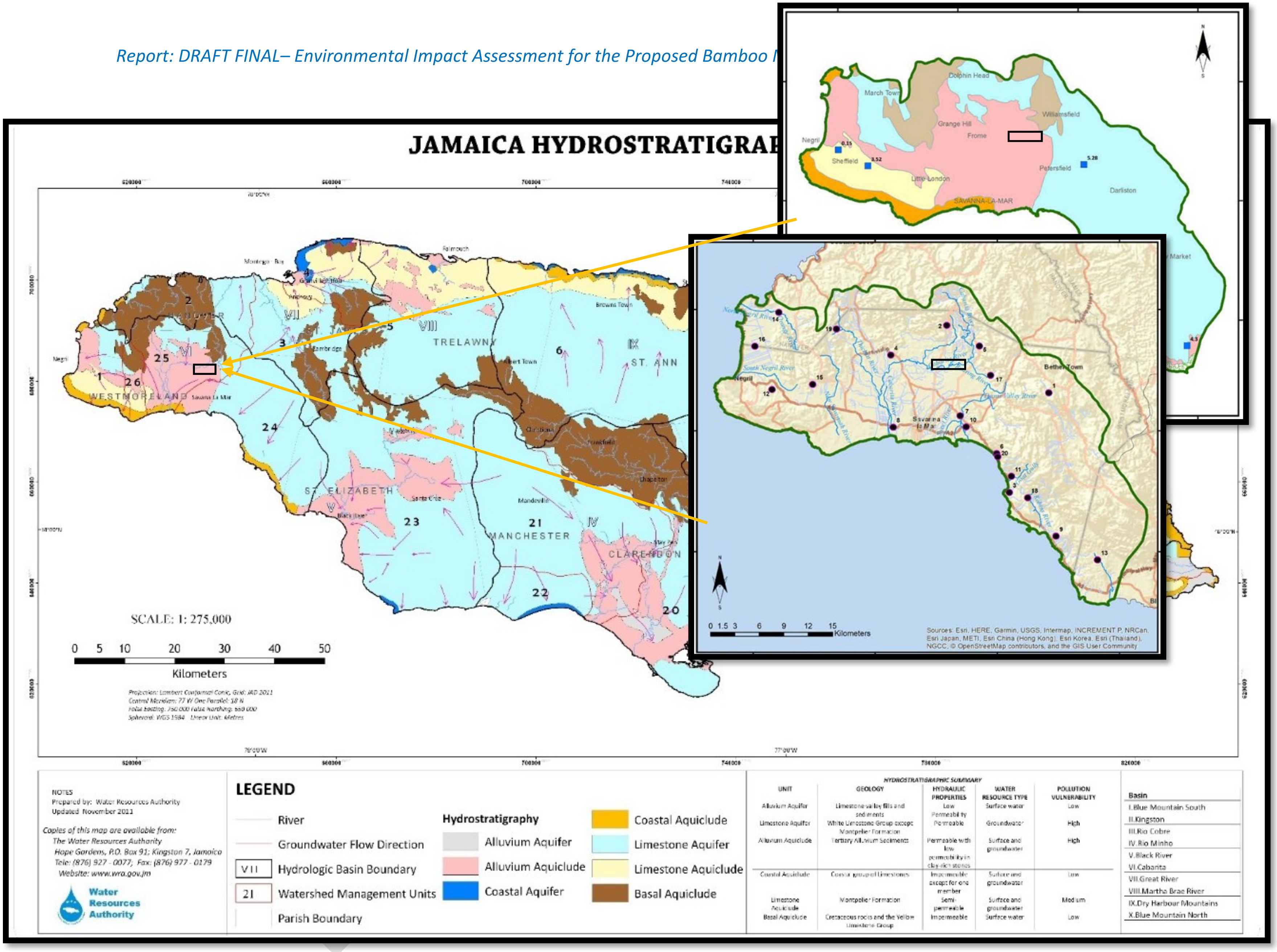


*Figure 5-27: Jamaican Hydrostratigraphy. *General Area of Water Quality Sampling Points delineated in Black Box (Source: Adapted from WRA, 2019)*

Nitrates, phosphates, sulfates, total phosphorus and suspended solids in the water sample were all relatively low. The nitrate and phosphate values were within the Jamaica National Ambient Water Quality Standards – Freshwater as depicted in Table 5-9.

There were no statistical outliers of the complete data set, however, it was noted that the nitrates of WQ9 (see Table 5-7) were higher than those seen in the other samples which also points towards a difference in source for this sample. Other drains were observed along the surface of the road. It is unclear whether these drains come from the project site or if the water within them originates from another river source. However, as this roadway is to be used as the entry point to the proposed project location, the potential impacts that increased vehicle movement through this community will have on the quality of the waters needs to be carefully considered. This water runs through a community, and it is unclear what the current use of these waters are. Hence, the water quality along this roadway will also need to be monitored.

It was observed that sulfates, chloride and sodium were below the stipulated range of the Jamaica National Ambient Water Quality Standards – Freshwater. However, it was found that the values obtained for these parameters were generally within the range as those reported in the Water Resources Authority Water Quality Atlas – 2019 (see Figure 5-28, Figure 5-29 and Figure 5-30). These waters were characterised as excellent or high quality based on the levels obtained for each of these parameters.

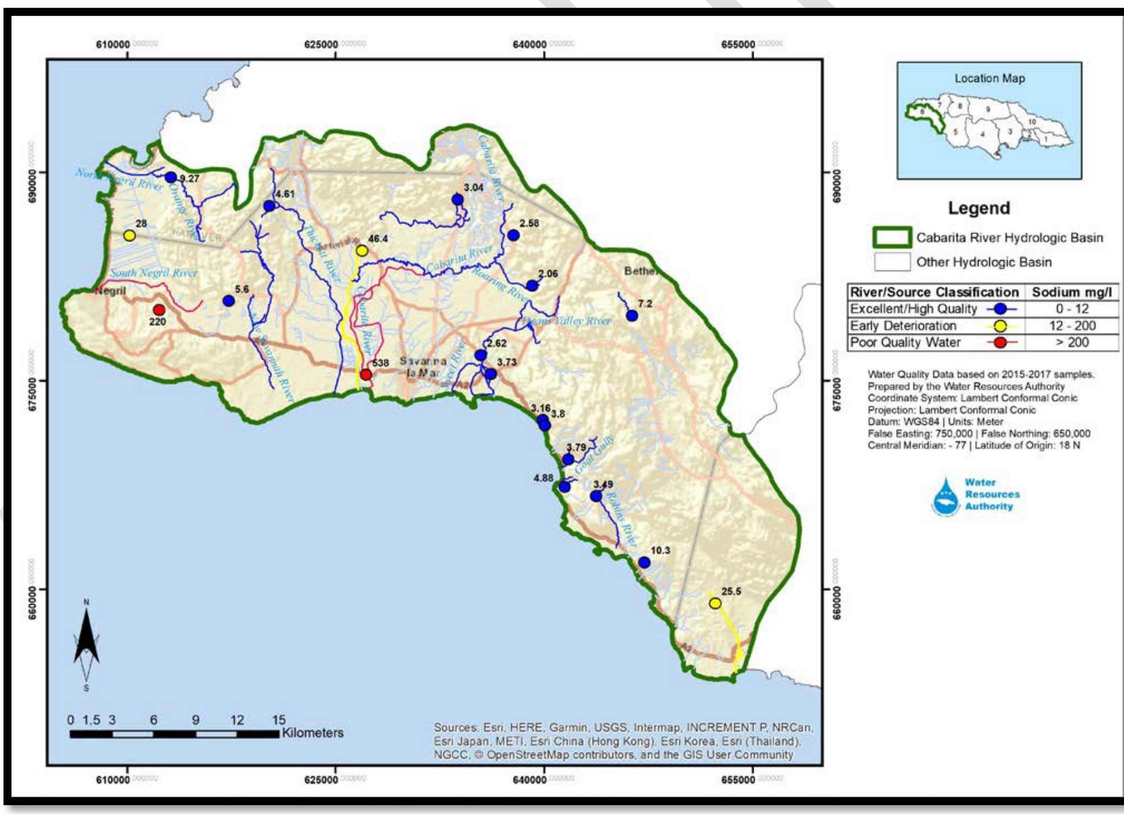


Figure 5-28: Cabarita River Hydrologic Basin Sodium Levels in Surface Water (Source: WRA, 2019)

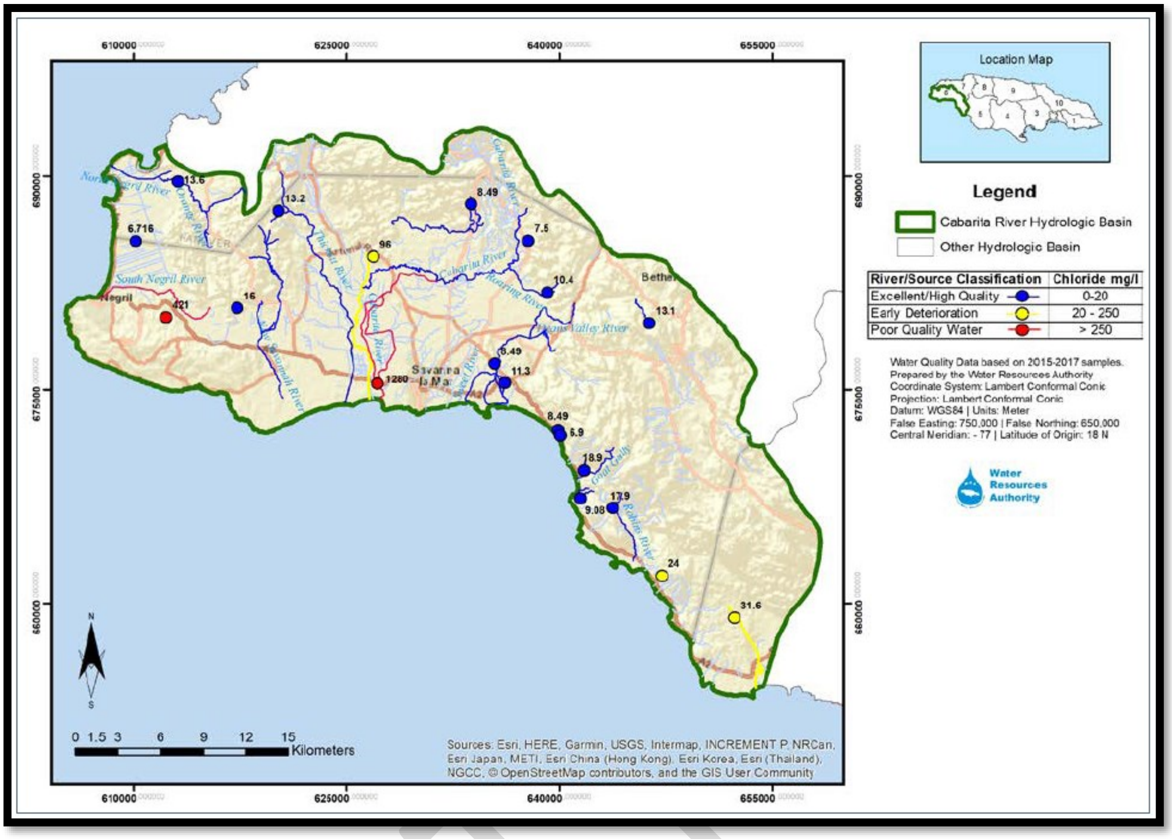


Figure 5-29: Cabarita River Hydrologic Basin Chloride Levels in Surface Water (Source: WRA, 2019)

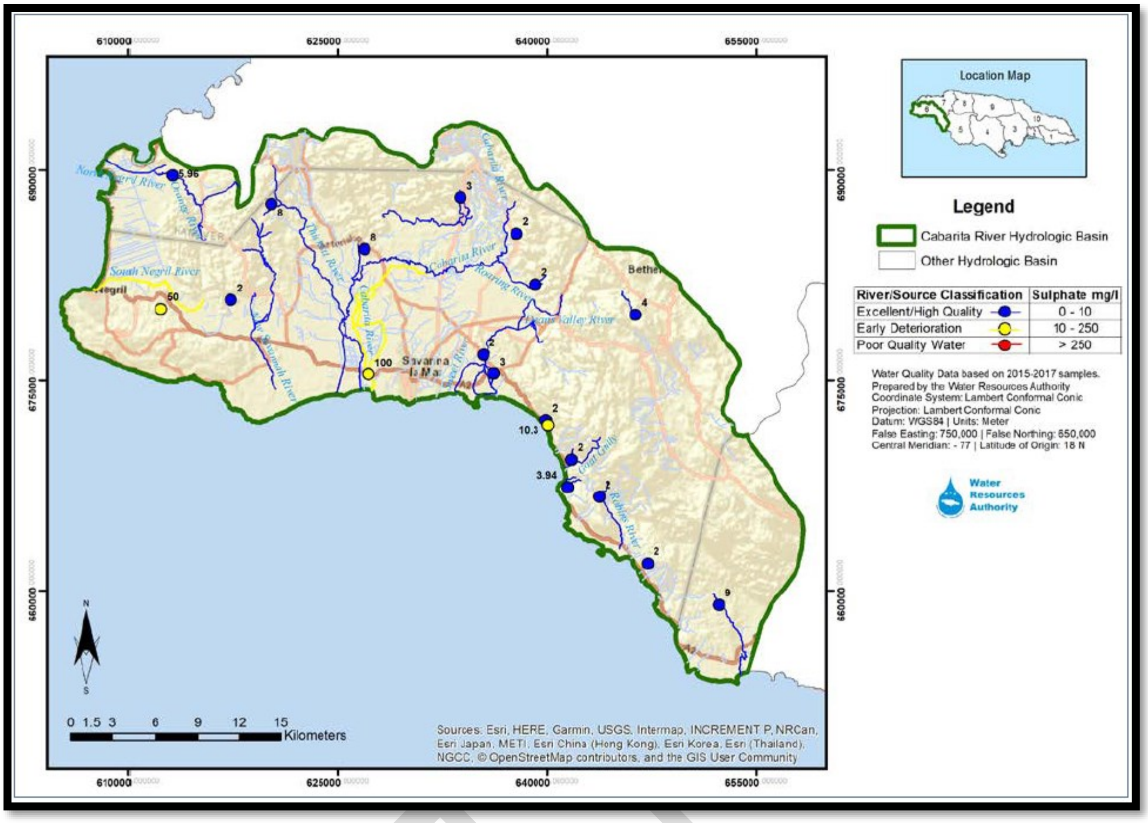


Figure 5-30: Cabarita River Hydrologic Basin Sulphate Levels in Surface Water (Source: WRA, 2019)

The Water Resources Authority (WRA) indicates that the project site is characterised as an alluvium aquiclude which rests on white limestone that is exposed to the east of the project site (see Figure 5-27). Alluvium aquicludes are comprised primarily of clay and are characterised by having low permeability in areas that have clay-rich soils/stones, while limestone aquifers are characterised as having high permeability. Based on the general hydrostratigraphy in the area, pollution of both surface and groundwater samples are of concern. However, based on where the mill site is located, surface water pollution will be more likely than groundwater pollution as clay soils have very good water holding capacity which will slow the percolation of water into the groundwater system. Although, surface water pollution is more likely, groundwater recharge mechanisms need to be evaluated to see if wells in the area may be affected by activities in the project. It must be noted that groundwater samples may show signs of pollution at a slower rate than surface waters as they move at a slower pace, and they can remain contaminated for much longer periods of time. If wells are to be dug on site, the client must be mindful of the potential impacts that mill operations will have on the quality of the subsequent groundwater.

Faecal coliform and *E.coli* were present in all water samples. Faecal coliform and *E.coli* in water samples, though typical of Jamaican surface waters, are linked to a source of recent faecal contamination. It is possible that the use of soak-away pits in this parish may be a major source of this faecal contamination. Animals, that use these water sources and live within them will also be a source of faecal coliform. It was observed that for all sampling locations, the majority of the faecal matter was characterised as *E. coli*.

Water along the Cabarita River, in addition to wells and springs, is one of the main surface water sources directly or indirectly used for public water supply in the parish of Westmoreland. If surface or well waters are considered to be used for domestic or production purposes, the water will need to be properly treated as these organisms can create health problems in humans, as well as animals, such as, but not limited to, diarrhoea, urinary tract infections and respiratory illnesses.

Since the client intends to use either the water from the Cabarita River or from commissioned wells close to or on the proposed project location as their boiler feedwater, the client may need to treat the water to reduce the hardness and the likely limescale build-up within equipment. If water is required for potable or domestic use, it must meet the local regulatory guidelines for potable water. If water is to be used for irrigation purposes at the mill (for e.g. on green spaces), it must also meet the local regulatory guidelines for irrigation. The effluent from any treatment process for production will be considered trade effluent and must be treated according to the applicable permit conditions.

5.1.6.2 Dry Season Assessment

Similar to the results obtained from the wet season assessment, results obtained for the dry season assessment were mostly compliant with the Draft Jamaica National Ambient Water Quality Standard – Freshwater, 2009. These results are presented in Table 5-10. Where results were not compliant (except for WQ12) with the standard for samples taken along and from tributaries of the Cabarita River, they were below the standard value. When the parameters exhibiting this trait (namely, sulfate, potassium, chloride and sodium) were compared to the data obtained from the WRA Water Quality Atlas, where applicable, they were all consistent with this Water Quality Atlas and fell within the range categorised as ‘excellent/high quality water’. Based on this and the results from the assessment, the Cabarita River and its tributaries, where assessed, did not show any signs of anthropogenic impact during this sampling activity complementing the results obtained from the wet season assessment. Additionally, for parameters that were described in detail in Section 3.2.1, all values were below or close to the typical limits listed for rivers not showing signs of deterioration due to anthropogenic impacts with the exception of mercury observed for WQ11 and WQ12. Mercury in freshwater systems can occur as a result of natural processes, however, this is unlikely and points to an anthropogenic source. WQ11 was taken from a point that was more densely populated as compared to the other sampling points, while WQ12 is downstream of this location. Additional investigations are recommended to evaluate the source of mercury in these water bodies as mercury can have devastating impacts on both human and aquatic health especially given the use and importance of this water body in the various communities.

Table 5-10: Description of Water Quality Parameters (March 2022)

PARAMETERS (units)	WQ1	WQ2	WQ3	WQ4	WQ5	WQ6	WQ7	WQ8	WQ9	WQ10	WQ11	WQ12
pH (pH units)	8.19 @ 26.2ºC	7.96 @ 24.8ºC	8.23 @ 25.9ºC	8.06 @ 26.6ºC	8.14 @ 24.4ºC	8.36 @ 25.4ºC	8.22 @ 24.7 ºC	8.15 @ 25.1ºC	6.98 @ 25.1ºC	8.13 @ 24.5ºC	8.16 @ 25.4ºC	7.65 @ 25.5ºC
Dissolved Oxygen (mg O_2/L)	7.19 @ 26.2ºC	7.77 @ 24.8ºC	8.15 @ 25.9ºC	8.02 @ 26.6ºC	8.80 @ 24.4ºC	8.18 @ 25.4ºC	7.34 @ 24.7 ºC	6.87 @ 25.1ºC	2.30 @ 25.1ºC	8.54 @ 24.5ºC	7.87 @ 25.4ºC	6.42 @ 25.5ºC
Conductivity (mS/cm)	0.352 @ 26.2ºC	0.361 @ 24.8ºC	0.335 @ 25.9ºC	0.330 @ 26.6ºC	0.325 @ 24.4ºC	0.282 @ 25.4ºC	0.330 @ 24.7 ºC	0.336 @ 25.1ºC	0.498 @ 25.1ºC	0.327 @ 24.5ºC	0.325 @ 25.4ºC	0.60 @ 25.5ºC
Salinity (ppt)	0.16 @ 26.2ºC	0.17 @ 24.8ºC	0.16 @ 25.9ºC	0.15 @ 26.6ºC	0.16 @ 24.4ºC	0.13 @ 25.4ºC	0.16 @ 24.7 ºC	0.16 @ 25.1ºC	0.24 @ 25.1ºC	0.16 @ 24.5ºC	0.15 @ 25.4ºC	0.29 @ 25.5ºC
Total Dissolved Solids (mg/L)	224.25@ 26.2ºC	235.95 @ 24.8ºC	214.50 @ 25.9ºC	208.00 @ 26.6ºC	213.85 @ 24.4ºC	182.00 @ 25.4ºC	215.80 @ 24.7 ºC	217.75 @ 25.1ºC	323.05 @ 25.1ºC	215.15 @ 24.5ºC	209.95 @ 25.4ºC	390.00 @ 25.5ºC
Nitrate (mg NO_3^-/L)	1.3	2.6	1.3	<1.3	1.3	<1.3	1.8	1.3	<1.3	<1.3	1.6	<1.3
Nitrate as Nitrogen (mg NO_3^--N/L)	0.3	0.6	0.3	<0.3	0.3	<0.3	0.4	0.3	<0.3	<0.3	0.4	<0.3
Total Nitrogen (mg/L)	2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	2.3	<2.2	<2.2
Orthophosphate (mg PO_4^{3-}/L)	0.09	0.14	0.10	0.05	0.07	0.06	0.09	0.12	0.04	0.07	0.07	0.07
Total Phosphorous (mg P/L)	0.08	0.10	0.06	0.06	0.04	0.04	0.06	0.04	0.07	0.06	0.04	0.04
Sulfate (mg SO_4^{2-}/L)	2	1	2	3	1	1	2	2	5	2	1	13
Faecal Coliform (MPN/100ml)	920	350	540	350	350	350	280	350	540	540	49	240
E. coli (MPN/100ml)	540	170	280	350	350	48	24	240	540	540	49	79
Total Suspended Solids (mg/L)	<1.6	2.1	<1.6	<1.6	<1.6	<1.6	<1.6	1.7	4.0	<1.6	2.0	2.7
Chloride (mg Cl^-/L)	6.0	3.6	6.4	6.4	4.4	4.8	5.6	3.2	5.2	4.0	4.0	10.4
Phenol (mg C_6H_5OH/L)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

PARAMETERS (units)	WQ1	WQ2	WQ3	WQ4	WQ5	WQ6	WQ7	WQ8	WQ9	WQ10	WQ11	WQ12
Total Alkalinity (mg $CaCO_3$/L)	179.5	189.1	176.1	159.0	172.0	143.7	175.1	175.1	267.2	177.5	171.3	175.9
Total Hardness (mg $CaCO_3$/L)	209.6	202.2	201.2	177.9	202.8	163.2	199.7	195.1	311.8	195.5	190.5	229.0
Chemical Oxygen Demand (mg O_2/L)	19	12	15	16	19	17	28	12	46	10	14	19
Dissolved Organic Carbon (mg/L)	0.56	0.56	0.59	1.3	0.68	0.82	1.6	0.51	3.3	0.65	0.78	0.61
Total Organic Carbon (mg/L)	0.57	<0.50	<0.50	1.2	0.51	0.56	0.66	0.61	3.5	0.53	0.55	0.60
Pesticide Screen (ppb)	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Biochemical Oxygen Demand (mg O_2/L)	0.7	0.8	0.8	0.9	1.3	1.1	0.4	0.9	3.3	0.9	0.8	1.0
Calcium (mg Ca/L)	72.3	76.4	74.3	68.1	72.1	58.9	73.6	73.3	117.0	72.7	70.4	77.4
Magnesium (mg Mg/L)	3.30	3.63	4.37	2.81	3.77	3.73	3.78	3.76	1.90	3.78	3.71	7.62
Silica (mg SiO_4/L)	9.39	10.6	11.9	11.9	11.4	12.5	11.6	11.7	6.42	11.5	11.5	9.52
Zinc (µg Zn/L)	<11.0	<11.0	<11.0	<11.0	<11.0	<11.0	<11.0	<11.0	<11.0	<11.0	<11.0	<11.0
Potassium (µg K/L)	<270	291	702	760	404	444	350	382	424	344	364	1800
Copper (µg Cu/L)	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6	<2.6
Arsenic (µg As/L)	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4	<3.4
Mercury (µg Hg/L)	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	<0.090	0.11	0.16
Chromium (µg Cr/L)	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
Manganese (µg Mn/L)	2.1	3.5	6.5	35.3	6.7	3.1	7.2	9.5	36.6	8.4	8.4	13.0

PARAMETERS (units)	WQ1	WQ2	WQ3	WQ4	WQ5	WQ6	WQ7	WQ8	WQ9	WQ10	WQ11	WQ12
Sodium (mg Na/L)	2.81	2.02	8.44	6.77	3.20	3.76	2.86	2.84	2.76	2.86	2.89	43.8
Lead (µg Pb/L)	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6
Iron (µg Fe/L)	<25.0	<25.0	76.2	238	43.3	42.6	60.4	119	1600	86.4	85.2	176
FOG (mg/L)	1	3	7	5	6	8	6	5	6	6	<1	<1

WQ9, the sample taken from a canal east of the proposed project location, and WQ12, the sample taken the most downstream of the proposed project locations, were the only two locations that exceeded the Draft Jamaica National Ambient Water Quality Standard – Freshwater, 2009, for total dissolved solids. In the case of WQ9, this may be as a result of the high calcium values seen at this location, which also exceeded the standard. This water body was also characterised by elevated iron levels, as well as TOC, DOC and COD values as compared to typical values of an unpolluted stream and/or the data obtained from the other water quality points from which samples were collected. The pH of this canal was also lower than the specifications of the standard and the other water quality points. This water sample was characterised as being yellow and slightly cloudy which may explain the elevated organic levels seen at this location. As defined in Section 3.2.1, total organic carbon (TOC) is the sum of dissolved organic carbon (DOC) and particulate organic carbon (POC) in a water body. As identified in the wet season assessment, based on the values obtained for TOC and DOC, it can be assumed that DOC was the fraction of TOC that was most prevalent in the water bodies and can originate from sources such as detritus and primary producers. Partially decomposed organic material can cause a water body to have a yellow-brown hue based on the substances produced. This site was heavily vegetated and slow moving and the processes occurring at this location may result in the water having this colour as well as the dissolved oxygen, chemical oxygen demand and TOC/DOC values observed. The elevated levels of iron within this water body may also be a contributing factor to the water colour observed at this location. Although a specific reason for the elevated levels of iron at this site was not observed, iron could originate from the source of the water, improper garbage disposal, rusting material close to the sample point or activities along the roadway which could result in run-off into the canal. Given the time of the collection of the water sample, the elevated mineral concentrations could also be due to the precipitation: dilution effect where reduced rainfall and water flow, as well as high evaporation rates can cause an increase in the concentration of some parameters.

As indicated in the above paragraph, WQ12 also exhibited levels of total dissolved solids which were consistent with the data from the WRA Water Quality Atlas. Similarly, WQ12 also had values that exceeded the Draft Jamaica National Ambient Water Quality Standard – Freshwater, 2009, for sulphate and sodium. However, given the results from the WRA Water Quality Atlas, this would also be typical of this water body. Based on this atlas, the increased sodium and sulphate values seen during this sampling exercise may result from a combination of inputs to the Cabarita River (i.e., tributaries) and/or activities along the river.

5.1.6.3 Comparison between Dry and Wet Season

A non-parametric test, the Wilcoxon signed-rank test, was used to compare the data obtained for the indicator parameters pH, DO and TDS across water quality samples taken along the Cabarita River (WQ3, 5-8) in the wet and dry seasons. Given the statistical test used, $p<0.05$ and $z>2/-2$ indicates a statistical difference between the two variables measured. Based on the results obtained, it was seen that there was a statistically significant difference between the pH obtained for the wet season and the pH obtained during the dry season ($z=-2.02$, $p=0.043$), whereas there was not a statistically significant difference between the DO and TDS obtained during the wet and dry seasons [$z = -1.753$, $p = 0.080$ (DO); $z = - 0.674$,

p = 0.500 (TDS)]. As such, it is assumed that parameters directly contributing to or having a direct relationship with TDS would also not be impacted by the wet or dry season.

It was seen that the pH during the wet season assessment of the assessed water quality points ranged from 7.65–7.94 pH units, while the pH during the dry season assessment ranged from 8.14–8.36 pH units. This indicates that pH levels during the dry season are higher than those seen in the wet season. This may be as a result of increased decay in organic matter from surface run-off. This process releases acidic compounds which may result in a slight lowering of pH. As the river is fast flowing, there may not be a drastic decrease in dissolved oxygen due to aeration of the water body resulting from turbulence as well as the lack of any significant polluters to the river system. However, it must be noted that the data pool was small and additional data points in both seasons may be necessary to ascertain, with full confidence, if seasonal variation is observed with the pH of the water body. Nonetheless, the pH obtained in both seasons would both be typical of Jamaican freshwaters (see Table 5-6). Although the DO levels obtained were not statistically different, there was an observed difference between the DO levels seen in the dry season ($\bar{x}$ = 7.87) as compared to the wet season ($\bar{x}$ = 7.11). This could possibly result from the lower levels of water observed in the dry season. Oxygen enters water bodies through the air-water interactions which increase with lower volumes of water. Additionally, with the decrease in the volume of the water body, there is an increase in the depth at which sunlight can penetrate the water column which may increase the rate at which aquatic plants photosynthesise. Most water samples were taken in a zone where aquatic plants were present.

There was also an observed difference in the total suspended solids, chemical oxygen demand, and fats, oil and grease (FOG) observed during both sampling exercises. The total suspended solids observed in the dry season ranged from >1.6 mg/L to 1.7mg/L, while the range in the wet season was from 1.7mg/L to 6 mg/L. Although in both seasons, the total suspended solids values were still relatively low, the data does suggest that the season may impact the total suspended solids seen in the water body. The increase in the TSS range observed in the wet season may possibly be due an increase in sedimentation present in the water body due to increased water flows, water levels, or run-off. The results obtained in the TSS values were also apparent in the appearance of the water during the wet season when compared to the dry season, that is, in the dry season, water appeared clearer than in the wet season.

Higher chemical oxygen demand values were observed in the dry season as compared to the wet season. Values in the wet season ranged from 3–10 mgO_2/L, while values in the dry season ranged from 12–28 mgO_2/L. It is unclear what may have resulted in the general increase seen in the chemical oxygen demand values taken in the dry season. However, the values obtained from the TOC/DOC and BOD tests were generally either similar to or lower than the values obtained in the wet season. Hence, the unassessed inorganic contributors, which may have increased in concentration due to the lower volume of water present in the river at the time of the assessment, could have contributed to the increase seen in the COD values. Additionally, the apparent increase in the fats, oil and grease levels will also contribute to the COD results obtained. Chemical oxygen demand is the measure of species, organic or inorganic, which can be broken down by a strong oxidising compound.

The FOG parameter was undetected at all locations during the wet season assessment, while there was a general increase seen across the water quality samples for the dry season. FOG refers to the substances that are generally immiscible in water and that are commonly used in industrial or daily activities such as cooking. Although there is no standard for FOG, this parameter can have deleterious impacts on aquatic life. Given the effects that this parameter may have on the environment, the USEPA recommends that *surface waters be virtually free from floating oils of both non-petroleum and petroleum natures.*[xxxvi] During the assessment, there was no film or sheen observed on the water surfaces of the Cabarita River complying with this recommendation from the USEPA. However, it must be noted that the use of the river for purposes such as washing or bathing could have contributed to the FOG observed in the water streams during the dry season assessment. An increase in river activities in and along the river (people were seen bathing, fishing, washing cars, etc.) was observed during the dry season assessment as compared to the wet season assessment. With further monitoring of the waterway over the various seasons, the trends in dry and wet season data should provide further information on the contributors to the quality of the water measured.

The tributaries as well as the canal were also assessed to determine if there was any evidence of seasonal variation in these water streams using the indicator parameters TDS, DO and pH. Since there was only one point per season taken for these tributaries, the data was assessed by comparing the relative percentage duplicate (RPD) where a value of greater than 5% was taken to show some amount of variation between the two values. For WQ1, an RPD of >5% was only observed for pH (RPD=9.2%). As for the water quality points taken from the main Cabarita River, the wet season pH was lower than that of the dry season pH which may also be attributed to the factors discussed above. For WQ4, an RPD exceeding 5% was observed for all parameters assessed suggesting that the quality of this water stream may be significantly impacted by seasonal changes (pH RPD = 10.4%; DO RPD = 26.1%; TDS RPD = 47.1%). Similar to the other water quality sampling points, the pH observed in the wet season was lower than that of the dry season and the dissolved oxygen was lower in the wet season as compared to the dry season. However, the TDS of this water body was higher in the dry season as compared to the wet season. Given that this is a smaller stream, the precipitation (dilution effect where reduced rainfall and water flow, as well as high evaporation rates, can cause an increase in the concentration of some parameters) may be evident at this location. The source of the water may also be a contributary factor in the results obtained at this location. When WQ9 was assessed, it was seen that the DO and TDS levels had an RPD exceeding 5% (DO RPD = 20.3%; TDS RPD = 14.0%). However, for the canal, it was seen where the DO was lower in the dry season and the TDS higher in the dry season. The cause for the lower DO in this canal as compared to the wet season may be due to the increased organic loading seen in water body as explained above, while less rainfall may cause the concentration of some parameters to increase as discussed.

Overall, from the two sampling exercises, the data indicated that there are possibilities of diverse inputs to the Cabarita River. Nonetheless, the various tributaries and the samples collected along the Cabarita River from both the wet and dry season assessments were of good quality, based on the parameters analysed, except for the bacterial levels in all water samples and the increase in metal and total dissolved solids concentration further downstream of the proposed project location. There will be a need to

[xxxvi] https://www.epa.gov/sites/default/files/2018-10/documents/quality-criteria-water-1976.pdf

implement a robust monitoring plan to ensure that the activities to be introduced in the area will not impact these water systems negatively. It should be taken into consideration, however, that the data presented is from one sampling exercise in each season and as such, additional data capturing spatial and temporal variations of the water quality should be done to assess the quality of the water in a more holistic manner.

5.1.7 AIR QUALITY

The locations of the seven monitoring sites are presented in Figure 3-5, Figure 3-6 and Figure 5-31. The descriptions of the air monitoring sites during each season are presented in **Appendix K.** Table 5-11 presents the results for the hydrogen sulphide (H_2S), nitrogen oxides (NO_x) and sulphur oxides (SO_x) obtained during the wet season, while Table 5-12 presents the results obtained during the dry season assessment. Although the results of the activity collected in November 2021 (wet season) cannot be used as an indication of ambient air quality, the data was still used for comparative purposes.

The data obtained for the nitrogen oxides, sulfur oxides and hydrogen sulfide were undetected at all sites where measurements were taken (see Table 5-11 and Table 5-12). It should be noted that rainfall was experienced during the wet season assessment. Both oxides of nitrogen and sulphur are water-soluble and will therefore be easily scrubbed from the atmosphere. However, given that no acidic gases were detected in the dry season assessment, it can be assumed that the monitoring sites generally had low concentrations of these gases. It is recommended that longer monitoring assessments for these gases be done for future sampling exercises given the low concentrations present in the environment.

Table 5-11: Acidic Gas Measurements for Selected Sampling Sites (November 2021)

LOCATION	NOx (ppm)	SOx (ppm)	H_2S(ppm)
Site 1	<0.99	<0.81	<0.00057
Site 2	<0.99	<0.81	<0.00057
Site 3	<0.99	<0.81	<0.00057
Site 4	<0.99	<0.81	<0.00057
Site 7	<0.99	<0.81	<0.00057

Table 5-12: Acidic Gas Measurements for Selected Sampling Sites (April 2022)

LOCATION	NOx (ppm)	SOx (ppm)	H_2S (ppm)
Site 1	<0.040	<0.032	<0.00057
Site 2	<0.037	<0.030	<0.00057
Site 3	<0.038	<0.031	<0.00057
Site 4	<0.038	<0.031	<0.00057
Site 7	<0.037	<0.030	<0.00057

For the wet season assessment, all PM_{10} data were below the 150 µgm-3 NRCA standard value (Table 5-13). The PM_{10} data ranged from <0.1 µgm^{-3} in the Friendship community (Site 3) to a high of 39.9 µgm^{-3} along the 'Hertford to Flowerhill' Road (see Figure 5-31). It must be noted that the environmental conditions present at the time of sampling, (e.g., slightly windy and rainy) created conditions that would result in lower concentrations of detected air quality parameters.

Table 5-13: PM_{10} Results for selected Sampling Sites (November 2021)

LOCATION	PM_{10} Concentration (µgm^{-3})*
Site 1	5.1
Site 2	39.9
Site 3	<0.1
Site 4	4.9
Site 5	2.1
Site 6	19.8
Site 7	29.6

***NRCA Particulate Matter Concentration (µgm-3) for 24-hour Period Standard = 150**

Sampling sites 2, 6 and 7 were located along the very busy 'Hertford to Flowerhill' Road (see Figure 5-31). As such, the particulate matter levels obtained were most likely due to motor vehicular exhaust and/or the high traffic density. Sites 1 and 5, although taken along the 'Truro Gate to Locust Tree' major road, had fewer vehicles traversing the roadway at the time of the assessment. Site 3, located north of the proposed sampling point was in a secluded area with few houses and had infrequent vehicle usage on the main road at the time of the assessment. Similarly, the air quality sample take at Site 4, Friendship Primary and Infant School, also had infrequent vehicle usage on the main road, similar to that seen at sites 1 and 5.

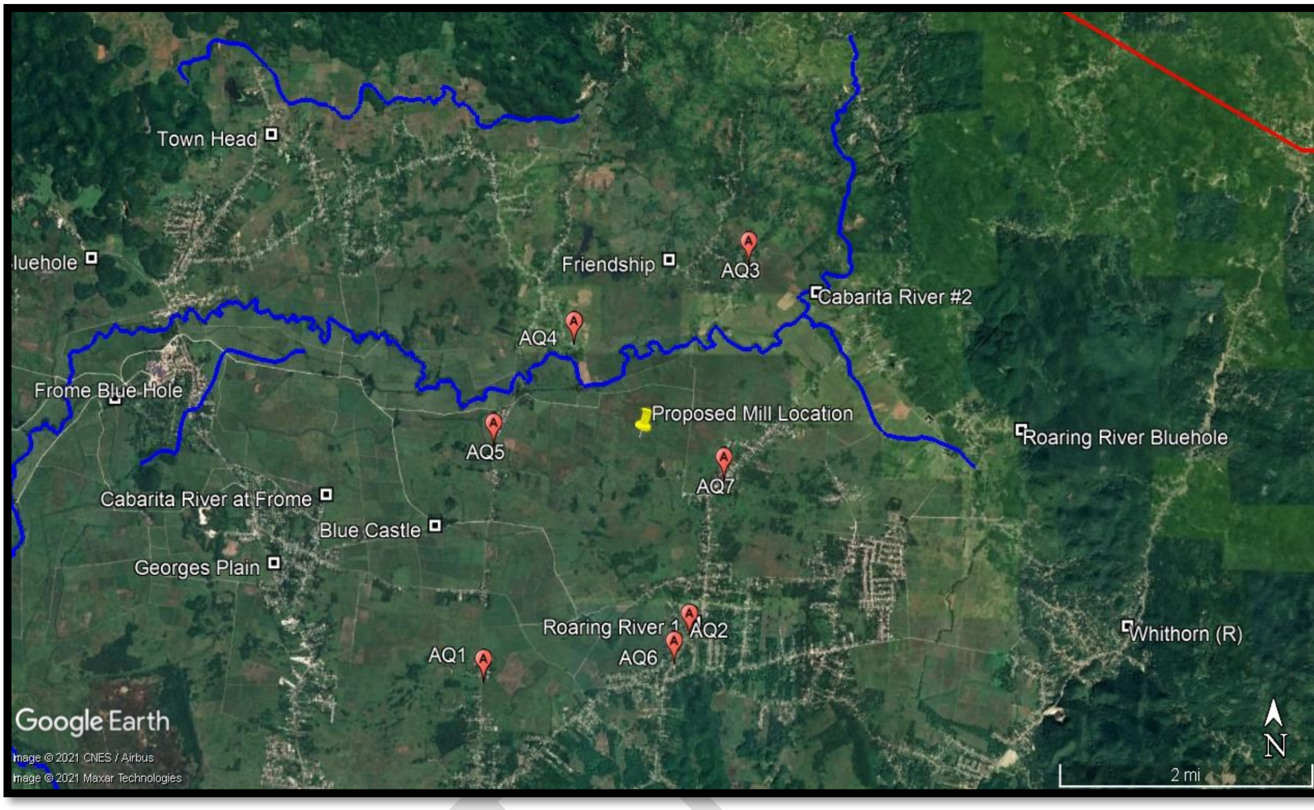


Figure 5-31: AQ and Noise Sampling Points (November 2021)

The elevated levels of PM_{10} seen along the 'Hertford to Flowerhill' Road point to an increased risk of exposure once traffic through the area is increased with the movement of trucks carrying materials for the proposed project. This roadway has been identified for potential entry locations for the proposed mill. Vehicular emissions and operations are sources of PM_{10} and vehicles which are not properly maintained may be considered major contributors to air pollution as their engine inefficiency may not only result in the incomplete combustion of fuels, but also emit larger concentrations of fine particulates.

Additionally, as some of the roads have unpaved sections, and several schools are located close to busy thoroughfares, it is advised that rigorous monitoring and management programmes be developed and implemented to carefully monitor and put into effect, where necessary, the appropriate corrective actions.

According to the Metrological Office in Jamaica, for the period November 2020 to October 2021, the prevailing wind direction obtained from the Savanna-la-Mar station, located approximately 5.5 km southwest of the Hertford community, was NNE and accounted for approximately a quarter (22.9%) of the wind directions. Prevailing winds are the direction that the wind blows from most often in particular locations on the Earth. Other common wind directions observed in the area were NE (20.8%), N (11.2%), and SW (12.4%). This suggests that the most sensitive receptors, based on proximity and wind direction, would be those communities located SSW, SW, S (between AQ1 and AQ6) and NE (AQ3) of the project location.

It is important to note that the aquatic and the riparian ecosystems present along the Cabarita River, located north of the proposed project site, will act as a buffer for any particulate matter, gases and other air emissions generated from the mill activities for receptors northwards of the proposed project location. Heavily vegetated areas will also act as a buffer as trees and plants act as natural filters and collect particulate matter. The clearing of vegetation in the area may greatly impact the concentration of particulate matter that affects communities west, east and south of the proposed mill location.

Similar to the results obtained during the wet season, all locations exhibited PM_{10} concentrations lower than that of the 24-hour NRCA Standard for PM_{10} concentrations (150 µgm^{-3}) during the dry season (see Figure 5-32).

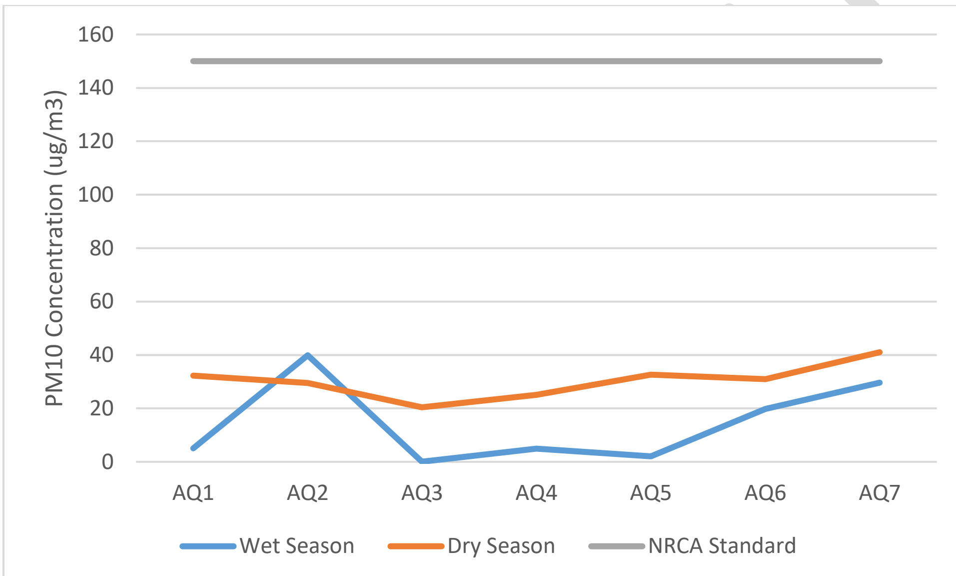


Figure 5-32: Comparison of Wet and Dry Season Data with NRCA Standards

Following the same trend as the wet season assessment, the data in the dry season ranged from a low of 20.42 µgm^{-3} (Site 3) in the Friendship community to a high of 41.03 µgm^{-3} (Site 7) along the busy 'Hertford to Flowerhill' Road (see Table 5-14).

Table 5-14: PM_{10} Results for Selected Sampling Sites (March 2022)

LOCATION	PM_{10} Concentration (µgm^{-3})*
Site 1	32.22
Site 2	29.58
Site 3	20.42
Site 4	25.14
Site 5	32.64
Site 6	30.97
Site 7	41.03

***NRCA Particulate Matter Concentration (µgm^{-3}) for 24-hour Period Standard = 150**

The sites showing the highest particulate matter concentrations were along the roadways that were more frequently used (i.e., the Hertford to Flowerhill Road and the Truro Gate to Locust Tree Road) whereas the roadways that were less frequently traversed (i.e., AQ3 and AQ4) presented the lowest PM_{10} concentrations; AQ3 had the lowest volume of observed traffic at the time of the assessment. Although all assessment sites were characterised by PM_{10} results that were lower than the NRCA limits for PM_{10} concentrations over a 24-hour assessment period, there was a general increase seen in the data obtained during the dry season as compared to the wet season. This suggests that "dry" conditions have an impact on the PM_{10} levels in the area. At the time of the assessment, the environmental conditions were dry and windy. The presence of exposed grounds and unpaved roadways in the area, as well as the lack of rainfall, may account for the increase in PM_{10} levels obtained during the dry season assessment.

As mentioned above, vehicular emissions and operations are sources of PM_{10}. With the proposed project, there will be an increase in vehicular traffic both directly and indirectly especially along the 'Hertford to Flowerhill' Road as this is one of the proposed entry points to the project site. Given the data obtained from the dry season and wet season assessments, additional management and monitoring plans may need to be considered in the dry season as there may be an increased risk of elevated PM_{10} levels, as well as acidic gases during this season. It is recommended that additional monitoring exercises be conducted prior to construction to establish a background concentration for the PM_{10}, H_2S, NO_x and SO_x levels in the ambient environment.

Although assessments were completed in both the wet and dry season, it is recommended that additional data collection activities be done prior to construction activities as to derive a baseline of ambient air quality conditions specifically as it relates to particulate matter (specifically PM_{10}) in the area. These activities should be done across both seasons as a post permit condition. It is proposed that the assessment locations include one site upwind and downwind of the proposed mill site, along with any areas of concern identified from the Air Dispersion Model Report. It is suggested that between 12- 16 samples are collected per season for the sites upwind and downwind of the mill site. At least 3 samples from the areas of concern should also be collected in each season. It is suggested that if the results are well within the ambient standard, that the sampling regime be less intense or discontinued upon approval from the regulatory agency.

5.1.8 NOISE

Noise measurements were collected from the same seven (7) sites as the air quality samples (see Figure 3-4 and Figure 5-31). The measurements were collected from these locations to assess the current noise levels in the area. As stated above, these roads may be used for the movement of materials (via trucks) and other heavy equipment during both the construction and operation phase of the proposed project. The current proposed points of entry of the project are along the 'Hertford to Flowerhill' Road. The descriptions of the noise survey sites from the assessments are presented in **Appendix L**. Figure 5-33 presents the results of the survey. The noise readings reported represents continuous noise levels taken over a 3-minute interval.

The average noise readings measured for all the sites assessed exceeded the NEPA Ambient Noise Standard of 55 dBA for residential areas, except for the day 2 survey for site AQ3 (see Table 5-15).

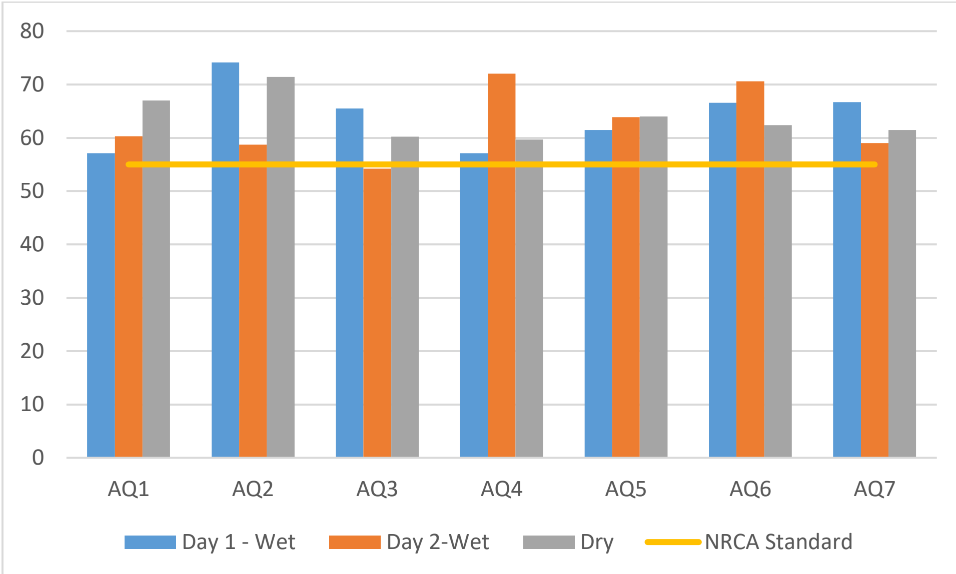


Figure 5-33: Variation in Noise Levels for Selected Sampling Sites

Table 5-15: Noise Measurements for Selected Sampling Stations*

Location	Noise Level (dBA)					NEPA Ambient Noise Standard (dBA) for Residential Areas
	Day 1	**Average Noise Level (dBA)**	**Day 2**	**Average Noise Level (dBA)**	**Average Noise Level for each Location (dBA)**	
November 2021						
Site AQ1	**57.1**		**60.3**		**58.7**	
Site AQ2	**74.1**		**58.7**		**66.4**	
Site AQ3	**65.5**		54.2		**59.8**	
Site AQ4	**57.1**	**64.1**	**72.0**	**62.6**	**64.6**	**55**
Site AQ5	**61.5**		**63.9**		**62.7**	
Site AQ6	**66.6**		**70.6**		**68.6**	
Site AQ7	**66.7**		**59.0**		**62.8**	
May 2022						
Location	**Noise Level (dBA)**		**Average Noise Level**		NEPA Ambient Noise Standard (dBA) for Residential Areas	
Site AQ1	**67.0**					
Site AQ2	**71.4**					
Site AQ3	**60.2**					
Site AQ4	**59.7**		**63.7**		55	
Site AQ5	**64.0**					
Site AQ6	**62.4**					
Site AQ7	**61.5**					

*Values that exceed the standard are highlighted in red.

The average noise levels ranged from a low of 54.2 dBA (at site 3) to a high of 74.1 dBA (at site 2) during the first assessment in November, while noise levels ranged from a low of 59.4 dBA (at site 4) to a high to 71.4 dBA (at site 2) during the second assessment conducted in May (Table 5-15). Although a standard value of 55dBA is being used since most of the areas are residential, it should be noted that there was a school located at Site 4 which would be categorised as a silent zone when in operation. In such cases, the noise level should not exceed 45dBA.

For all sampling locations, noise levels could be attributed to vehicular noises and this observation highlights the susceptibility of the residents in the area to impacts from increased noise levels during the passage of trucks during both the construction and operational phases. Rainfall experienced during the survey would have also impacted the noise levels experienced during the first assessment. As such, it is recommended that additional surveys over longer periods be conducted to derive a baseline representative of the existing community.

The project intends to use electric trucks during the operational phase and this should minimise the noise added to these communities. As such, it is recommended that a maintenance schedule be developed and implemented for all vehicles to minimise or eliminate adverse environmental impacts. It should be noted that additional sources of noise will be introduced to the areas during the project's construction and operational phases, however, by implementing the recommended mitigative measures, it is expected that the negative impacts that arise would either decrease or would be minimal.

A paired t-test was used to assess the average noise values obtained from the first assessment conducted in November 2021 and the noise values obtained from the second assessment conducted in May 2022. It was found that there was no statistically significant difference between the noise levels obtained in November ($\bar{x} = 63.3$; sd = 3.50) versus those obtained in May ($\bar{x}=63.7$; sd = 4.18); [$t(6)= -0.191$; $p=0.855$]. This suggests that management strategies for noise pollution could be maintained throughout changes in seasons as variations in the values obtained were minimal.

5.1.9 SOURCES OF EXISTING AND POTENTIAL POLLUTION

5.1.10 AIR EMISSIONS

EXISTING SOURCES

- There were no observed sources of significant air emissions associated within the direct proposed project location and within the 2 km sphere of influence.
- Outside of the proposed project location but within the 2 km sphere of influence, the primary sources of pollutant air emissions observed were respirable particulates associated with vehicular traffic.
- Outside of the 2 km sphere of influence, existing companies may contribute to elevated air emissions.

POTENTIAL SOURCES

- Emissions into air from a typical Kraft pulp mill originate from the offloading and conveyance of chips, the cooking digester, pulp washing, the TCF bleaching plant, bleaching the chemical preparation, recovery of chemicals, evaporation, other auxiliary boilers, the recovery boiler, white liquor preparation, tanks and pulp drying. They consist mainly of compounds containing sulphur, for example, sulphur dioxide (SO_2) and malodorous reduced sulphur compounds such as H_2S. From the furnaces of the Recovery Boiler, nitrogen oxides, particulate matter, volatile organic compounds (VOCs) and carbon monoxide (CO) can also be emitted. An overview of the potential emissions to air from a Kraft pulp mill and air emissions from the proposed mill are illustrated in Figure 4-23 and Table 4-8 in Section 4.11.

5.1.11 NOISE

EXISTING SOURCES

- There were no observed sources of significant noise pollution associated within the proposed project site.
- Outside of the proposed project site, the primary source of noise pollution is associated with vehicular traffic.

POTENTIAL SOURCES

- It is likely that both stationary and moving sources of noises will be associated with the proposed project. The major stationary sources include mechanical equipment, physical activities on the site, as well as energy usage and production equipment such as steam generation systems and vacuum pumps. The moving sources include trucks and vehicles carrying and offloading raw materials, fuels and finished goods and any conveyance systems.

5.1.12 WATER

EXISTING SOURCES

- Although typical for Jamaican freshwaters, high levels of faecal matter exist within the water body which may be due to the use of soak-away pits, animal/human use and/or surface run-off.

POTENTIAL SOURCES

- Effluents from operations are anticipated to be a potential source of water contaminants.
- Emissions to water from a typical Kraft pulp mill will be predominantly oxygen-consuming organic substances, which are measured as chemical oxygen demand (COD) and biological oxygen demand (BOD) (
- Figure 4-18). Emissions to water may also include heavy metals, suspended solids, dissolved solids and nutrients such as nitrogen and phosphorous. The wastewater will include pulp mill wastewater, blow down from recovery boilers, cooling tower, sanitary wastewater from the mill and other miscellaneous streams. Additionally, the pollution depends mainly on the design and operation of the processes that cause most of the discharges and on the degree of closure of the mill.
- According to the European BAT Guidelines, the potential emissions that could be released into water resources are presented in Figure 5-34.

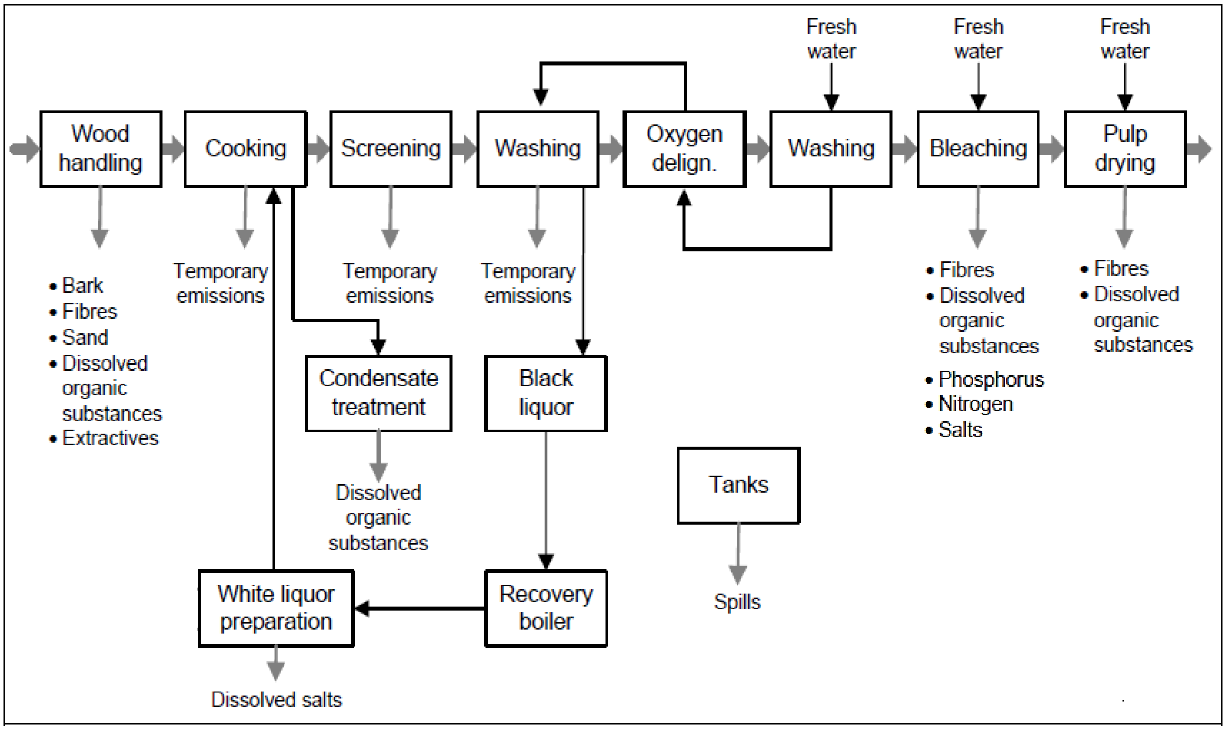


Figure 5-34: Emissions to Water and/or Water Treatment Plant that are typically produced by a Kraft Mill, adapted to the Project Information provided (Source: Adapted from the European BAT Guidelines, 2015)

5.1.13 SOLID WASTE

EXISTING SOURCES

- Existing sources of solid waste pollution are generated from the current farming activities (sugar cane) and associated influence of human use at the site and nearby communities.

POTENTIAL SOURCES

- The proposed project is expected to generate non-hazardous solid waste, with limited hazardous wastes in conformance with the European BAT Guidelines presented in
- Figure 4-18 and Table 4-4. These include residual waste from processing and harvesting bamboo, inorganic sludge (e.g., green liquor sludge, lime sludge) from chemical recovery, general trash (e.g., plastics) and biological sludge from wastewater treatment. Hazardous waste may include oil and grease residues, scrap electrical equipment and some chemical residues.

5.1.14 POTENTIAL PATHWAYS FOR CONTAMINATIONS ASSOCIATED WITH PROJECT

Potential pathways from contaminant sources identified above include:

- Site visitors, site workers, construction workers ➔ physical contact, ingestion, inhalation of dust/fumes
- Groundwater and/or Surface water ➔ leaching, runoff may be the source of organic pollution and faecal contamination in nearby water resources, flooding
- Land quality before/during/after development ➔ leaching, surface water/groundwater runoff, direct contact
- Adjacent site users before/during/after development ➔ leaching, surface water/groundwater runoff, direct contact
- Biodiversity ➔ direct contact, ingestion/uptake, ingestion, inhalation of dust, surface water, groundwater, invasive nature of bamboo species.

5.1.15 POTENTIAL RECEPTORS

Potential receptors associated with the proposed project include:

- People (on or off site)
- Nearby agricultural lands, including fields and allotments used to grow food
- Drainage systems
- Homes, or groups of homes (communities, housing developments)
- Playing fields and playgrounds (or other communal/green spaces)
- Footpaths
- Schools, hospitals, and other public buildings
- Drinking water supplies
- Water sources, e.g., ponds, streams, rivers, dams
- Groundwater and connectivity
- Conservation and habitats protected areas and areas of scientific interest
- Protected, rare, endangered, or economically important species
- Wildlife and marine life

5.2 ECOLOGICAL ENVIRONMENT

5.2.1 GENERAL ECOLOGY ASSESSMENT

5.2.1.1 Vegetation/Flora

The proposed project site is on agricultural land and consists of a large expanse of cane fields bordered to the north by the Cabarita River. The area was surveyed twice, during the wet season and dry season within 2 km of the project site. Wet season surveys occurred during November 2021 and dry season surveys occurred in late February 2022. The dry season spans between December–March and the rainy season spans between April–November which can be divided into an early rainfall season (April–June) and a late rainfall season (September–November). A mid-summer minimum in July separates the early and late wet seasons. Jamaica receives most of its rainfall during the late rainfall season, with May and October being the rainiest months, while February and March are the driest months of the year.

The area surveyed during the wet season, on November 4–5, 2021, spanned between the Moram Bridge towards the west and just east of the Friendship Bridge, as well as extending southward towards the linear community of Hertford as seen in Figure 5-35. A limitation of the survey was the accessibility to some areas based on the tall, thick and extensive sugarcane (Plate 5-1) and the presence of private properties. The flora and fauna identified were found to be continuous and repetitive. There were no notable changes between the flora and fauna identified during the dry season, compared to the wet season.

There were no biologically unique landscapes or areas with special conservation status identified within or in the immediate surroundings of the project area.

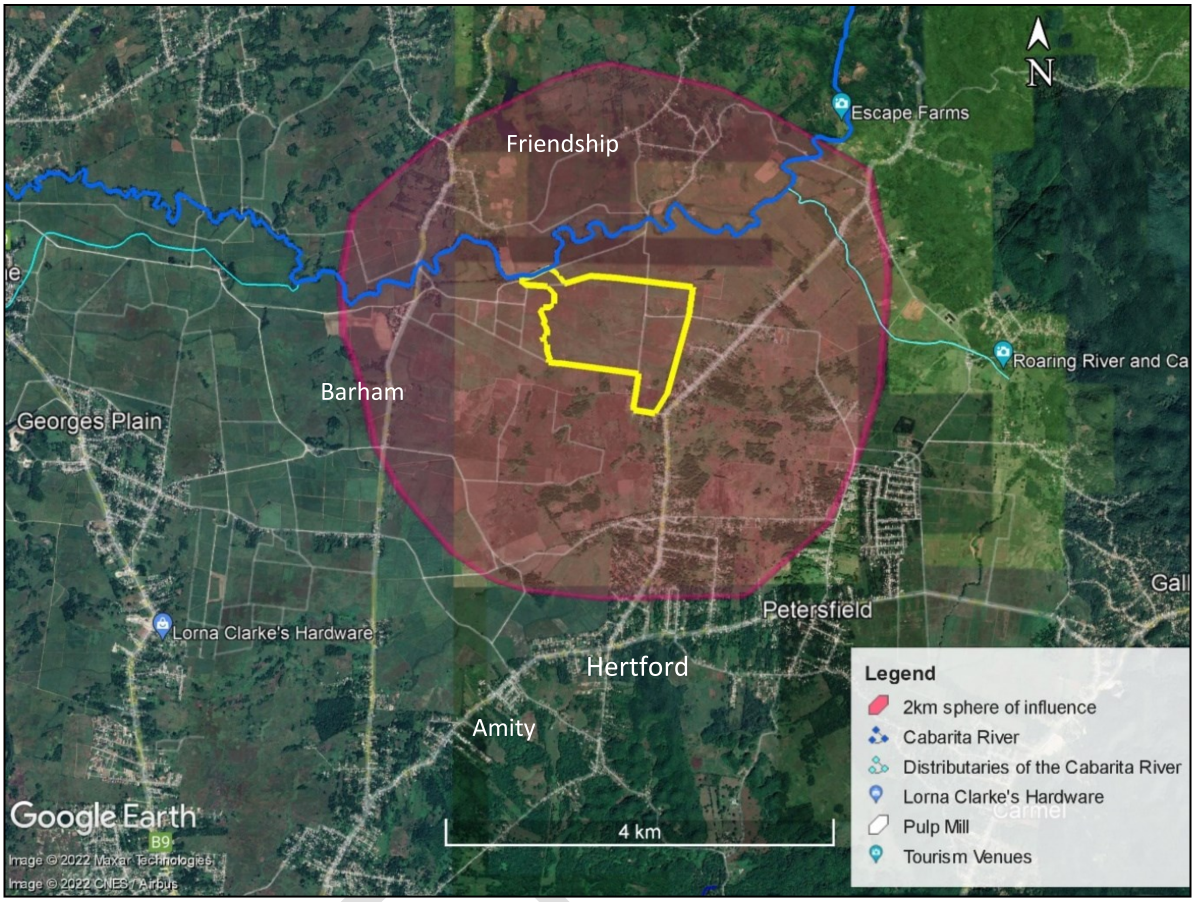


Figure 5-35: Aerial Extent of ecological Survey Area (Source: Google Earth Pro, 2021)

5.2.1.2 Flora Assessment

5.2.1.2.1.1 On land within the project area

In combination with the sugarcane plants identified, the localised vegetation groups observed across the study area consisted of perennial grasses, riparian vegetation and shrubs/scrubs. Each of these serve their own purpose and contribute to the diversity in fauna, particularly birds, identified on site.

The perennial grasses were found lining the cane field and the existing informal marl roads that run across the site (Plate 5-1). These consisted of a low diversity collection of seeded grasses of which Guinea Grass (*Panicum maximum*), Crab Grass (*Digitaria* sp.) and Piano Grass (*Themeda arguens*) were the most dominant. Other grass species identified along with the shrubs/scrubs, vines and runners which were found growing amongst these grass tufts are listed in Table 5-16. Whilst these do not serve as sensitive habitats with endemic species, they operate as key ecosystems that supports multiple taxa and provide several functions. These grasses serve as a food source for much of the associated fauna identified. Therefore, their presence promotes increase in biodiversity and sustenance to a variety of ecosystem functions, promoting the creation of multifunctional agricultural landscape. Notable ecosystem functions include methane consumption, pest suppression, pollination, and conservation of grassland birds.

Plate 5-1: Sample of perennial Grass and Shrubs/Scrubs on Site

5.2.1.2.1.2 Along the Cabarita River

The northward riparian vegetation, whilst not directly located within the demarcated Bamboo site, was also investigated both upstream and downstream of the proposed intake and treated waste outfall area along the Cabarita River (Figure 5-35). The majority of emergent vegetation and trees were located along this area and provides a number of functions to the river. These were dominated by mainly Guango, West Indian Almond, West Indian Tulip and Trumpet trees with a herbaceous shrubby understory (Plate 5-2 and

Table 5-16). Already, there is also several stalks of Bamboo interspersed between the existing vegetation. It is anticipated that the vegetation along the river will remain largely undisturbed by the development.

Plate 5-2: Vegetation identified along the Cabarita River

Table 5-16: Main Flora identified across Study Area

Species Name	Common Name	DAFOR
Riparian Vegetation		
Samanea saman	Guango	D
Terminalia catappa	West Indian Almond	D
Cocos nucifera	Coconut	O
Bambusa vulgaris	Bamboo	F
***Ficus* sp.**	Fig	R
Spathodea campanulata	African Tulip Tree	A
Jacaranda mimosifolia	Jacaranda	R
Cecropia peltata	Trumpet Tree	A
Cedrela odorata	West Indian Cedar	O
Albizzia lebbek	Woman's Tongue Tree	O
Perennial Grasses and Scrubs/Shrubs		
Panicum maximum	Guinea Grass	D
Themeda arguens	Piano Grass	A
***Setaria* sp.**	Foxtail	A
Centrosema pubescens	Butterfly Pea	O
Mimosa pudica	Shame Weed	F
***Crotalaria* sp.**	Rattlebox Weed	A
Cladium mariscus	Sedge	A
Dactyloctenium aegyptium	Crowfoot Grass	A
Brachiaria decumbens	Signal Grass	F
***Digitaria* sp.**	Crab Grass	F
Asystasia gangetica	Chinese Violet	F
Bidens pilosa	Spanish Needle	O
Synedrella nodiflora	Node Weed	O
Tridax procumbens	Three Flower Daisy	F
Ipomoea tilliacea	Wild Slip	A
Euphorbia heterophylla	Milk Weed	A

Typically, the changes in ecology in the dry season are directly correlated to the type of geology and changes in hydrology and rainfall patterns, specifically the decline in water availability and soil moisture content. Westmoreland, on average receives over 2,000mm of rain per year with approximately 500mm during the dry season and approximately 1,500mm during the wet season (State of the Jamaican Climate, 2015). As such, Westmoreland is considered to be one of the wettest parishes and experiences afternoon convectional showers almost daily, even during the dry season. Nevertheless, it was noted that the water levels in the river were noticeably lower than that which was noted during the wet season. Flora were, however, not observed to be responding to limited water availability, regardless of distance from the river. More specifically, there were no signs of wilting and a number of flowers were beginning to bloom as the time of year also coincided with the onset of spring.

The soil type within the study tends to retain moisture which may be facilitating adequate soil moisture distribution to flora during the dry season.

5.2.1.3 Fauna assessment

The fauna observed was typical of what is observed along rivers, grasslands and agricultural fields. The assessment was conducted according to the classifications and information found within the literature. Table 5-17 provides a list of fauna that was identified across the site and surrounding areas during the daytime and night-time surveys. Some photographs of the fauna are presented in Plate 5-3.

There were no notable changes between fauna identified during the dry season, compared to the wet season. Overall, none of the species identified had xerophytic features which indicates that the area is not as affected by very dry conditions with which they need to compensate.

Table 5-17: Fauna observed during the Survey

	Family Grouping	Family	Common Name	Scientific Name	Status	Notes	DAFOR
1	**Bitterns and Herons**	**Ardeidae**	Cattle Egret	*Bubulcus ibis*	b	Very common across Jamaica in open fields and croplands	**O**
2	**Bitterns and Herons**	**Ardeidae**	Green Heron	*Butorides virescens*	b	Occasionally seen along cane roads and verges	**O**
3	**Bitterns and Herons**	**Ardeidae**	Yellow-crowned Night Heron	*Nyctanassa violacea*	b	Occasionally seen along cane roads and verges	**O**
4	**New World Vultures**	**Cathartidae**	Turkey Vulture	*Cathartes aura*	b	Easily observed soaring above from almost anywhere in Jamaica	**F**
5	**Pigeons & Doves**	**Columbidae**	Common Ground-Dove	*Columbina passerina jamaicensis*	bes	This species has high detectability because it frequents the pathways and is easily seen	**O**
6	**Pigeons & Doves**	**Columbidae**	White-crowned Pigeon	*Patagioenas leucocephala*	b	Commonly seen flying above the canopy, more common in forested areas	**R**
7	**Pigeons & Doves**	**Columbidae**	White-winged Dove	*Zenaida asiatica*	b	A few seen feeding along the roadways	**O**
8	**Pigeons & Doves**	**Columbidae**	Mourning Dove	*Zenaida macroura*	b	A few seen feeding along the roadways	**F**
9	**Pigeons & Doves**	**Columbidae**	Zenaida Dove	*Zenaida aurita*	b	A few seen feeding along the roadways	**F**
10	**Cuckoos and Anis**	**Cuculidae**	Smooth-billed Ani	*Crotophaga ani*	b	Common in groups in open fields	**F**
11	**Bananaquits**	**Emberizidae**	Bananaquit	*Coereba flaveola faveola*	bes	Generally widespread but more abundant in wooded areas a few were detected.	**O**
12	**Tanagers and Allies**	**Emberizidae**	Jamaican Euphonia	*Euphonia jamaica*	be	Single individual seen	**O**
13	**Parrots and Parakeets**	**Psittacidae**	Jamaican Parakeet	*Eupsittula nana nana*	bes	Frequently seen and heard around the area, detectable over relatively large distances	**F**
14	**Emberizids**	**Emberizidae**	American Redstart	*Setophaga ruticilla*	w	Most abundant and widespread migrant warbler species in Jamaica	**O**
15	**Emberizids**	**Emberizidae**	Prairie Warbler	*Setophaga discolor*	w	Locally common winter migrant more common in secondary scrub or open habitats	**R**

	Family Grouping	Family	Common Name	Scientific Name	Status	Notes	DAFOR
16	Emberizids	Emberizidae	Northern Waterthrush	*Seiurus novebocensis*	w	Typical in mangroves or coastal riverine habitats, several observed along the main river	F
17	Emberizids	Emberizidae	Northern Parula	*Parula americana*	w	Common winter visitor in wooded habitats	O
18	Emberizids	Emberizidae	Yellow-throated Warbler	*Dendroica dominica*	w	Uncommon winter visitor in Jamaica, a few seen in the area	O
19	Emberizids	Emberizidae	Common Yellowthroat	*Geothylpis trichas*	w	Common in dense marshes or thick cover in moist forested areas, a few heard	O
20	Emberizids	Emberizidae	Black and White Warbler	*Mniotilta varia*	w	Common winter visitor in wooded habitats	R
21	Emberizids	Emberizidae	Jamaican Oriole	*Icterus leucopteryx leucopteryx*	bes	Common and widespread, highly vocal in therefore easily detected	R
22	Emberizids	Emberizidae	Palm Warbler	*Dendroica palmarum*	w	More common in coastal habitats in winter but one individual observed near the river	R
23	Emberizids	Emberizidae	Yellow-faced Grassquit	*Tiaris olivacea*	b	Occasional along grassy trails an fields, most often heard and less seen	F
24	Emberizids	Emberizidae	Black-faced Grassquit	*Tiaris bicolor*	b	Commonly seen in grasses along roadways and heard during counts	R
25	Falcons & Caracaras	Falconidae	American Kestrel	*Falco sparverius*	b	A few individuals observed hunting from perches on power lines	O
26	Raptors	Accipitridae	Red-tailed Hawk	*Buteo jamaicensis*	b	Two observed soaring over open fields, more common in forested habitats than canefields	R
27	Swallows and Martins	Hirundinidae	Cave swallow	*Petrochelidon fulva*	bes	Several observed mainly over the River	O
28	Grackles	Icteridae	Greater Antillean Grackle	*Quiscalus niger crassirostris*	bes	Very few seen, often more common in groups in open areas and even the suburbs	R

	Family Grouping	Family	Common Name	Scientific Name	Status	Notes	DAFOR
29	**Mockingbirds & Thrashers**	**Mimidae**	Northern Mockingbird	*Mimus polyglottos*	b	Abundant throughout the area	**A**
30	**Woodpeckers & Allies**	**Picidae**	Jamaican Woodpecker	*Melanerpes radiolatus*	be	Frequently heard and a few seen in large trees along the river	**F**
31	**Hummingbirds**	**Trochilidae**	Jamaican Mango	*Anthrocothorax mango*	be	One seen along roadside, often more common in forested areas especially dry forests	**R**
32	**Hummingbirds**	**Trochilidae**	Red-billed Streamertail	*Trochilus polytmus*	be	Endemic species widespread in habitats with flowering plants	**O**
33	**Hummingbirds**	**Trochilidae**	Vervain Hummingbird	*Mellisuga minima*	bes	Males are very vocal butonly one was heard (and then seen)	**R**
34	**Swifts**	**Apodidae**	Antillean Palm Swift	*Tachornisphoenicobia*	b	Several seen flying overhead along roadways between fields	**F**
35	**Tyrant Flycatchers**	**Tyrannidae**	Loggerhead Kingbird	*Tyrannus caudifasciatus jamaicensis*	bes	Very common resident seen in several locations throughout the study area	**D**
36	**Tyrant Flycatchers**	**Tyrannidae**	Sad Flycatcher	*Myiarchus barbirostris*	be	A common endemic, only one observed, they are more freguent in well wooded areas	**R**
37	**Barn Owls**	**Tytonidae**	Barn Owl	*Tyto alba*	bes	Two observed at night, common in open areas and woodlands but also in towns	**O**
38	**Potoos**	**Nyctibiidae**	Northern Potoo	*Nyctibius jamaicensis*	bes	Common mainly in well wooded areas but sometimes in mixed fields with wooded plots	**R**
39	**Munias**	**Estrildidae**	Scaly-breasted Munia	*Lonchura punctulata*	i	Introduced species now breeding and spreading in open fields e.g. cane roads and verges	**A**
40	**Vireos & Allies**	**Vireonidae**	Jamaican Vireo	*Vireo modestus*	be	Usually common and vocal endemic, easily detected but only one detected in the area	**R**
41	**Dragonflies**	**Libellulidae**	Common skimmers	*Erythrodiplax bromeliicola*	b	Common species in Jamaica, detected along cleared routes within cane fields	**F**

	Family Grouping	Family	Common Name	Scientific Name	Status	Notes	DAFOR
42	**Butterflies**	**Pieridae**	Jamaican Grass Yellow Butterfly	*Eurema*			**F**
43	**Bees**		Carpenter bees	*Xylocopa virginica*			**F**
44	**Frogs**	**Eleutheroda-ctylidae**	**Lesser Antillean Whistling Frog**	*Eleutherodactylus johnstonei*	b	Invasive/introduced; Heard across the site	
45	**Fish**	**Mugilidae**	**Mullet**	*Mugil cephalus*	b	Native	**A**
46	**Fish**	**Anguillidae**	**Eel**	*Anguilla rostrata*	b	Native	**O**
47	**Fish**	**Mugilidae**	**Mountain**	*Dajaus monticola*	b	Native	**F**
48	**Fish**	**Mugilidae**	**Hog mullet**	*Joturus pichardi*	b		**F**
49	**Fish**	**Parastacidae**	**Red Claw Crayfish**	*Cherax quadricarinatus*	b	Introduced	**F**
50	**Fish**	**Centropomidae**	**Tarpon**	*Centropomus pectinatus*	b	Native	**F**
51	**Fish**	**Centropomidae**	**Snook**	*Centropomus parallelus*	b	Native	**A**
52	**Fish**	**Eleotridae**	**Mudfish**	*Dormitator maculatus*	b	One of two species	**F**
53	**Fish**	**-**	**Sandfish**	-	-	-	

Classification updated to International Union for Conservation of Nature (IUCN) and BirdLife accepted Classifications

Status according to Downer and Sutton "Birds of Jamaica"

KEY		
STATUS		**DAFOR**
b = Breeding species		D = Dominant
be = Jamaican endemic species		A = Abundant
bes = Jamaican endemic sub-species		F = Frequent
bs = Summers and breeds		O = Occasional
i = Breeding introduced		R = Rare
w = Winters		

Plate 5-3: Fauna identified on Site

With the impact of climate change on the area, the parish may either experience less rainfall or more intense periods of sporadic rainfall. With more intense dry seasons and lowering river levels, both riverine and terrestrial flora and fauna can be affected, given their relationship for habitat and food. Additionally, pumping water from an already low river supply can potentially exacerbate the issues identified. Maintaining ecological relationships are essential to the ecosystem balance within the area and its various uses.

5.2.2 CABARITA RIVER ECOSYSTEM ASSESSMENT

Five sites along the Cabarita River were selected for the Freshwater Ecology Assessment of the Cabarita River (Figure 5-36).

Figure 5-36: Location of River Assessment Survey Sites in relation to the Bamboo Mill Site (red outline) and the 2 km Sphere of Influence (yellow outline)

5.2.2.1 Location, Altitude and Physical and Chemical Parameters

The location, altitude and physical and chemical data for the sites assessed along the Cabarita River are presented in Table 5-18. Barring Site 1, flow rate, discharge, pH and water temperature decreased with increasing altitude. Conductivity of Sites 2 to 5 was similar, while conductivity at Site 1 was very high.

Table 5-18: Location, Altitude and Physical and Chemical Parameters of Sample Sites along Cabarita River

	SITE				
Parameter	**Site 1 – Mouth**	**Site 2 – Barham Bridge**	**Site 3 – Friendship**	**Site 4 – Hartford**	**Site 5 – Fort Williams**
GPS Coordinates	18.226043 N, 78.160712 W	18.293505 N, 78.110106 W	18.297875 N, 78.088121 W	18.301542 N, 78.068215 W	18.307231 N, 78.061308 W
Altitude (masl)	5	23	37	60	105
Canopy Cover (%)	20	50	80	100	20
Channel Width (m)	18	15.5	22.5	5	8
Mean Flow Rate ($m\ s^{-1}$)	0.035	1.169	0.839	0.485	0.205
Discharge ($m^3\ s^{-1}$)	1.057	25.304	11.833	1.191	0.616
Mean pH	7.06	8.19	8.18	8.05	7.33
Mean Conductivity ($\mu S\ cm^{-1}$)	4737	316	319	334	323
Mean Water Temperature (°C)	26.61	25.05	25.04	24.47	24.13

Plate 5-4 gives pictures of Sites 1 and 2 along the Cabarita River. At the time of the survey, the scent of sulphur was strong at Site 1 and the water was black. Site 2 was significantly more transparent and odourless. The section of the river at Site 2 was surrounded by sugar cane and other natural vegetation.

Plate 5-4: Sample Sites 1 and 2 along the Cabarita River

Plate 5-5 depicts Sites 3 and 4 along the Cabarita River. Individuals can be seen carrying buckets of water from the river at Site 3. Site 4 was the only site where other individuals were not seen using the river.

Plate 5-5: Sample Sites 3 and 4 along the Cabarita River

Plate 5-6 depicts Sites 5 along Cabarita River. This source of this stream was groundwater.

Plate 5-6: Sample Site 5 along the Cabarita River

5.2.2.2 Invertebrates

5.2.2.2.1 Summary

A single individual of a water strider was the only invertebrate collected at the mouth of the Cabarita River (Site 1). However, three species of crabs were sighted in the wetlands adjacent to the river: the giant blue land crab (*Cardisoma guanhumi*); the fiddler crab (Ocypodidae); and the black land crab (*Gecarcinus ruricola*). Hundreds of these crabs were found among holes in the mud. Two individuals of the fat sleeper fish (*Dormitator maculatus*) were also collected. At the time of the study, no fish were identified in the river likely due to the anoxic state of the river. However, community members have noted the following types of fish have been caught from the river when it is in a less anoxic state, i.e., snook, mudfish, tarpon, blackfish among several others. Crocodiles have been observed in the river a well. Due to the lack of invertebrates collected by kick net, Site 1 was unsuitable for in-depth analyses.

A total of 18 taxa of invertebrates was collected along the Cabarita River (Figure 5-37 and Table 5-19). Snails represented 54% of abundance and 20% of the number of taxa present. Insects were the most speciose group, with 50% of all species collected being insects. The worms (flatworms and roundworms) represented the smallest proportion of taxon richness and abundance. The most abundant taxa across all sites were the snails *Neritina punctulata* (20%) and *Melanoides tuberculata* (19%), followed by the stonecase caddisfly *Helicopsyche* sp. (18%). Photographs of some of the specimens identified are presented in Figure 5-38.

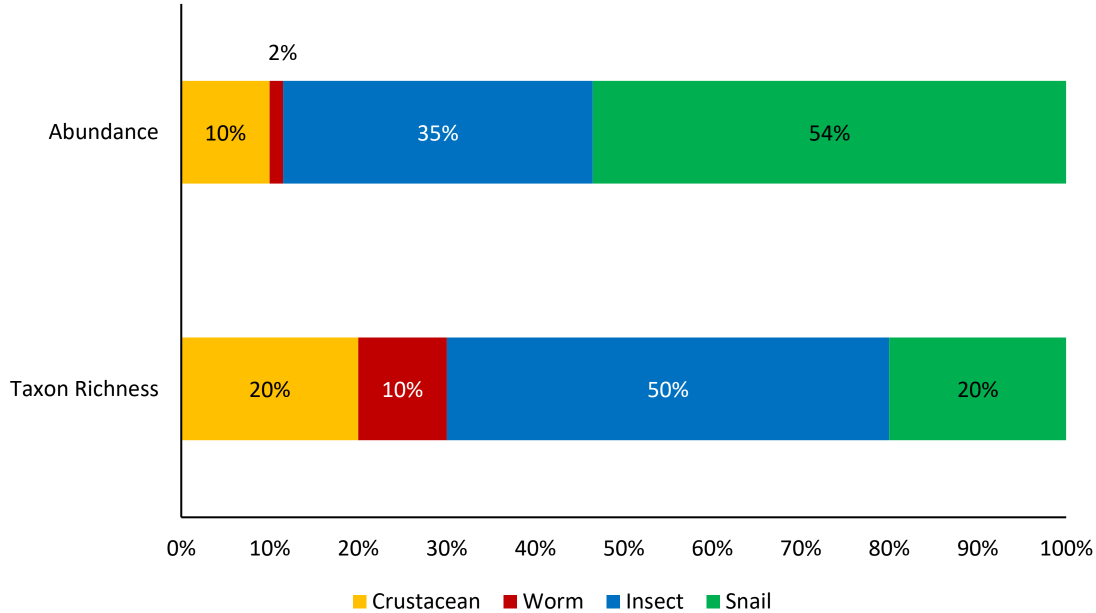


Figure 5-37: Taxon Richness and Abundance of Invertebrates in Cabarita River

Table 5-19: List of Taxa Found at Cabarita River

No.	Higher Taxon	Lowest Taxon	Common Name	Functional Feeding Group
1	Malacostraca	*Macrobrachium acanthurus*	Shrimp	Shredder
2		*Macrobrachium faustinum*		Shredder
3		*Potimirim* sp.		Shredder
4		*Xiphocaris elongata*		Shredder
5	Annelida	Flatworm	Flatworm	Predator
6		Roundworm	Earthworm	Collector-Gatherer
7	Insecta	*Helicopsyche* sp.	Stonecase Caddisfly	Scraper
8		*Rhagovelia* sp.	Small Water Strider	Predator
9		Leptophlebiidae	Mayfly	Collector-Gatherer
10		Chrysomelidae	Leaf Beetle	Shredder
11		Dolichopodidae	Long-legged Fly	Predator
12		Elmidae	Riffle Beetle	Shredder
13		Hydropsychidae	Caddisfly	Filterer
14		Philopotomidae	Caddisfly	Filterer
15	Gastropoda	*Melanoides tuberculata*	Snail	Scraper
16		Lymnaeidae		Scraper
17		Ampullariidae		Scraper
18		*Neritina punctulata*		Scraper
19	Mugilidae	*Mugil cephalus*	Mullet	Detritivores

No.	Higher Taxon	Lowest Taxon	Common Name	Functional Feeding Group
20	Eleotridae	*Dormitator maculatus*	Mudfish	Omnivores
21	Centropomidae	*Centropomus parallelus*	Snook	Carnivores (feed on fish and crustaceans)
22	Mugilidae	*Joturus pichardi*	Hog mullet	Herbivores (algae)
23	Parastacidae	*Cherax quadricarinatus*	Crayfish	Detritivores
24	Mugilidae	*Dajaus monticola*	Mountain Mullet	Detritivores
25	Centropomidae	*Centropomus pectinatus*	Tarpon	Carnivores (feed on fish and crustaceans)
26	Crocodylidae	*Crocodylus acutus*	American Crocodile	Carnivore/ Predator

SPECIMEN PHOTOGRAPHS

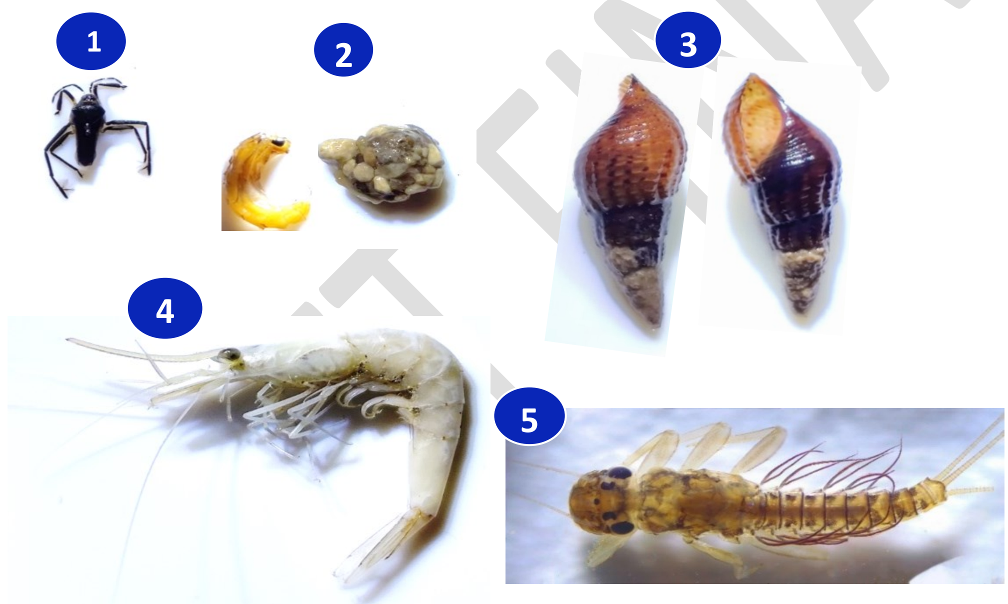


Figure 5-38: A Selection of Invertebrates from Cabarita River

Specimen Key

1. *Rhagovelia sp.* (Small Water Strider)
2. *Helicopsyche* sp. (left) and stone case (right)
3. *Melanoides tuberculata (Snail)* – aperture up (left) and aperture down (right)
4. *Macrobrachium faustinum* (Shrimp)
5. *Leptophlebiidae*

5.2.2.2.2 Simpson's Index – Alpha and Gamma Diversity

Gamma diversity along the river was high at 0.94 (Figure 5-39). However, among the sites, alpha diversity (i.e., the mean diversity of species in each site at a local scale) was moderate. Site 3 supported the greatest taxon richness and alpha diversity, while Sites 2 and 4 supported the lowest. *Macrobrachium acanthurus, Melanoides tuberculata, Neritina punctulata* and Lymnaeidae were the only species found across all four sites.

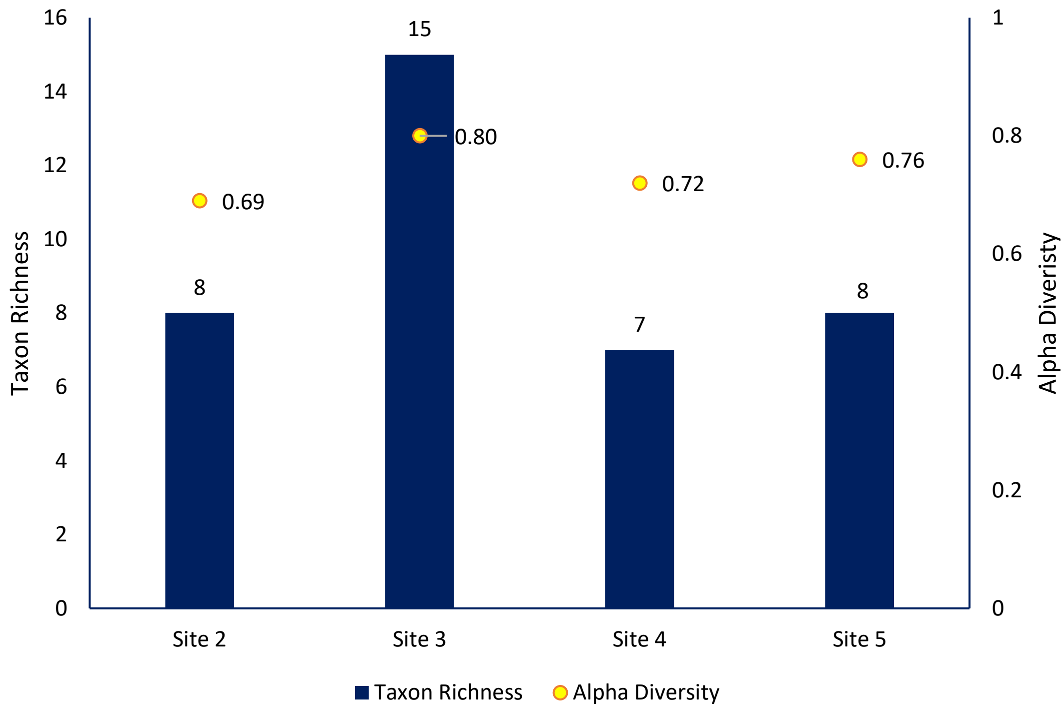


Figure 5-39: Taxon Richness and Alpha Diversity at Sample Sites Along Cabarita River

5.2.2.2.3 Sorensen's Dissimilarity Index – Beta Diversity

All dissimilarity values ranged from 0.25 to 0.48 (Figure 5-40). The greatest dissimilarity in taxa was between Sites 2 and 3, while the greatest similarity was between comparisons of Site 5 with Sites 2 and 4.

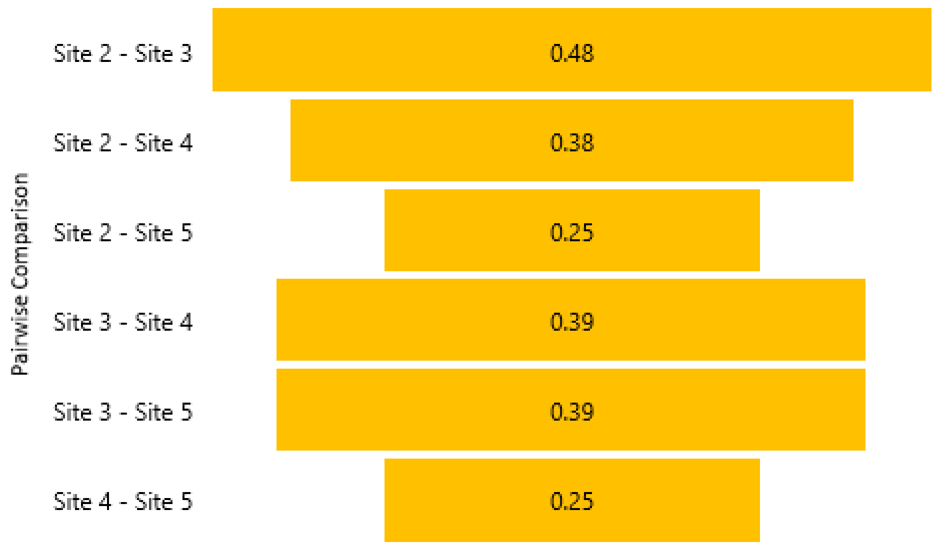


Figure 5-40: Pairwise Comparison of the Taxa at Sample Sites along the Cabarita River

5.2.2.2.4 Functional Feeding Groups

The scraper feeding group was dominant across all sites, accounting for 62–86% of the functional feeding groups among the sites (Figure 5-41). This was followed by the shredder and predator groups. The least represented was the filterer feeding group, with below 5% at each site.

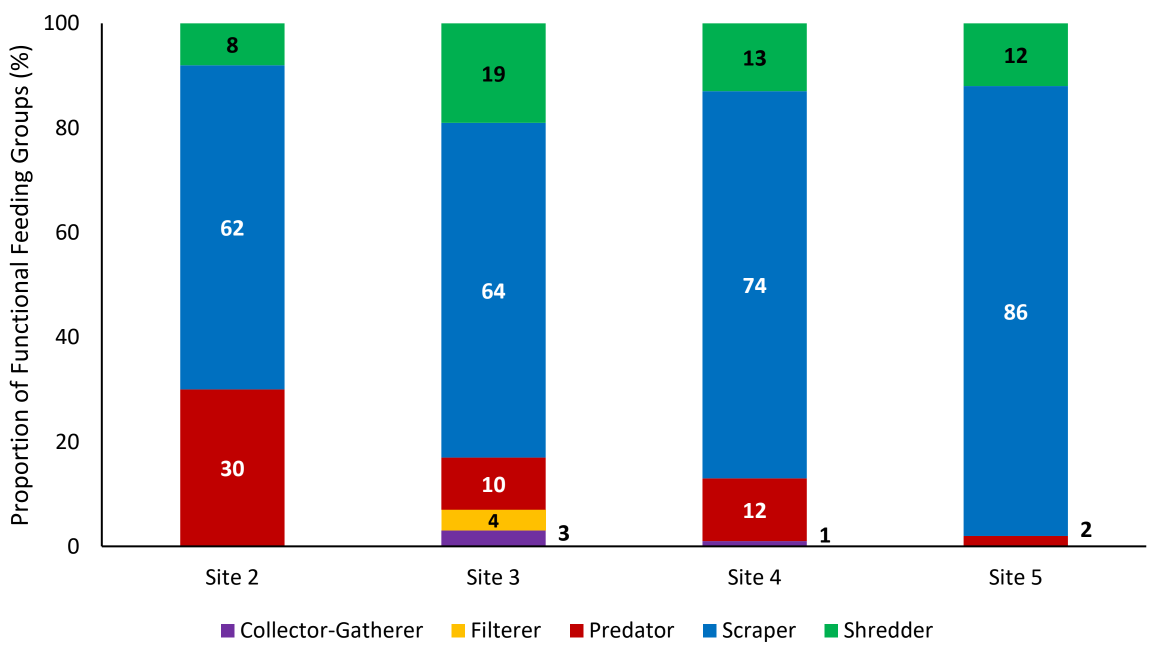


Figure 5-41: Functional Feeding Groups among Sample Sites along the Cabarita River

5.2.2.3 Observations

Individuals were seen utilising the river for various purposes including washing vehicles, washing clothes and bathing. The riverbed consisted of mainly river stones and/or organic material from the surrounding trees. The latter, altered the river depth in some areas.

5.2.2.4 Discussion

5.2.2.4.1 Taxon Richness and Diversity

All sites except Site 1 were indicative of mildly disturbed to undisturbed aquatic environments. Site 1 was greatly lacking in fauna potentially due to the input of fertilizer and other chemical runoff (locally described as 'dunder') into the river during the harvesting period. Coupled with the characteristically low velocity of the relatively wide river channel, the resulting impacts that were observed included a change in colour (blackening of the river), unpleasant sulphuric-based odour, and dark residue when the river water was filtered. It is suggested that these unfavourable conditions may be linked to the drastic reduction in riverine organisms compared to what was found upstream. Residents in the area noted that this was the case for this section of the river for approximately half the year after sugar cane had been harvested. They also noted that the fish do return to the area following the constant flushing overtime once the harvesting period has been completed. Further studies would need to be done to determine if there has been a decline in the abundance of the fish when they return each year. Another factor hindering the establishment of freshwater fauna at Site 1 was the influence of the sea. Sections of the river at the mouth were noted as flowing backwards resulting in the increased salinity of the river (as is also indicated by the considerably high conductivity levels recorded), limiting the establishment of freshwater fauna. Typical brackish water species were also not observed. Nevertheless, the 'dunder' is likely the main contributor to the lack of fauna recorded.

Among the other sites of Cabarita River, pH, conductivity and water temperature were within acceptable ranges despite the use of the river for domestic and recreational purposes. Along these sections (Site 2 to Site 5), very few areas of standing water and eutrophication were identified, and the water was clear with healthy vegetation surrounding the river. The canopy was intact and substantial among most sites, highlighting the limited deforestation occurring within the immediate vicinity of the riverbanks. This allows the continuous input of organic matter into the river to support the aquatic invertebrates and limits high water temperatures, to which higher altitude fauna are sensitive.

The taxon richness and gamma diversity (i.e., the total species diversity along the entire river) were high. Taxon richness and alpha diversity were highest at Site 3 due to the variety of habitats present, namely aquatic vegetation, small areas of algal growth, rocks, pools, riverbanks and the wider river channel. The similarity of taxa was generally greater when comparing sites closer to each other due to faunal composition changing gradually as environmental conditions change along the river. Of note was the genus *Helicopsyche*, all species of which exist in Jamaica are endemic. They are commonly indicative of unpolluted environments (Johanson, 2003). However, it was noted that no dragonfly or damselfly nymphs were recorded at any site. These species are also an indication of high water quality and their absence may indicate pollution, but may also be due to differences in geographical conditions.

5.2.2.4.2 Functional Feeding Groups

The dominance of the scraper functional feeding group (stone case caddis fly and snails) indicates the high availability of benthic microinvertebrates such as diatoms, algae, fungi and bacteria (Ramírez and Gutiérrez-Fonseca, 2014). Dominance of the shredder group (crustaceans) can also be attributed to the invasive nature of *Melanoides tuberculata* reproducing rapidly. Such assemblages indicate levels of disturbance in native fauna, possibly due to the use of the river for domestic, recreational, and economic activities. Prolonged changes in water quality could further alter aquatic assemblage reducing taxon richness and biodiversity. The dominant predator was the small water strider *Rhagovelia* sp. feeding on the terrestrial flora falling into the river.

5.2.2.5 Impacts and Mitigation

In consideration of the proposed Bamboo Pulp Mill within proximity to the Cabarita River, it is important to consider and mitigate against the following potential effects on the Cabarita River, its tributaries, aquifers and surrounding temporary and permanent water bodies. The impacts and mitigation measures presented below apply primarily to the mill, during the construction and operation phases. Impacts and Mitigation for the Pulp Mill.

Potential impacts on the surface water quality and aquatic environment can occur during the construction and operational phases of the pulp mill and include:

Construction

- Generation of erosive processes and sedimentation of the river
- Change in quality of surface water due to improper disposal of waste
- Change in aquatic ecosystems
- Risk of degradation of flora and habitat loss to fauna during construction

Operations

- Change in water quality due to improper waste disposal
- Change in water quality due to leaks and chemical spills
- Change in river quality
- Change in aquatic ecosystem and habitat

Other impacts that would more affect the social environment that utilizes the river include the disruption to economic, domestic and fishing activities, both during the construction and operational phases, due to restricted access.

The Source-Pathway-Receptor model was used to assess the potential impacts and risks and determine potential mitigative measures. This model is used in the industry to identify the potential causes and sources of pollution, how the pollution can travel through the environment (pathway); and who and what (physical, human and environmental receptors) can be the potential receptors. The receptors of focus in this assessment are the aquatic flora and fauna of the Cabarita River. Potential sources of the impacts and recommended mitigative measures are presented in Table 5-20. The list of mitigative measures found in Table 5-19 are by no means exhaustive and will complement other recommendations provided in **Chapters 8, 9 and 12**.

Table 5-20: Potential Impacts and mitigative Measures of the Pulp Mill on the aquatic Environment of the Cabarita River with an Indication of Time the Impact could occur in and its potential Source(s)

Impact No.	POTENTIAL IMPACTS	PHASES (Construction – C) (Operations – O)	SOURCE ACTIONS OF THE IMPACTS	RECOMMENDED MITIGATIVE MEASURES
1	Generation of erosive processes and sedimentation of the river	C	• Preparation of the construction site • Earthworks, excavation and water intakes in land areas near to the river	• Implement an Erosive Process Control and Monitoring Plan; • Supervise construction works and ensure it is in compliance with the Environmental, Health and Safety Management and Monitoring Plans; • Build a temporary structure/silt-sized sediment trap to contain sediments during construction; • Plan the execution of earthworks and land preparation preferably outside of the wet/rainy season.
2	Change in quality of surface water due to improper disposal of waste	C & O	• Preparation of the construction site • Installation of the pulp mill • Generation of sanitary wastewater • Generation of solid waste	• Implement recommendations as above from the "**Generation of erosive processes and sedimentation of the river**"; • Apply the best practices in solid waste management in accordance with the laws and regulations; • Implement a Solid Waste Management Programme; • Train operators in the correct disposal of waste; • Use certified companies to collect the wastewater from portable toilets and ensure that the wastewater is disposed of in an environmentally sound manner. If chemical baths/other amenities are available, ensure that wastewater generated is treated and disposed of in an environmentally sound manner; • Implement a water quality monitoring programme during both construction and operations; • Implement an aquatic community monitoring programme.
3	Risk of degradation of flora and habitat loss to fauna during construction	C	• Collecting surface water, flora and fauna during construction for consumption, as pets and other uses	• Ensure construction workers are sensitised of any restrictions on the collection or harassment of aquatic fauna.
4	Change in water quality due to leaks and chemical spills	O	• Discharge of Treated Effluent • Improper storage and handling of chemicals causing leaks or spills • Vehicle maintenance	• Implement, monitor and manage a system for the collection and handling of leaks and spills; • Ensure operators are trained in the handling, storage and transportation of chemical products;

Impact No.	POTENTIAL IMPACTS	PHASES (Construction – C) (Operations – O)	SOURCE ACTIONS OF THE IMPACTS	RECOMMENDED MITIGATIVE MEASURES
			• Transport of chemicals	• Implement containment and waterproofing systems surrounding chemical tanks; • Use the best available technologies (BAT) in the production process to minimise the generation of liquid effluents; • Ensure effluent treatment plant constructed is based on the best available practical technology (modern and safe), the activated sludge system and tertiary treatment; • Properly operate the effluent treatment plant so that the discharge of treated liquid effluents complies with current legislation; • Carry out a periodic inspection of the emissary system and its diffusers; • Develop and implement an Effluent Treatment Plant (ETP) Monitoring Programme.
5	Change in river quality	C & O	• Preparation of the construction site • Installation of the pulp mill, especially sites of water collection and discharge • Inadequate generation and disposal of sanitary wastewater • Inadequate generation and disposal of solid waste • Water abstraction • Installation of water and effluent pipes • Any discharge or untreated effluent	• Recommendations as above from the "**Generation of erosive processes and sedimentation of the river**", "**Change in water quality due to leaks and chemical spills**", "**Change in quality of surface water due to improper disposal of waste**" • Monitor the operations of the water and wastewater treatment plants to ensure they are in compliance with the law and regulations; • Ensure all operators and supervisors are sensitised to the Environmental Monitoring and Management Plans; • Implement a water quality monitoring programme during both construction and operations.

Impact No.	POTENTIAL IMPACTS	PHASES (Construction – C) (Operations – O)	SOURCE ACTIONS OF THE IMPACTS	RECOMMENDED MITIGATIVE MEASURES
6	Change in aquatic ecosystems and habitats	C & O	• Installation of water and effluent pipes • Construction of the pulp mill leading to some disturbance of the nearby habitat • Discharge of treated effluent • Any earthworks or construction that alter the natural state of the river	• Recommendations as above from the "**Change in river quality**"; • Implement a programme to monitor water quality based on stipulated standards to preserve the existing aquatic communities of the Cabarita River within the vicinity of the mill or as directed by the regulator; • Supervise construction works and ensure it is in compliance with the Environmental, Health and Safety Management and Monitoring Plans; • Properly operate the effluent treatment plant so that the discharge of treated liquid effluents complies with current legislation; • Develop and implement an Effluent Treatment Plant (ETP) Monitoring Programme; • Ensure any design plans that alter the natural state of the river are approved and monitored by the regulator; • Implement water quality and aquatic communities monitoring programmes before and during construction and during operations.

Other mitigative measures that would apply to the impacts that could affect the social environment include:

1. Sensitising the public of operations and how it could affect people that use the river, both during construction and operations;
2. Ensuring that the treated effluent released complies with the legal and regulatory standards;
3. Ensure Environmental, Health and Safety Management and Monitoring Plans are comprehensive and implemented;
4. Facilitate continuous engagement with users of the Cabarita River;
5. Implement a water quality monitoring programme.

5.2.2.5.1 Impacts and Mitigation Measures for Potential Farm Sites if located within proximity to the Cabarita River

Whilst it is not within the scope of this EIA to cover the farm sites, if the project is successful and while the farm sites are being negotiated by BBP, it is prudent to identify potential impacts and mitigative measures, in the event that any of the farm sites (once finalised) are within proximity to the Cabarita River. The impacts identified and recommendations for mitigative measures were identified based on the Cabarita River Ecosystem Assessment.

Five (5) potential impacts were identified if the bamboo farms, once finalised, are located within proximity to the Cabarita River. They are:

i. **Obstruction of the River**

Obstruction of the river can occur from the improper disposal of bamboo shoots and leaves into the river or from the growth of the dense rhizomes too close to the river. Both would act as physical barriers limiting or diverting the flow of water and sediment needed downstream. It can also potentially result in shallowing of the river depth if vegetative material is being added at a faster rate than it is being broken down. As such, all bamboo material must be kept far from the river and its tributaries and disposed of properly to prevent this. Large and small particles of bamboo must be filtered out of surface water before release into the river or its surrounding water bodies. BBP has already indicated that no bamboo plants will be cultivated too close to the river, but this potential impact must be raised.

ii. **Water Abstraction**

Any abstraction of water for operation of the mill and potential farms within proximity to the river must be seen as secondary to continuing the flow of the river as it occurs naturally. Abstraction must not result in the cessation of river flow, as mass death of fauna and vegetation would occur. River access must also be made available to community members who rely on it for domestic purposes, recreation, and food. Activities of the bamboo mill and farms must not impede the livelihoods of community members.

iii. **Loss of the Riparian Vegetation**

Riparian vegetation and fauna are essential to maintaining the health of the riverine ecosystem. The shade provided by the trees limits drastic changes in temperature and the leaves act as a source of nutrients, habitat and casements for aquatic species. Bamboo leaves are decomposed by aquatic fauna more slowly than the leaves of native trees (O'Connor et al., 2000). With the high leaf fall rate of bamboo, the plant stands to overwhelm riverine ecosystems, and may lead to the smothering of fauna and obstructing light needed for benthic algae, diatoms and bacteria. The loss of riparian vegetation and introduction of bamboo risk disturbing the aquatic environment greatly and can also affect the stability of the riverbanks, particularly during heavy rainfall periods.

The bamboo that will be farmed is *Bambusa vulgaris*, an open-clumping, sympodial[xxxvii] bamboo species. As bamboo is listed as an *Invasive Alien Species in Jamaica*,[xxxviii] with a high rate of growth, effective mitigation measures must be in place to prevent it from establishing outside of the designated farm area and displacing native vegetation. The International Bamboo and Rattan Organization (INBAR) has conducted research into the management of invasive species and have concluded that there is information accessible to knowledge resources to effectively manage the species. There are a number of easy ways to reduce the risks of bamboo invasion through the implementation of preventative measures, assessing the risks of introducing bamboo species, enacting legislation and regulations to restrict the planting and use of certain species of bamboo and effective management strategies. The Bureau of Standards Jamaica has also published the JCP 8: 2021 Jamaican Standard Code of Practice for Bamboo Plantation (2021) to guide the preparation and management of bamboo plantations in Jamaica.

iv. Public Safety Risk

Water collecting in the hollow bamboo shoots forms temporary water bodies which can serve as breeding sites for different species of mosquitoes. Increasing habitat availability for mosquito breeding increases the risk of the transmission of mosquito-borne diseases such as dengue and chikungunya. No bamboo shoots must be allowed to collect water for more than 3 days and must be properly disposed of as soon as possible. In the case of the mill, BBP has indicated that measures will be taken to ensure that the bamboo culms stored in horizontal piles do not become breeding grounds for mosquitoes.

v. Pollution

Aquatic fauna are sensitive to water quality changes, thus any interaction with the river must not result in significant water quality changes. The water temperature, dissolved oxygen, pH, conductivity, and other parameters must be regularly monitored to ensure that the operations of the mill and farm are not negatively affecting the river. It is recommended that monthly monitoring is good and can be done with a multiparameter probe by an environmental officer. The note on thermal pollution extends to other forms of pollution including, but not limited to, organic, chemical and noise pollution.

Given the potential impacts of wastewater and chemicals released from other economic activities downstream of the proposed mill site, there is a strong possibility that any negative effect of the Bamboo Mill will result in cumulative impacts. The recommended measures must therefore be implemented and monitored to ensure the mill operations do not lead to deterioration in water quality. It is anticipated that there will be minor to negligible negative effects from the bamboo mill that may compound the issues in the lower sections of the river, causing further deterioration of river quality and its supporting fauna functions and services based on the information provided and if BBP maintains best practise in the following areas:

i. Environmental, Health and Safety Management and Monitoring Plans during construction and operations;
ii. The release of treated effluent into the Cabarita River; and
iii. Management of the potential release of chemicals, stormwater and other solid and liquid waste into the Cabarita River.

5.2.2.6 Conclusion

Five sites along the Cabarita River were assessed, prioritising areas within the 2 km circle of influence of the proposed bamboo mill for a freshwater ecology assessment. Chemical and physical parameters were recorded, and it was found that all sites, except Site 1, were indicative of mildly disturbed to undisturbed aquatic environments. Site 1 was greatly lacking in fauna and this hindrance could be attributed to improper discharges into the river by neighbouring economic activities along the Cabarita River, sea water intrusion or other domestic activities; however, further investigations would be required. Chemical parameters such as pH, conductivity and water temperature were within acceptable ranges despite the use of the river for domestic and recreational purposes. Along Site 2 to Site 5, very few areas of standing water and eutrophication were identified, and the water was clear with healthy vegetation surrounding the river. The taxon richness and gamma diversity (i.e., the total species diversity along the entire river) were high and indicated that the most sites had a high water quality. Prolonged changes in water quality could further alter aquatic assemblage reducing taxon richness and biodiversity.

Potential impacts of the mill within proximity to the Cabarita River were identified as well as their mitigative measures. They were divided into those that affected construction and operations of the mill. The presence of neighbouring economic activity facilities along the Cabarita River and their operations indicate that there may be some cumulative impact from the release of treated effluent from the pulp mill. However, it is our professional opinion that there will be minor to negligible negative effects from the bamboo mill that may compound the issues in the lower sections of the river, thus minimising further deterioration of river quality and its supporting fauna functions and services, once best practice and mitigation measures have been successfully implemented.

5.3 EXISTING SOCIOECONOMIC SETTING

The report of the SIA conducted is found in **Appendix O.** The final EIA report will include additional information such as the Community Survey Questionnaires, Attendance Sheets, Consultation Analysis, Plan and Grievance Mechanism and Monitoring Plan, and the Social Impact Management Plan. A summary of the results prepared thus far is presented in the subsequent sections.

5.3.1 SPHERE OF INFLUENCE

The proposed pulp mill is located in the Friendship area in the parish of Westmoreland. Based on the government agency, the actual location varies. The proposed mill can be situated in the Frome Electoral Division (Electoral Commission of Jamaica), between the Frome/Blackness and Petersfield Local Development Areas within the Constituency of Westmoreland Central, or primarily within the community of Hertford. As there are different delimitations of boundaries among local agencies, the nearest community of Friendship will also be used in this Section. The proposed mill is approximately 6.05 km south of the boundary with the parish of Hanover and approximately 22km west of the boundary with the parish of St. Elizabeth. The sphere of influence for the site varies. As there are intentions to move bamboo from farm sites to the proposed pulp mill and from the proposed pulp mill to the Port of Montego Bay, the sphere could be national. However, specifically for immediate mill operations, and not inclusive of the transport of pulp from the mill to the Port of Montego Bay, the sphere is illustrated in Figure 5-42.

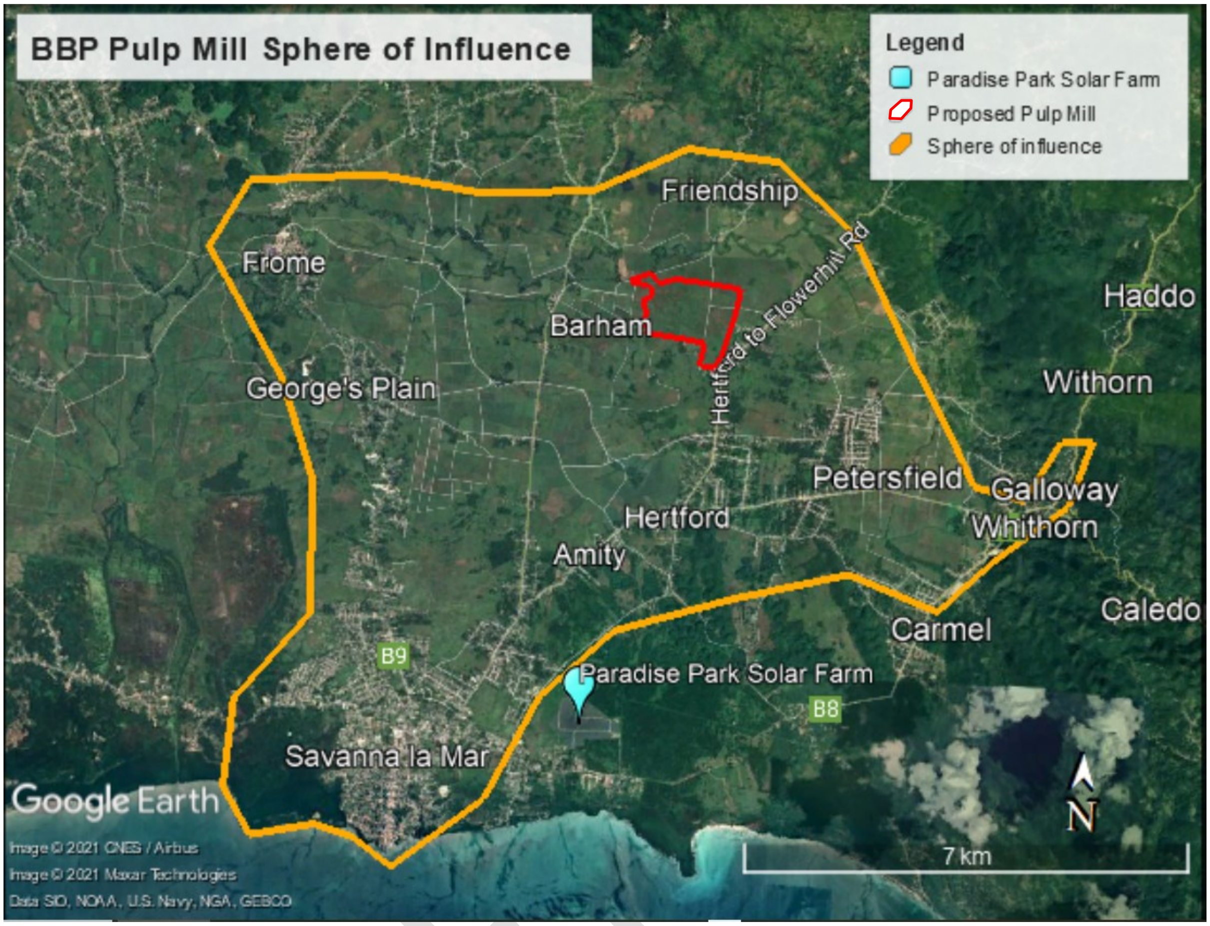


Figure 5-42: Project Sphere of Influence (highlighted in orange). The Sphere of Influence was determined by a minimum 2 km Distance from the proposed Project Site and the Use of a 1 km Distance from the main Trucking Route proposed for the Project

Communities examined and engaged during the SIA included **Hertford, Amity, Petersfield, Friendship, Frome and Savanna-la-Mar** and feedback from the communities will be discussed in the subsequent sections.

5.3.2 LAND USE PATTERNS OF THE SITE AND SURROUNDING AREAS

The proposed project site is land that was formerly under sugar cane cultivation and is surrounded by land formerly under sugar cane cultivation. Within close proximity to the site is the Cabarita River to the north of the site and residential areas to the south on tracks entering the site and southwest of the site along the Hertford to Flowerhill Road. The immediate nearby communities of Friendship, Barham, Hertford and Petersfield are all agricultural/residential. According to the report, 'Assessment ff Land Use Change in

Jamaica' (Forestry Department and International Institute for Environment and Development, 2021) the mill site and surrounding locations are classified as cultivated cropland[xxxix] and settlement[xl].

The land for development is zoned for agriculture and is proposed to remain as agricultural lands in the current Development Order for the parish (Figure 5-43). The Proposed Land Use in Figure 5-43 was guided by the Town and Country Planning (Westmoreland Area) Confirmed Development Order, 2021. The surrounding lands are also designated as agricultural land in the Development Order until you reach the communities, which have been identified as designated planning areas. Policies from the Town and Country Planning (Westmoreland Area) Confirmed Development Order, 2021 that apply to the proposed project can be found in **Appendix D**.

[xxxix] Defined by the Forestry Department as a deliberately or accidentally introduced species to an area different from its native range. The Forestry Department, through its Forestry Stewardship Council DRAFT Interim National Standard of Jamaica (2022), shall only use alien species when knowledge and/or experience have shown that any invasive impacts can be controlled. Cultivated cropland described as (Forestry Department and IIED, 2021)

[xl] Settlement refers to buildings and other construction features such as airstrips, roads, and bridges and s largely capture the distribution of urban population in Jamaica (Forestry Department and IIED, 2021)

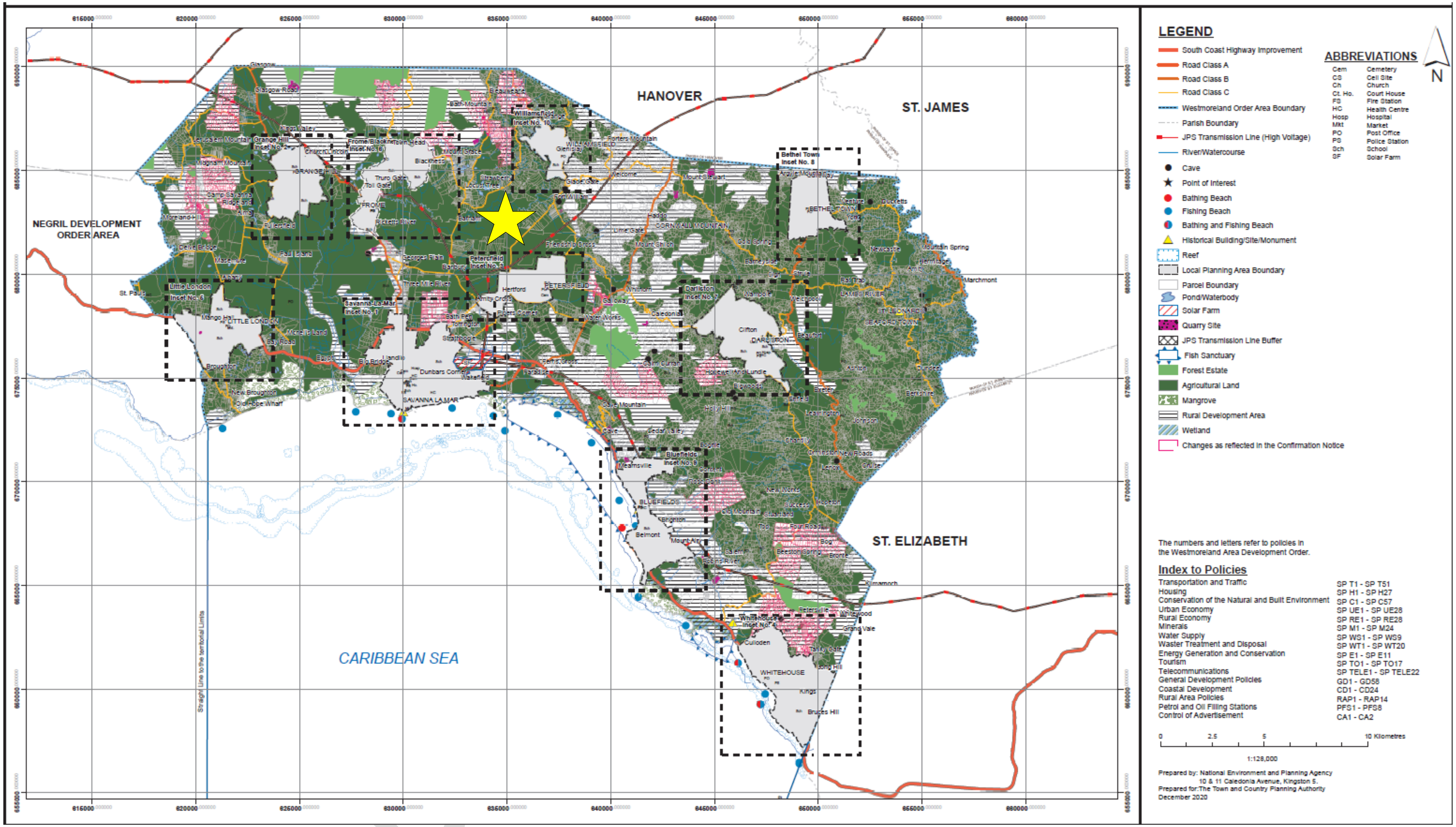


Figure 5-43: Westmoreland Proposed Land Use with the proposed Mill Site situated on Agricultural Land between the recently proposed Development Areas of Frome and Petersfield (Source: Westmoreland Municipal Corporation, 2021)

5.3.3 DEVELOPMENTS UNDERWAY

The Westmoreland Municipal Corporation (WMC) was contacted about the current and planned developments in the area and within proximity to the mill and they responded that there were none present or planned. Other developments that could have an impact on the overall project include:

- **Housing** – The National Housing Trust (NHT) will be undertaking three housing developments in Westmoreland during the next four years. The Savannah Park Scheme, which is located five minutes away from Savanna-la-mar and which is closest to the proposed mill location could facilitate an increase in accommodation of up to 82 people (NHT, 2021);
- **Road Network** – The expansion of the South Coast highway is underway which will reduce times for the transportation of raw material via the road network to the mill, if required;
- **Port Expansion** – There are ongoing plans to expand the docking port at the Montego Bay Free Port so that cargo ships will have an area, separate from the Cruise ships, to dock and offload. Currently, cargo and cruise ships share the same port. Based on the expansion plans, the dredging to deepen the shipping channel has already taken place and within the next few years, the port upgrade should be completed. This activity is being led by the Port Authority of Jamaica;
- **Expansion of the Runway at Sangster's International Airport** – A US$112 million expansion programme is earmarked for the expansion of the runway at Sangster's International Airport in Montego Bay;
- **Expansion of The University of the West Indies Western Campus** – There is a planned expansion for The University of the West Indies Western Campus. This could facilitate the education component of the project.

5.3.4 POPULATION AND HOUSEHOLD DEMOGRAPHICS

According to the 2011 Census, the population of Westmoreland was 145,628 residents and the parish has 84 districts. Most residents live in rural districts with 28.3% (14,294) living in urban areas and 71.6% (36,069) living in rural areas. The population of the six settlements engaged in the SIA is approximately 21,400. A significant portion of the populations of Petersfield and Savanna-la-Mar comprises children and young adults. Hertford, Frome and Amity operate in the reverse, and are skewed to older populations. Most households are headed by males. A breakdown of the demographics for each of the investigated communities is presented below.

5.3.4.1 Frome

The total population of Frome is approximately 1,460 persons. Of that amount, 43.9% are males and 46% are females between the ages of 0–64 years. Of the overall population, 58.5% comprises the overall workforce between the ages of 15–64. The elderly population, 65 years and older, comprise 10.1% of the overall population. Twenty-one percent (21%) of Frome's 417 households are headed by unemployed individuals. The average household size is 3.5 and more than 50% of households are headed by males. It was estimated that 40% of household members had no academic qualifications.

5.3.4.2 Savanna-la-Mar

The estimated population size of the area is 13,930. Of the total population, 28.5% are in the 0–14 years age cohort, 17.7% are of the 1524 age cohort, and 37.8% of the population is in the 30–64 years age cohort. There are 3,980 households with 49.1% of the households headed by males. The average household comprises 3.5 individuals. Within households, 69.6% are headed by persons who are employed. In terms of academic qualifications, 67.3% of household heads have no academic qualifications.

5.3.4.3 Petersfield

The overall estimated population size of Petersfield is 3,400 individuals with an estimated 680 dwellings headed mostly by males. Of the overall population, 16.5% are within the 0–14 years age cohort, while 8.17% are in the 15–24 years age cohort, and 6.55% of the population are within the 25–34 years age cohort. There is a higher male population within the 0–14 years age cohort, however, there are more females in the 15–24 and 25–34 age cohorts in the community. Some 42% of the households are headed by persons who are unemployed.

5.3.4.4 Hertford

The overall population of Hertford is estimated to be 2,535 with approximately 766 households. The average size of each household being 3.3 individuals. Many households (76%) are headed by males. Approximately 74% of the households in Hertford are headed by employed individuals. It was estimated that 81.8% of household heads had no academic qualification, while 45.5% of household members had no academic qualification.

5.3.4.5 Friendship and Amity

No demographic data was provided for these areas.

No information was provided on the population growth/decline over time or population density. Information was not provided for all communities regarding the gender of persons heading households.

Settlements closest to the proposed mill include Hertford, Friendship and Petersfield.

5.3.5 HOUSING AND PROPERTY OWNERSHIP

A summary of the housing statistics for Petersfield, Hertford, Frome and Savanna-la-Mar are provided in Table 5-21. Information on Amity and Friendship was very limited and thus not presented. Photographs of houses seen during the site reconnaissance are presented in Plate 5-7.

Table 5-21: Summary of Housing and Property Ownership Information in the Settlements investigated in the SIA

CATEGORIES	COMMUNITIES			
	Petersfield[41]	**Hertford**[42]	**Frome**[43]	**Savanna-la-Mar**
Land ownership	Owned land – 91% Rent – 9%	Captured land – 42.9% Owned land – 26% Rent land – 22.1%	Owned land – 26.8%	Captured land – 25.5% Owned land – 23.9% Family-owned land -16.6%
Home ownership		Owned houses – 94.8%	Owned houses –73.8%	
No. Housing Units	1777		445	6846
Housing construction material/ composition		Board/wood – 63.1% Blocks – 26.2% Board and blocks-10.6%	Mostly wooden "barracks-style houses"	
No. of Dwellings	1871		515	7564
No. of Households	1878		525	7620

Plate 5-7: Houses seen during the Site Reconnaissance in the immediate area surrounding the proposed Mill Site

5.3.6 DESCRIPTION OF EXISTING INFRASTRUCTURE

The infrastructure is typically what is found in a rural community in Jamaica and is maintained by the WMC. The WMC is mandated to provide services that take care of physical infrastructure, infirmaries and welfare services. The WMC has been involved in the maintenance of roads, disaster management through bushing and drain cleaning, monitoring water supply, public water supplies, garbage

[41] Land ownership data from the stakeholder surveys. All other data was compiled from socioeconomic survey conducted by SDC, 2005.
[42] Data was compiled from socioeconomic survey conducted by SDC, 2008/9.
[43] Data was compiled from socioeconomic survey conducted by SDC, 2009.

collection, the provision of technical services, facilitating tourism, for example, by repairing the Roaring Park and Cave, and assisting in the adequate provision of social services.

The communities investigated occasionally suffer a full or partial loss/loss of function of infrastructure from flooding. The WMC is actively involved in drain cleaning in areas like Petersfield, Friendship and Frome, along with other ongoing activities towards the upkeep of physical infrastructure.

Water Supply, Sewerage, Garbage Collection and Pollution

Surveys have indicated that public services are provided at the basic level as most people in these communities receive piped running water and have garbage receptacles available to them for disposal purposes. Water is piped to most residences from the NWC, although some from the communities of Hertford, Petersfield and Friendship collect water from nearby sources, such as rivers, wells and other sources. Of the six settlements investigated, Friendship has a deficit in water supply and water is routinely trucked to this community. There is no central sewage treatment system in the area. Community members report the use of septic tanks and soak-away pits. The National Solid Waste Management Authority (NSWMA) collects and disposes of solid waste in all the communities. Some residents reported that collection of solid waste was inconsistent.

Surveys of 102 community members showed that 93% of all respondents use garbage bins as their mode of disposal, while 23% rely on using garbage bins and the burning garbage. Burning garbage and the "slash and burn" method, commonly observed on sugar cane farms are forms of pollution that threaten public health and land sustainability. Also, the uncontrolled spread of fires could negatively affect the environment by negatively impacting the soil, water resources, air quality and physical infrastructure. Historically, activities form the Frome Sugar Estate have also potentially impacted these receptors through reports and allegations of ongoing negative effects from high dust emissions, odour from the degrading sugar cane, and the reduction of fish in the Cabarita River.[44]

Road Network and Drainage Infrastructure

Most of the roads in the settlements consist of Class C roads, tracks and paths with Class A and B roads found in and going towards Savanna-la-Mar. Traffic on this road is generated from cars, trucks and 'bike taxis'. Most residents perceive road safety to be at a medium level. No comments were made on the current road quality. Bridges can be found along the Cabarita and Roaring Rivers; however, their quality and state were not assessed.

Utilities

Electricity is supplied by JPS Co. No information was provided regarding any gaps in the service. Telecommunications is provided by two providers – Flow and Digicel. No information was provided on the coverage or internet/data coverage.

5.3.7 ECONOMIC ACTIVITIES

Based on the history of the development of the area, the economy is highly dependent on and has been shaped by agriculture and manufacturing. In 2007, it was found that farmlands comprised about 11% of Westmoreland, making it the parish with the 4th largest proportion of the total land in farming in Jamaica. However, with the national decline in sugarcane production, the economic development

[44] Fond memories of a dying Cabarita River | Western Focus | Jamaica Gleaner (jamaica-gleaner.com)

of the settlements and farming areas have been stunted over the years. Other issues such as praedial larceny have also had an impact on agriculture. Tourism is a major activity in two of the settlements – Petersfield and Friendship. This was facilitated due to their proximity to the Cabarita River, Roaring River and Cave which are used for recreational activities. However, this was also negatively impacted during the COVID-19 pandemic. Outside of these two industries, the settlements investigated have several small businesses, such as eating and drinking establishments, supermarkets, and retail outlets. More economic opportunities, however, are concentrated in Petersfield and the capital, Savanna-la-Mar.

Most of the communities have low levels of economic opportunities. This is due to the decline in the sugar industry as well as a lack of training and employment opportunities. Respondents to surveys in the SIA also indicated that existing jobs are 'typically low-paying'. Common occupations in these areas include business owners (many of whom own retail outlets and food establishments), retail employees, taxi operators, construction workers, carpenters, farmers and students. Youth and adult unemployment levels remain high in Frome, which has led to several issues including brain drain and people resorting to illegal economic activities such as 'scamming'.

Within the six settlements investigated in the SIA, all can be considered as 'residential'. Savanna-la-Mar and Petersfield are also designated as 'commercial', while Petersfield, Amity, Friendship, Frome and Hertford are also designated as farming.

5.3.8 FARMING

The Frome Sugar Estate in Frome is the main commercial farming enterprise in the parish of Westmoreland. It is also one of Jamaica's last and largest existing sugar factories and is considered one of Westmoreland's main single sources of income, outside of tourism. The factory was built by Tate and Lyle in 1938, amalgamating seven area factories. The factory is now owned by the Chinese PCSC and has been underperforming for the past several years, in spite of multi-million-dollar rehabilitation efforts made in 2015. Its low performance levels are due to incidences of cane fires, a decrease in cane cutting employees, sugar trafficking, and flooding as of 2020.

Farming is also done at the Cabarita River Adventure and Mesopotamia Leisure Farm tourist attraction in Friendship. Crops grown at this site include plantain, pumpkins, corn, pineapple, guava, breadfruits, yams, bananas and sugar cane.

5.3.9 TOURISM

Tourism is primarily concentrated in Petersfield. Tourism attractions and businesses within 4 km of the proposed mill are displayed in Figure 5-44 and these are:

- Roaring River and Cave attractions located in Petersfield and Whithorn (>2000 tourists visit annually);
- The Yardy River Adventure Tours at the Roaring River in Petersfield;
- Cabarita River Adventure and Mesopotamia Leisure Farm in Friendship;
- The Yahso Jungle Adventure in the Fort William District; and
- The RastaSafari Experience in Petersfield.

Tourist attractions within the area provides eco-tourism and water activities such as cave exploring, swimming, river tubing, boat rides and ATV tours. The closest tourist attraction to the proposed mill site is the Cabarita River Adventure and Mesopotamia Leisure Farm located 0.5 km straight-line distance downstream from the proposed mill, specifically, 0.5km downstream from the proposed siting of the treated wastewater outfall in the concept layout in Figure 4-15. This attraction is the most exposed to the mill operations and trade effluent discharge.

Figure 5-44: Tourist Sites within 4 km of the proposed Mill Location in Friendship, Westmoreland

5.3.10 GENDER DISTRIBUTION OF LABOUR

Employment levels in the area favour females over males. It was identified in the SIA that factors contributing to this include:

i. Pressure for many low-income males throughout Jamaica to drop out of secondary school to help to contribute financially to the family unit; thus, encouraging their participation in informal and/or illicit economic activities. Additionally, the lack of academic or vocational certifications limits their ability to be employed in higher-income, formal jobs later in life;

ii. Decline in traditionally male-dominated industries (e.g., agriculture).

Even though the rise in female employment has led to the economic empowered of women, several hurdles that must be overcome are issues stemming from deeply entrenched patriarchal attitudes and norms in Jamaica. These include limits on the upward professional mobility of females, the common acceptance of workplace sexual harassment, the preference shown towards males by financial institutions when lending support to new entrepreneurs, and the cultural practice of passing land inheritance on to sons instead of daughters. The latter could hinder females' ability to enter into farming contracts in the project.

5.3.11 USE OF RIVERS WITHIN THE PROPOSED PROJECT AREA

As the proposed mill intends to extract water and release treated effluent into the Cabarita River, an assessment of the use of the rivers within the proposed project area and from the proposed mill to the marine environment was necessary. Figure 5-45 presents the relevant tributaries and distributaries relevant to the project. The current uses of the rivers are presented below.

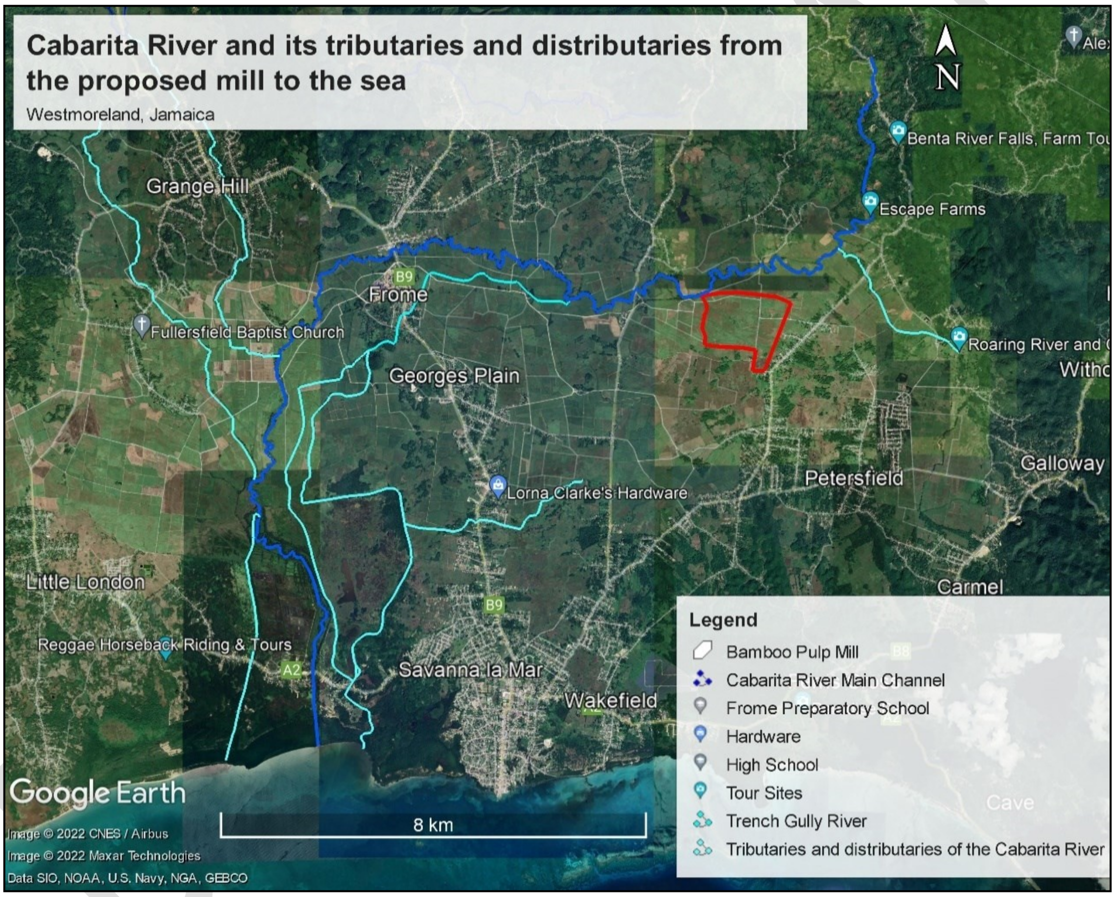


Figure 5-45: Tributaries and Distributaries of the Cabarita River within the Vicinity of the proposed Mill to the Sea

5.3.11.1 Fishing

Interviews with residents reveal that the Cabarita and Roaring Rivers in the area are used for subsistence and commercial fishing (Figure 5-46). In the community of Big Bridge near the mouth of the Cabarita River main channel and its distributaries, fishing used to be a main activity; however, the contamination of the river from what is locally described as 'dunder' has reduced this activity.[45]

[45] https://jamaica-gleaner.com/article/western-focus/20150519/fond-memories-dying-cabarita-river

Private fish ponds, with an area of 1.15km were also operational in Big Bridge, Savanna-la-Mar adjacent to the river, however, they were discontinued.

5.3.11.2 Recreational Swimming/Bathing/Tourist Activities

It was indicated that residents and tourists use the Cabarita and Roaring Rivers for recreational swimming/bathing, river tubing, boating and for tourism. The location of tourist sites within 4km of the proposed site is presented in Figure 5-44. Other facilities from the outlet of the mill to the sea were investigated and the only tourist facilities located from the outlet of the proposed mill to the sea are the Cabarita River Adventure and Mesopotamia Leisure Farm in Friendship and the Cabarita River Raft and Tours in Big Bridge.

5.3.11.3 Religious Purposes

In advertisements for the Cabarita River Adventure and Mesopotamia Leisure Farm in Friendship, it was indicated that the Cabarita River is also used for baptisms. The Burnt Savannah Church of the Nazarene also uses the Cabarita River for baptisms near the Frome Technical High School.[46]

5.3.11.4 Irrigation and for Domestic Purposes

An indication was given that the water from the river, in addition to rainwater, is used for irrigation in areas such as Hertford, Friendship and Petersfield which at times depend on alternative supplies of water. Observations and discussions with community members made during the fish assessment and subsequent visits showed that the river is used to wash both cars and clothes.

Figure 5-46: Uses of the Rivers in the Area which include for Religion (TOP LEFT), Fishing (TOP RIGHT) and Recreation/Tourism (BOTTOM) (Sources: Cabarita River Adventure and Mesopotamia Leisure Farm, 2021;[47] Taken during Ecological Survey (ESL, 2021)

[46] https://www.mesoamericaregion.org/en/2016/09/12/ ;
[47] Taken from the Gallery. Gallery - www.cabaritariveradventure.com

5.3.12 COMMUNITY SERVICES

Table 5-22 below shows the social services available in the various communities examined in the SIA. It is evident that most of the services are concentrated in the capital – Savanna-la-mar. The settlement of Amity has the least services offered.

Table 5-22: Social Services within the Communities examined in the SIA

HERTFORD	FRIENDSHIP	PETERSFIELD	AMITY
Places of Worship • Hertford New Testament Church of God • Wesleyan Holiness Church • Petersfield Seventh-day Adventist Church **Major Roads** • Torrington to Galloway Road • Hertford to Flowerhill Road **Schools** • Bastard Cedar Walk Early Childhood • Institution	**Places of Worship** • Friendship Apostolic Church • Friendship Seventh Day Adventist Church • Friendship Assemblies of Holiness **Major Roads** • Truro Gate to Locust Tree Road **Educational/Training Institutions** • Bleawarrie Primary School • Friendship Primary & Infant School **Other community assets** • Bath Mountain Community Center • Mount Grace Junior High and Primary School • Strawberry Postal Agency	**Places of Worship** • St. Peter's Anglican Church • Spiritual Church of the Nazarenes **Major Roads** • Torrington to Galloway Road • Hertford to Flowerhill Road • William Road **Educational/Training Institutions** • Petersfield High School • Petersfield Vocational Training Center • Petersfield Primary & Infant School **Other Community Assets** • Petersfield Post Office • Petersfield Health Centre • Westmoreland Parish Library (Petersfield) • Petersfield Galloway Benevolent Society (formerly known as the Association of Clubs) • Petersfield Community Centre • Petersfield Cemetery • "Pride of Petersfield" Park	**Major Roads** • Torrington to Galloway Road **Other Community Assets** • Amity Square • DCS Nursing Home

FROME	SAVANNA-LA-MAR
Places of Worship • Townhead Baptist Church • Ricketts River Wesleyan Holiness Church • Water works Seventh-day Adventist • Church • St. Patrick's Methodist Church • Burnt Savanna Nazarene Church • Truro Seventh-day Adventist Church • Burnt Savannah Wesleyan-Holiness • Church • Kingdom Hall of Jehovah's Witnesses **Major Roads** • Truro Gate to Locust Tree Road **Educational/Training Institutions** • Frome Technical High School • Frome Preparatory School • Montego Bay Community College (Frome Campus) • Frome Early Childhood Institution • Three Miles River Early Childhood Institution	**Places of Worship** • Savanna-la-Mar New Testament Church of God • Savanna-la-Mar Methodist Church • Savanna-la-Mar Seventh-day Adventist Church • St. Joseph Catholic Church • St. George's Anglican Church • Footprints Seventh-day Adventist Church • Savanna-la-Mar United Church • Church of Jesus Christ of Latter-day Saints (Savanna-la-Mar Branch) • Kingdom Hall of Jehovah's Witnesses **Major Roads** • Great George Street • Rose Street • Barracks Road • Strathbogie Road • Seaton Street • Darling Street

FROME	SAVANNA-LA-MAR
Other community assets • Frome Police Station • Frome Post Office • Frome Sports Complex	**Educational/Training Institutions** • Manning's School • Godfrey Stewart High School • Savanna-la-Mar High School • Savanna-la-Mar Primary School • Unity Primary School • Sir Clifford Campbell Primary School • Kiddies Preparatory School • Llandilo School of Special Education • Savanna-la-Mar Inclusive Infant Academy • Supreme Kids Kindergarten • UWI Open Campus (Savanna-la-Mar) • Westmoreland Business College • Westmoreland Driving Institute **Medical Services** • Savanna-la-Mar Hospital • Royale Medical Centre • Savanna-la-Mar Health Centre • Westmoreland Infirmary • TRVALA Health Clinic • Urgent Care 360+ Family Medicine • Sav Gynae Center **Other community assets** • Savanna-la-Mar Police Station • Savanna-la-Mar Fire Station • Savanna-la-Mar Post Office • Savanna-la-Mar Tax Office • Savanna-la-Mar Court House • Westmoreland Family Court • Westmoreland Parish Library • Westmoreland Municipal Corporation • Westmoreland Health Department • Registrar General's Department • HEART Trust NSTA Parish Office • Westmoreland Youth Innovation Centre • Llandilo Sports Complex • West Palm Memorial Garden • Independence Park

5.3.13 EXISTING COMMUNITY CHALLENGES

The main community issues faced include limited maintenance of infrastructure, proliferation of informal settlements/land tenure, home ownership, migration, youth unemployment, damage, low economic opportunities and low wages, lack of water especially in Friendship and the negative impacts of flooding on crops, infrastructure and livelihoods. A summary of the challenges identified by the communities from the SIA are presented in Table 5-23.

Table 5-23: Major Concerns of the Settlements investigated in the SIA

HERTFORD	FRIENDSHIP	PETERSFIELD	AMITY
• High levels of adult (25yrs and over) unemployment • High levels of youth unemployment (14–24 years) • Low skill levels • Limited/no opportunity for training and employment • Poor roads	• Low level of economic opportunities present • External migration to other areas is fairly common • Insufficient number of businesses to hire people in this area	• Unemployment • Need for proper recreational and skills training facilities (e.g., community centres, playfields, etc.) • Need for a better drainage system • Lack of effective community organization • Need for better road surfaces	• Small population size • Residents typically employed at low-income jobs • May have a significant proportion of elderly residents
FROME		SAVANNA-LA-MAR	
• High levels of adult and youth unemployment • Poor Parenting • Limited/No opportunity for training & employment • Limited access to required amenities • Poor representation by elected political leaders		• Poor road conditions • High levels of youth unemployment (15–24 years) • High levels of high school dropouts • Poor representation by elected political leaders • Low skill levels • Poor drainage facilities	

5.3.14 ARCHAEOLOGY/HERITAGE

The Jamaica National Heritage Trust (JNHT) was consulted on the proximity of heritage sites to the proposed mill and the need for an Archaeological Impact Survey and no indication was given for either. Desk reviews on the JNHT interactive web map indicated that there were no national heritage sites within a minimum of 5 km of the proposed mill site. Heritage sites are located within the capital of Savanna-la-Mar; however, these are not within 5 km of the proposed mill.

During the site reconnaissance, no heritage sites were observed. According to the SIA (see **Appendix O**), the towns of cultural heritage include Petersfield, Frome and Savanna-la-Mar. The cultural heritage in these communities and towns were mostly shaped by their history in sugar plantation economy. Of note, the 1938 labour riots, stemming from a mass redundancy drive eventually led to the passing of Universal Adult Suffrage in 1944, a new Constitution and ultimately Jamaica's Independence from Britain. Remnants of Jamaica's bygone sugar eras can be seen in the form of centuries-old church buildings and Georgian architecture, which can be seen in Savanna-la-mar.

5.3.15 TRAFFIC ASSESSMENT

The road network serving the zone of impact of 1 km surrounding the mill and en route to deliver the produced pulp to the Port of Montego Bay comprises 1 Class A Road (Galloway to Reading to the Port of Montego Bay – seen as the B8 road in Figure 5-7; 2 Class B Roads (Hertford to Galloway and Hertford to Ferris Cross); 1 Class C Road (Hertford to Flowerhill Road) adjacent to the proposed mill; and multiple tracks and other types of smaller roads. Residential community roads and farm roads branch from the Hertford to Flowerhill Road adjacent to the proposed mill.

Observations made during the site reconnaissance indicated that that Class B and C roads experience traffic flows from the nearby Friendship Estate and surrounding communities. The 'Hertford to Flowerhill' Road experiences significant traffic as it facilitates travel between the parishes of Westmoreland and Hanover. The Class A road from Galloway to Reading also experiences traffic as it facilitates travel between the parishes of St. James and Westmoreland and is used for transit between Montego Bay and Westmoreland.

Findings from the SIA indicated that there were concerns on the potential for BBP trucks to increase congestion and levels of deterioration on local roads. Responses from BBP on this concern included:

i. BBP could prevent increased traffic by transporting BBP materials via trucks primarily at night and requesting that GoJ build separate 'bamboo roads' for BBP trucks;
ii. BBP can help to maintain heavily used roads most in need of repairs.

The potential risk was preliminarily investigated through a basic traffic study. Traffic study measurements were provided by the National Works Agency (NWA) for five intersections in the proposed transit routes of material to and from the proposed mill. These measurements were used to assess the impact on local transport infrastructure due to this proposed project. The roads assessed and their significance to the project are presented in Table 5-24, Table 5-25, Figure 5-47 and Figure 5-48.

Table 5-24: Traffic Data assessed for Intersections within the Project's Zone of Influence (Source: NWA, 2021)

Traffic Data	Date collected	Significance to the Project
Galloway Intersection: Roads to Ferris Cross, Petersfield, Whithorn	June 2015	Ingress and egress to the pulp mill.
Hertford Intersection: Roads to Petersfield, Amity Cross, Friendship Cross **(*closest to the proposed mill*)	June 2014	
Bogue Road to Reading	March 2019	Transit between the proposed pulp mill and the Port of Montego Bay.
Intersection of Bogue Road and Bogue Estate	May 2017	
Intersection of Alice Eldemire Drive, Bogue Road and Barnett Street	December 2014	

Table 5-25: More detailed Information on the Traffic Data. Road Information from Friendship Cross to Hertford was extracted as this is the most relevant Road to the proposed Project Site.

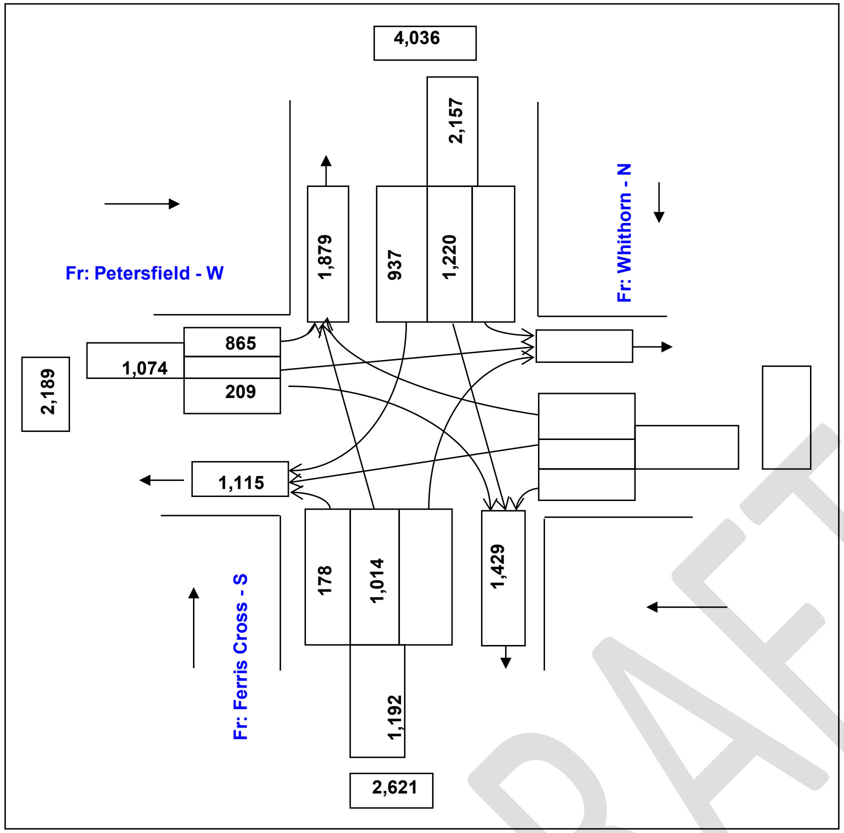
Traffic Date	Max. No of Vehicles reaching the Intersection	Most used Leg	Peak Hours for Traffic Data
Galloway Intersection: Roads to Ferris Cross, Petersfield, Whithorn (see LEFT in **Figure 5-47)**	**4036** *Cars – 3794* *Trucks - 242*	Whithorn to Galloway	AM Peak (7:30–8:30) Mid Peak (11:00–12:00) PM Peak (16:00–17:00)
Hertford Intersection: Roads to Petersfield, Amity Cross, Friendship Cross (see RIGHT in **Figure 5-47)**	**6029** *Cars – 5685* *Trucks - 344*	Amity Cross to Hertford	AM Peak (8:00–9:00) Mid Peak (12:30–13:30) PM Peak (15:30-16:30)
**** Friendship Cross to Hertford Intersection (adjacent to the proposed mill)** (see RIGHT in **Figure 5-47)**	**2099** *Cars – 2017 (96%)* *Trucks – 82*	Northbound from Hertford to Friendship Cross	AM Peak (7:30–8:30) Mid Peak (12:00–13:00) PM Peak (16:00–17:00)
Bogue Road to Reading ***Only N route from Reading to Bogue considered**	**797** *Cars – 723* *Trucks – 74*	N/A as only one route being used	AM Peak (9:00–10:00) Mid Peak (11:30–12:30) PM Peak (17:00–18:00)

Traffic Date	Max. No of Vehicles reaching the Intersection	Most used Leg	Peak Hours for Traffic Data
(see TOP RIGHT in **Figure 5-48)**		from Bogue to Barnett Street	
Intersection of Bogue Road and Bogue Estate (see TOP LEFT in **Figure 5-48)**	**<u>28,279</u>** *Cars – 26,530* *Trucks – 1749*		AM Peak (7:30–8:30) Mid Peak (12:30–13:30) PM Peak (17:00–18:00)
Intersection of Alice Eldemire Drive, Bogue Road and Barnett Street (see BOTTOM in **Figure 5-48)**	**<u>23,978</u>** *Cars – 23,094* *Trucks – 884*		AM Peak (9:00–10:0) Mid Peak (11:30–12:30) PM Peak (17:00–18:00)

Based on the traffic data above, the most relevant intersection – Friendship Cross to Hertford – will significantly be impacted by the mill operations as an estimated increase of the transit of 240 trucks[48] which is nearly three times the normal traffic at this intersection. This may increase traffic congestion as well as reduce the lifespan of local roads. One recommendation provided in the SIA (**Appendix O**) was to transport material during off-peak hours. The off-peak hours for the five intersections are presented in Table 5-25. A more detailed traffic assessment will be required once BBP provides more information on the electric-powered trucks.

The weight limits for Jamaican roads as stipulated by the NWA are 5,000 kg for Front Axle-Single Tyre and 10,000 kg per axle for Rear Axle-Dual Tyre trucks (NWA, 2006). BBP intends to procure/purchase electric-powered trucks to transport the raw bamboo chips/culms from the Port of Montego Bay to the mill and the produced bamboo pulp from the mill to the Port of Montego Bay. Transport of the material by these electric-powered trucks should conform with the current local weight limits until they are revised. However, it is important to note that the weight of the truck is highly dependent on the bulk density of bamboo (whether whole culms or chipped or pulp-form) where the volume, and not the weight, is the limiting load factor.

[48] Assume 30–40 containers moved daily equates to 60–80 trips by truck. Add 50–80 truck entering the mill with raw bamboo daily equates to a max of 160 trips. 80+160 = 240.



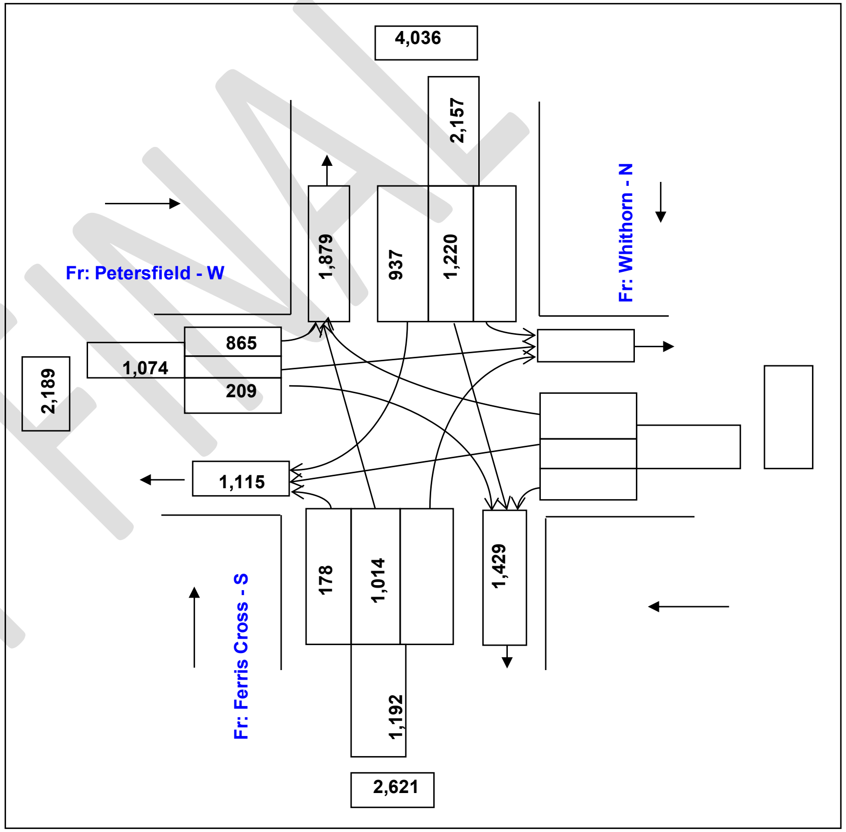


Figure 5-47: Ingress and Egress Intersections to and from the proposed Mill. LEFT: Galloway Intersection. RIGHT: Hertford Intersection.

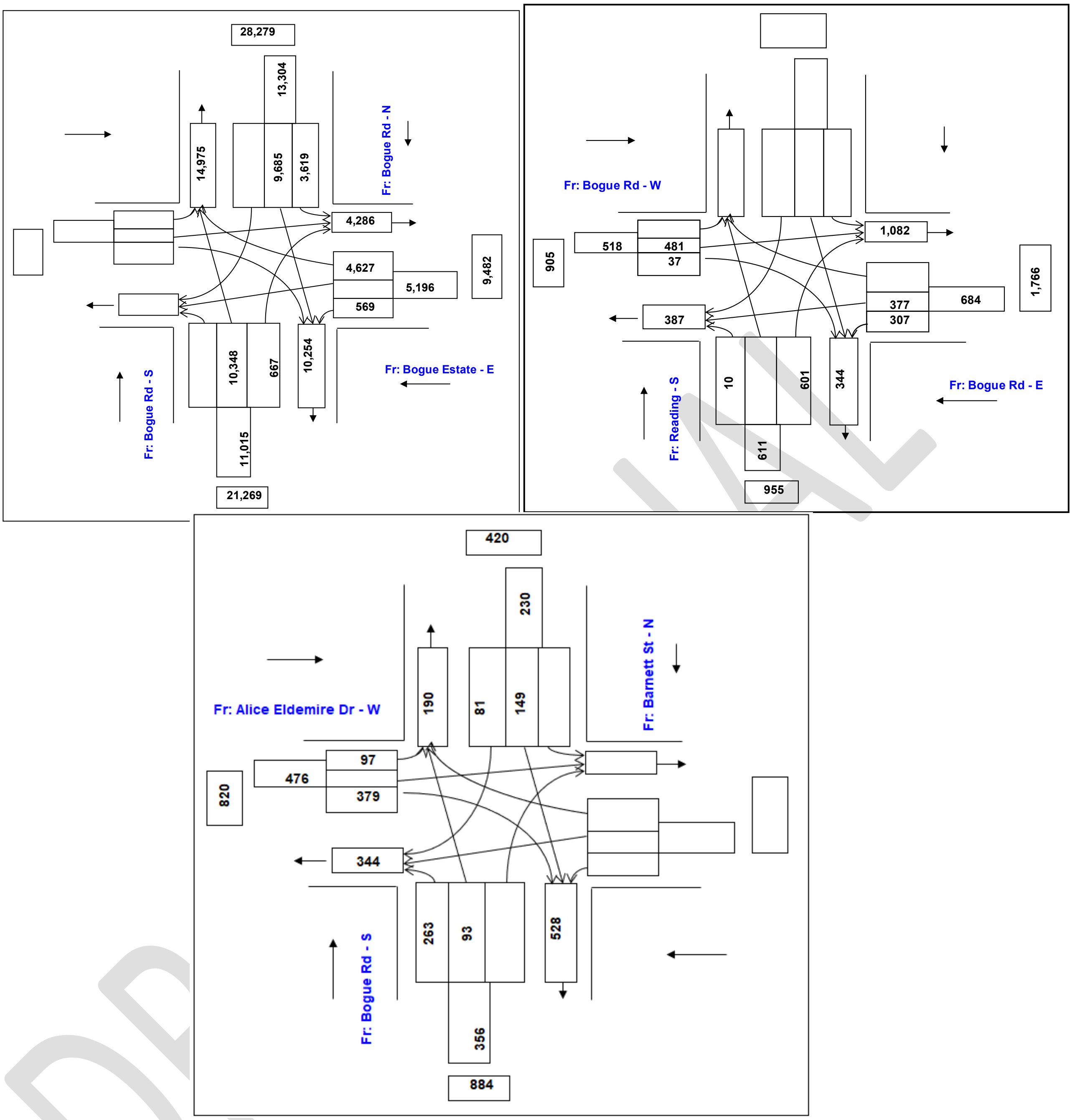


Figure 5-48: Intersections in Transit from the proposed Mill to the Port of Montego Bay, cumulatively and at Peak Hours. TOP LEFT: Bogue Road to Bogue Estate. TOP RIGHT: Bogue Road to Reading. BOTTOM: Alice Eldemire Drive Intersection (Source: NWA, 2021)

5.4 PUBLIC PARTICIPATION

The public participation consisted of several stakeholder meetings with key stakeholders, the surveying of 102 individuals the nearby communities, the hosting of a Community Open-Day and subsequent feedback. As the consultations were conducted during the COVID-19 Pandemic, many surveys were held virtually with some face-to-face. Stakeholder meetings were held in July 2021 with the Political Representatives, General Parish Stakeholders and Agricultural Stakeholders and Community Members. The results of the meetings were disclosed among stakeholders at an in-person event on October 23, 2021, held at the Frome Technical High School.

5.4.1 SUMMARY CONCERNS FROM THE COMMUNITY MEETING AND KEY STAKEHOLDERS

Table 5-26 presents the top 10 issues raised at the initial stakeholder interviews held in July 2021. Table 5-27 displays the stakeholder issues and responses from the initial stakeholder meetings and interviews. Table 5-28 displays the questions and responses from participants that attended the Open Day on October 23, 2021.

Table 5-26: Summary of the top 10 Issues raised in the Stakeholder Interviews

Top 10 Issues Raised in Stakeholder Interviews
Local Labour Market
Lack of employment opportunities and the prevalence of fairly low-paying jobs in LDAs.
Lack of Training
Lack of training opportunities in LDAs.
Farming Contracts
Concerns regarding the difficulty with which contracted farmers' land can transition to cultivating other crops once bamboo is farmed and their contracts end.
Local Government Involvement
Low levels of local government involvement, especially in the areas of local employment, housing and road works.
Water Supply
Some LDAs may experience the frequent dysfunction of public facilities aimed to supply water.
Pollution
• Concerns regarding the environmental and health impacts of the mill's dust emissions. • Concerns regarding the potential for the fluid waste generated from the mill to contaminate local waterbodies • Concerns regarding the practice of negative agricultural methods among contracted farmers (e.g., the 'slash and burn' technique which can result in air pollution)
Health
• The Petersfield Health Centre needs improved equipment and, possibly, increased human resources. • The Savanna-la-Mar Public General Hospital is in need of improved medical infrastructure and increased human resources in order to provide sufficient COVID-19 relief to the parish.
Social Nets
• The following vulnerable groups are in need of social aid: ○ The elderly ○ Children ○ People with disabilities ○ The economically disadvantaged
Road Safety
Levels of road safety can be improved upon. Issues like speeding, incompetent driving, and road deterioration need to be tackled.
Traffic
Concerns expressed regarding the mill's potential to increase traffic due to the commutes of BBP trucks

Source: SIA (see **Appendix O** for full report)

Table 5-27: Snapshot of most of the Stakeholder Issues and Responses identified during the Stakeholder Meetings and Interviews extracted from the SIA

Issue	Stakeholders Who Raised Issue	Response (avoid, mitigate, manage, communicate)
Local Labour Market		
Lack of employment opportunities and the prevalence of fairly low-paying jobs in LDAs.	• Surveyed Community members • Political Representatives • General Parish Stakeholders • Westmoreland Chamber of Commerce	BBP will increase local employment opportunities by hiring residents of LDAs and surrounding areas to work on the development and running of the BBP mill.
Farming Contracts		
Concerns regarding the practice of negative agricultural methods among contracted farmers	Agricultural Stakeholders	BBP will discourage the use of the slash and burn method and teach contracted farmers eco-friendly bamboo farming techniques.
Lack of Training		
Lack of training opportunities in LDAs.	• Surveyed Community members • Political Representatives • General Parish Stakeholders • Westmoreland Chamber of Commerce	BBP will increase local training opportunities by partnering with secondary and post-secondary institutions.
Local Government Involvement		
Low levels of local government involvement, especially in the areas of local employment, housing and road works.	Surveyed Community members	BBP will advocate for the governmental prioritization of specific issues and will offer assistance in finding/providing solutions.
Water Supply		
Some LDAs may experience the frequent dysfunction of public facilities aimed to supply water.	Surveyed Community members	BBP can partner with the WMC to improve the sustainability of public water supply services.
Pollution		
Concerns regarding the potential for the fluid waste generated from the mill to contaminate local waterbodies	• Surveyed Community members • General Parish Stakeholders • Agricultural Stakeholders • Westmoreland Chamber of Commerce	BBP mill plans to recover 85% of its chemicals used on a continuous basis by channeling water through to a water treatment plant. This will lead to residual bamboo waste (e.g., lime sludge) being used to produce bioproducts onsite.

Source: SIA (see **Appendix O** for full report)

Table 5-28: Questions and Answers from the Community Open-Day held on October 23, 2021

ENVIRONMENTAL IMPACT	SALES
Q: How much energy will be generated to run the mill? Will some of it be given back to the community? A: *This is currently under discussion with the respective authorities*	Q: What is **BBP**'s expected profitability margin? A: *This has not yet been determined.*
Q: How does the mill intend to control the amount of dust emissions it has? A: *Dust will filter through an advanced dust collection system causing the dust emissions to be below the legal amount based on work wide standards.*	Q: Does **BBP** have plans to start manufacturing and exporting finished products (rather than simply exporting raw materials), in its later stages of operations? A: *Trash from the bamboo will be used to make straws*
Q: Will **BBP** trade carbon credits? A: *This has not yet been determined.*	

FARMING	
Q: What guarantee of protection will farmers get from **BBP** (e.g., to protect against the possibility of farmers spending the first year growing bamboo only for **BBP** to later decide to go in another business direction)? A: ***BBP** will draw up long term, legally-binding contracts for farmers.*	Q: Approximately how many workers will be needed for factory? A: *The project will generate approx. 1,000 direct high paying Jamaican jobs, placing professionals, skilled labour and farm labour in year-round employment*
Q: Will farmers be trained based on **ISO** standards? A: *Yes.*	Q: How will we propagate the bamboo? A: *The propagation method(s) has not yet been decided upon. It should be noted, however, that methods may differ based on area in which it is farmed.*
Q: How will payment to farmers take place? E.g., Frequency etc. A: *This has not yet been determined.*	
Q: What will be the average yield per hectare? A: ***BBP** will have the final figure once the period of due diligence has finished.*	Q: Will farmers get better pay from planting bamboo than they would typically from planting cane? A: *Yes*
Q: Can small scale farmers (e.g., those who only own an acre or two of land), still eligible to enter into **BBP** farming contracts? A: *Yes, many people who have already expressed interest in entering into **BBP** farming contracts are small-scale farmers of such sizes.*	Q: How soon should farmers start looking into acquiring seedlings once the contracts are formed? A: *It is recommended this occurs immediately*

Source: SIA (see **Appendix O** for full report)

5.4.2 PUBLIC PERCEPTION SURVEY OPINIONS

A public perception survey was conducted as part of the project. The summarised views of the public are presented in Figure 5-49 below. If additional information on the demographics of the respondents, type of respondents and details on the questions asked is required, it will be provided in the final draft of the EIA.

Most people interviewed and stakeholders consulted indicated high levels of support for the development of the proposed mill. A breakdown of the levels of support is presented in Figure 5-49. It was identified in the SIA that the generally positive attitudes were primarily influenced by the hope of increased employment, training and economic activity to be brought on by the mill's development and eventual operations. However, the main issues that may have impacted the percentage of acceptance were the risk of increased pollution and other environmental issues (raised by over 50% of participants), a strain on public resources and infrastructure, and the effects of increased traffic in the area. On a positive note, it can be assumed that the public is interested in the project and want to be informed as 89% of all respondents shared their contact information in order to receive future updates on the progress of the project.

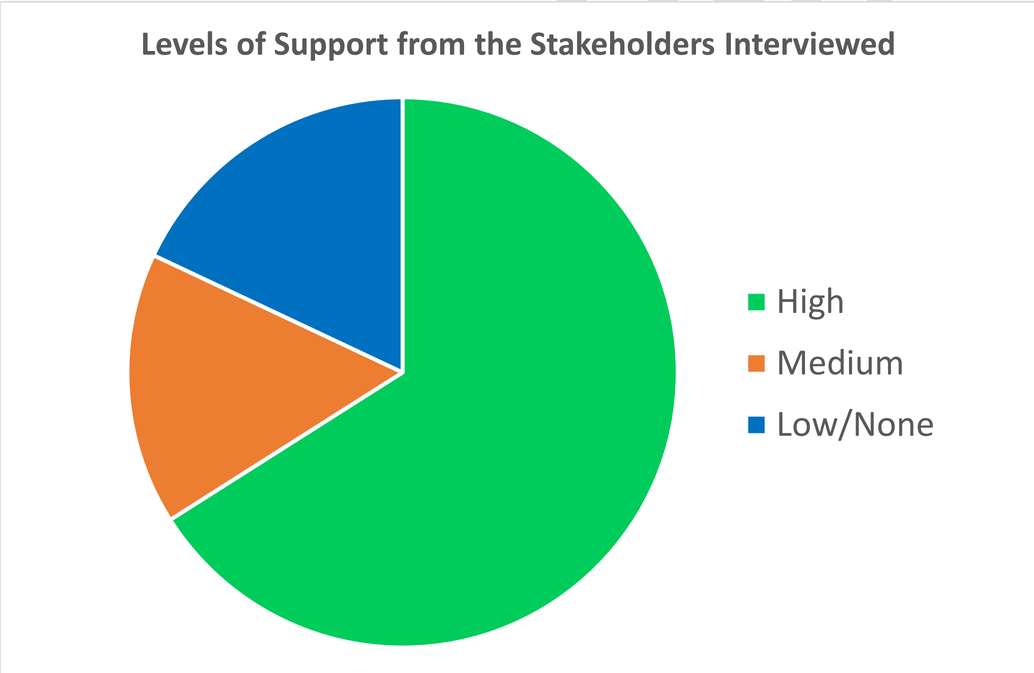


Figure 5-49: Graph showing the Levels of Support indicated by the Stakeholders surveyed

6 CLIMATE VULNERABILITY AND RISK ASSESSMENT

The Climate Vulnerability and Risk Assessment (CVRA) is used to identify and assess the potential Climate Change (CC) and associated hazard risks to the proposed mill and its environs and propose recommendations for the project's resilience. The funders of this proposed development requested that this detailed analysis be integrated into the environmental and social evaluation of the proposed project. This is accomplished through assessing the current and potential future vulnerabilities and using them to inform the risk assessment. The methodology of the CVRA is presented in **Figure 3-7** in Chapter 3. As the CVRA is in compliance with the Equator Principles, Chapter 6 will present the CVRA in the format required by the Equator Principles.

6.1 VULNERABILITY ASSESSMENT

A broad definition of vulnerability is the potential for harm or loss inherent in a person or thing (Weichselgartner, 2001). For different disciplines, the word has specific meanings (Furedi, 2004). In climate and disaster studies, vulnerability is key to understanding impacts. In 2015, the UNISDR expanded their 2009 definition of vulnerability to 'the conditions determined by physical, economic, social and environmental factors, which increase the susceptibility of a community to the impacts of a hazard'. This Vulnerability Assessment (**Figure 3-7**) includes an examination of the following three components to determine overall project vulnerability within its specific location and context:

- Sensitivity Assessment
- Exposure Assessment
- Adaptive Capacity Assessment.

The subsections below present the findings of each.

6.1.1 SUSCEPTIBILITY/ SENSITIVITY ASSESSMENT

Sensitivity is the degree to which the 'facility' is likely to experience one of the following in response to exposure to climate hazards:

- **Direct physical damage** to infrastructure, resulting in added repair costs and potential operational disruptions; or
- **Operational disruptions** (partial or complete), meaning services are limited or stalled for a period (UNCTAD, 2017).

This is generally the first step to understand how sensitive the proposed pulp mill, communities/Local Development Areas and the soil could be to damage or disruption from different climate related hazards.

Specifically, this subsection examines the existing and future sensitivity of the project location. It discusses the frequency with which the area, and specifically how the pulp mill and surrounding communities could be affected by climate-related hazards in the present and future. There is some mention to farm sites as identified, however this is minimal. It also examines how climate change and other future developments could affect the frequency of climate-related hazards affecting the area.

6.1.1.1 The Project Areas and Zone of Influence

Stakeholder consultations and the literature suggest that the main hazards experienced in the project area and its zone of influence are flooding and drought. A list of all the climate-related hazards identified is presented below and a summary of the existing and future sensitivities of the project site and surrounding communities/LDA's are presented in Table 6-1.

Flooding - The low-lying coastal town of Savanna-la-Mar, the capital of Westmoreland, is historically vulnerable to flooding from heavy rainfall from rainfall events, tropical storms and storm surges. Westmoreland is designated as a flood-prone area by the Office of Disaster Preparedness and Emergency Management (ODPEM). This will affect some communities that may have to be evacuated in extreme cases. Some stakeholders believe that flooding is also caused by the blocking of drains with debris due to improper garbage disposal as well as housing developments, and this, in turn, blocks the free flow of water. In addition, the soil texture at the bamboo pulp mill is clay/loamy. These properties increase the probability of retaining water rather than simply absorbing water, , thus increasing the likelihood of a flood event. Furthermore, there is a possibility of the nearby Cabarita River overflowing its banks. Section 5.1.5 discusses the future sensitivity of flooding in the project area.

Hurricanes and Extreme Wind - High velocity winds associated with hurricanes are quite common in the area. It is projected that there will be more Category 5 hurricanes, with their associated wind speeds. This may affect the businesses and homes near the project site and the surrounding communities. It will also affect the smaller bamboo plants, because the sturdy and flexible nature of the mature standing bamboo plants will cause them to bend, absorbing the wind energy of the storm, but will not break.

The mill is being designed and will be built to protect itself from Category 5 hurricane winds.

Rainfall/Dry Periods - The westernmost part of Jamaica, where the project site is located receives the second highest rainfall in the country. Rainfall in the west peaks in May and September to October. It follows the bimodal rainfall season, but there is less variability in rainfall from rainy to dry season, and is generally wet all-year round. It is projected that from the 2020s onward to the 2080s, there will be a decadal decline in rainfall. This is likely to affect the rainfed water that supplies the freshwater consumed by residents of the area, as well as the operations of the proposed mill, which will be supplied by the Cabarita River.

Storm Surge - Savanna-la-Mar is the capital of the parish of Westmoreland, in which the project site and the adjacent communities are located. Established in 1730, it is located on the southwestern part of the island. It is a low lying coastal town with wetlands in its western boundaries. It is because of these characteristics that it is extremely susceptible to inundation from storm surge and other hurricane-related damage. In 1780, the town was destroyed by a powerful hurricane, now known as the 'Savanna-la-Mar hurricane'. Since that time, several other hurricanes passing to the south of Jamaica have resulted in extensive damage and even loss of life. For this reason, Savanna-la-Mar is considered a vulnerable area for natural hazards (Jamaica Social Investment Fund, 2021). Storm surge flooding in Savanna-la-mar can exacerbate several rivers (Gooden's River, Smithfield River, Dunbar River) emptying along that area of the coastline, which tend to overflow its banks resulting in increased flood waters (Jamaica Social Investment Fund, 2021).

Storm Surge and **Port Facilities:** According to the 2015 State of the Jamaican Climate Report, it is projected that there will be an increase in the severity of storms and storm surges (CSGM 2017)**.** Storms can damage port infrastructure and interrupt commercial activities. Goods stored in wharehouses at ports can be lost, costing companies millions of dollars in inventory. This could also add further delays to shipping times and can stall other logistics for for intermodal routes that also use trucking freight partners to complete their supply chain[49]. Although BBP's port designated for the export of the product is not primarily assessed in this report, given this is a component of the overall project, it was important in this CVRA to highlight the existence of this risk.

[49] https://www.archwaymarinelighting.com/marine-safety/the-impact-of-hurricanes-on-waterways/

Table 6-1: Existing and Future Sensitivity of the Project Site and surrounding communities/LDAs. Table 6-2: Existing and Future Sensitivity of the Project Site and surrounding communities/LDAs.

Hazards	EXISTING SENSITIVITY		FUTURE SENSITIVITY	
	Level of Sensitivity/ Susceptibility	Description of Existing Sensitivity/ Susceptibility	Level of Sensitivity/ Susceptibility	Description of Future Sensitivity/ Susceptibility
Riverine flooding	High	The project site is within proximity to the Cabarita River which heightens the possibility of flooding due to heavy rainfall. Friendship, the community closest to the mill, is also very vulnerable to this hazard.	High	The detailed hydrological modelling indicated that only a small part of the mill, the north-western section that is nearest to the Cabarita River, would be sensitive to flooding, however, this section will be elevated to prevent this hazard.
Pluvial flooding[50]	High	The area floods with heavy rainfall. The soil is predominantly clay, and it takes several days to drain. Flooding occurs once there are extended periods of heavy rainfall. This has become a problem for the area since 2020.	High	Climate change projections point to more variable rainfall, specifically including increases in short duration of high intensity rainfall that can cause severe localised flooding. This is compounded by the soil type and textures in the area.
Wind Damage	High	Only occurs if there is a hurricane or a severe tropical storm with heavy winds. It affects businesses and the homes within the surrounding areas	Moderate	Hurricanes are projected to be more intense. As such, wind speeds will increase. They are unlikely to damage the mill which is being built to withstand the most extreme of hydrometeorological events. Additionally, if there are farm sites located within the 6 LDA's they are unlikely to damage the more mature bamboo plants. However, it may damage businesses and the homes within the surrounding areas.

[50] A pluvial flood occurs when an extreme rainfall event creates a flood independent of an overflowing water body.

Hazards	EXISTING SENSITIVITY		FUTURE SENSITIVITY	
	Level of Sensitivity/ Susceptibility	Description of Existing Sensitivity/ Susceptibility	Level of Sensitivity/ Susceptibility	Description of Future Sensitivity/ Susceptibility
Drought/ Water Availability	Moderate	Tends to occur in the dry season in the general area (mid-summer dry spell, July). This is especially acute in the Friendship community which does not have potable water and must resort to alternative sources, such as rainwater catchment tanks and water pumps and more recently, water has been trucked into the community.	Moderate	Mean, minimum and maximum temperatures are projected to increase, reducing water availability from rivers and aquifers. The detailed hydrological modelling results will confirm the significance of this change. More water will have to be trucked into more communities. More variability, but an overall reduction in rainfall.
Hurricanes and Tropical Storms	High	The site is affected once there is a hurricane coming from the south. Rainfall induced by hurricanes affects the project site and its nearby communities.	High	Hurricanes are projected to be more intense. As such wind speeds and rainfall will likely increase and thus affect the site.
Storm Surges	High	The topography of Savanna-la-Mar where the project site is located renders it susceptible to inland flooding from storm surges and other hurricane-related damage.	Extreme	Hurricanes are projected to intensify, and sea levels are projected to rise which will increase the probability of inland flooding. Though not within the 6 LDAs, flooding can also damage port infrastructure and supporting services and will also further delay shipping times and can stall other logistics for intermodal routes.

6.1.2 EXPOSURE ASSESSMENT

'Exposure' is the amount of infrastructure, population and assets geographically located within a hazard area. This section describes the main infrastructure, population and any other assets that are within the hazard areas associated with the construction of the Bamboo Pulp Mill in Westmoreland. It looks at existing exposure and future exposure with respect to climate change projections. It identifies the assets that are being proposed under this Consultancy that will be within the hazard area.

6.1.2.1 Project assets and infrastructure

This subsection describes the existing and proposed project assets and infrastructure in Friendship, Frome, Savanna-la-Mar, Amity, Petersfield and Hertford areas. It also identifies the hazards that have affected the existing assets and infrastructure in the past and indicates if the proposed assets and infrastructure are likely to be affected in the future as a result of climate change.

6.1.2.1.1.1 Friendship

The community and district of Friendship is the location of the proposed development.

6.1.2.1.1.1.1 Existing Exposure

Friendship is the closest area in proximity to the Cabarita River and as such, is highly exposed to flooding. Additionally, regular seasonal flooding contributes to the overall poor condition of the roads in Friendship and adjoining communities. Additionally, there is no health center in Friendship which increases the community's sensitivity to hazards.

Tourism is the main economic driver of the area followed by crop cultivation. Crops grown in Friendship include plantains, pumpkins, corn, pineapples, guavas, breadfruits, yams, bananas and sugar cane.

The area consists of a fair amount of modern infrastructure used for both social and commercial purposes. However, in recent years Friendship has suffered from a water shortage due to a defunct solar water pump and a leaky catchment. Other infrastructure in Friendship has benefited from improvement projects organized by the WMC.

Infrastructure that exists within the area includes:

Places of Worship	Major Roads	Educational/Training Institutions	Other Community Assets
• Friendship Apostolic Church • Friendship Seventh-day Adventist Church • Friendship Assemblies of Holiness	• Turo Gate to Locust Tree Road	• Bleawarrie Primary School • Friendship Primary and Infant School • Mount Grace Junior High and Primary School	• Bath Mountain Community Center • Strawberry Postal Agency

6.1.2.1.1.1.2 Future Exposure

As previously outlined, the following infrastructure has been proposed for the project site in Friendship:

- Bamboo Pulp Mill
- LNG Energy Facility
- Lorry Station
- Additional Roads
- Onsite Wastewater Treatment Plant
- Water Abstraction and Treatment Facility
- Chemical Storage Facility

Due to its proximity to the Cabarita River, the most imminent hazard that threatens the area is riverine flooding and the proposed infrastructure mentioned above could be negatively impacted during a flooding event. The hydrological assessment, found in Section 5.1.5.5 and in **Appendix N**, revealed that the north-western section of the mill would be vulnerable to flooding. However, plans are in place to elevate this area.

Over time the seasonal flooding from rainfall will contribute to the overall poor conditions of the road which would affect the transportation facilities of the pedestrians in the mill's workforce, and this could impact operations.

A decrease in rainfall and increase in droughts, increased temperatures and drier conditions create the right environment for the spread of fires, and so drought conditions could not only potentially yield a reduction in water availability but could also lead to an increase in fires. The cane fires that commonly pose a risk to the area are generally due to anthropogenic activities as part of a cultural practice, but this is being mentioned here as drought conditions create the ideal environment for fires to spread quickly. Climate change is also likely to increase exposure of the project assets and infrastructure to these identified hazards. ***Figure 6-1*** presents the exposure assessment of assets and infrastructure in Friendship.

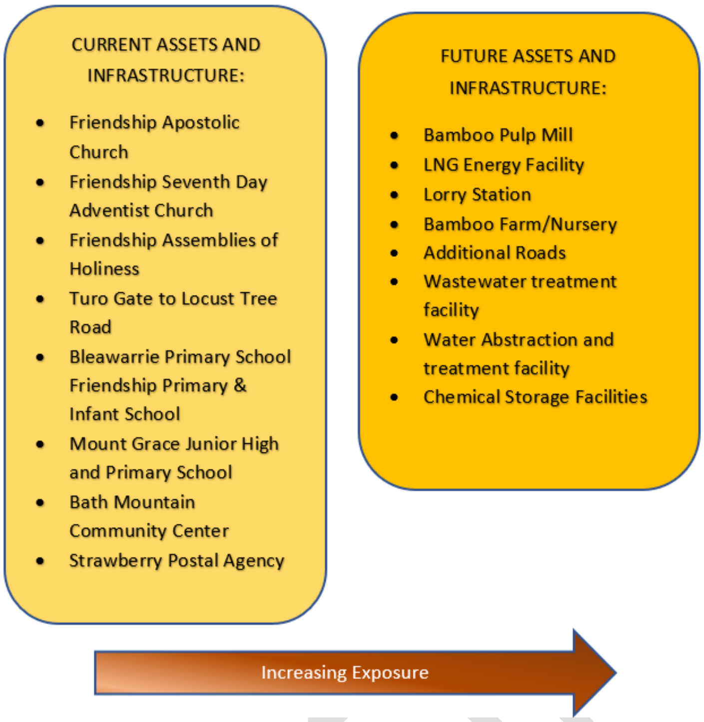


Figure 6-1: Exposure Assessment of Current and Future Assets and Infrastructure in Friendship.

It is projected that climate change will increase the exposure of Friendship community to hazards. With a reduced level of rainfall and increased temperatures, the area's sensitivity to drought is amplified due to its challenges with access to potable water and, with increasing temperatures, the potential for the increased incidents of vector-borne diseases, in particular, dengue fever transmission (CSGM, 2019). This is because heat creates favourable conditions for the maturity of the vector (Aedes aegypti) and the mosquitoes will bite more often. Furthermore, necessary water storage in this community creates favourable breeding grounds for this virus.

6.1.2.1.1.2 Frome

The Frome area is susceptible to several hazards and is one of the closest communities to the proposed development. This community is also home to an agro-industrial facility – the Frome Sugar Factory.

6.1.2.1.1.2.1 Existing Exposure

Currently, the Frome community is home to one of the largest sugar estates remaining in Jamaica with the Frome Sugar Factory at its centre. These lands and the factory are owned by the Chinese firm - Pan Caribbean Sugar Company (PCSC). The area has experienced several hazards over the years ranging from human-induced cane fires to most recently, the 2020 flood events.

The general area does consist of modern infrastructure and as such, the current exposure is greater than other more rural areas related to the development of the bamboo pulp mill. This infrastructure includes access to public piped water as well as garbage collection services from the NSWMA.

There is a high rate of tourist activity associated with the nearby Cabarita River as well as sporting events and school functions which take place within Frome.

Infrastructure that exists in the area includes:

Places of Worship	Major Roads	Educational/Training Institutions	Other Community Assets
• Townhead Baptist Church • Ricketts River Wesleyan Holiness Church • Water Works Seventh-day Adventist Church • St. Patrick's Methodist Church • Burnt Savanna Nazarene Church • Truro Seventh-day Adventist Church • Burnt Savannah Wesleyan-Holiness Church • Kingdom Hall of Jehovah's Witnesses	Truro Gate to Locust Tree Road	• Frome Technical High School • Frome Preparatory School • Montego Bay Community College (Frome Campus) • Frome Early Childhood Institution • Three Miles River Early Childhood Institution	• Frome Police Station • Frome Post Office • Frome Sports Complex

Due to its proximity to the Cabarita River, the most imminent hazard that threatens the area is flooding. The cane fires that commonly pose a risk to the area are generally due to anthropogenic activities as part of a cultural practice, but this is mentioned here because drought conditions create the ideal environment for fires to spread quickly.

6.1.2.1.1.2.2 Future Exposure

There was no information provided regarding planned developmental changes for Frome or if any additional infrastructure is to be added to the division, by the developers of the Bamboo Pulp Mill.

The area is typically affected by flooding, and it is highly likely that any infrastructure could be negatively impacted during a flooding event. A decrease in rainfall and increase in droughts and drier conditions create the right environment for the spread of fires and so drought conditions could not only potentially yield a reduction in water availability but could also result in a possible increase in anthropogenic fires.

6.1.2.1.1.3 Savanna-la-Mar

Savana-la-Mar, as the capital of Westmoreland, is the most developed of the areas surrounding the proposed Bamboo Pulp Mill development site.

6.1.2.1.1.3.1 Existing Exposure

Savanna-la-Mar acts as a hub of activities within the parish of Westmoreland and as such is home to much of the parish's public facilities, services and amenities. The area is described within the social assessment as economically diverse and therefore possesses the relevant infrastructure necessary to support the proposed project activities.

Being a coastal town, Savanna-la-Mar has a greater level of exposure than the other communities assessed. Having been established in the 16th century the age of the infrastructure that exists as well as the capital's location increases its susceptibility to hazards.

Most households within Savanna-la-Mar have accesses to public piped water as well as garbage collection facilities.

Infrastructure that exists in the area include:

Places of Worship	Major Roads	Educational/Training Institutions	Medical Services	Other Community Assets
• Savanna-la-Mar New Testament Church of God • Savanna la Mar Methodist Church • Savanna-la-Mar Seventh-day Adventist Church • St. Joseph Catholic Church • St. George's Anglican Church • Footprints Seventh-day Adventist Church • Savanna-la-Mar United Church • Church of Jesus Christ of Latter-day Saints (Savanna-la-Mar Branch) • Kingdom Hall of Jehovah's Witnesses	• Great George Street • Rose Street • Barracks Road • Strathbogie Road • Seaton Street • Darling Street	• Manning's School • Godfrey Stewart High School • Savanna-la-Mar High School • Savanna-la-Mar Primary School • Unity Primary School • Sir Clifford Campbell Primary School • Kiddies Preparatory School • Llandilo School of Special Education • Savanna-la-Mar Inclusive Infant Academy • Supreme Kids Kindergarten • UWI Open Campus (Savanna-la-Mar) • Westmoreland Business College • Westmoreland Driving Institute	• Savanna-la-Mar Hospital • Royale Medical Centre • Savanna-la-Mar Health Centre • Westmoreland Infirmary • TRVALA Health Clinic • Urgent Care 360+ Family Medicine • Sav Gynae Centre	• Savanna-la-Mar Police Station • Savanna-la-Mar Fire Station • Savanna-la-Mar Post Office • Savanna la Mar Tax Office • Savanna-la-Mar Court House • Westmoreland Family Court • Westmoreland Parish Library • Westmoreland Municipal Corporation • Westmoreland Health Department • Registrar General's Department • HEART Trust NSTA Parish Office • Westmoreland Youth Innovation Centre • Llandilo Sports Complex • West Palm Memorial Garden • Independence Park

Savanna-la-Mar remains the most exposed area to the effects of sea level rise, flood events caused by storm surges as well as the storm force winds of hurricanes and other tropical cyclones. Coastal erosion is another event that poses a risk to the infrastructure found in the area. The increased level of development that exists further contributes to the area's exposure.

6.1.2.1.1.3.2 Future Exposure

The development of the Bamboo Pulp Mill site in Friendship is likely to increase the level of exposure that exists in Savanna-la-Mar. This would be due to increased vehicular activity within the area from the trucking of material in and out of Westmoreland. There will also be likely migration and movement of persons seeking employment.

Climate change is expected to have a negative impact on the area as it will increase the severity of the hazards to which it is exposed. Sea level rise will impact the severity of flooding in Savanna-la-Mar as well as contribute to storm surges with higher wave heights. Higher wave action also increases the exposure of the town's assets to coastal erosion.

An increase in global temperature and water bodies is expected to increase the likelihood of more frequent and severe hurricanes and tropical storms, thus increasing Savanna-la-Mar's exposure to the effects of these hazards. ***Figure 6-2*** presents the exposure assessment of assets and infrastructure.

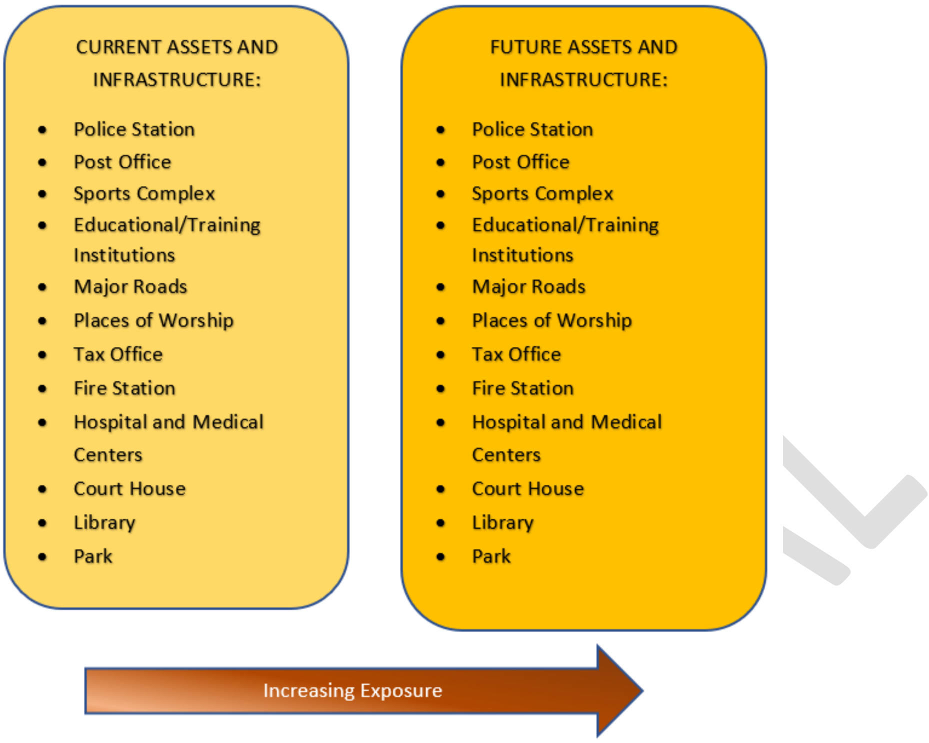


Figure 6-2: Exposure Assessment of Current and Future Assets and Infastructure in Savanna-la-Mar

6.1.2.1.1.4 Petersfield

The community of Petersfield, near Frome and Hertford, is susceptible to various hazards. Most of the modern amenities located within Petersfield are due to the number of tourist attractions found within the community.

6.1.2.1.1.4.1 Existing Exposure

Petersfield is an area which possesses a moderate level of exposure to hazards. Although the area is home to one of the largest sugar estates in the parish, much of the economic activity is driven by tourism. Many of the tourist attractions that are present are centred around the Roaring River which surfaces in the community. The Roaring River Park Estate alone sees approximately 2,000 visitors per year.

Being an area that was developed in the 17th century much of the existing infrastructure is older and as such is susceptible to hazards. However, in recent years there have been several rehabilitation efforts which have helped to improve the existing infrastructure of Petersfield.

Infrastructure that exists within the area includes:

Places of Worship	Major Roads	Educational/Training Institutions	Other Community Assets
• St. Peter's Anglican Church • Spiritual Church of the Nazarenes	• Torrington to Galloway Road • Hertford to Flowerhill Road • William Road	• Petersfield High School • Petersfield Vocational Training Center • Petersfield Primary & Infant School	• Petersfield Post Office • Petersfield Health Centre • Westmoreland Parish Library (Petersfield) • Petersfield Galloway Benevolent Society (formerly known as the Association of Clubs) • Petersfield Community Centre • Petersfield Cemetery • "Pride of Petersfield" Park

Due to its proximity to the Roaring River, flooding is the hazard that is an imminent threat to Petersfield. All the assets that exist within the area located closest to the Roaring River are therefore at risk of damage due to flood events.

6.1.2.1.1.4.2 Future Exposure

There was no information provided as to what developmental changes are to be made in Petersfield or if any additional infrastructure is to be added to the division, by the developers of the Bamboo Pulp Mill. Climate change will impact the level of exposure to hazards within the area. An increase in the severity of rainfall and storms event will potentially increase the level of exposure of any future infrastructure to flooding.

6.1.2.1.1.5 Hertford

Hertford is one of the more rural townships within the parish of Westmoreland and it is located to the south of the proposed mill site. Although many of the other areas associated with the development of the Bamboo Pulp Mill are also described as rural, Hertford possesses the least physical infrastructure when compared to communities like that of Frome, Friendship or the other areas mentioned above.

6.1.2.1.1.5.1 Existing Exposure

As previously discussed, the community of Hertford does not possess the same level of infrastructural development as the other areas discussed above. However, the infrastructure which does exist is still exposed to hazards. Residents can access services such as health care and postal services in nearby Petersfield. There is still heavy reliance on the sugar industry for much of its economic activity. Many persons still reside in old barracks located on the sugar estate lands.

Infrastructure that exists within the area includes:

Places of Worship	Major Roads	Educational/ Training Institutions
• Hertford New Testament Church of God • Wesleyan Holiness Church • Petersfield Seventh-day Adventist Church	• Torrington to Galloway Road • Hertford to Flowerhill Road	• Bastard Cedar Walk Early Childhood Institution

The most imminent hazard the infrastructure presents in Hertford would be the exposure to anthropogenic cane fires. There is no indication that the area is currently affected by cane fires and as such, the level of exposure can be described as low to medium. Barracks are typically wooden structures, therefore, the sensitivity of these structures to fire is high.

6.1.2.1.1.5.2 Future Exposure

There was no information provided regarding potential developmental changes e to be made in Hertford or if any additional infrastructure is to be added to the community by the developers of the proposed Bamboo Pulp Mill.

It is, however, likely that climate change will increase the exposure of Herford to fires as increased temperatures and lower rainfall creates the environment for the easy spread of fires.

6.1.2.1.1.6 Amity

Similarly, to Hertford, Amity is a rural community lacking significant physical infrastructure or development. This reduces the level of exposure of the area to hazards.

6.1.2.1.1.6.1 Existing Exposure

There are a few small business establishments located within Amity and not much other development. Limited economic activity exists within the area and as such there is a relatively low level of exposure to hazards. The hazards to which Amity would more likely be exposed to are hurricanes or tropical storms and their associated impacts, namely, winds and heavy rains.

Infrastructure found in the area includes:

- DCS Nursing Home
- Amity Jerk Centre
- Sirju Supermarket
- Devon House, I Scream.

6.1.2.1.1.6.2 Future Exposure

There was no information provided outlining developmental changes to be made in Friendship or regarding any additional infrastructure to be added to the community by the developers of the Bamboo Pulp Mill.

Climate change is likely to increase the level of exposure within the area as storm events are expected to become more severe over time, increasing the likelihood of negative impacts.

6.1.3 SUMMARY OF THE EXPOSURE ASSESSMENT

Table 6-3 below presents the summary of the exposure assessment.

Table 6-3: Summary of the Level of Exposure of Communities surrounding the Proposed Bamboo Pulp Mill Development site to various hazards

HAZARDS	LOCAL DEVELOPMENT AREAS AND LEVEL OF EXPOSURE					
	Frome	**Savanna-la Mar**	**Friendship**	**Amity**	**Hertford**	**Petersfield**
Flooding	Medium	High	High	Low	Low	High
Anthropogenic (human-induced) Fires	High	Medium	High	Low-Medium	Medium	Low
Sea Level Rise	Low	High	Low	Low	Low	Low
Hurricanes/ Tropical Storm Winds	Medium	High	Medium	Medium	High	Medium
Storm Surges	Low	High	Low	Low	Low	Low
Coastal Erosion	Low	High	Low	Low	Low	Low
Landslides	Medium	Low	Medium	Low	Low	Medium
Droughts	Medium	High	Medium	Medium	Medium	Medium

6.1.3.1 Community/ Population Exposed

In recent years the parish of Westmoreland has been known primarily for its contributions to the tourism industry of Jamaica. It is considered a key economic driver and plays a vital role in the employment of persons in the parish. However, it is important to understand the age, gender ratio and disabilities in the communities because the impacts of climate change tend to have a greater effect on the vulnerable population such as the young and elderly, females, as well as low income and disabled persons. These are considered the vulnerable groups. The following subsections indicate briefly the general age and employment levels of the residents in the areas under consideration.

6.1.3.1.1.1 Frome

The Frome Sugar Estate and associated factory have played a significant role in the development of the area, dating back to the 17th century. The sugar estate was once a pillar of Westmoreland's economic development before the rise in tourism. However, within Frome, the estate still provides the vast majority of the employment activities within the area. As a result of the decline in the sugar industry, some 21% of households in Frome are headed by unemployed individuals and the youth unemployment rate remains high.

The total population of Frome is approximately 1,460 persons. Of that amount, 43.9% are males and 46% are females between the ages of 0-64 years. Of the overall population, 58.5% comprises the overall workforce between the ages of 15-64. The elderly population, 65 years and older, comprises 10.1% of the overall population.

Consistent with several rural townships, the vulnerability to natural disasters of settlements included in the project area is heightened by the presence of this high level of unemployment and generally low incomes.

6.1.3.1.1.2 Savanna-la-Mar

Savanna-la-Mar is the most economically diverse of all the areas within the sphere of influence of the development of the BBP pulp mill. According to the social assessment, 69.6% of households are headed by persons who are employed. Savanna-la-Mar has one of the highest rates of employment within the parish of Westmoreland as well as the greatest number of employment opportunities amongst the assessed areas.

The estimated population size of the area is 13,930 with 3,980 households and an average household size of 3.5 individuals. Of the total population 28.5% are between the ages 0-14, 17.7% are in the 15-24 age group; and 37.8% of the population comprises those between the age range of 30-64 years. The population of Savanna-la-Mar is afflicted by a high level of youth unemployment and a low level of skills training.

It can therefore be said that the age and rate of unemployment increase the exposure and vulnerability of Savanna-la-Mar to hazards.

6.1.3.1.1.3 Petersfield

Unemployment is a major issue within Petersfield. Although there are several local business and services found in the area some 42% of households are headed by persons who are unemployed. Petersfield is one area likely to be positively affected by the development of the proposed BBP pulp mill as this is expected to provide several employment and vocational training opportunities.

The overall estimated population size of Petersfield is 3,400 with an estimated 680 dwellings headed mostly by males. Of the overall population, 16.5% are within the 0-14 years age category, 8.17% are 15-24 years old, and 6.55% of the population are within the age range of 25-34 years.

Petersfield’s vulnerability to natural hazards is greatly increased due to the low levels of income opportunities and the high level of unemployment.

6.1.3.1.1.4 Hertford

Hertford is described as having a high level of employment amongst its inhabitants. The population is described as aging due to the migration of younger individuals to urban areas with greater opportunities. However, approximately 74% of the households in Hertford are headed by employed individuals. This is the highest reported value of all the areas assessed.

The overall population of Hertford is estimated to be 2,535 with approximately 766 households. The average size of each household being 3.3 individuals. Many households (76%) are headed by males. Although the level of employment in the area is high, there is still a lack of academic qualification and skills training.

Many Hertford locals have lived, for generations, in wooden houses known as barracks. These houses were provided to sugar workers by the estate as a means of temporary housing and as such lacked access to basic facilities and amenities such as piped water. Attempts have been subsequently made by the government of Jamaica to improve the living conditions of these residents as well to regularise the ownership of these properties and the lands on which they are located.

Although there is a high employment level in Herford, the age ranges and overall living conditions of members still leave the area at risk of being negatively affected by the impacts of climate change.

6.1.3.1.1.5 Friendship and Amity

No demographic data was provided for these areas to allow for a thorough investigation of how the populations are exposed or vulnerable to potential hazards.

Issues raised about these areas included, low-paying jobs and few business opportunities as well as a prominence of vulnerable groups, such as the elderly and children.

6.1.4 ADAPTIVE CAPACITY ASSESSMENT

The United Nations Institute for Disaster Risk Reduction (UNISDR) defines adaptation as the "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (UNISDR, 2009); while adaptive capacity refers to the ability to take action to reduce adverse impacts, moderate harm, or exploit beneficial opportunities from current climate extremes and long-term climate change (Snover, et al, 2007).

The terms "coping" and "adaptation" are often used interchangeably; however, it is important to understand the distinctions. As seen in Table 6-4, coping tends to be actions carried out in the short term and motivated by crisis. Whereas adaptation activities tend to involve planning and are more sustained and oriented towards longer-term livelihood security.

Table 6-4: The Differences between Coping and Adaptation (Source: CARE, 2019).

COPING	ADAPTATION
Short-term and immediate	Practices and results are sustained
Oriented towards survival	Oriented towards longer-term livelihood security
Not continuous	A continuous process
Motivated by crisis; reactive	Involves planning
Often degrades the resource base	Uses resources efficiently and sustainably
Prompted by a lack of alternatives	Focused on finding alternatives
	Combines old and new strategies and knowledge

When individuals or communities/ organizations have a high adaptive capacity, they are better able to deal with the impacts of climate change. This is because they tend to have a greater ability to adjust to change, moderate potential damage, take advantage of opportunities, and cope with the consequences. This section outlines the work of the Westmoreland Municipal Corporation and its Parish Disaster Committee, which is the main organisation involved in disaster risk management in the Westmoreland parish. In addition, the section details the existing coping and adaptation strategies employed by those residing in the project area and the surrounding communities of Frome, Amity, Hertford, Friendship, Petersfield and Savanna-la- Mar.

6.1.4.1 Existing Coping Mechanisms and Adaptation Measures employed by Friendship and nearby communities

The project site and its nearby communities are particularly prone to flooding and in Friendship, in particular, drought is of concern. These are both extremes in the hydrological cycle. The ODPEM has designated the parish of Westmoreland as a flood prone area. This is attributed to the high likelihood of flash flooding in the area. During the hurricane season, extreme weather is anticipated which includes long periods of intense rainfall and high velocity winds. Impacts from these extreme weather events can pose significant risk to the project infrastructure, investments, business continuity and human life. There is a significant number of persons living in Friendship and neighbouring communities who are unemployed and underemployed, and that status will affect their adaptive capacity. Many only have secondary school educational qualifications and have received subsequent informal training. The major inhibitors to adaptation, therefore, appear to be linked to costs and perception of risk. The following subsections suggest that generally Friendship and nearby communities have a low adaptive capacity. This is due not only to their socioeconomic status, but also to the weaknesses of their physical dwellings, which are largely board homes or barrack-style housing that may not be able to withstand the Category 5 hurricanes that are projected to occur.

6.1.4.2 Friendship and surrounding communities

Based on the description given in Table 6-4 and information in Table 6-5, people in Friendship, the project site and surrounding communities have simply been coping with the hazards rather than adapting. Most of the adaptation measures have been linked to drought and flooding. This aligns with the literature, that has suggested that persons tend to adapt based on their perception of the stressor (Reser and Swim, 2011).

Table 6-5: Existing Coping and Adaptation Measures employed in the Project Area and nearby Communities.

Hazard/ Stressor	Coping/ Adaptation Mechanism		Effectiveness
Drought/ Dry Periods/ Increased Temperatures	**Coping**	During drought periods, most communities that would receive piped water are without water. The WMC trucks water to these areas. The WMC fills the water tanks of households (if present at households) and piped water. In Friendship, water is extracted from the Cabarita River.	They receive treated potable water, most times at no cost. Residents of Friendship pool funds to get potable water that is trucked in periodically. The Cabarita River is a nearby water source.
	Adaptation	Sugar cane farmers surrounding the project site and nearby communities do not farm during the drought period. Operational costs are prohibitive.	Irrigation is used only on farmlands owned and operated by the Frome Estate of the Pan Caribbean Sugar Company
Flooding	**Coping**	During hurricane season, when there is extensive flooding due to heavy rainfall and storm surges, the population shelters in designated places, and are advised by the Parish Disaster Coordinator (PDC) to shelter	Short-term solution, but is effective resulting in reduced losses, including loss of life due to potential flooding.

Hazard/ Stressor	Coping/ Adaptation Mechanism		Effectiveness
		at the nearest community centre or school.	
	Adaptation	Many homes in Friendship and nearby communities are on stilts. When the budget allows, the WMC, facilitates the removal of debris from major drains and culverts prior to the hurricane season. Presentations and other fora about climate change and its impacts are widely disseminated among the citizenry.	Prevents flooding from affecting the housing. This allows the free flow of water and reduces the probability of flooding on major streets and roadways.
Hurricane	**Adaptation**	Adaptation strategies for hurricanes are similar to those employed during floods. The PDC leads sensitization sessions regarding climate change impacts to improve knowledge and awareness of climate change.	Increasing residents' resilience to climate-related shocks and hazards.
	Coping	Temporary relocation and evacuation to shelters	Short-term solution, but is effective resulting in reduced losses, including loss of life due to potential flooding
Storm surge	**Adaptation**	Many homes in Westmoreland are built on stilts and this may be a form of adaptation.	Reduces the probability of flooding entering the housing units.
	Coping	Temporary relocation and evacuation to shelters.	Short-term solution, but is effective resulting in reduced losses, including loss of life due to potential flooding

6.1.4.3 Institutional Capacity

Local institutions (both formal and informal), such as the WMC play an important role in building resilience and reducing vulnerability to climate change. The vision of the WMC is to "*foster the orderly development and good governance of Westmoreland by providing effective and efficient service to residents and visitors and facilitating commercial activities within a planned and sustainably developed environment*". This Corporation is responsible for disaster management at the local level.

The Parish Disaster Coordinator (PDC) who works for the WMC, is mandated to coordinate activities related to disaster preparedness. This includes training community persons and government workers in disaster response and relevant persons in shelter management and coordinating volunteers. This office is frequently called by community or church groups to do presentations. Therefore, the awareness of the citizens of Westmoreland regarding climate change is significant all things considered.

In times of disaster, the PDC is activated by firstly learning about impacted areas, and then encouraging persons to go to shelters. They will then work with the relevant Ministries, namely the Ministries of Labour, Health and Wellness, Social Security and Sports, and the Health Department, who will conduct assessments of the conditions of the persons inside the shelters. The PDC will also work with the Red Cross, the Salvation Army and the Adventist Disaster Relief Agency who will distribute emergency relief supplies to persons in need. There is not enough budgeted for disaster management in the WMC, but there are provisions for disaster preparedness, for example, the removal of debris from blocked drains is an event that happens occasionally and is usually financed by external parties.

Flooding is a major hazard in Westmoreland. It is important to note that in Westmoreland, citizens are largely reactive to an event and are unlikely to plan for a major event. So, in the event of flooding, for example, residents will respond rather than plan for an event. Furthermore, many persons engage in unsuitable activities that exacerbate the impact of flooding. In fact, many citizens block drains when building their homes, which exacerbate the impact of this type of hydrometeorological event.

Stakeholder consultations within the communities revealed that in times of disaster, persons either stay at home or use the nearby school or community center for shelter.

6.1.5 SUMMARY OF THE VULNERABILITY ASSESSMENT

Table 6-6 presents a summary of the vulnerability of the Friendship project site and nearby communities of Frome, Amity, Petersfield, Hertford and Savanna-la-Mar which are considered vulnerable to climate-related and geophysical hazards. Friendship is vulnerable due to its proximity to the Cabarita River and is also highly vulnerable to incidental flooding in the likelihood of the passage an extreme event, which would likely cause an overflow.

Savanna-la-Mar and Frome are among the communities more vulnerable to hazards, because they are less able to adapt to any climate hazard due to their socioeconomic circumstances (significant rate of unemployed of the heads of households) and their infrastructure which are homes of mixed dwelling material (board, wood etc.).

Table 6-6: Vulnerability of Friendship and surrounding Communities to climate-related Hazards

Project Area	Projected Level of Sensitivity/ Susceptibility to Climate-related Hazards	Future Exposure (with project assets and infrastructure implemented)	Existing Adaptive Capacity	Vulnerability
Friendship and its zone of influence	High	High	Low	High

The following section takes this analysis even deeper and tries to understand the risks and identify opportunities to reduce the risks associated with the project site and neighbouring communities.

6.2 CLIMATE RISK ANALYSIS

This section of the report analyses the risks associated with the climate-related hazards discussed in previous sections for the project site, and its nearby communities. The means of arriving at the risk and risk assessment are presented in Table 6-7, Table 6-8, Table 6-9 and Table 6-10. The impacts associated with these hazards can result in potential gain or loss and the magnitude of these impacts may vary as a function of how vulnerable the assets and infrastructure are, as well as their importance to the project.

Table 6-7: Probability Categories

	Description	Probability	Scale Value
C	Almost certain	81 - 100%	**5**
H	Likely	61 - 80%	**4**
M	Possible	41 - 60%	**3**
L	Unlikely	21 - 40%	**2**
R	Rare	0 - 20%	**1**

Table 6-8: Impact Categories

	Description	Guide Scenario	Scale Value
C	Critical	Major negative impact that could have a substantial financial, technical, environmental, or social consequence for the project, which may be irreversible. If it were to materialise it would be a challenge to address. It could have an impact on the project viability.	**5**
H	High	Significant negative impact that could have a substantial financial, technical, environmental or social consequence for the project, which could be irreversible. If it were to materialise it would be possible but difficult to address. It could have an impact on the project viability.	**4**
M	Medium	Limited negative impact that could have a financial, technical, environmental or social consequence for the project. If it were to materialise, it may not have an impact on the performance of the project and could be accommodated within the budget.	**3**
L	Low	Small negative impact that could have a minor financial, technical, environmental or social consequence for the project, which may be irreversible. It could have an impact on the project viability.	**2**
R	Insignificant	No impact on project	**1**

Table 6-9: Risk Scoring Matrix

Impact	Critical	5	5	10	15	20	25
	High	4	4	8	12	16	20
	Medium	3	3	6	9	12	15
	Low	2	2	4	6	8	10
	insignificant	1	1	2	3	4	5
			1	2	3	4	5
			Rare	Unlikely	Possible	Likely	Almost Certain
			Probability				

No Risk	
Low	
Medium	
High	
Critical	

Table 6-10: Climate Risk Assessment

Climate Variable/ Hazard	Current Stresses	Projected Stresses from Climate Change	Likely Impacts on the proposed Assets/ Infrastructure/Community	Probability	Impact	Risk	Mitigation/Adaptation Measures
PROJECT SITE and NEARBY COMMUNITIES							
Temperature	Increasing annual temperatures	Increases in the mean, minimum and maximum temperatures from the 2020s to the 2080s.	Higher temperatures may lead to lower productivity among outdoor workers due to inability to concentrate. Heat-related illnesses such as heat stress and heat stroke may occur in extreme cases. For farm sites: Increased potential for evapotranspiration, hence an increase in irrigation demand.	Almost Certain (5)	High (4)	**High**	Cooling methods such as shade houses can be used for seedlings. For farm sites: *Bambusa vulgaris* species needs water and irrigation during the first two years. Therefore, irrigation should be more effectively timed to be at cooler times of the day.
			Increased temperatures are likely result in the increase in reproduction and metabolic rates of pests and fungi. Higher temperatures are likely to lead to increased rainfall an increase in dengue fever transmissions. The dengue fever virus is hyperendemic to Jamaica. Jamaica has all four serotypes (strains) of this virus. Westmoreland was listed as one of the parishes with the highest rates of transmission.	Likely (4)	Medium (3)	**High**	Take measures to minimise/prevent mosquito breeding on the project site. Also, sensitise staff as a way to share information with the community.
Rainfall		Reduction in rainfall from	Reduction in rainfall will result in less potable water for consumption.	Almost certain (5)	High (3)	**High**	There would be further demand on the WMC and NWC to truck in water to the affected communities.

Climate Variable/ Hazard	Current Stresses	Projected Stresses from Climate Change	Likely Impacts on the proposed Assets/ Infrastructure/Community	Probability	Impact	Risk	Mitigation/Adaptation Measures
	Overall reduction in annual rainfall	in the 2030's and continues through to the 2080's. The drying trend is greatest in the 2080's.	Greater dependence on alternative sources.				Development should consider alternative water sources overtime.
			Reduction in rainfall would limit the growth of *Bambusa vulgaris* species which needs 1500 mm to 3800 mm of rainfall a year to thrive.	Possible (5)	High (4)	**High**	Alternative sources of water would have to be considered to irrigate these plants, should water levels in the Cabarita River be decreased overtime.
	Higher rainfall intensity for short periods at certain times for the year	Short duration, high intensity rainfall expected to become more frequent.	If/when Cabarita overflows its bank due to intense rainfall, it may damage roads, domestic crops, drainage systems and drainage infrastructure.	Likely (4)	High (4)	**Critical**	Elevate roads. Mill design should be adequately elevated to mitigate against flooding.
			Ponding on site due to slow drainage and infiltration could damage the *Bambusa vulgaris* plant	Likely (4)	High (4)	**High**	Storage of waste should be properly contained to avoid land and water pollution in the event of flooding.
Hurricanes and Tropical Storms	Occasionally impacted by hurricanes and tropical storms	Hurricane intensity expected to increase (not necessarily frequency).	There are likely to be more intense hurricanes resulting in higher wind speeds, and this will have differing effects on the assets and the infrastructure. For farm sites: However, bamboo stalks are strong and flexible and are more likely to bend during hurricane winds thus absorbing the energy of the tropical storm, rather than breaking. Heavy rainfall and high velocity winds will seriously affect coastal communities and businesses.	Likely (4)	Critical (5)	**Critical**	The mill structure should be designed to sustain Category 5 wind speeds. Climate risk sensitisation of residents, which includes encouraging them to use proper building materials and discouraging them from building within disaster zones.

Climate Variable/ Hazard	Current Stresses	Projected Stresses from Climate Change	Likely Impacts on the proposed Assets/ Infrastructure/Community	Probability	Impact	Risk	Mitigation/Adaptation Measures
Storm Surges	An effect of the occasional impact of a hurricane	Catastrophic flooding of Savanna-la-Mar and nearby communities	Storm surges travelling inland will result in the flooding of commercial enterprises and major roadways along the coast and further inland. This could disrupt economic activity along the coast. It could also displace citizens and destroy communities. Death by drowning could occur in extreme cases. It could destroy navigational markers making it impossible to navigate. Flooding would also lead to shipping delays.	Likely (4)	Critical (5)	**Critical**	Climate risk sensitisation of residents, which includes encouraging residents to use proper building materials and discouraging them from building within from disaster zones. Removal of debris from drains and culverts. Ensure that warehouses storing material for export are constructed or utilized in a way that considers this hazard and takes measures to both protect the product as well as reduce the potential impact of the product on the environment.
Landslides	The project area and nearby communities are for the most part flat and there is little risk of being affected by landslides.	None	None	Rare (1)	Insignificant (1)	**Low**	N/A

6.3 EQUATOR PRINCIPLES

This section of the CVRA, as guided by the Equator Principles, highlights climate-related risks to the project in two categories:

- Physical Risks - Relate to the physical impacts of climate change; and
- Transition Risks - Relate to the transition to a lower-carbon economy

This segment is also complemented by projections for temperature and rainfall as provided by the World Bank Climate Change Knowledge Portal website for the island. These projections provide a general overview of climatological trends for Jamaica for the period 2020-2099, which is the estimated duration for the mill site in Westmoreland.

6.3.1 PHYSICAL RISKS OF CLIMATE CHANGE ON THE PROJECT IN WESTMORELAND

Climate Variables/Geophysical Hazards/Extreme Events	Impacts	Mitigation measures
ACUTE RISKS		
Heavy rainfall	Increasing hurricanes will lead to increased intensity in rainfall. RCP 8.5 emission scenarios projected that hurricane related rainfall would increase by 51% The soil surrounding the mill has clay and loamy characteristics and so is more likely to have a slower runoff. This has implications for ponding of rainfall excess.	The mill will be elevated to facilitate runoff. Drainage pathways will be installed during the construction period to control flood hazards, ponding, and sediment run-off due to land clearing and exposed surfaces, for example, cut-off or intercept drains to be established to redirect stormwater away from cleared areas and slopes to stable (vegetated) areas or effective treatment installations.
Flooding	It is projected that the risk of flooding from heavy rainfall is very high and is likely to impact the northern section of the mill site. This is due to the location of the mill site in a watershed. Bamboo on hillside lands in some areas in Jamaica usually uproot and topple during heavy rainfall due to the heavy canopy and shallow root structure.	Most of the development would be on high ground and will not be affected by flood waters. Areas at risk identified from the flood inundation assessment for 10-, 25-, 50- and 100-year events will be elevated. Periodic inspection of the construction site to be conducted to ensure drainage systems are not impacting the surrounding environment. An Environmental Management and Monitoring Plan to be developed and implemented. Sediment traps to be installed, where necessary, to avoid sedimentation of the nearby waters during construction. Avoid planting bamboos in the highlands when assessing locations for farm sites and apply strategies that would eliminate toppling (if required) so as to minimise the risk of increased sedimentation rates and aggravation of flooding.

Climate Variables/Geophysical Hazards/Extreme Events	Impacts	Mitigation measures
Extreme temperatures	**Higher temperatures are likely to affect the productivity of the workers by 25% and their physical health. (State of the Jamaican Climate, 2019)** According to the Wet Bulb Global Technique (WBGT) that measures labour capacity (occupational measure of the working time required to safely perform sustained labour under environmental heat stress) there will be a 25% reduction in labour capacity due to heat stress with temperatures ≥ 26 degrees. RCP 8.5 emissions scenarios for 2020-2030, indicated that there would only be a reduction in labour capacity during the months of June to November. For the 2050-2090 period for the scenario, however, it is predicted that labour capacity would be reduced by 25% for all months.	Install cooling aids such as fans in the facilities for workers. Harvest the bamboo stalks early mornings when the diurnal temperatures would be cooler.
	Higher temperatures are likely to lead to an increase in dengue fever transmissions. The dengue fever virus is hyperendemic to Jamaica. Jamaica has all four serotypes (strains) of this virus. Westmoreland was listed as one of the parishes with the highest rates of transmission.	Promote awareness campaigns of how to minimise the increase and transmission of dengue fever among the mill staff.
	Temperature increases will lead to quicker transmission of the virus, as the main vector (Aedes Aegypti mosquito) matures faster and will bite more often.	Eliminate or close all open water storage containers on the facility which would be breeding grounds for the dengue vector.
	Higher temperatures which induces increased rainfall could also lead to an increased prevalence of infectious and non-infectious diseases directly and indirectly. These warmer temperatures coupled with excessive heat and harmful carbon emissions may affect air quality and lead to increased incidence of cardiovascular and respiratory diseases among workers with prolonged exposure to these conditions.	Implement integrated pest management techniques.

Climate Variables/Geophysical Hazards/Extreme Events	Impacts	Mitigation measures
Hurricanes	**Hurricanes usually do not impact Westmoreland unless they approach the island from the South Coast.** According to the State of the Jamaica Climate (SOJC, 2021), a 2°C temperature increase, due to global warming, will increase the southern section of the island's **susceptibility to hurricane influence** and this is where the project is located. There will be increased incidence of Category 4 and 5 hurricanes (wind speeds greater than 130 miles per hour) at the end of century with hurricanes expected to increase by 2-11% with higher wind speeds and increased potential for damages.	The roof of the mill will be designed to sustain Category 5 wind speeds. If Bamboo farm sites are located within the 6 LDA's, harvest the younger bamboo stalks prior to the landfall of a potential hurricane/ tropical storm. An early warning system will be developed for the mill, as well as a disaster risk management plan, while an evacuation plan will be developed for the labour force.
Drought	Jamaica has a bimodal rainy season from April to November with an early rainfall season (April to June) and late rainfall season (September to November) and a midsummer drought in July. The RCP 8.5 emissions scenarios projected that there will be an abnormal drying across the Caribbean dry season (December to January) from as early as the 2020s, by up to 4% in the 2050s and 12% by the end of century.	Innovative water conservation technologies will be implemented which reduces raw water consumption through water reuse and recycling.
Storm Surges	**Impacts on Port Facilities** Hurricanes are projected to intensify, and sea levels are projected to rise which will increase the probability of inland flooding. Storm surges can damage port facilities. Flooding will also further delay shipping times and can stall out other logistics for intermodal routes.	The local Met Services and Port Authority will be consulted to establish facilities and measures for disaster management that could impact the exportation of the manufactured pulp.
Sea Level Rise	For RCP 8.5 emission scenarios, the projections for the mean sea level rise for Jamaica is 0.13m in 2020; 0.33 m in 2050 and 0.71m by 2090.	The local Met Services and Port Authority will be consulted to establish facilities and measures for disaster management that could impact the exportation of the manufactured pulp.

Climate Variables/Geophysical Hazards/Extreme Events	Impacts	Mitigation measures
NON-ACUTE RISKS		
Earthquakes	The site is not located within proximity to a fault line. A few earthquakes with magnitude between 2.7 and 3.2 on a Richter scale were recorded between 1998 and 2010.	**The bamboo pulp mill designs have already considered the maximum ground acceleration.**
Landslides	North of the mill site is prone to land slippage during heavy rains and is a possible source of sediment deposit in the flood risk area. This increases the risk of soil erosion and the rate of sedimentation to the drainage network. This could potentially affect the transportation route of the pulp from the Galloway to Ramble to the Port of Montego Bay.	Standards for drainage and building codes will be considered based on climate change projections. Roads in the community must be elevated to reduce flooding or alternative measures must be utilised.
Tornadoes	There will be little to no tornado risk at the project site.	

Sources: State of the Jamaican Climate 2019: Historical and Future Climate Changes for Jamaica (Second Draft); Hydrological Impact Assessment of Bamboo Bioproducts

6.3.1.1 Temperature and Rainfall Projections for 2020-2099 period for the SSP 5- 8.5, multi-model ensemble for Jamaica

Temperature

In Figure a), based on the projected mean temperature anomaly for the 2020–2039 period, according to the SSP 5–8.5 multi-model ensemble, the projected maximum change in temperature is expected to be 0.77°C in September and 0.78°C in October, while the projected minimum change in temperature is likely to be 0.61°C in February.

In Figure b), based on the projected mean temperature anomaly for the 2040–2059 period, according to the SSP 5–8.5 multi-model ensemble, the projected maximum change in temperature is expected to 1.59°C in August and 1.58°C in September, while the projected minimum change in temperature is likely to be 1.25°C in February.

In Figure c), based on the projected mean temperature anomaly for the 2060 - 2079 period, according to the SSP 5-–8.5 multi- model ensemble, the projected maximum change in temperature is expected to be 2.56°C in July and 2.52°C in August, while the projected minimum change in temperature is likely to be 2.05°C in February.

In Figure d), based on the projected mean temperature anomaly for the 2080-–2099 period, according to the SSP 5-–8.5 multi- model ensemble, the projected maximum change in temperature is expected to be 3.51°C in July and 3.56°C in August, and while the projected minimum change in temperature is likely to be 3.02°C in February.

In conclusion, as projected by the SSP 5-8.5 multi model ensemble, temperatures will increase steadily in the latter months of the year, and it will be the coolest in the earliest months of the year from 2020 - 2099.

Rainfall

In figure a), based on the projected precipitation percentage change anomaly for the 2020 - 2039 period according to the SP5-8.5 multi-model ensemble, the maximum change in precipitation is expected to be 7.67% in November and -1.07% in December; and the minimum change in precipitation will be -7.89% in February.

In figure b), based on the projected precipitation percentage change anomaly for the 2040-2059 period according to the SP5-8.5 multi-model ensemble, the maximum change in precipitation is expected to be 7.34% in November and 6.93% in December; and the minimum change in precipitation will be -15.35% in July.

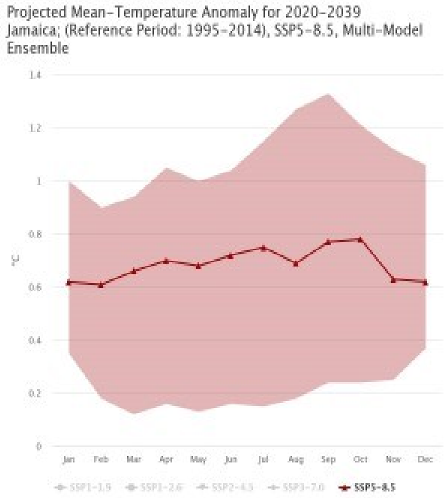
In figure c), based on the projected precipitation percentage change anomaly for the 2060 - 2079 period according to the SP5-8.5 multi-model ensemble, the maximum change in precipitation is expected to be 8.08% in November and -0.85% in December; and the minimum change 38.05% in in June.

In figure d), based on the projected precipitation percentage change anomaly for the 2080 - 2099 period according to the SP5-8.5 multi-model ensemble, the maximum change in precipitation is 9.16% in November and 1.7% in December; and the minimum change in precipitation will be -46.29% in July.

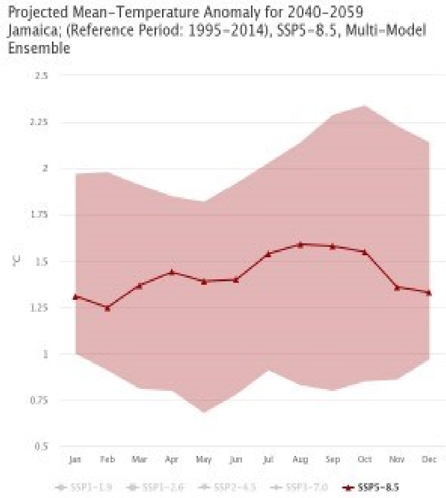
In conclusion, as projected by the SSP 5 - 8.5 multi-model ensemble, projected percentage changes in precipitation for the 2020 - 2099 period, are the highest in the 2020 - 2090 period for the months of November to December which experience the most variability, however, in the months of June and July, precipitation waivers for the 2040 - 2099 period.

Temperature Projections for Jamaica from 2020-2099 using SSP 5-8.5 Multi-Model Ensemble

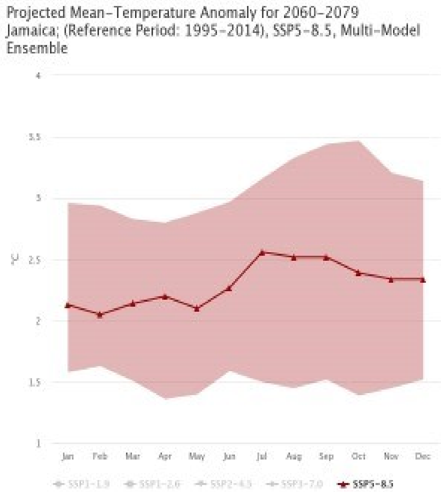
a)



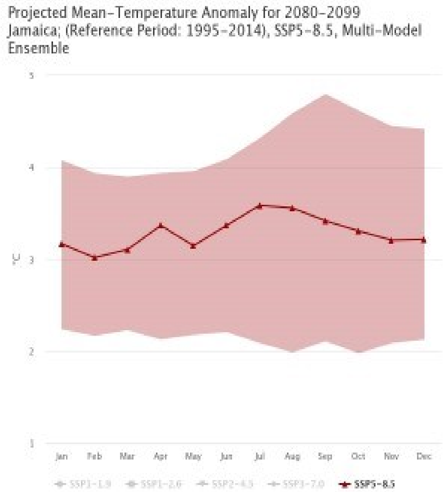
b)



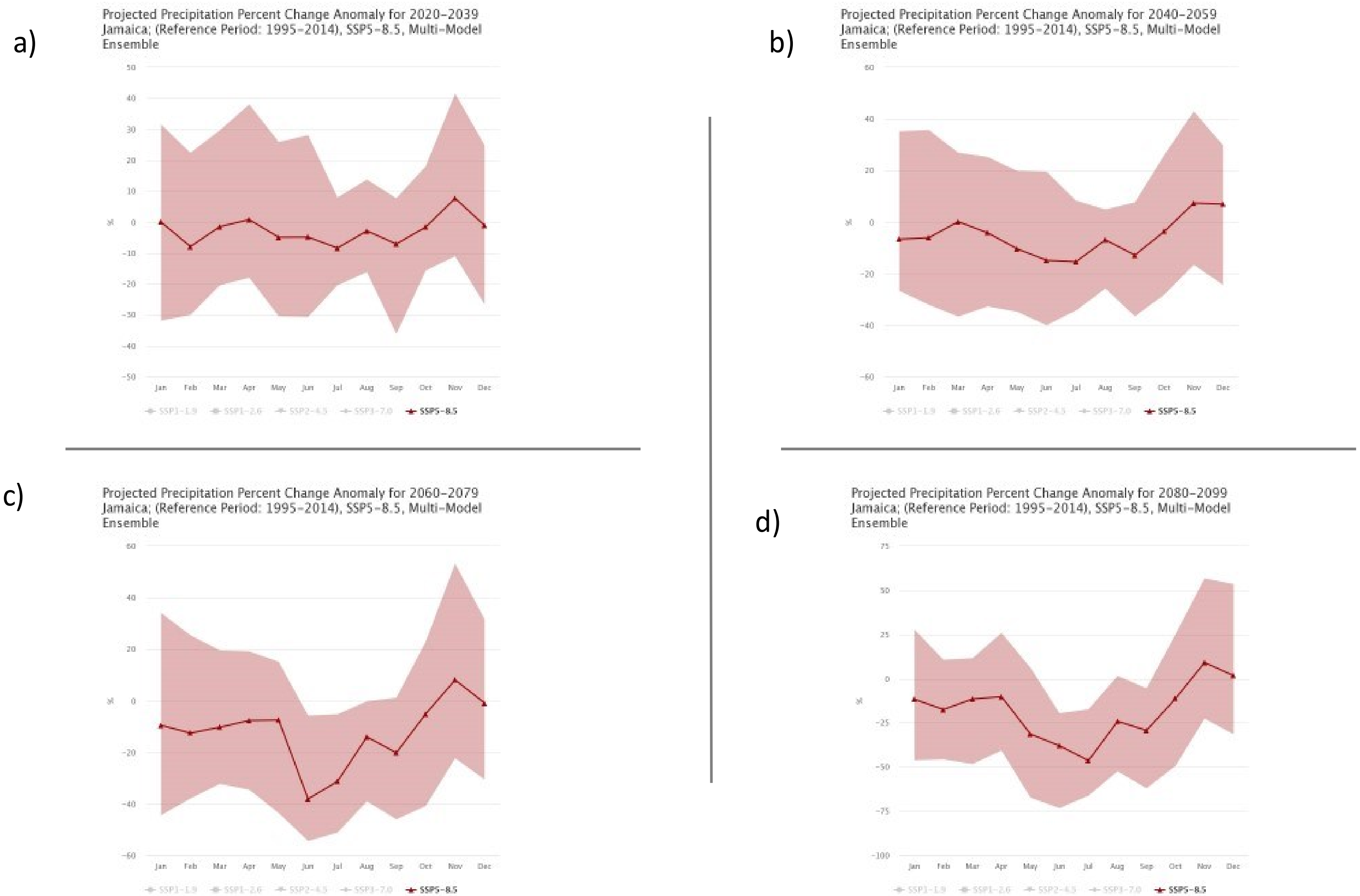
c)



d)



Rainfall Projections from 2020-2099 for Jamaica using SSP 5-8.5 Multi-Model Ensemble



Source: World Bank Climate Change Knowledge Portal - Climate Change Projections for Jamaica https://climateknowledgeportal.worldbank.org/country/jamaica/climate-data-projections

6.3.2 TRANSITION RISKS

According to the Equator Principles there are four (4) types of transition risk: policy and legal risk, technology risk, market risk and reputation risk.

6.3.2.1 Policy and Legal Risks

It is not anticipated that there will be any policy or legal risks associated with this project. This is because the Jamaican government, legislation and policies remain committed to development that considers climate change. While Jamaica does not have a climate policy or is guided by a legally binding framework, it is a party to many international bodies/agreements that recognise climate change as a significant priority. The general thrust of this project therefore moves in accordance with Jamaica's climate priorities which seek to build resilience to the persistent threat of climate change impacts through emission reducing activities. According to the 2016 Climate Change Policy Framework for Jamaica, "Jamaica as a party to the United Nations Framework Convention on Climate Change (UNFCCC) remains committed to reducing greenhouse gas emissions through "no regrets" mitigations which can lead to not only reducing emissions, but also cost savings and environmental and social benefits for the country".

6.3.2.2 Technological Risk

Technological risks are likely to be low if the BBP management team follows its chemical treatment processes. As the mill site will use the Cabarita River, it is important that the technology minimises all potential pollution from the mill that could impact it. This river is an economically important body of water for the area as it is the mainstay for the local tourist economy. The Cabarita River Adventure and Mesopotamia Farm is frequented by tourists who bathe, swim and use the river for tubing and this tourist attraction employs many residents within the Friendship community. Although it was significantly impacted by the onset of the COVID-19 pandemic, this attraction historically generates revenue for the area.

There is a perception that fluid waste from the mill site will contaminate these and other water bodies. However, these risks will be eliminated by the BBP's process where the mill will recover 85% of its chemicals used on a continuous basis. This water will be channelled through to a water treatment plant and residual waste (for e.g., lime sludge) is under investigation to be used to the mill's processes.

6.3.2.3 Reputation Risk

The BBP team will maintain a good reputation with the Friendship and adjoining communities if they invest in infrastructural development in the communities and protect the water quality of the Cabarita River. Friendship and other communities are impacted by poor road surfaces which are worsened by poor drainage, improper garbage disposal and seasonal rainfall. It would improve BBP' s reputation if they periodically invested in road maintenance in the communities.

The BBP also stand to be impacted by a negative reputation if they pollute the Cabarita River which is a multiuse resource in the area for many communities adjoining the mill site. Steps need to be taken to eliminate any possibility of contamination of the Cabarita River.

6.3.2.4 Market Risk

There would be a relatively low market risk for this project. This is because globally, there has been a shift in consumption patterns to more sustainable or "green options". As a result, the pulp harvested from the mill and its subsequent products will always be in demand. Secondly, within local economies across rural areas in Jamaica there is high unemployment and lack of opportunities. Therefore, this mill site's location would guarantee a steady stream of workers from the areas closest to the project site and also the adjoining communities.

6.4 RECOMMENDATIONS

Recommendations arising from the vulnerability and risk assessment to improve the resilience of Friendship and its zone of influence, which may have both a direct and indirect impact on the proposed pulp mill's operations include:

1) Improving standards for drainage and building codes in view of climate change projections;
2) Developing as a matter of priority a Disaster Risk Management Plan for the proposed pulp mill operation;
3) Elevating roads in the community so as to reduce flooding or employing engineering measures. Consideration must be made for any road cutting or improvement programmes that may be implemented by BBP;
4) Encouraging harvesters of bamboo to not engage in slash-and-burn methods because that practice exacerbates soil erosion and contributes to flooding during the hurricane season;
5) Encouraging the use of evaporation and transpiration reduction measures;
6) Liaise with Met Services and Port Authority in relation to port facilities used to export the produced pulp.
7) Implementing appropriate measures at the mill's operational levels since Westmoreland is known as a high-risk area for dengue fever transmission, and given the climate change projections that warmer temperatures and drought conditions could exacerbate the vulnerability of the mill's workforce and operations, preventive measures must be put in place to reduce the likely significant impact of high rates of infection.

7 AIR DISPERSION MODELLING ASSESSMENT

7.1 INTRODUCTION

Bamboo Bioproducts Limited (BBP) is required to provide an air dispersion modelling study of emissions in fulfilment of the required application for licence under the Natural Resources Conservation Authority (Air Quality) Regulations (2006) for Air Pollutant discharge, and as requested by the National Environment and Planning Agency (NEPA), upon their review of the draft Environment and Social Impact Assessment submitted on January 18, 2022.

Bamboo Bioproducts Limited (BBP) proposes to construct and operate a Bamboo Market Pulp Mill. The facility will be located in Friendship, Westmoreland and operate using one recovery boiler unit that will provide power to the mill. LNG and lignin, a by-product of the bamboo pulping, will be used as the fuel to fire the waste recovery boiler. Lignin, a by-product of the bamboo pulping process and waste gases will be heated and converted to steam used in steam turbines to produce energy for the mill. LNG will be used as the fuel during start-up of the mill, but Lignin will be used after the mill has started up.

The following sections describe the dispersion modelling for emissions of sulphur dioxide (SO_2), nitrogen oxides (as nitrogen dioxide (NO_2), carbon monoxide (CO), and particulate matter less than 10 microns (PM_{10}) from the proposed facility. The model predictions are compared with Jamaican National Ambient Air Quality Standards (JNAAQS). The methodology and inputs used for the air dispersion modelling are described in Sections 7.2 and 7.3. The results and the air quality assessment are presented in Section 7.4.

7.1.1 PROCESS DESCRIPTION AND SOURCES OF AIRBORNE POLLUTANTS

The projected airborne pollutants are described below in Table 7-1.

Table 7-1: Description of Pollutants and Sources.

SOURCES	POLLUTANTS
Combustion of LNG for the production of hot gases for the operating of boilers	Oxides of sulphur, nitrogen and carbon [SO_2, NO, NO_2, CO and CO_2) and particulate matter (PM_{10})]

Detailed information on the processes that will occur at the proposed mill can be found in **Chapter 4**.

7.2 DISPERSION MODELING ASSESSMENT AND METHODOLOGY

The modelling approach used was to compare the model predictions plus the relevant background concentrations with JNAAQS as seen in Table 7-2.

Table 7-2: Jamaican National Ambient Air Quality Standards (JNAAQS)

Pollutant	Averaging Time	Standard Maximum Concentration μg/m³
Total Suspended Particulate Matter (TSP [li])	Annual 24 h	60 150
PM_{10} [lii]	Annual 24 h	50 150
Lead	Calendar Quarter	2 -
Sulphur Dioxide [liii]	Annual 24 h 1 h	80 Primary; 60 Secondary 365 Primary; 280 Secondary 700
Ozone	1 h	235
Carbon Monoxide	8 h 1 h	10,000 40,000
Nitrogen Dioxide [liv]	1 h Annual	400 100

The assessment methodology for the air dispersion modelling exercise follows the guidelines specified in the Natural Resources Conservation Authority (NRCA) Ambient Air Quality Guideline Document 2006.

A detailed modelling exercise was conducted. The detailed model recommended in the Ambient Air Quality Guideline Document is the AMS/EPA Regulatory Model - AERMOD. The model selected was the ISC-AERMOD View dispersion model, developed by *Lakes Environmental Software*. This model is used extensively to assess pollution concentration and deposition from a wide variety of sources. ISC-AERMOD View is a Microsoft Windows application and runs in Windows applications. AERMOD is a regulatory steady-state plume modelling system with three separate components:

- AERMOD (AERMIC Dispersion Model),
- AERMAP (AERMOD Terrain Preprocessor)
- AERMET (AERMOD Meteorological Preprocessor).

[li] TSP – All particles and aerosols with aerodynamic diameter of 100 micrometers or less and can be measured by the high volume sampling method.

[lii] PM_{10} refers to particles with an aerodynamic diameter of 10 micrometers or less as measured by the PM_{10} sampler.

[liii] The secondary standards for sulfur dioxide are designed to protect public health and welfare. They represent the long-term goal for air quality and provide the basis for an anti-degradation policy for unpolluted areas of the country and for continuing development of pollution control technology.

[liv] 1h averaging standard for Nitrogen Dioxide is a guideline standard concentration and not actually a part of the JNAAQS but is still used by National Environment and Planning Agency as material consideration

The AERMOD model includes a wide range of options for modelling air quality impacts of pollution sources, making it a popular choice among the modelling community for a variety of applications. The following are some of the modelling capabilities of AERMOD:

- The AERMOD model may be used to model primary pollutants and continuous releases of toxic and hazardous waste pollutants;
- Source emission rates can be treated as constant or may be varied by month, season, hour-of-day, or other optional periods of variation. These variable emission rate factors may be specified for a single source or for a group of sources. On this project all emission rates were treated as constant;
- The model can account for the effects of aerodynamic downwash due to nearby buildings on point source emissions. Plume Rise Model Enhancements (PRIME) building downwash algorithms based on the ISCPRIME model has been added to the model;
- Receptor locations can be specified as grid and/or discrete receptors in a CartEIAn or polar coordinate system. A new type of receptor was included, that is, - the discrete CartEIAn receptors that allow for grouping of receptors;
- For applications involving elevated terrain, the user must also input a hill height scale along with the receptor elevation. The United States Environmental Protection Agency (U.S. EPA) AERMAP terrain preprocessing program was used to generate hill height scales as well as terrain elevations for all receptor locations;
- The model contains algorithms for modelling the effects of settling and removal (through dry deposition) of large particulates and for modelling the effects of precipitation scavenging for gases or particulates.
- AERMOD requires two types of meteorological data files: a file containing surface scalar parameters and a file containing vertical profiles. These two files are provided by the U.S. EPA AERMOD Meteorological Preprocessor (AERMET) program (meteorological preprocessor for the AERMOD model).

Figure 7-1 shows the model domain that was utilised in the project, including the receptor grid and the plant boundary, as well as the location of all emission sources and buildings that were modelled for the facility. Table 7-3 in Section 7.3 contains the location data for all sources that were modelled for the facility. The location data included stack coordinates, stack heights, stack inside diameters, stack exit velocities, and base elevations for the stacks identified. These data were obtained from plant data, topographic maps supplied by Google Earth and the use of Jamaica Metric Grid 1:50,000 map.

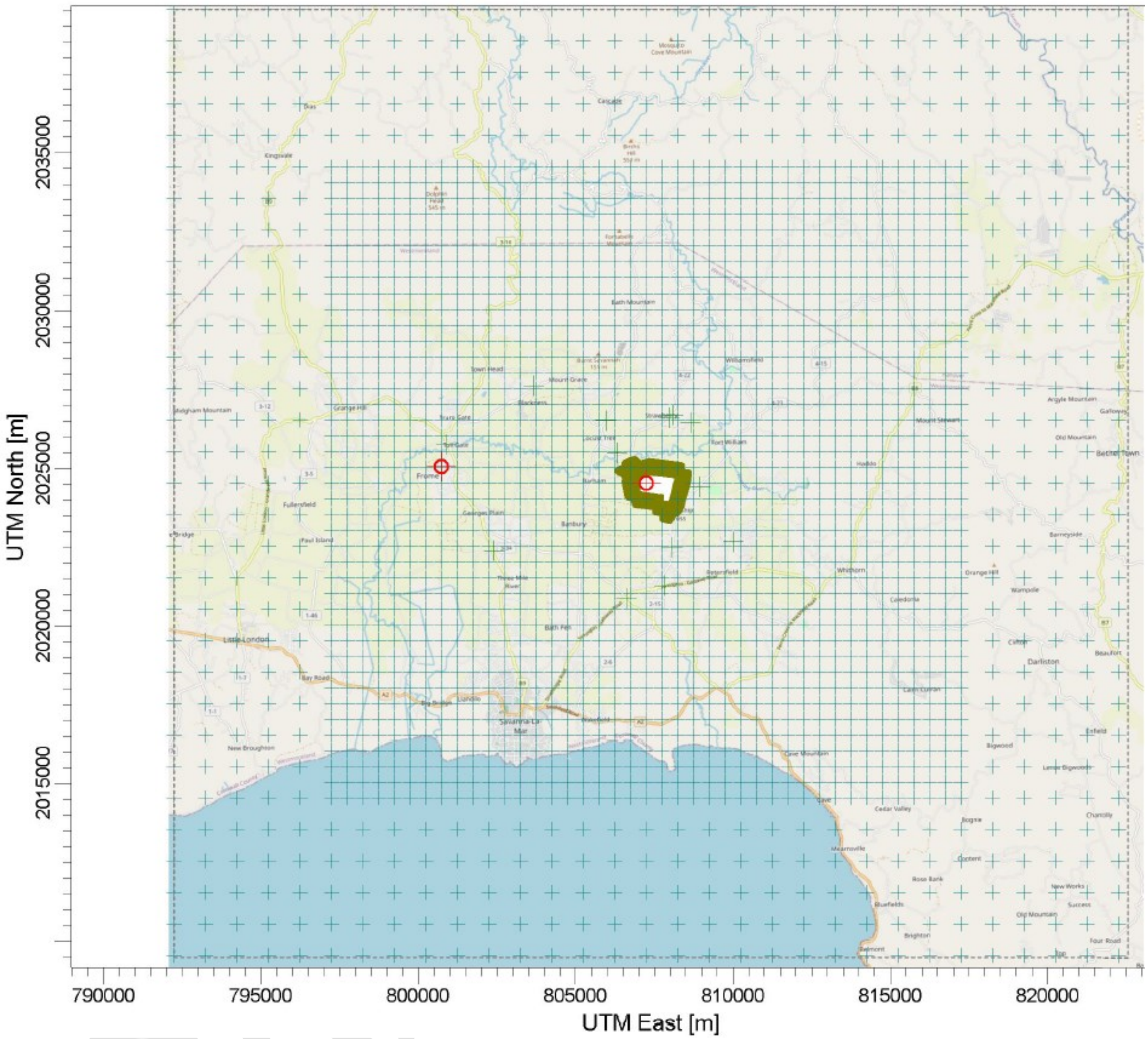


Figure 7-1: Grid and Receptor Map used in the Modelling and the Mill boundary in dark green. The Emissions Sources and Buildings are indicated by red circles. They are the Frome Sugar Factory (left) and the BBP Recovery Boiler (right and on the Mill Property).

7.3 INPUTS

7.3.1 MODEL DOMAIN, GRIDS AND RECEPTORS

The model domain selected was 15km (east-west) by 15km (north-south) with an origin (centre) at 2024543.51m E, 807244.28m N in the Universal Transverse Mercator (UTM) coordinate system. All UTM distances are in meters (m) and the notation m will be omitted hence forth.

Estimates of ground level concentrations were calculated at the intersection of the following grids and along the fence line for a total of up to 4719 receptors as follows:

- A fence line grid with distance from boundary of 100m, spacing of 50m for a total of 2490 receptors. There are 15 additional receptors that make the plant boundary.
- A 2-tier grid covering the entire domain; with 1st tier a spacing of 500m and a distance of 10km from the centre and a 2nd tier, covering a distance of 15km with spacing 1000m, for a total of 2201 receptors.
- 13 Discrete Receptors located in the residential communities and commercial areas along (see Table 3-1 for the Receptors).

Table 7-3: Special Receptor Grid and discrete Receptor Grid.

	X coordinates	Y coordinates	ELEVATION (m above sea level)
FRIENDSHIP PRIMARY AND BASIC SCHOOL	806308.5	2025513	30.92
PETERSFIELD HIGH SCHOOL	810012.9	2022683	53.7
SCN CHURCH	808943.1	2024415	49.99
NEW TESTAMENT CHURCH	808076.7	2022511	43.41
ASSEMBLES OF HOLINESS	808647.4	2026457	53.13
FRIENDSHIP SDA	808095.7	2026702	52.45
FRIENDSHIP BAPTIST CHURCH	807983.6	2026617	55.78
PETERSFIELD SDA	805959.7	2026525	35.74
HERFORD APOSTOLIC CHURCH	807820.2	2021296	41.84
GEORGES PLAIN PRIMARY SCHOOL	806618.9	2020886	23.3
FROME HIGH SCHOOL	802413.7	2022391	12.43
FROME PRIMARY SCHOOL	800900.2	2025772	11.43
GEORGES PLAIN BAPIST	803669.0	2027643	33.57

Digital elevation data with 90 m spacing were obtained for the study area from a Geographic Information Systems Resource (www.webgis.com). The elevation data were used to construct digital elevation model (DEM) files which are required for use in the model.

Data were collected to determine the plant boundary, building dimensions and the locations of sources. Figure 7-1 and Figure 7-2 illustrate the model domain, the regular CartEIAn grids with the plant boundary near the centre and special receptors as well as the plant boundary (fence line).

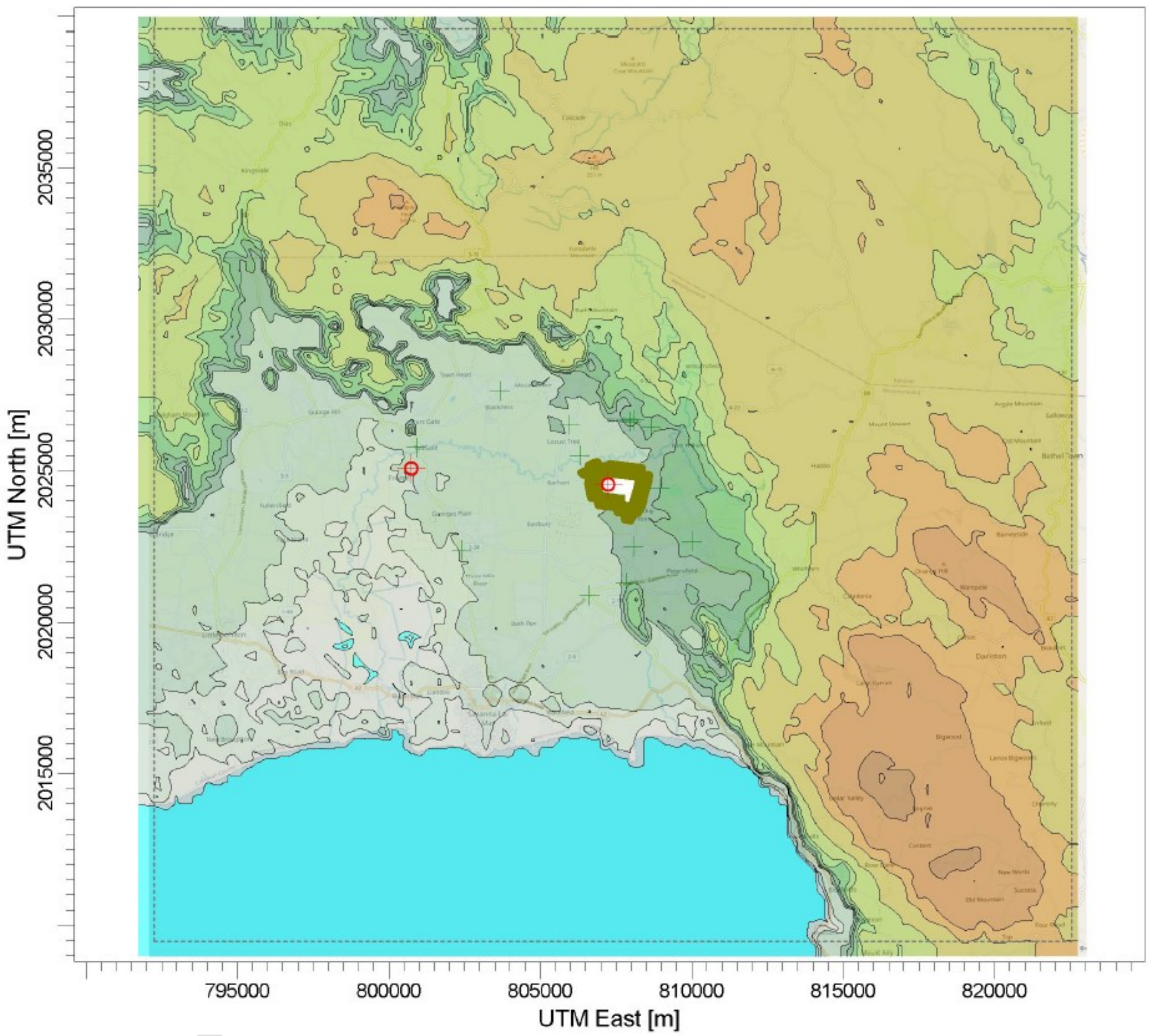


Figure 7-2: Digital Terrain Elevation Map Overlay. The Emission Sources and Buildings are indicated by red circles. They are the Frome Sugar Factory (left) and the BBP Recovery Boiler (right and on the Mill Property).

7.3.2 METEOROLOGICAL DATA AND PROCESSING

Meteorological information was provided using the MM5 pre-processed modelling data for a 5-year period provided by *Lakes Environmental Software*. Lakes Environmental offers a service providing **modelled meteorological data** for any location in the world. Lakes Environmental obtain this data by running the National Center for Atmospheric Research's (NCAR) MM5 prognostic meteorological model for a specified location and site domain.

Once the MM5 preprocessing was completed, the MM5 output file was converted into a format recognised by the **AERMET model**. The final output was generated by creating a pseudo meteorological station at the specified site location. Figure 7-3 is the output wind rose.

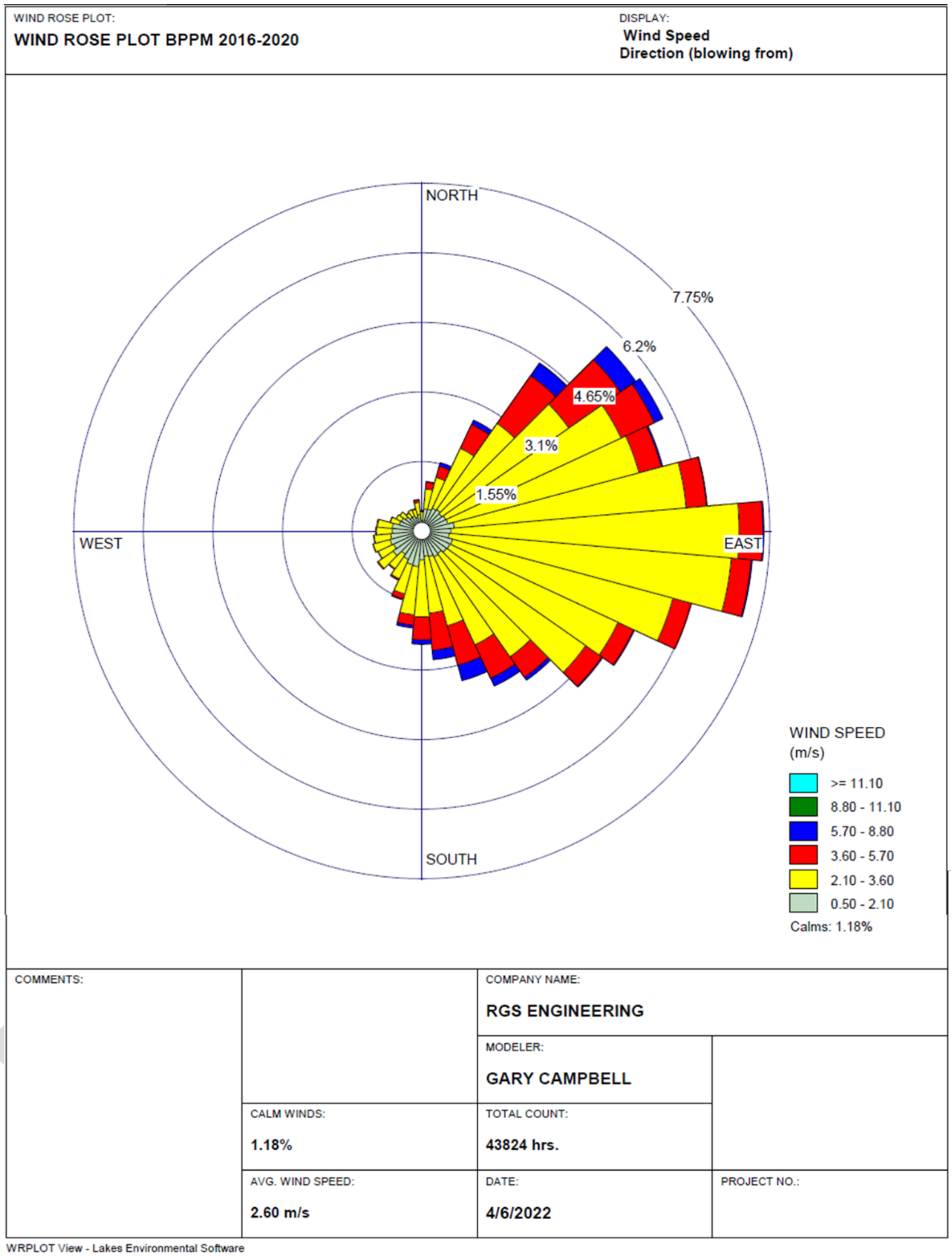


Figure 7-3: Wind Rose Data 2016-2020 for Pseudo Meteorological Station – Donald Sangster International Airport

7.3.3 EMISSIONS INVENTORY FOR THE BPM FACILITY

An emissions inventory was conducted using information provided from BBP design parameters for the recovery boiler (see Table 7-4). This Recovery Boiler is the only significant source of emissions at the proposed facility. There is an auxiliary boiler at the mill that will act as a back-up system, hence both boilers in theory will not be used at the same time and as such the emissions from the Recovery Boiler which will be in use during most of the operations, will be considered in this exercise. Fuel quality data provide from the LNG Analysis were provided by BBP based on their design specifications for fuel (Table 7-5). LNG was provided and used in the modelling assessment to simulate a worst-case scenario. The proposed LNG fuel emissions inventory was developed using emission factors AP 42, *Fifth Edition Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources* and the EU BATs based on the specification proposed for the proposed boiler.

Table 7-4: Information provided by BBP on the Recovery Boiler

Boiler Emission Information		
Preliminary Predicted Recovery Boiler emissions levels at 6% O_2, dry	Average CO	300 mg/Nm^2
	Average NO_x	450 mg/Nm^2
	Average SO_2	25 mg/Nm^2
	Average TRS	5 mg/Nm^2
	Average Dust	25 mg/Nm^2

Table 7-5: Normal predicted LNG Consumption Scenario during Commissioning and Start-up of the Pulp Mill or for example a Maintenance Outage at the Mill.

Initial Mill Commissioning & Start-up (normal case) LNG Consumption Forecast		
Start-up:	600	MWhrs
TOTAL	**600**	**MWhrs**
Typical heating value LNG:	50	MJ/kg
	0.013889	MWh/kg
Total LNG for normal cold start:	43,200	kgs
Total LNG usage for normal case mill cold start:	**43.2**	**tonnes**

A detailed review of the proposed process was completed to:

- Identify all possible emission points, including non-significant and fugitive emission sources;
- Obtain data on source operations and controls;
- Compile fuel use on each unit.

The emissions inventory was generated using the methods outlined in the NRCA (Ambient Air Quality) Guideline Document and the AP 42, *Fifth Edition Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources*. Source input files were created according to the US EPA modelling guidance 40 CFR Part 51 Appendix W. An inventory for all other sources external to the facility within a 15km radius was developed so that the cumulative impact could be determined. Data on these sources were obtained from NEPA.

7.3.3.1 POLLUTANTS

The pollutants modelled were SO_2, NO_2, CO and PM_{10}. The rates of emission are presented in Table 7-6 below and were determined using the data provided as mentioned above as well as the emission source data seen in Table 7-7.

Table 7-6: Estimated Emission Rates for Sources used in Model.

EMISSION RATES				
	NO_2 (g/s)	CO (g/s)	PM_{10} (g/s)	SO_2 (g/s)
BBP Recovery Boiler	4.50	3.00	0.25	0.25
FROME FACTORY BOILER	44.17	6.01	62.78	1.90

Table 7-7: Emission Source Data for all Sources used in Model from the modelling software.

Desc	SourceID_Prefix	Base_Elev	Height	Diam	Exit_Vel	Exit_Temp	X1	Y1
		[m]	[m]	[m]	[m/s]	[K]	[m]	[m]
RECOVERY BOILER		39.68	60	1.8	3.92975	500	807244.68	2024543.51
FROME FACTORY BOILER		12.49	60	5.29	8.2	346	800733.86	2025071.67

7.3.3.2 BACKGROUND CONCENTRATIONS

Background concentrations are an essential part of the total air quality concentration to be considered in determining source impacts. Background air quality includes pollutant concentrations due to:

- Natural sources
- Nearby sources other than the one(s) currently under consideration
- Unidentified sources

Typically, air quality data should be used to establish background concentrations in the vicinity of the source(s) under consideration. The monitoring network used for background determinations should conform to the same quality assurance and other requirements established at the regulating Agency, in this case NEPA. An appropriate data validation procedure should be applied to the data prior to use. Unfortunately, no air monitoring network has been established in this airshed, hence default background concentrations from the NRCA air quality guidelines were adapted in the results.

7.4 RESULTS OF DISPERSION MODEL EXERCISE

The input files created by auxiliary programmes were used to perform runs for sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO) and particulate matter less than 10 microns (PM_{10}). A summary of the maximum average concentrations at the averaging periods related to the JNAAQS is shown in Table 7-8. All runs were conducted using the averaging times that correspond to the JNAAQS. Background concentrations were taken from NRCA air quality guidelines. Table 7-8 took into consideration two scenarios – one with the proposed mill and another with both the proposed mill and the Frome Sugar Factory. All maximum model predicted concentrations were within the JNAAQS required parameters, however, the contribution of the Frome Sugar Factory resulted in a predicted a cumulative concentration for NO_2 over the 1-hour period as almost twice that of the standard. While the value calculated for BBP is compliant with the JNAAQS, the Frome Sugar Factory, also operating in the airshed could affect the short-term exposure.

Section 7.6 provides all the graphical display maps overlayed on Google Earth (Figure 7-4 to Figure 7-21). These maps show clearly the concentration contours and indicate the location of the maximum predicted concentrations in relation to communities and businesses in the air shed. All runs were successful and showed that the proposed facility will not breach any existing JNAAQS.

Table 7-8: Showing Summary of highest Predicted Concentration Fallout from the Pulp Mill.

PARAMETERS				BBP Recovery Boiler	COORDINATES		ALL SOURCES	COORDINATES	
POLLUTANT	***AVG. Time***	***Background Conc. (µg/m³)***	***JNAAQS (µg/m³)***	***Max Model Predicted Conc. (µg/m³)***	***UTM North (m)***	***UTM East (m)***	***Max Model Predicted Conc. (µg/m³)***	***UTMN***	***UTME***
Sulphur Dioxide SO_2	1 hr		700	6.69912	805244.7	2029044	30.33829	798744.7	2029544
	24 hrs		365	1.35031	804244.7	2029544	3.88492	797744.7	2030544
	Annual		80	0.04729	806840.8	2024212	0.17606	793244.7	2027544
Nitrogen Dioxide NO_2	1 hr		400	120.58418	805244.7	2029044	705	798744.7	2029544
	Annual		100	0.85119	806839.1	2024222	4.02	793244.7	2027544
Particulate Matter (PM_{10})	24 hrs	9	150	21.35	804244.7	2029544	128.2284	797744.7	2030544
	Annual	20	50	4.0478	806840.8	2024212	5.40635	793244.7	2027544
Carbon Monoxide CO	1 hr		40,000	80.38945	805244.7	2029044	96.06426	798744.7	2029544
	8 hr		10,000	36.4303	804244.7	2029544	36.79779	804244.7	2029544

7.5 CONCLUSIONS

Based on the results of this exercise, ambient concentrations for all pollutants modelled from this proposed Bamboo Pulp Mill using an LNG fuel fired Recovery Boiler, (worst case scenario although lignin will be the primary fuel source after start-up), plus the background concentration are predicted to meet the Jamaica National Ambient Air Quality Standards (JNAAQS) and guideline concentrations.

The bamboo facility using LNG was not predicted to have a significant impact on the air shed. However, the contribution of the Frome Sugar Factory led to a prediction that the cumulative concentration of NO_2 for the proposed bamboo facility and Sugar Factory, over a 1-hour period, would exceed the standard for this short-term exposure. This is important to note as the operations of other operators in the airshed can affect short-term exposures. The report concludes that the proposed facility is predicted to be in full compliance with the ambient standards for SO_2, NO_2, PM_{10} and CO.

7.6 DISPERSION MODEL MAPS

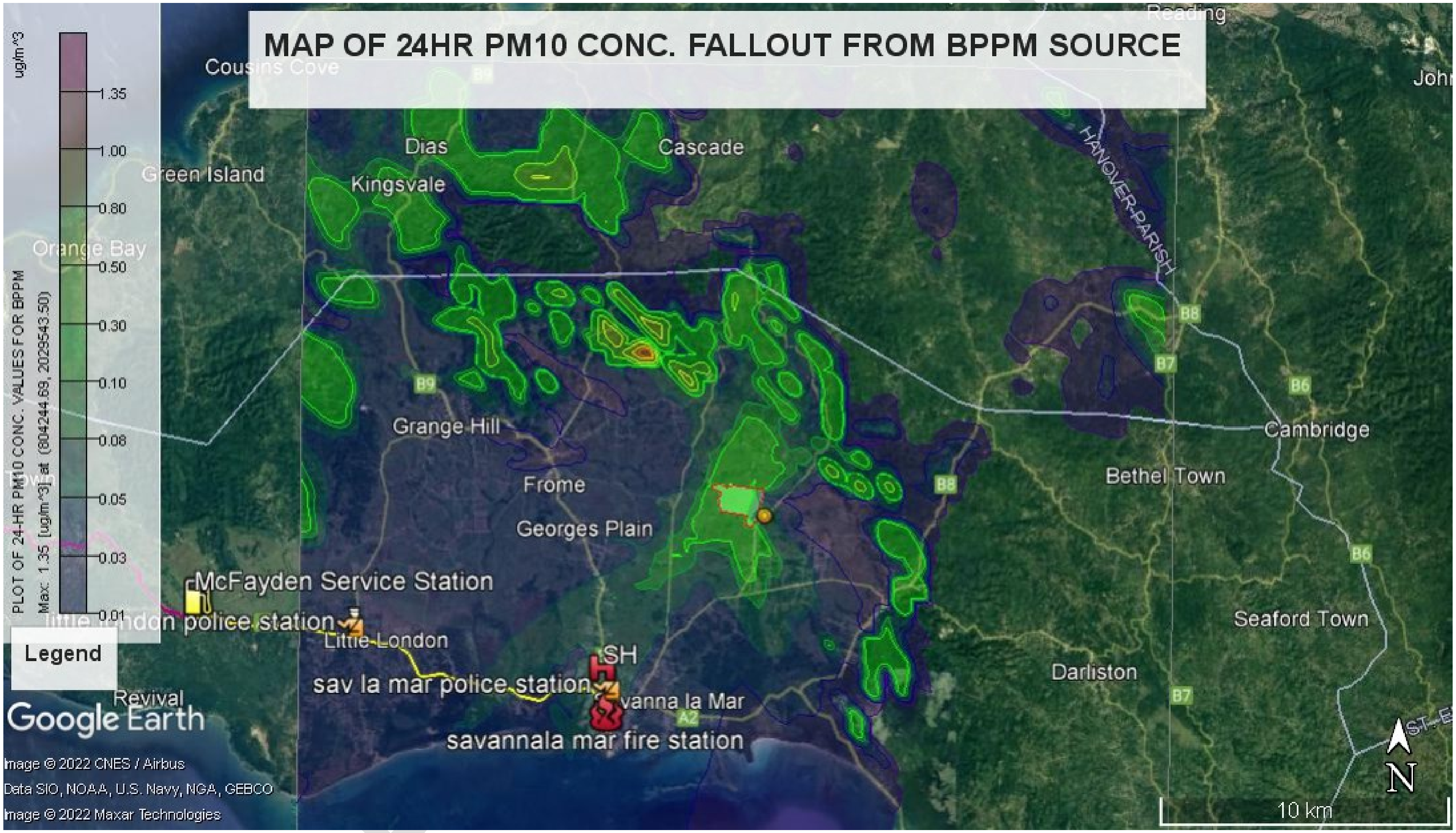


Figure 7-4: Dispersion Fallout Concentration Plot for 24-Hour PM_{10} (Full view)

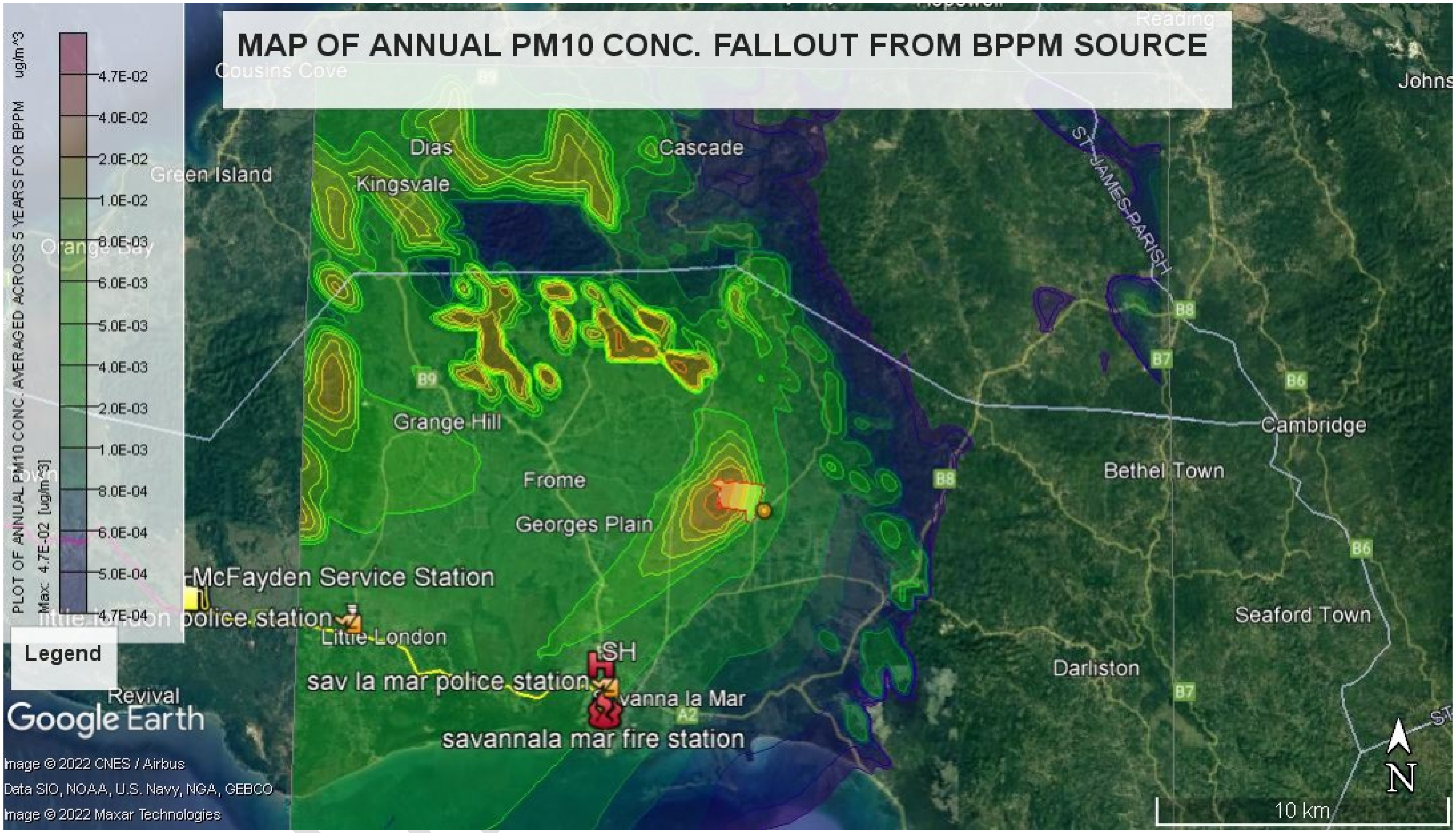


Figure 7-5: Dispersion Fallout Concentration Plot for Annual PM_{10} (Full screen)

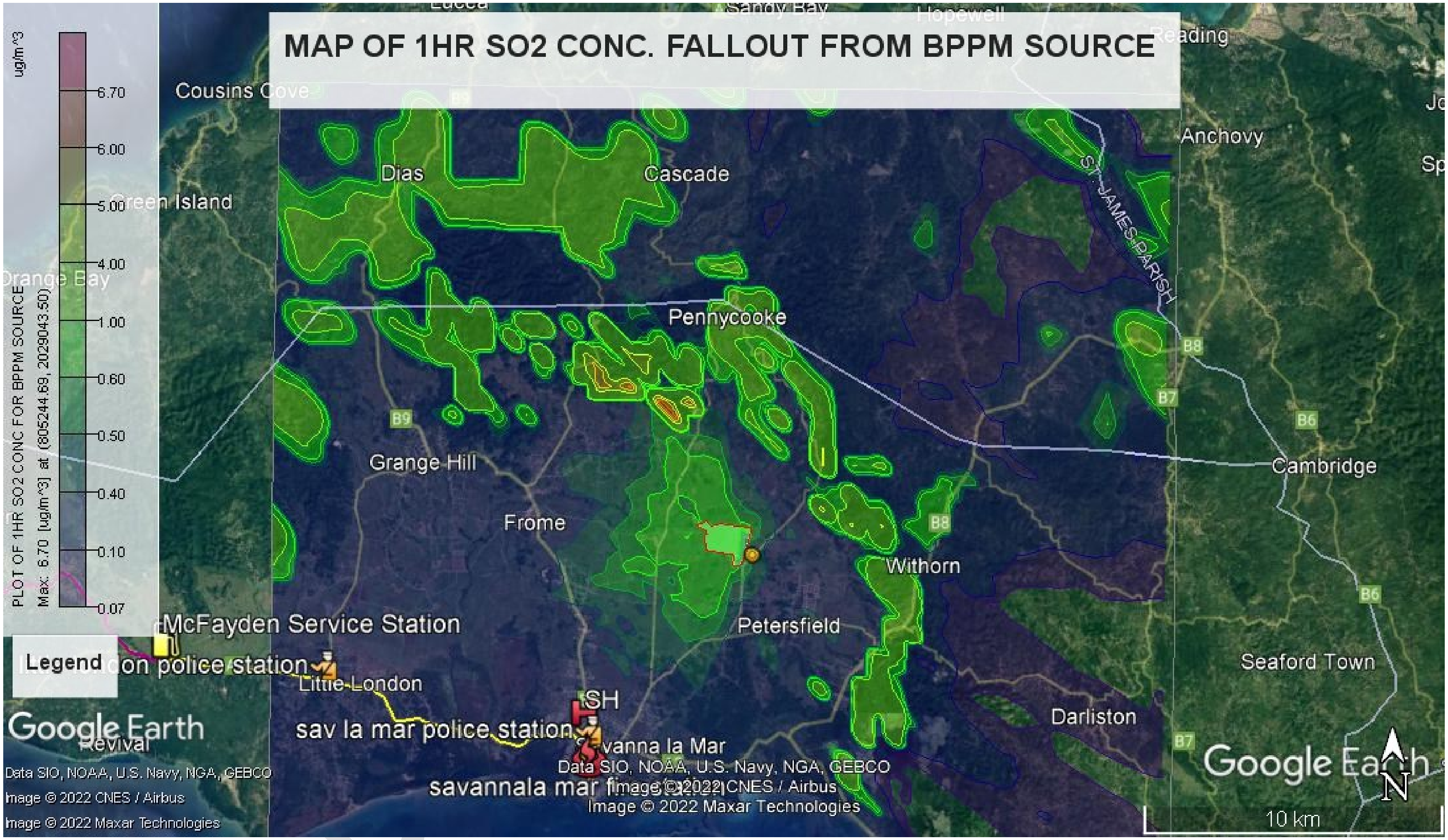


Figure 7-6: Dispersion Fallout Concentration Plot for 1 Hour SO_2

Figure 7-7: Dispersion Fallout Concentration Plot for 24-Hour SO_2 (Full Screen)

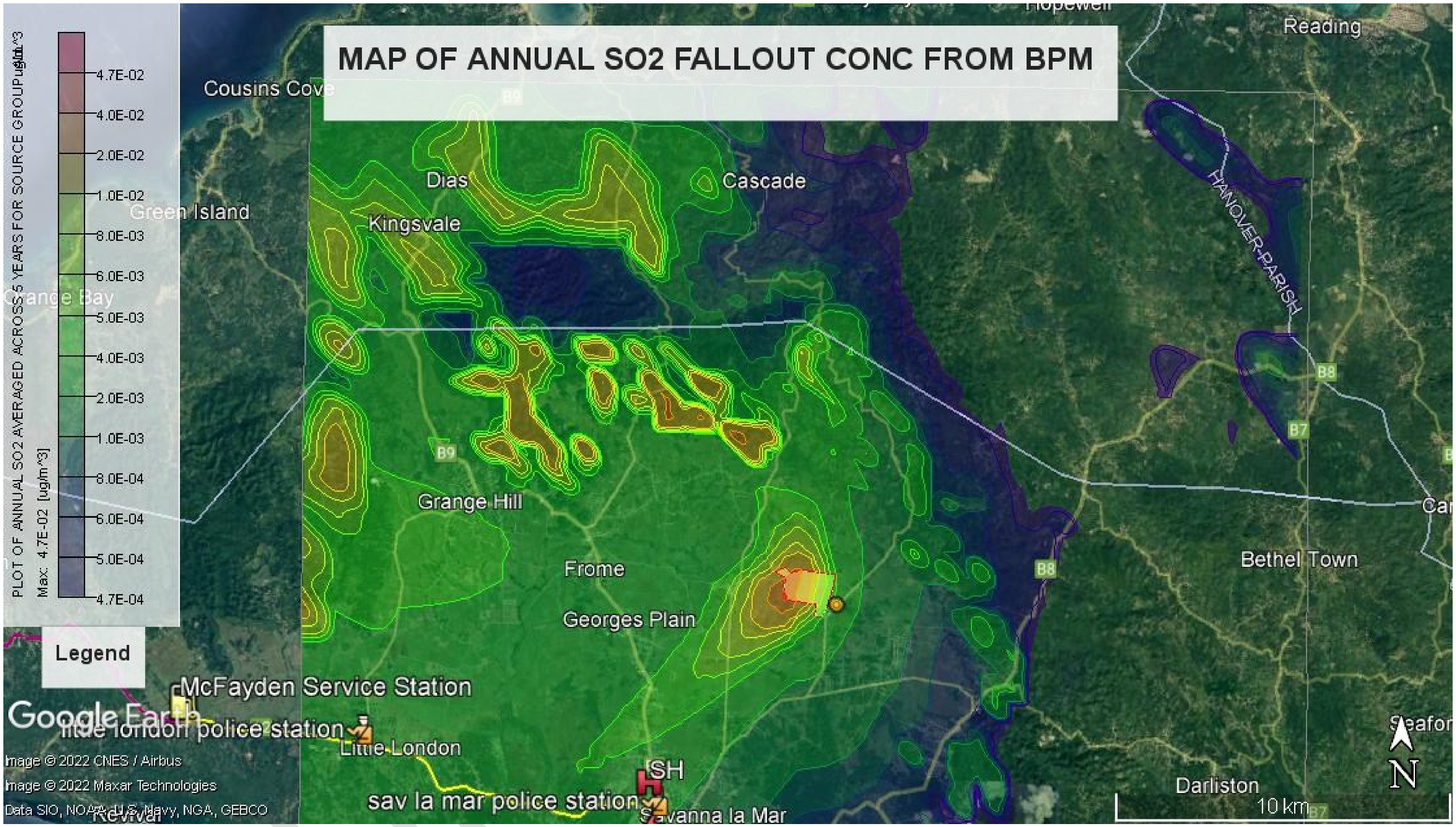


Figure 7-8: Dispersion Fallout Concentration Plot for Annual SO_2

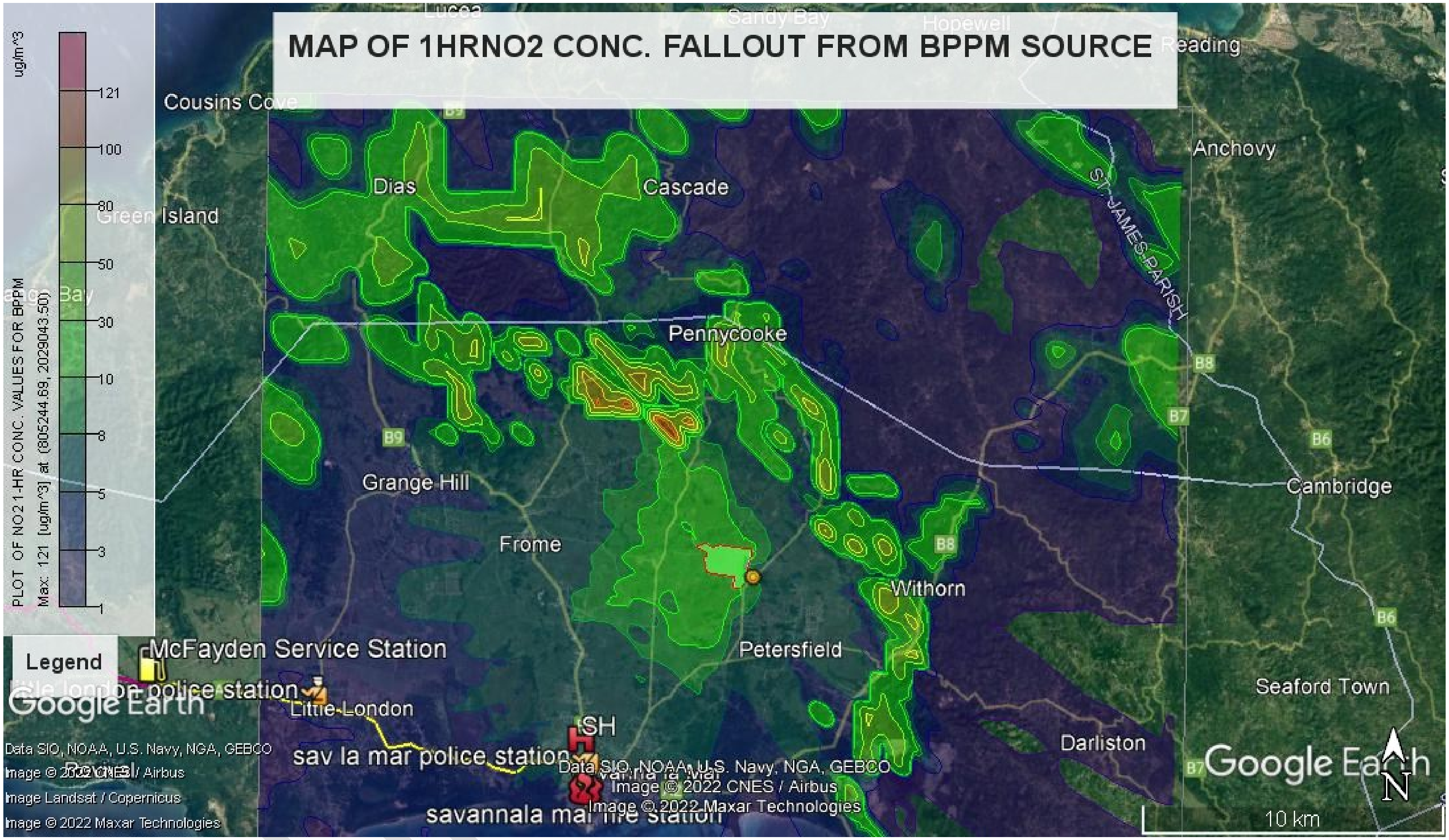


Figure 7-9: Dispersion Fallout Concentration Plot for 1 Hour NO_2 (Zoom)

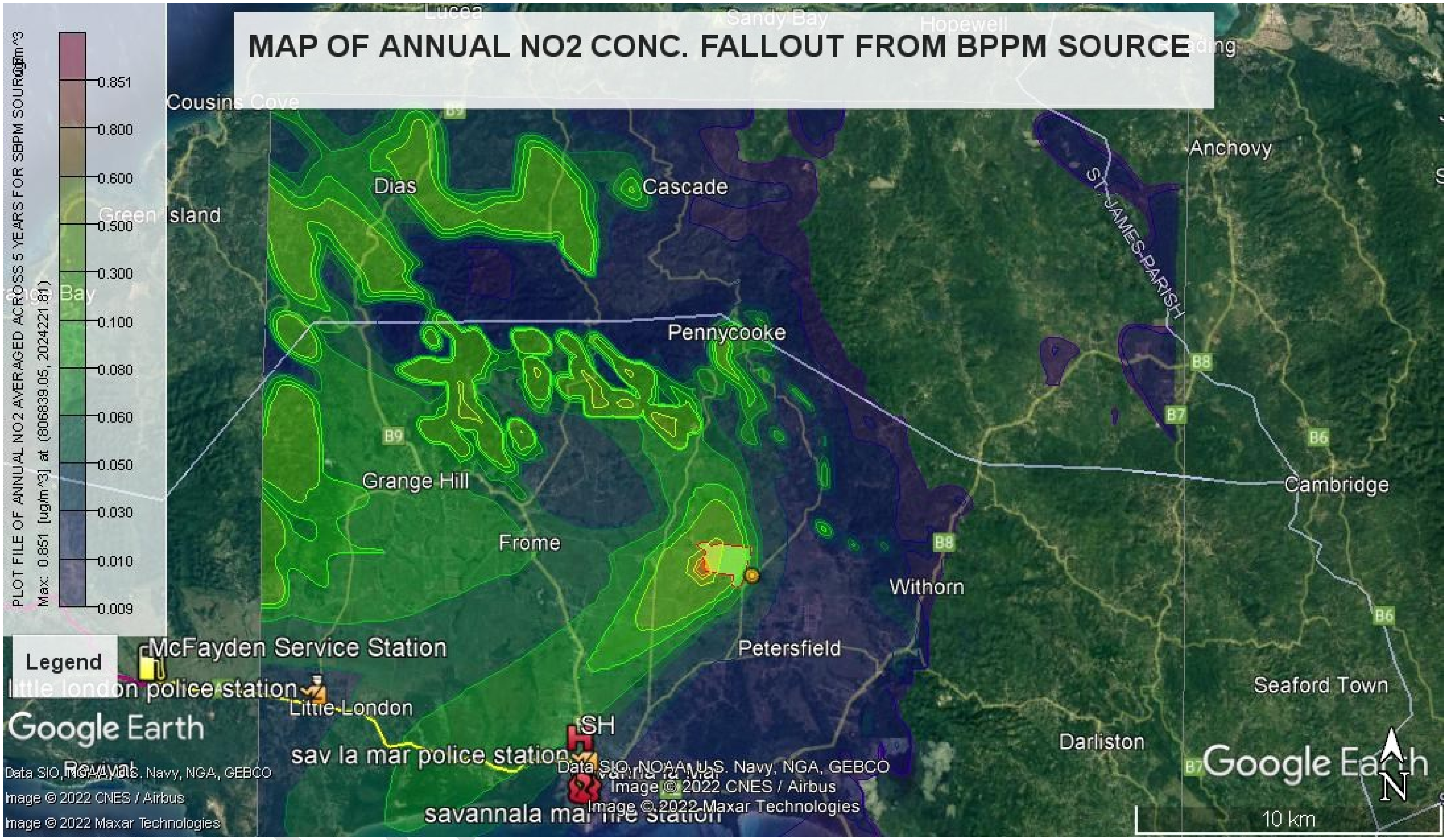


Figure 7-10: Dispersion Fallout Concentration Plot for Annual NO_2 (Zoom)

Figure 7-11: Dispersion Fallout Concentration Plot for 1 Hour CO

Figure 7-12: Dispersion Fallout Concentration Plot for 8-hour CO

Figure 7-13: Dispersion Fallout Concentration Plot for 24-Hour PM_{10} (ALL SOURCES)

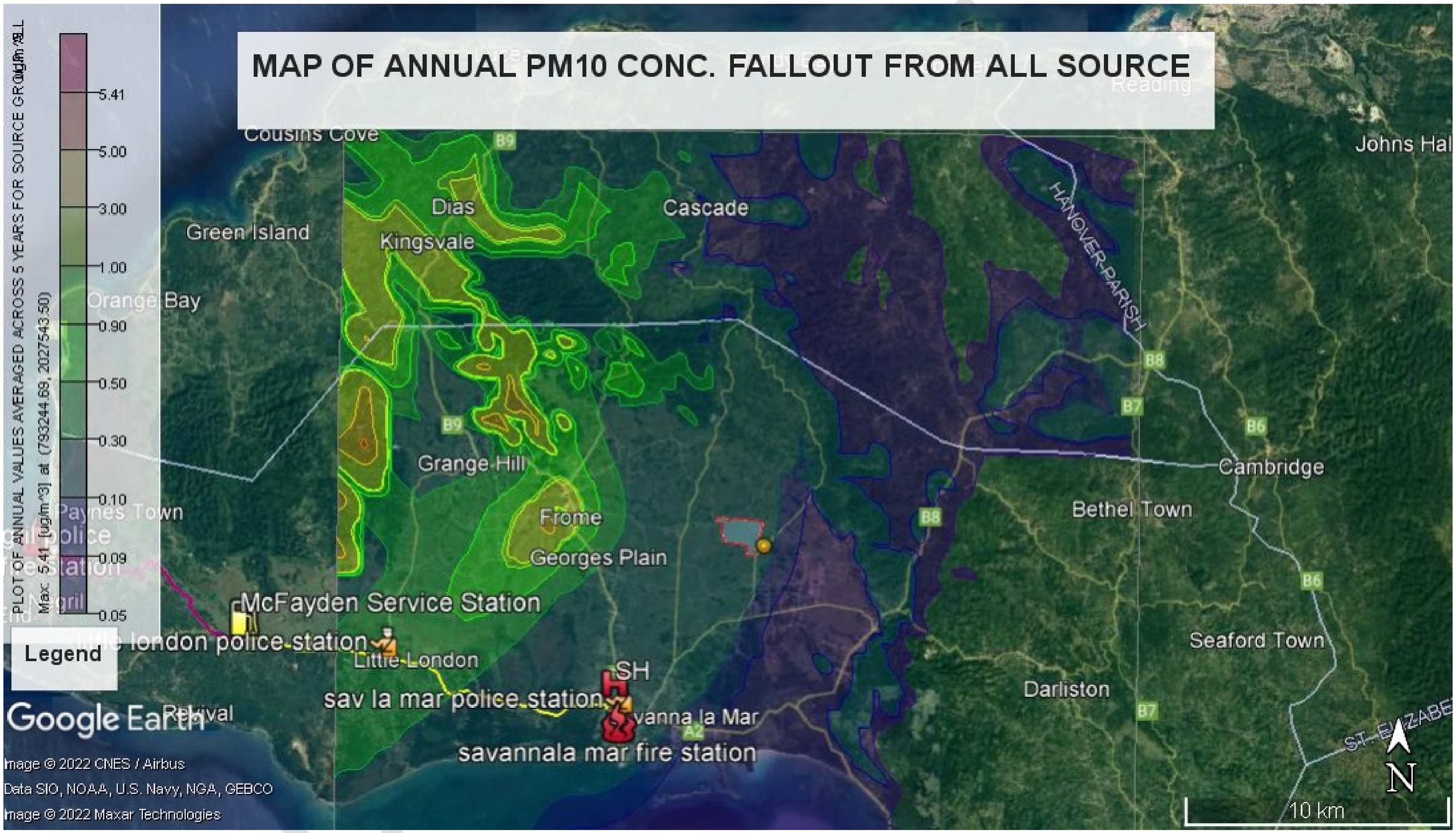


Figure 7-14: Dispersion Fallout Concentration Plot for Annual PM_{10} (ALL SOURCES)

Figure 7-15: Dispersion Fallout Concentration Plot for 1 Hour SO_2 (ALL SOURCES)

Figure 7-16: Dispersion Fallout Concentration Plot for 24-hour SO_2 (ALL SOURCES)

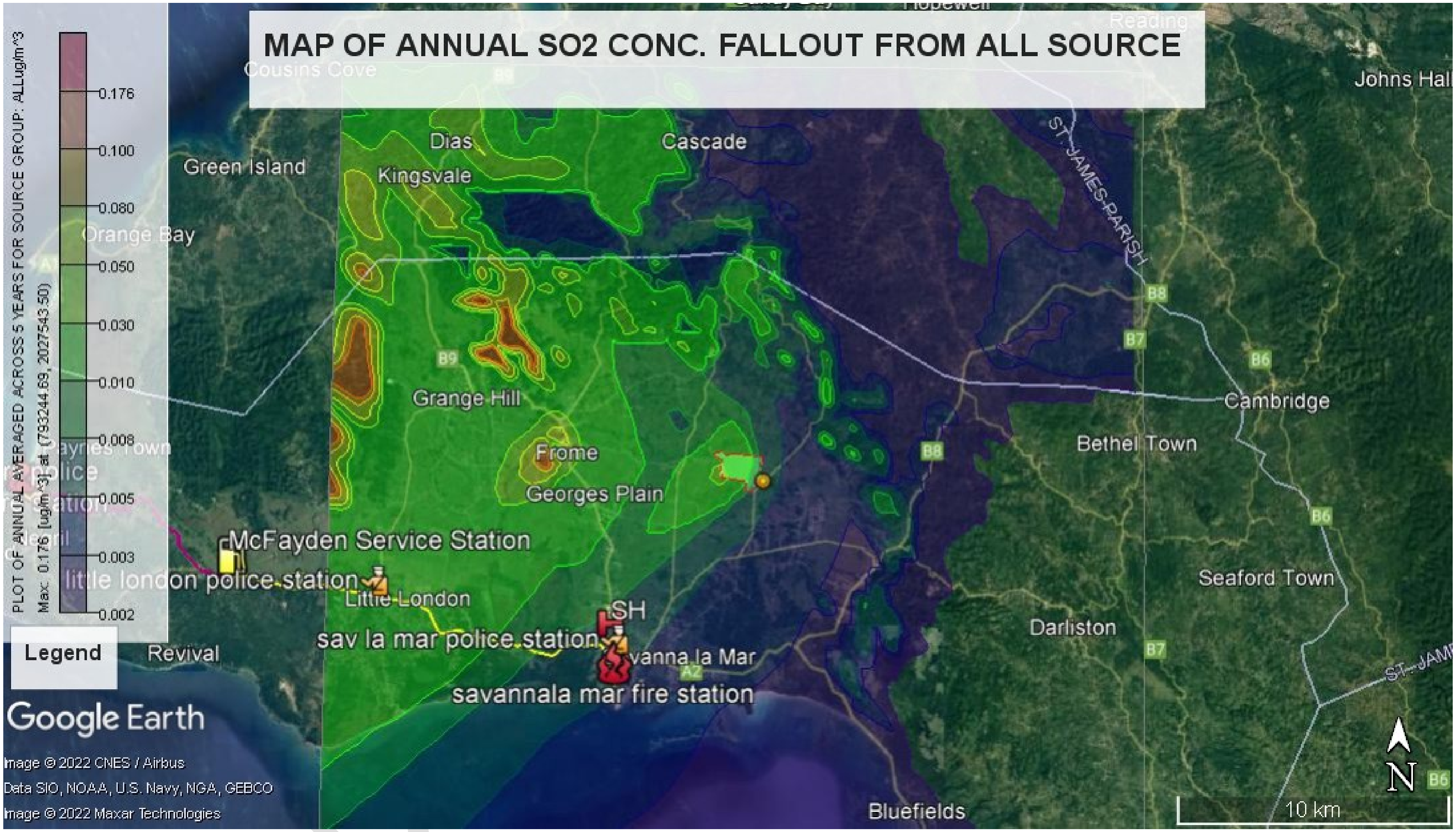


Figure 7-17: Dispersion Fallout Concentration Plot for Annual SO_2 (ALL SOURCES)

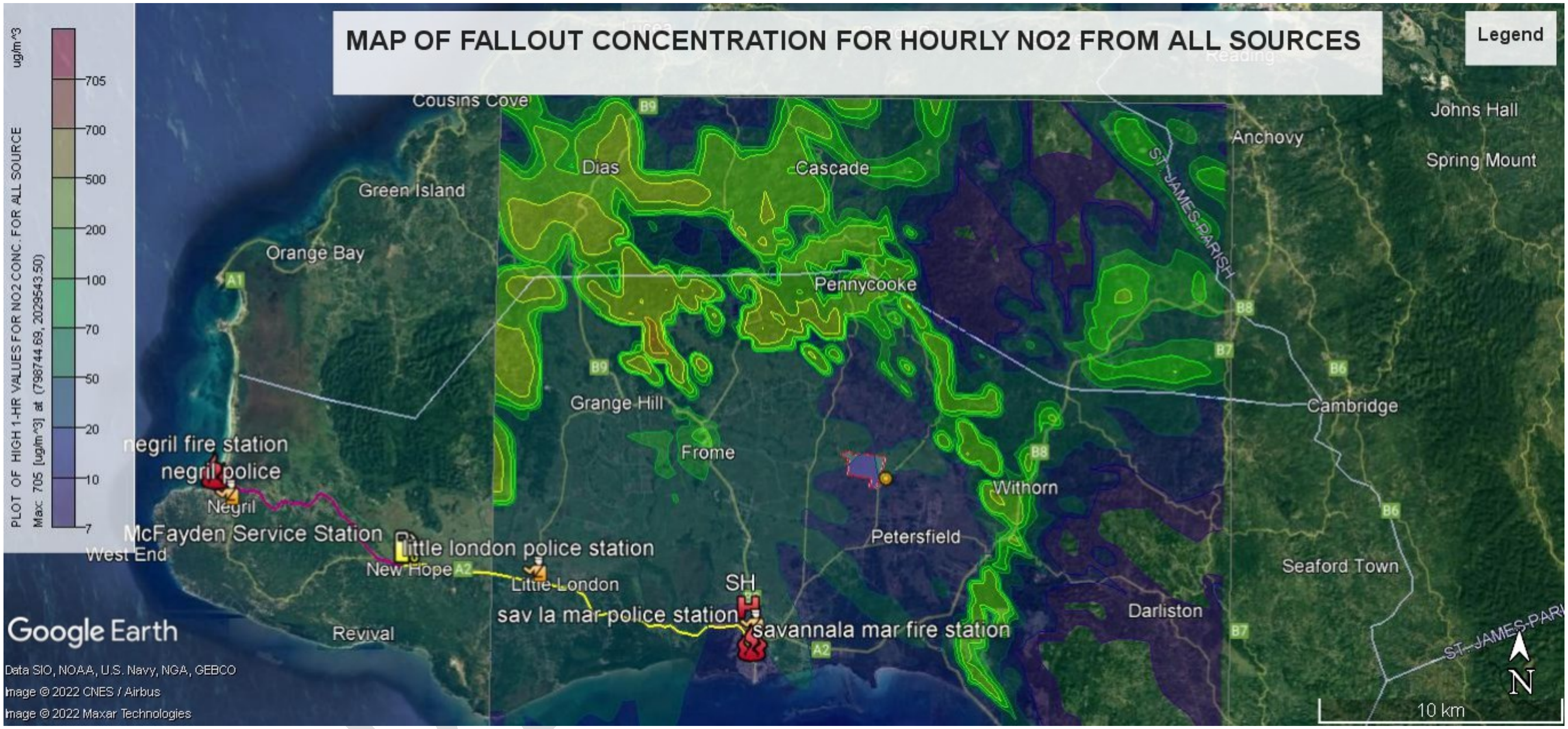


Figure 7-18: Dispersion Fallout Concentration Plot for 1 Hour NO_2 (ALL SOURCES)

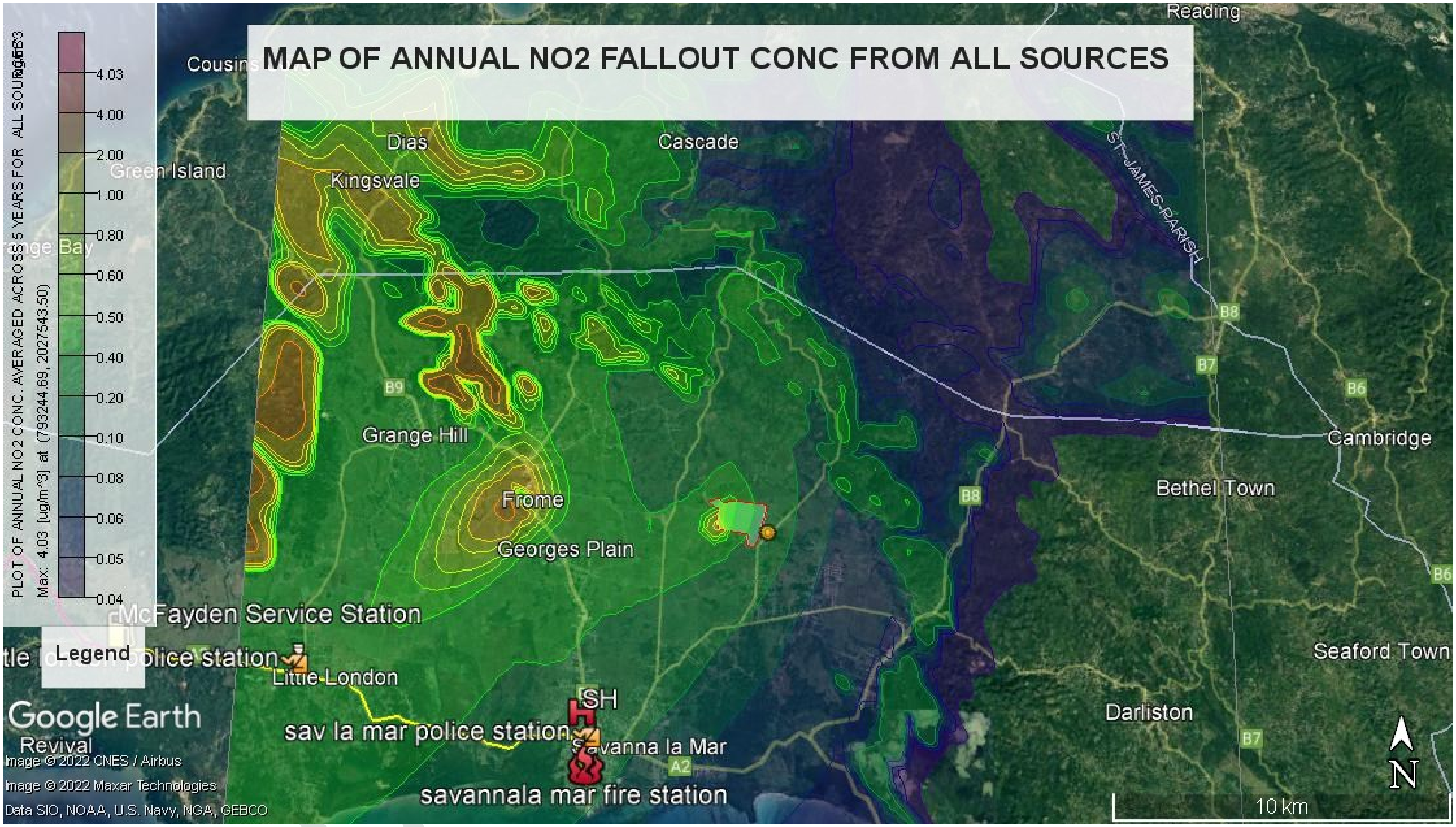


Figure 7-19: Dispersion Fallout Concentration Annual NO_2 (ALL SOURCES)

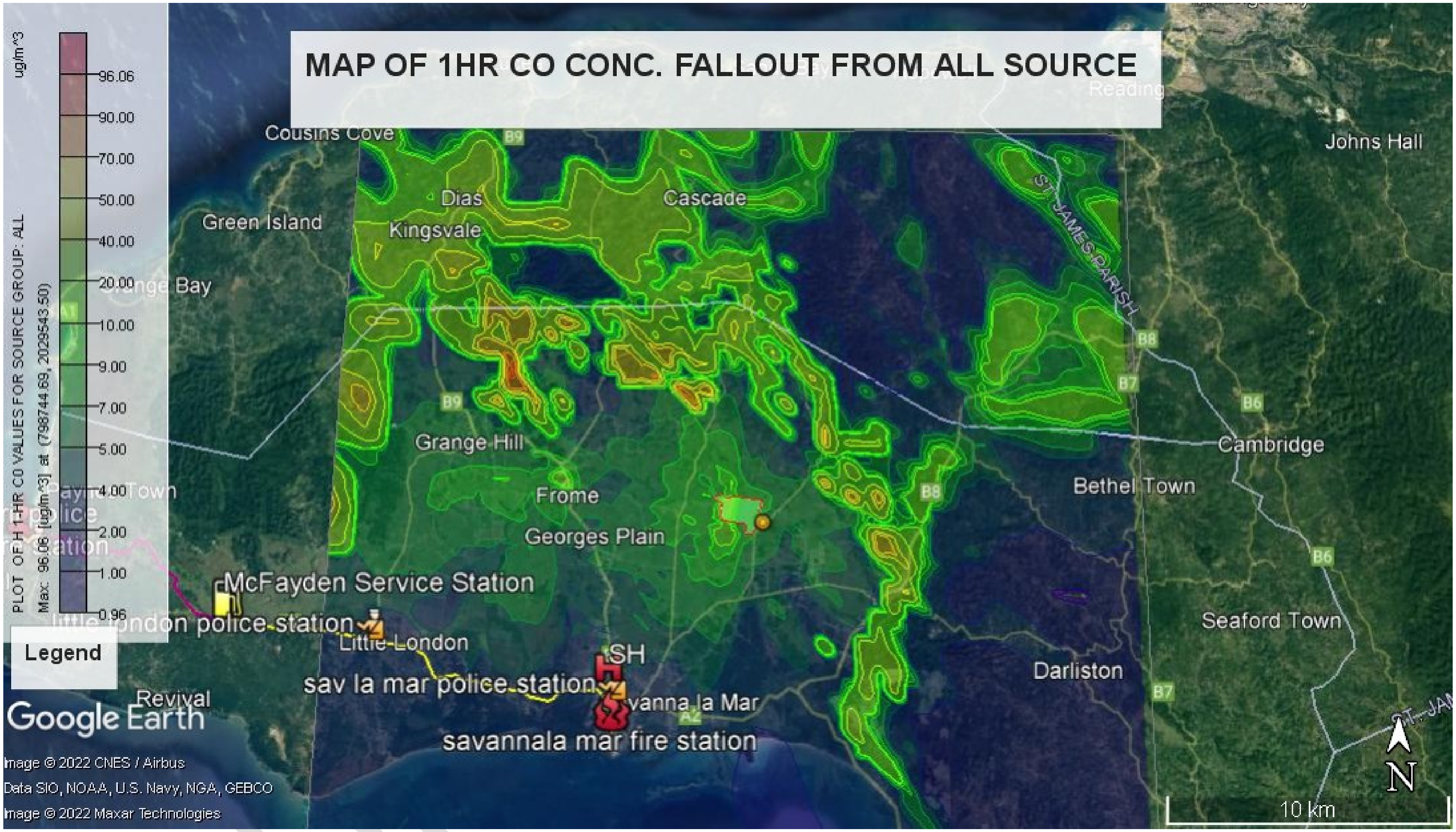


Figure 7-20: Dispersion Fallout Concentration 1 Hour CO (ALL SOURCES)

Figure 7-21: Dispersion Fallout Concentration 8-hour CO (ALL SOURCES)

8 IMPACTS IDENTIFICATION AND CORRESPONDING MITIGATION MEASURES/ POSITIVE ENHANCEMENTS

International standards and guidelines will be used primarily during both the construction and operational phases of the proposed Project. These standards and guidelines include identification of potential impacts and suggested mitigation for the biological and physical environment as well as general occupational health and safety. For holistic purposes, it also includes the potential impacts of farm sites if they are established. IFC Environmental Health and Safety (EHS) Guidelines are used for technical reference with general and industry-specific examples of Good International Industry Practice (GIIP). The EHS Guidelines contain the performance levels and measures that are normally acceptable to the IFC and that are generally considered to be achievable in new facilities at reasonable costs by existing technology.

IFC Environmental Health and Safety (EHS) Guidelines specific to this proposed Project include.

EHS Guidelines General Guidelines

The standard that guides all industry related EHS. It includes information on Environmental matters, Occupational Health and Safety, Community Health and Safety and Construction and Decommissioning. It is used with the Industry-specific guidlines.

EHS Guidelines for Pulp and Paper Mills

Information relevant to pulp and paper manufacturing facilities including wood-based chemical and mechanical pulping, recycled fiber pulping, and pulping based on non-wood raw materials such as bagasse, straw, and reed.

EHS Guidelines for Perennial Crop Production

Includes information relevant to large-scale plantation crops and outgrower systems and focuses on the primary production and harvesting through farming and plantation forestry of major multi-year food, fiber, energy, ornamental, and pharmaceutical crops, located in both temperate and tropical regions.

EHS Guidelines for Forest Harvesting Operations

Information relevant to the management of both plantation and natural forests, in temperate, boreal and tropical zones. The information looks at the Industry-Specific Impacts and Management and Performance Indicators and Monitoring.

The industry sector EHS Guidelines listed above, are designed to be used together with the IFC General EHS Guidelines which provides guidance to users on common EHS issues potentially applicable to all industry sectors. The EHS Guidelines for Perennial Crop Production and Forest Harvesting Operations will be used in the SEA Report.

An analysis of the proposed Project has been carried out to identify the major potential environmental and social risks and opportunities. The impacts have been distinguished by of the following criteria that are internationally applicable and are presented in Table 3-5 such as:

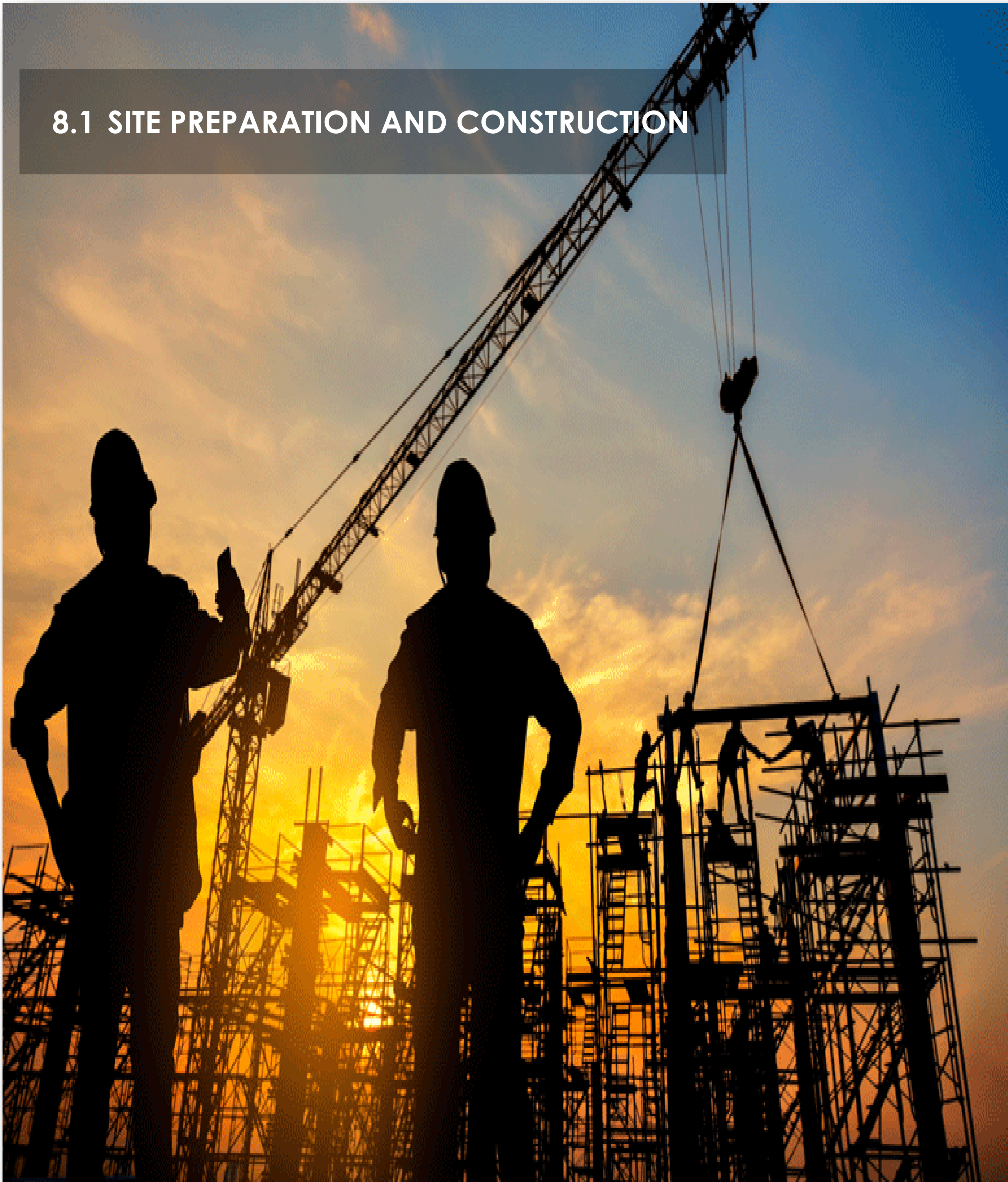
- **Probability of impact**: Almost certain, likely, possible, unlikely, rare
- **Direction**: Positive or negative
- **Duration**: Short term (0-5 years), medium term (5-15 years), long term (project lifetime)
- **Permanence**: Reversible or irreversible (also whether cumulative)
- **Magnitude**: Minor, moderate, significant
- **Spatial extent**: Local (project area of influence), regional (parish level), national (Jamaica)
- **Residual Impact:** Associated impact remaining after the implementation of mitigation measures (minor, moderate, major, significant)

The impacts have been considered for both the construction and operational phases; however, some impacts are common to both phases and as such will not be repeated in the discussion. Cumulative impacts have also been identified considering previous developments and any proposed development within the sphere of influence of the proposed works and operation. Where appropriate, mitigation measures have been recommended. It should be noted that the impacts addressed below are not exhaustive but considers those that are most likely. A summary of the impact assessment is presented in Table 9-1.

The potential receptors considered in the impact analysis include:

- People (on or off site)
- Nearby agricultural lands
- Drainage systems
- Other businesses
- Fields and allotments used to grow food
- Homes, or groups of homes (communities, housing developments)
- Playing fields and playgrounds (or other communal/green spaces)
- Footpaths and roads
- Important archaeological/heritage sites
- Schools, hospitals, and other public buildings
- Drinking water supplies
- Water sources e.g., Ponds, streams, rivers, dams
- Groundwater and connectivity
- Protected, rare, endangered, or economically important species

8.1 SITE PREPARATION AND CONSTRUCTION



The site preparation and construction impacts were generated based on the general guidelines for the construction of industrial facilities and the information currently provided by BBP.

8.1.1 PHYSICAL

This includes the following activities related to levelling of the proposed site, construction, and erection of Project components.

8.1.1.1 Air Quality

The area is characterised by mostly residential units with churches, schools and health centres. Particulate matter (PM_{10}) data were within the NRCA guideline at all sites.

Impacts of construction activities on air quality are cause for concern especially in the dry months due to fugitive particulate matter particles. The main sources of emission during the construction period are land clearing activities, increased vehicular traffic, the movement of equipment at the construction site and dust emitted during construction related activities. The magnitude of these impacts will depend on the ambient humidity levels, the direction of the prevailing winds relative to the location of the receptor and whether there are buffers such as tall vegetation or water bodies between the source and the receptor. The impact will be for short duration and confined locally to the construction site.

Exhaust emissions from vehicles and equipment deployed during the construction phase are also likely to result in marginal increase in the levels of sulphur oxides (SOx), nitrogen oxides (NOx), particulate matter

(PM_{10}), carbon monoxide (CO) and volatile organic compounds (VOCs). It is therefore critical that robust maintenance plans be developed and implemented or be required (from contractors) to ensure that levels of these pollutants remain minimal. Frequent spot checks, where applicable, should also be employed to assist with the aforementioned suggestion.

Receptors include occupants of nearby residential properties, construction workforce and local ecology in the 2 km sphere of influence.

RECOMMENDED MITIGATION MEASURES

The following are recommended measures to prevent or reduce adverse impacts related to air emissions during construction:

- Construct dust screens around the proposed site
- Frequently wet site to reduce fugitive dust (consider every 4-6 hours), particularly in the dry season.
- Establish speed limits on and around the site to reduce fugitive dust generation
- Phase land clearance activities and minimize cleared areas, re-grass or pave exposed ground as soon as possible
- All fine earth material should be covered during transportation to and storage on site; cover or wet construction materials stored on site
- BBP should consider biophilic design of Project components (Figure8-1), the development and maintenance of a greenbelt around the Project area and local vegetation along internal roads within and leading into the Project site
- Develop and implement an Environmental Management and Monitoring Plan, which should include a Dust Management Plan, Vehicle Maintenance Plan and a Grievance Mechanism.

Figure8-1: Illustrations of biophilic designs integrating vegetation into design components.

8.1.1.2 Noise and Vibration

The major sources of noise during the construction phase will be associated with vehicular traffic, construction equipment like dozers, scrapers, concrete mixers, cranes, pumps, compressors, pneumatic tools, saws, vibrators etc. Site clearance for the construction of the proposed Project will require the use of heavy equipment e.g., bulldozers, backhoes etc. which have the potential to cause a direct negative impact on the noise climate. The operation of these equipment will generate noise ranging between 85-100 dBA near source (Table 8-1). These noises will be generated mostly at the construction site and will be transient in nature.

Based on the results of the noise surveys conducted, noise levels exceeded the standard value for residential areas of 55dBA during the daytime. As such, it is expected that the noise levels may increase due to the construction activities within the area. Monitoring of the noise during the construction phase will need to be done at a frequency determined by the regulators to ensure that all mitigative measures implemented have been effective to reduce noise levels during said phase.

Table 8-1: Typical construction equipment noise levels

TYPE OF EQUIPMENT	TYPICAL SOUND LEVEL AT 50FT (dBA)
Dump Truck	88
Portable Air Compressor	81
Concrete Mixer (Truck)	85
Jackhammer	88
Scraper	88
Bulldozer	87

TYPE OF EQUIPMENT	TYPICAL SOUND LEVEL AT 50FT (dBA)
Paver	89
Generator	76
Rock Drill	98
Pump	76
Pneumatic Tools	85
Backhoe	85

Source: Adapted from - Route 101A Widening and Improvements, City of Nashua Hillsborough County, New Hampshire; McFarland-Johnson, Inc. May 30, 2007

While construction activities may generate vibrations, it is not anticipated that there will be any impacts from vibration on nearby sensitive receptors based on the distance of the proposed mill and the nearest sensitive receptor. The recommended mitigation measures do address the potential for this impact.

Receptors include occupants of nearby residential properties, construction workforce and sensitive ecological receptors (e.g. avi-fauna) in the 2 km sphere of influence.

RECOMMENDED MITIGATION MEASURES

The following are recommended mitigation measures for noise and vibration during construction:

- Consider establishing 24-hr continuous monitoring noise baseline values under different conditions, including weekdays and weekends. This may assist in guiding negotiations with the regulators for the establishment of monitoring standards for noise levels which are attainable but does not negatively impact the people and the environment.
- Use equipment that has low noise emissions as stated by manufacturers. Where this is not possible, noise reduction devices should be used to attenuate noise for e.g., mufflers. This equipment should be placed in areas downwind of sensitive receptors.
- Operate noise-generating equipment during regular working hours (for e.g. 7am-7pm) to reduce noise nuisance at night.
- All personnel operating noise-generating equipment should be equipped with the appropriate personal protective equipment (PPE) for noise protection. For example:
  - Workers exposed to equipment generating noise ≥80dBA for 8 hours or more should wear earmuffs
  - Workers exposed to prolonged noise levels at 70-80dBA should wear ear plugs
- Temporary noise barriers can be erected around noisy areas using plywood or any other absorbing material
- Stationary noise sources like generators and compressors should be positioned as far as possible from noise sensitive receivers such as workers.
- Develop and implement an Environmental Management and Monitoring Plan, which should include a Grievance Mechanism.

- Develop and implement a Traffic Management Plan for the proposed construction site to ensure that:
    - Trucks and other heavy-duty vehicles are restricted to travelling between 7am-5pm when impacts to operations of schools, residents and health centres will be minimal.
    - Mandate that all vehicles inclusive of trucks are maintained and serviced regularly
    - Guidelines regarding speed and load are enforced to ensure that they do not produce excess noise during transit.
    - Trucks and other heavy-duty machinery required to adhere to speed limits of 30km/h along access routes

8.1.1.3 Hydrology and Drainage

As discussed in Section 5.1.5 – Hydrology and Drainage, the proposed site has a very slow internal drainage which has implications for ponding of rainfall excess, making the site hazardous to flood rains. Changes and potential impacts could result from: sedimentation of waterways during construction; improper storage and/or disposal of construction material which could block drainage pathways; improper disposal of waste which could change the quality of the surface water; oil/fuel contamination from poorly maintained equipment on site.

Receptors include surface water features and downstream residential settlements.

RECOMMENDED MITIGATION MEASURES

The following are the recommended mitigation measures:

- Appropriate drainage pathways will need to be put in place during the construction period. This is to control flood hazards, ponding, and sediment run-off due to land clearing and exposed surfaces.
    - For example, establish cut-off or intercept drains to redirect stormwater away from cleared areas and slopes to stable (vegetated) areas or effective treatment installations
- Appropriate implementation and use of sediment traps where necessary to avoid sedimentation of the nearby waters during construction
- Periodic inspection of the construction site to ensure drainage systems are not impacting the surrounding environment.
- Develop and implement an Environmental Management and Monitoring Plan

8.1.1.4 Water Supply and Quality

Currently, there are existing demands on the water resources upstream and downstream of the Cabarita River including a tourism facility located 0.5km downstream of the site (Section 5.3.9). The requirement of the pulp mill being 14,200 cumecs is therefore 12% of the reliable combined flows.

The peak requirement for water during construction will be about 200-500m^3/day, which could be either supplied from the existing Cabarita River, a well and/or trucking. If water is to be abstracted from the Cabarita River or a well, the Client will need to obtain abstraction licenses from the WRA. The Client will also need to ensure this is included in the final designs of the proposed Project.

The construction equipment will primarily be related to mechanical fabrication, assembly, and erection of Project components. Temporary sanitation facilities (portable toilets) should be set up for disposal of sewage generated by the work force. Since most of the construction work force will likely consist of transient/floating population, the demand for water and sanitation facilities is likely to be low. As discussed, as there is currently no water abstraction system, mechanisms will need to be put in place to ensure the health and safety of workers on site.

The water quality assessment results show that all parameters considered were within the NRCA ambient water guidelines (Section 5.1.6). Potential contaminants associated with construction activities (suspended solids, oils and hydrocarbons, concrete and cement products, heavy metals and other chemicals stored on site) pose a risk to surface water features at the proposed Project site. Surface water may become contaminated because of construction activities or spillage. Appropriate mitigation measures must be implemented to ensure potential impacts are minor, reversible and short-term.

Receptors include surface water features, and downstream residential settlements and activities.

RECOMMENDED MITIGATION MEASURES

Construction activities may pose risks to the Cabarita River. As such, the following are mitigation measures to be implemented during the site preparation and construction include:

- Implement technology which reduces the consumption of raw water through reuse and recycling.
- Portable sanitary convenience should be provided (25 workers per chemical toilet is recommended), incl. showers. These systems should be placed away from waterways and sinkholes to reduce the impacts from spills and regularly checked to ensure they are working and maintained properly. Workmen should also be sensitized on the proper use these facilities.
- Fine earth material should be stored away from drainage path and properly beamed.
- Hazardous materials such as chemicals and oils should be stored in secured labelled areas, over spill kits (where applicable) and away from waterways and sinkholes.
- All equipment should be properly maintained to prevent spills from occurring on the site and the possible contamination of surface runoff and waterways.
- Excavated material should not be stockpiled onsite.
- Excavated material should not be stored along drains or in the path of natural drainage.
- Discharge of effluent is to be maintained above surface.
- Develop and implement an Environmental Management and Monitoring Plan.
- Sensitise the public of operations and how it could affect people that use the river during construction.
- Continuous engagement with users of the Cabarita River.

8.1.1.5 Solid Waste

During construction, non-hazardous solid waste may be generated from the activities such as site clearance (debris), packaging for construction materials (pallets, cardboard, plastics etc.) and generally from workers on site. To a lesser degree, construction activities may also generate hazardous waste e.g., unset cement, concrete additives, paint, and varnish containing organic solvents or other dangerous substances, empty packaging contaminated with residues of dangerous substances etc.

Receptors include surface water features, construction workforce and local ecology within 2 km sphere of influence.

RECOMMENDED MITIGATION MEASURES

Recommended mitigation measures for the management of solid waste during the construction phase include:

- Establishing a Waste Management Plan that considers prevention, reduction, reuse, recovery, recycling, removal, and disposal of wastes.
- Instituting good housekeeping and operating practices including inventory control to reduce the amount of waste resulting from packaging materials etc.
- Strategic placement of skips and bins should be strategically within the proposed construction site.
- Skips and bins should be adequately designed and covered to prevent entry by pests and to minimise odour.
- Regularly empty skips and bins to prevent overfilling.
- Ensuring that hazardous wastes are separated from non-hazardous wastes.
- Solid waste disposal should be done at an approved disposal site.

8.1.1.6 Storage and Transportation of Raw Materials

Raw construction materials will be stored onsite and there is potential for them to become water or air borne. Stored fuels and the repair of construction equipment has the potential to leak hydraulic fuels, oils etc.

Receptors include surface water features, construction workforce and local ecology within 2 km sphere of influence.

RECOMMENDED MITIGATION MEASURES

The following are the recommended mitigation measures:

- A central area (labelled and demarcated) should be designated for the storage of raw materials. This area should be lined in order to prevent the leakage of chemicals into the sediment.
  - Hazardous waste should be stored in closed containers away from direct sunlight, wind, and rain
  - Secondary containment systems should be constructed with appropriate materials for the wastes being contained
  - Conduct periodic inspections of waste storage areas
- Raw materials that generate dust should be covered or wetted frequently to prevent them from becoming air or waterborne.
- Fine grained materials (sand, marl, etc.) will be stockpiled away from drainage channels and low berms will be placed around the piles which themselves will be covered with tarpaulin to prevent them from being eroded and washed away.

- Raw material should be placed on hardstands surrounded by berms.
- Equipment should be stored on impermeable hard stands surrounded by berms to contain any accidental surface runoff.
- Bulk storage of fuels, oils or chemicals should be in clearly marked containers (tanks/drums etc.) indicating the type and quantity being stored. In addition, these containers should be surrounded by bunds to contain the volume being stored in case of accidental spillage.
- Prepare and implement spill response and emergency plans to address accidental releases.

The use of trucks and heavy equipment will be used during construction to transport raw materials, which can have adverse impacts on local roads.

- Implement paths that reflect planned roadways, rather than creating temporary pathways only for equipment access.
- Erect adequate and appropriate signage to warn road users of the construction activities.
- Raw materials such as marl and sand should be adequately covered within the trucks to prevent any escaping into the air and along the roadway.
- The trucks should remain parked on the proposed site until they are off loaded.
- Heavy equipment should be transported early morning (12 am – 5 am) with proper pilotage.
- The use of flagmen should be employed to regulate traffic flow.

8.1.1.7 Soil and Bedrock

The proposed Project site is currently being used largely for agricultural activities. The construction activities will result in loss of vegetation cover and topsoil to some extent in the Project site, specifically at the mill location. There is also the potential for introduction of pathways for contamination resulting from excavation and construction works e.g., fuel spills.

Receptors include adjacent land users, land quality, biodiversity, surface water within 2 km sphere of influence.

RECOMMENDED MITIGATION MEASURES

The recommended mitigation measures include:

- Conduct geotechnical investigations prior to the start of any proposed construction activities.
- Ensure land clearing is done in a phased manner
- The topsoil requires proper handling e.g., separate stacking so that it can be used for greenbelt development (if implemented).

8.1.2 ECOLOGICAL

During the site preparation and construction phase, vegetation clearance is likely to displace some of the fauna on the property. It should be noted that most of the proposed Project site has been heavily used for agriculture for several decades. Nevertheless, both the existing agricultural crops and surrounding vegetation serve as a habitat for the fauna identified and therefore clearing the land will eliminate these foraging grounds within the study site. However, given that similar types of vegetation can be found growing around the proposed site for development, fauna will likely relocate to these areas.

The water bodies on the property, namely the Cabarita River, are utilized by the wildlife and the community members who fish in the river. Potential impacts from site clearance and construction include: Changes in quality of surface water due to improper disposal of waste; sedimentation of the river; change in aquatic ecosystems; risk of degradation of flora and habitat loss to fauna during construction. Site clearance and construction activities are not anticipated to impact these areas once appropriate mitigation measures are implemented. Mitigative measures identified in Section 5.2.2.5 from the Cabarita River Freshwater Assessment are also included below.

Receptors include vegetation, local fauna, protected fauna, nesting birds, aquatic flora and fauna of the Cabarita River and marine fauna.

8.1.2.1 Concerns Raised by Residents

According to residents living in the communities within proximity to the Cabarita River, historically, the removal of trees along the river to support surrounding agricultural activities led to the destabilized banks, flooding, and reduced water availability downstream. Therefore, trees should remain to facilitate effective channelling of water and maintain flow for use by residents upstream. The main uses of the Cabarita River include fishing, bathing, washing, recreation and the extraction of water for domestic purposes. Without consistent flow these activities would be compromised.

RECOMMENDED MITIGATION MEASURES

The following are recommended measures to prevent or reduce adverse impacts on flora and fauna during site preparation and construction of the pulp mill:

- Several of the trees should be incorporated in the development as they would provide a habitat for several bird species that can coexist in a disturbed habitat.
- An environmental management and monitoring plan (EMMP) should be prepared before the start of construction and must be complied with during construction. This should include procedures for contacting NEPA should there be a sighting of any species of concern, and this should be fully communicated to all workers. The plan should also outline measures to ensure that construction does not impact sensitive and/or protected fauna.
- Where possible, vegetation clearance and construction activities should take place outside of the March to September breeding season for birds. In the event that these activities must occur within the restricted activity period, appropriate setback distances from active nest sites should be established and a qualified ecologist /NEPA, should be consulted. If the status of the nest cannot be confirmed, or if a nest is found outside of the breeding season, an appropriate setback distance should be implemented until such time that the nest status can be confirmed.
- Heavy equipment used near vegetated areas to be minimized whenever possible and should have the minimal weight/size class possible. This will reduce accidental destruction of flora and reduce soil compaction (negatively affects soil, air and water).
- Cleared vegetation should be disposed of in a suitable manner, e.g., woodchipper and recycled into soil, given to persons who make charcoal, or sent to Retirement Landfill, and not burned.
- In the proposed intake and outfall areas, removal of vegetation should remain limited so as not to undermine the functions that the existing vegetation provides for the stability of the riverbank and maintaining high water quality. Therefore, trees should remain to facilitate effective channelling of water and maintain flow for use by residents upstream.
- Based on the value of the grass to biodiversity and the sustenance to a variety of ecosystem functions, it is recommended that the bordering grass habitat is not completely removed from the area.
- In the proposed intake and outfall areas, removal of vegetation should remain limited so as not to undermine the functions that the existing vegetation provides to the river. Riparian vegetation is quite important to the stability of the riverbank, and it is essential for maintaining high water quality. During high stream flows, like that experienced after heavy rainfall upstream (or during storm events), the riparian vegetation slows and dissipates potential floodwaters. This prevents erosion and undercutting that can lead to compromised integrity of the riverbank, thus limiting its ability to contain water.
- To reduce the potential siltation of the river during construction, it is recommended to implement an Erosive Process Control and Monitoring Plan and build a temporary structure/silt-sized sediment trap to contain sediments during construction.
- Plan the execution of earthworks and land preparation preferably outside of the wet/rainy season to reduce the potential impact of increased sedimentation of the Cabarita River, flooding, etc.

- Implement a Solid Waste Management Programme and apply the best practices to manage solid waste in accordance with the law and regulation during construction to prevent the contamination of the Cabarita River and surrounding areas.
- Use certified companies to collect the wastewater from portable toilets and ensure the wastewater is disposed of in an environmentally sound manner. If chemical baths/other amenities are available ensure wastewater generated is treated and disposed of in an environmentally sound manner.
- Ensure construction workers are sensitised on any restrictions (if available) on the collection or harassment of aquatic fauna.
- Ensure any design plans that alter the natural state of the river are approved and monitored by the regulators WRA and NEPA.
- Implement water quality and aquatic communities monitoring programmes before and during construction. These programmes would be able to monitor water quality based on stipulated standards to preserve the existing aquatic communities of the Cabarita River within the vicinity of the mill or as directed by the regulator, NEPA.

8.1.3 SOCIOECONOMIC IMPACTS ASSOCIATED WITH CONSTRUCTION

The impacts on the human, social and economic environment stemming from site clearance and construction activities include:

- Direct, indirect and induced employment from construction activities.

- Internal migration and temporary squatting of transient workforce on available land in and around the proposed Project area.
- Changes in air quality as a result of construction activities may affect the health of those working, living or visiting local and nearby communities and businesses.
- Noise and vibration during construction may have negative effect on local workforce and nearby communities.
- Runoff from the construction site will impact the turbidity of the water and the wash down of chemicals such as petroleum used on site can contaminate the Cabarita River. This can potentially impact the health of those residents who use these locations largely for recreational bathing, fishing for food consumption and in a few cases domestic purposes. Critically also is the fact that visitors are attracted to the Tourism facility 0.5km downstream of the site, swimming, river tubing and boat rides. Impacts would negatively affect residents and visitors from all walks of life.
- Increased construction-related traffic could have negative impacts on access/route of entry to the Friendship property (routes through Hertford, Petersfield and Adelphi)
- Changes in baseline traffic due to construction activities may affect local road network operations relating to traffic speeds and capacity of highway links and network
- Large heavy goods vehicles (HGV) may cause disturbances to local receptors.
- Increased vehicular activity could increase potential risk of accidents and compromise road safety for road users
- Increase in construction-related solid and hazardous waste

Receptors include labour force, local communities and businesses, road users.

RECOMMENDED MITIGATION MEASURES

- Consideration should be given to the provision of housing solutions for workers that seek employment from outside of the immediate sphere of influence. This can be done through collaboration with the National Housing Trust who has plans to increase housing solutions in Westmoreland and through leasing houses to workers. Additionally, other agencies that can be engaged are the Housing Agency of Jamaica, the Squatter Management Unit, the Ministry of Housing in the Ministry of Economic Growth and Job Creation, the WMC, SCJH Limited, National Land Agency, Ministry of Labour and Social Security, private housing developers, NGO's for e.g., Food for the Poor and others should also be included in mitigating this impact.
- It is also recommended that priority be given to the employment of persons who reside in the immediate sphere of influence.
- The developers should work closely with the Westmoreland Municipal Corporation to ensure that the needs of any transient workforce are anticipated and planned for accordingly.
- Drainage off-site should be well developed to prevent potential contaminants from e.g., petroleum products and high turbidity levels due to runoff from areas cleared of vegetation into the nearby water sources used by residents and aquifer, which supplies potable water to NWC wells.
- All non- hazardous waste generated should be disposed of using approved methods. Waste should only be dumped at an approved landfill. It must be transported by either NSWMA or an approved contractor by NSWMA.

- Any hazardous material such as waste oil and tires, asbestos containing material and contaminated soil should be disposed of via approved contractors in locations approved by NEPA. A special permit for removal and transportation is a requirement of NEPA.
- Potential hazardous material should be identified prior to the start of construction.
- A schedule for collection of waste must be developed and never stored in waterways or along the road.
- The impacts of construction traffic can be minimised and managed through the implementation of a Traffic Management Plan. The plan must be developed by the selected contractor.
- Occupational health and safety (OHS) risks associated with the construction activities should be mitigated through the following:
  - Provision and wearing of appropriate personal protective equipment (PPE), such as high visibility vests, hard hats and boots (in compliance with the appropriate ASTM standards),
  - Safety and emergency response training
  - Proper signage around the construction site
  - Implement a mechanism for logging all incidents.
  - Mandatory provision of bathroom facilities for workers and access to medical attention throughout the activities
- The construction methodology should mitigate/manage the occupational health and safety risks to site visitors by outlining the following:
  - The work area should be cordoned off to prevent direct access of individuals not associated with construction
  - Wardens should be places at strategic points along the work area to enforce safety requirements.
  - Equipment should be escorted by at least one 'spotter' to facilitate the passage of HGVs on site.
- Given that the land being considered for development was previously a sugarcane plantation, an Archaeological Impact Assessment or a Chance Find Programme may be necessary.

POSITIVE ENHANCEMENTS

- ✓ Plans for BBP to improve the road network would be good for the community. However, this improvement would need to include safety amenities which are currently inadequate for higher volumes of traffic. The construction of sidewalks in critical areas especially along narrow sections of the road and pedestrian crossing at all major intersections and educational institutions would need to be put in place to facilitate road safety.

8.2 OPERATIONS

The operational impacts were generated based on the EHS Guidelines, European BAT Guidelines, Project Description of the pulp mill in Section 4.5 and information on the Kraft Pulping Process provided in **Appendix H**.

8.2.1 PHYSICAL

8.2.1.1 Air Emissions

Emissions of consideration were presented in Figure 4-23 and include:

- Malodorous reduced sulphur compounds (denoted as total reduced sulphur, TRS)
- Particulate emissions
- Nitrogen dioxides
- Sulphur dioxide
- Flue gases (these also emit particulate matter, sulphur compounds and nitrogen dioxides)

Information with the predicted air emissions from the processing units most likely to produce emissions were provided by BBP. This information was used as inputs in an Air Dispersion Modelling Assessment to determine their potential impact on the surrounding environment and if it would conform with the national guidelines. Based on the results of the ADM assessment, ambient concentrations for all pollutants modelled from this proposed Bamboo Pulp Mill using a LNG fuel fired Recovery Boiler, in addition to the existing background concentrations in the area is predicted to meet the Jamaica National Ambient Air Quality Standards (JNAAQS) and guideline concentrations. The pollutants monitored were SO_2, NO_2, PM_{10} and CO. The bamboo facility using LNG was not predicted to have a significant impact on the Air shed. However, mitigation measures will be mentioned below especially with respect to vehicular emissions.

Receptors for these emissions include Occupants of nearby residential and commercial properties, BBP staff members and contractors, local ecological receptors.

RECOMMENDED MITIGATION MEASURES

Relevant measures to control air emissions related to the operation of the proposed Project include the following:

- Reduce the risk of fire by reducing the build-up of potential fuel sources and controlling weeds and invasive species. Avoid open burning for land preparation, weed control, and post-harvest treatments. Where burning is unavoidable, potential impacts should be identified and weather conditions monitored to schedule burning to minimize impacts.
- Burning of solid waste or plant material should not be encouraged or practiced, and if necessary, should be done in a controlled environment under conditions which will prevent the release of any air pollutants.
- Develop and implement a preventative maintenance schedule for all equipment on site. Consideration should be given to inventory of critical items and parts of equipment's to ensure speedy remediation of any equipment failures.

- Gas recovery and leak detection systems in keeping with industry best practices should be a part of the operations involving LNG/NG.
- Develop and implement an Environmental Management and Monitoring Plan, including checklists for regular inspection of equipment that are critical to the operations of the Project and for pollution abatement (for e.g., scrubbers, Recovery Boiler etc.).
- Develop and implement a Grievance Mechanism
- The facility will conduct ambient monitoring as required by the Regulator
- Establish continuous monitoring station(s) as required by the Regulator, NEPA in addition to the outputs of the ADM. The sites for the passive monitoring should be determined by NEPA and can be assisted by the results of the air dispersion model (see **Chapter 7** for the assessment conducted for this EIA). Passive monitors to be used will be exposed for an extended period of time given the low concentrations measured over the 24-hour period and environmental conditions.
- All unpaved areas should be paved or grassed.
- Periodic washing/wetting of paved areas, particularly during the dry season.
- Consider the implementation of vegetation buffers or a green belt between the proposed Project site and adjacent areas. Establish natural wind barriers—such as vegetative field borders, hedgerows, herbaceous wind barriers, and tree/shrub establishment—to intercept airborne particulate matter and droplets, which may also include contaminants.
- All fine earth material should be covered during transportation to and storage on site.
- Establish slow speed limits on and around the site to reduce fugitive dust generation.
- Establish and implement a maintenance plan for vehicles.

Recommended emissions mitigation strategies for the operation of a typical kraft pulp mill include the following:

- Design stacks according to the Good International Industry Practice (GIIP) approach provided by the IFC General EHS Guidelines e.g., a single stack over 100m in height above immediately surrounding land. As far as possible, the point of discharge of the necessary emergency vents to the atmosphere should be a high, hot stack.
- Consider the use of secondary particulate emission controls e.g., electrostatic precipitators (Becker, 2010 [lv]) in recovery boilers and auxiliary boilers to reduce particulate emissions and potential risk to health and safety of workforce and nearby settlements. **The outputs from the Recovery Boiler include air emissions and fly ash, the latter which will be recycled in the process. Any residual fly ash will be sent to a vent gas scrubber and high-efficiency electrostatic precipitator.**
- Consider the use of secondary SO_2 emissions controls for e.g., alkaline wet scrubbers (Figure 8-2) for removal of acid gases and by-products of the incineration of TRS gases to control malodourous gas emissions. **The ANDRITZ equipment that will be used has a design to ensure optimum combustion control, minimum emissions and carry-over. Strong, malodorous gases will be collected and burnt (oxidised) in the recovery boiler, a common practice in European pulp mills. The BBP concept will incorporate this, and all safety measures with special care for burner design**

[lv] https://www.researchgate.net/figure/Conceptual-diagram-of-an-electrostatic-precipitator-Source-Data-from-Becker-30-C2010_fig3_313428450

and air distribution to eliminate explosive conditions. Scrubbers will be used to treat flue-gases from dedicated burners for heat recovery and the removal of sulphur dioxide (SO_2). The scrubber water will be led back to the chemical recovery system.

- Reducing heat losses and heat consumption by increasing efficiency of steam boilers. ***BBP is proposing that excess steam will be condensed.***
- When wastewater treatment plant odours are problematic, consider the use of oxygen activated sludge with capture and subsequent incineration of gaseous emissions. **BBP already has this designed in the WWTP being designed by SUEZ as found in Section 4.7 as part of the Stage 2 treatment.**
- Consider adopting a combined energy strategy which includes a reduction in energy demand, use of cleaner fuels and applications of emissions control, where necessary efficiency to reduce NOx, SOx, PM, VOC and GHG emissions. ***BBP has already proposed to use the heat generated from black liquor combustion to power the mill and will likely exceed the energy requirement for the entire production process (about 27MW).*** Additionally ***liquid natural gas (LNG), a cleaner burning fuel source will be used as a secondary fuel. LNG emits 50-60% less carbon dioxide and minute levels of Sulphur dioxide and particulate matter.***

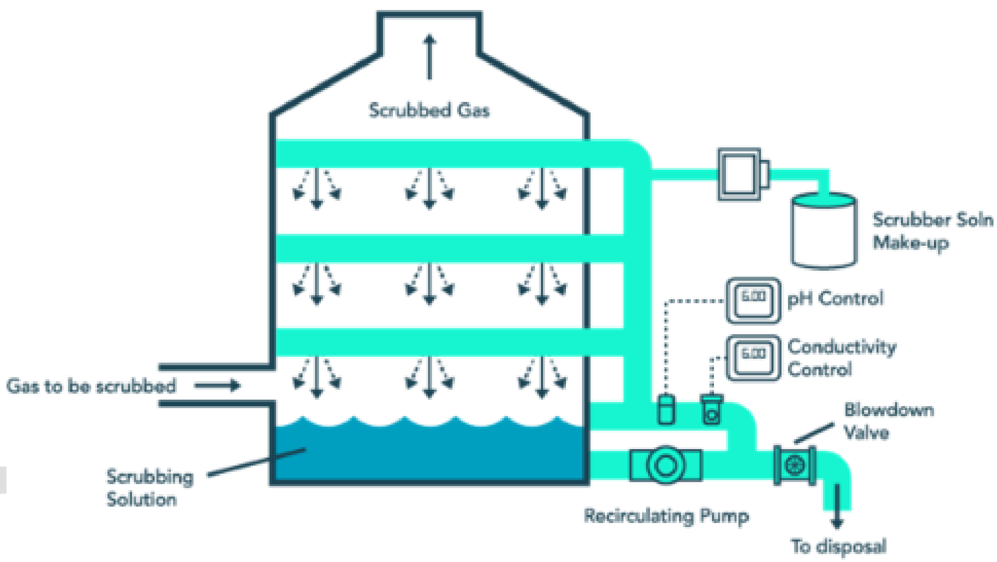


Figure 8-2: Conceptual diagram of a wet scrubber. Source: https://sensorex.com/wet-scrubbers/

8.2.1.2 Noise

Due to the large amount of mechanical equipment, transport vehicles and physical activities associated with the operation of the proposed Project, the potential for noise hazards is high. The IFC Environmental Health and Safety Guidelines provide measures for noise management, which BBP must consider.

Receptors to noise pollution include occupants of nearby residential and commercial properties, BBP staff members and contractors and local ecological receptors.

RECOMMENDED MITIGATION MEASURES

- Develop and implement a Traffic Management Plan to ensure that trucks are moved during a time of the day where the impacts to the operations of churches, schools, residents and health centres will be minimal. This plan should mandate that all vehicles inclusive of trucks are maintained and serviced regularly and that strict guidelines to speed and load are enforced to ensure that they do not produce excess noise during transit.
- During the operational phase, an occupational health, and safety (OHS) noise assessment should be done to determine areas where hearing protection will be necessary. A hearing protection program may also need to be developed.
- Buffer zones should be constructed/maintained around areas where there may be loud blow offs. Consider implementing a green belt to leverage natural topography and vegetation of the proposed site (Figure 8-3).
- Equipment with a low noise rating should be considered. Where this is not possible, noise dampeners should be used to attenuate noise. This equipment should be placed in areas downwind of sensitive receptors.
- Where possible, limit the hours of operation for mechanical equipment that produce high levels of noise.
- Where possible, ensure noise sources are located in less sensitive areas (away from sensitive receptors) to take advantage of distancing and shielding.
- Develop and implement an Vehicle Maintenance Plan and an Environmental Management and Monitoring Plan, including a Grievance Mechanism.

Figure 8-3: Example – (L) Greenbelt (R) Vegetation buffers

8.2.1.3 Water Supply and Quality

Details of the existing water supply and quality have been described in Section 5.1.5. The net freshwater ADt daily water requirement for the project from the Cabarita River is estimated at 14,200 m^3/day, based on a daily pulp production rate of 710 tonnes and estimated water requirement of 20 m^3/day per tonne. The requirement of the pulp mill is therefore 12% of the reliable combined flows and will be sufficient for the mill's operations in the near future and throughout its estimated lifetime. The WRA has confirmed that the estimated municipal water demand for the Cabarita WMU in 2020, 2080 and the estimated parish irrigation demand are within range for the project. Although this demand at the pulp mill will be significantly increased over time, the available resource is adequate to address this demand now and in the future.

Given the importance of water, specifically in the Cabarita River WMU, extreme care should be taken with respect to the extraction of raw water and the treatment and discharge of both trade and sewage effluents. Potential impacts on the water supply and quality from the operations include: Change in water quality due to improper waste disposal; change in water quality due to leaks and chemical spills; change in river quality and change in aquatic ecosystem and habitat.

Receptors of water pollution include surface water features, groundwater resources, downstream settlements (residential, commercial) and local ecology.

RECOMMENDED MITIGATION MEASURES

The Client should consider the following recommendations to mitigate against potential adverse environmental impacts. These include:

- Using technology which reduces the consumption of raw water through reuse and recycling
- Ensure all surface runoff from paved areas and the factory are directed towards grassed areas or to retention ponds depending on its quality.
- Design, implement and monitor treatment plants for the treatment of sewage and trade effluent to meet the relevant NRCA standards.
- Consider constructing a retention pond with the capacity to hold at least one day's worth of effluent with operations at maximum capacity.
- All discharge of effluent is to be maintained above surface and channelled directly to a fast-moving body of water (in this case the Cabarita River) to increase the dilution potential. The flow of the river should be monitored so that discharge volumes can be adjusted to ensure the water body is not negatively impacted
- A formal spill prevention and control plan should be developed in coordination with local regulatory agencies that addresses significant scenarios and magnitude of releases that may impact water quality.
- Ensure operators are trained in the handling, storage and transportation of chemical products

- Where hazardous materials will be stored on site, this should be done in accordance with international best practices. Use of equipment such as containment booms, absorbent pads and dispensers (to aid in microbial degradation) can be considered.
- Establish a rigorous monitoring program as a part of the Environmental Monitoring Plan for critical water ways.
- Implement a water quality monitoring programme before and during operations based on regulatory standards. Data should be continuously monitored as well as assessed and the necessary mitigative measures should be implemented to preserve the existing aquatic communities of the Cabarita River within the vicinity of the mill or as directed by the regulator. This can be supplemented by implementing an aquatic community monitoring programme as guided by the local regulator.
- Always use the best available technologies (BAT) in the production process to minimize the generation of liquid effluents.
- Carry out a periodic inspection of the drainage systems and infrastructure to ensure they are properly maintained.
- Ensure any design plans that alter the natural state of the river are approved and monitored by the regulator.
- A program of water quality monitoring of selected down gradient wells should be carried as specified by the Regulator, as part of the milling operations.

Water supply mitigation strategies include:

- Implement water conservation techniques, including rainwater harvesting
- Periodic maintenance and inspection of irrigation systems on the site and associated infrastructure

8.2.1.4 Wastewater

Prior to treatment, effluent from the proposed Project is expected to be high in total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD) and dissolved organic compounds. There is potential for the nitrogen and phosphate compounds to be released in wastewater from the Project, which may contribute to nutrient enrichment/eutrophication of receiving waters. Untreated wastewater can result in the emission of odours, fish tainting (impacting fishers), disruption to water activities and tourism, pathogenic contamination and spread of water-borne illnesses. Other issues related to wastewater discharge includes spills from overflowing tanks, which may contain toxic chemicals leached to the soil. The WWTP being designed by and to be operated by SUEZ has calculated that the targeted discharge from the WWTP should comply with local and international standards and guidelines for pulp mills and industrial facilities. The design and targeted discharge should minimise the aforementioned negative impacts once they are maintained.

Additionally, there is also the potential for increased surface runoff in paved areas, particularly during heavy rainfall events. This can also lead to ponding, flooding, damage to infrastructure and siltation in receiving waters.

Receptors for wastewater contamination include surface water features, groundwater, downstream settlements (residential, commercial) and local ecology.

RECOMMENED MITIGATION MEASURES

In general, wastewater management includes water conservation, wastewater treatment, stormwater management and wastewater and water quality management. Wastewater treatment technologies will vary with several factors including effluent composition. It is recommended that wastewater treatment include:

- Primary treatment – consider neutralisation, screening, sedimentation to remove suspended solids. Specifically, mechanical clarification basin(s) and/or settling/retention ponds should be considered to remove suspended solids. Chemical flocculation can also be used to assist (Figure 8-4).
- Biological/secondary treatment should be considered to reduce the organic content in wastewater and destroy toxic organics. This is typically applied in operations with relatively high discharge of organic pollutants, including toxic compounds. Specifically, biological treatment methods that should be considered include (combinations can be applied for to increase efficiency):
  - Activated sludge
  - Aerated lagoons (Figure 8-5)
  - Biological filters of various types (in combination with other methods)
  - Anaerobic treatment used as a pre-treatment stage, followed by an anaerobic biological stage
  - Tertiary treatment (optional) to further reduce toxicity, suspended solids, organics, and colour
  - Bamboo on the proposed site can be used in the wastewater treatment process as it has the capacity for high nitrogen uptake, thus preventing harmful run-off from entering nearby streams.
  - Additionally, extended aeration time should be considered to reduce biological sludge formation and help ensure consistently high levels of treatment. Favourable treatments also include anaerobic biological pre-treatments for effluents high in COD/BOD and low in toxic substances.
- In processing the bamboo for pulp, the main delignification process involves the use large quantities of caustic, which is a source of hydroxide. It is recommended that a rigorous monitoring system be developed and implemented to continuously assess the water qualities of all receiving, or close by water bodies.
- All phosphate values were well below the NRCA guideline of 0.8mg/L; it is necessary to ensure that the concentrations are not increased significantly, and extra care is taken to not create conditions that may results in eutrophication.
- All wastewater discharge should be kept to a minimum through water use planning and recycling.

Stormwater management

As it relates specifically to stormwater run-off:

- Stormwater should be separated from process and sanitary wastewater streams to reduce the volume of wastewater to be treated prior to discharge

- Runoff from areas with potential sources of contamination should be minimized e.g. limit area of impermeable surfaces. Peak discharge rates should be reduced e.g. using vegetated swales or retention ponds
- If possible, stormwater should be managed as a resource (for groundwater recharge or meeting water needs on site)
- Oil water separators and grease traps should be installed and maintained around fuel storage and containment areas, refuelling facilities, parking areas.
- Sludge from stormwater catchments or collection and treatment systems may contain elevated levels of pollutants. This should be disposed of in compliance with NRCA guidelines for the protection of public safety and long-term sustainability of water and land resources.

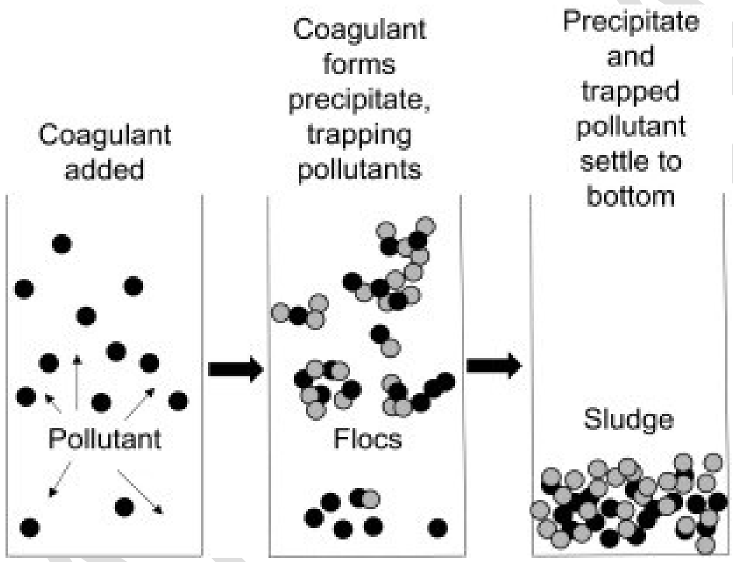


Figure 8-4: Conceptual diagram showing chemical flocculation in wastewater treatment. Source: https://www.sciencedirect.com/topics/engineering/chemical-coagulation

Figure 8-5: Example of Aerated lagoons.

8.2.1.5 Residues and Waste

The proposed Project is expected to generate quantities of non-hazardous solid waste, with limited hazardous wastes. These include residual pith, inorganic sludge (e.g., green liquor sludge, lime sludge) from chemical recovery, general trash (e.g., plastics) and biological sludge from wastewater treatment. Hazardous waste may include oil and grease residues, scrap electrical equipment and some chemical residues.

Receptors of residues and waste include surface water features, construction workforce and local ecology within 2 km sphere of influence.

RECOMMENDED MITIGATION MEASURES

Recommendation mitigation measures for solid waste management include:

- Consider recycling waste products e.g., ash as fill material in construction work, road construction, as a soil conditioning agent, or otherwise landfilled which ***BBP has proposed to do.***
- Establishing a Waste Management Plan that considers prevention, reduction, reuse, recovery, recycling, removal, and disposal of wastes.
- Ensure all solid waste generated from the operations have designated storage areas which are constructed to prevent the entry and breeding of pests.
- Ensure incompatible solid waste materials are not stored together.
- Ensure all chemicals are handled, stored and used in an appropriate manner and all spills are dealt with in a manner in compliance with the Spill Management Plan.
- Prohibit burning of packaging, plastics or other solid waste.
- Consider procuring fuels, oils and chemicals in bulk quantities to reduce the volume of waste containers
- Instituting good housekeeping and operating practices including inventory control to reduce the amount of waste resulting from packaging materials etc.
- Periodic inspections of storage tanks and components to check for corrosion and structural integrity.
- Strategic placement of skips and bins should be strategically within the proposed construction site.
- Skips and bins should be adequately designed and covered to prevent entry by pests and to minimise odour.
- Regularly empty skips and bins to prevent overfilling.
- Ensuring that hazardous wastes are separated from non-hazardous wastes.
- Solid waste disposal should be done at an approved disposal site and using approved Contractors.

8.2.2 ECOLOGICAL

8.2.2.1 Pulp Mill Operations

Ecological species that could exist on the pulp mill site include greenspace vegetation (grasses), some trees, birds, soil fauna and insects. No bamboo will be cultivated on the mill site. However, bamboo culms and chips will be stored on site for use the pulp mill processes.

Mill operations could potentially impact the ecology, both aquatic and terrestrial through operations such as the discharge of treated effluent, vehicular transit, transportation of chemicals and general operations. Some of the potential impacts arising from these operations are:

i. A higher risk of running over animals before and within the pulp mill site due to an increase in vehicular traffic, through trucking, with the transportation of raw and produced material to and from the pulp mill.
ii. Injury or death to fauna and flora due to the inappropriate generation and improper disposal of solid waste (industrial and non-industrial) and spills.
iii. Noise related disturbances on fauna due to a change in the use of the site from idle sugar cane land to an industrial facility, thus changing the terrestrial habitat.

The water bodies on the property, namely the Cabarita River, are utilized by the wildlife and the community members who fish in the river. Potential impacts during operations include: Change in water quality due to improper waste disposal; change in water quality due to leaks and chemical spills; change in river quality; change in aquatic ecosystem and habitat. Mitigative measures identified in Section 5.2.2.5 from the Cabarita River Freshwater Assessment are also included below.

Receptors include vegetation, local fauna, protected fauna, nesting birds, aquatic flora and fauna of the Cabarita River and marine fauna

RECOMMENDED MITIGATION MEASURES

- All vegetation that borders the property should be preserved (as much as possible) as they provide habitat for significant fauna on the property, and help to maintain the biodiversity and ecological balance, namely, pollination, a corridor for diverse fauna inclusive of natural predators for pests and nutrient balance.

- Apply the best practices in solid waste management in accordance with the law and regulation through the development and implementation of a Solid Waste Management Programme.
- Use certified companies to collect any onsite generator of wastewater (e.g., portable toilets if present) and that the wastewater is disposed of in an environmentally sound manner. If chemical baths/other amenity is available ensure wastewater generated is treated and disposed of in an environmentally sound manner.
- Ensure designs have accommodated the prevention of soil and groundwater contamination (waterproofing) in all areas where industrial solid waste is handled, processed, treated, stored and disposed of.
- Implement, monitor and manage a system for the collection and handling of leaks and spills.
- Ensure operators are trained in the handling, storage and transportation of chemical products.
- Where possible, apply early-warning mechanisms for pests and diseases (i.e., pest and disease forecasting techniques.
- Ensure vector-control measures are in place where bamboo culms are stored on site to prevent them from becoming breeding sites for mosquitoes. **BBP has indicated that measures will be taken to ensure that the bamboo culms stored in horizontal piles do not become breeding grounds for mosquitoes.**
- To minimise the impact of noise generated at the mill some options include: acquire machines and equipment with low noise levels; acoustic enclosure for equipment with a high sound pressure level; install silencers, attenuators, sound energy absorbers, if necessary.
- Inform and raise awareness among vehicle drivers, especially truck drivers, about defensive driving to minimise animals from being run over in transit to and from the pulp mill.
- Use the best available technologies (BAT) in the production process to minimize the generation of liquid effluents.
- Ensure effluent treatment plant constructed is based on the best available practical technology (modern and safe), the activated sludge system and tertiary treatment.
- Properly operate the effluent treatment plant so that the discharge of treated liquid effluents complies with current legislation.
- Carry out a periodic inspection of the emissary system and its diffusers.
- Develop and implement an Effluent Treatment Plant (ETP) Monitoring Program.
- Monitor the operations of the water and wastewater treatment plants to ensure they are in compliance with the law and regulations
- Ensure all operators and supervisors are sensitised to the Environmental Monitoring and Management Plans.
- Implement a water quality monitoring programme during both construction and operations.

- Implement a programme to monitor water quality based on stipulated standards to preserve the existing aquatic communities of the Cabarita River within the vicinity of the mill or as directed by the regulator.
- Properly operate the effluent treatment plant so that the discharge of treated liquid effluents complies with current legislation
- Develop and implement an Effluent Treatment Plant (ETP) Monitoring Program
- Implement water quality and aquatic communities monitoring programmes during before and during operations.

8.2.2.2 Preliminary considerations for Farming Bambusa vulgaris

As discussed in Section 4.2.1, the (*Bambusa vulgaris*) is an invasive species that can spread rapidly forming extensive monospecific stands which outcompete native vegetation by shading native plants and monopolizing resources.[lvi] This can potentially simplify the structure of forests and modify or decrease its biological diversity. Bamboo invasion into nearby forests can also reduce the biomass of resident plants. The impacts of bamboo dominated forests on the diversity of fauna remains undetermined as there have been limited studies. There are some predictions that the progression of bamboo expansion and eventual fusion of bamboo patches may lead to reduced avian diversity as a result of decreased variety of foods and habitats.

In the case of the operation of the proposed bamboo farms, wherever they are located in Jamaica, the developers will need to implement and maintain appropriate mitigation to control the spread of the species to the adjacent water bodies and moist limestone forest. It should be noted that stands of bamboo are currently found growing uncontrolled within and around the proposed Project site.

Diseases of *B. vulgaris* include leaf blight (*Cercospora* sp.), basal culm rot (*Fusarium* sp.), culm sheath rot (*Glomerella cingulata*), leaf rust (*Kweilingia divina*) and leaf spots (*Dactylaria* sp. and *Glomerella cingulata*). Harvested culms are very vulnerable to attack of powder-post beetles (*Dinoderus* spp.). Termite damage can be serious, especially of harvested culms in contact with ground (Dransfield and Widjaja, 1995; PROTA, 2014).

Pests should be managed through a process of integrated pest management[lvii] (IPM) that combines chemical and non-chemical approaches to minimize pest impact, while also minimizing the impact of such measures on the environment. Pesticides (if required as a last resort) should be used only to the extent necessary under an IPM and integrated vector management (IVM) approach, and only after other pest management practices have either failed or proven inefficient.

[lvi] Defined by the Forestry Department as a deliberately or accidentally introduced species to an area different from its native range. The Forestry Department, through its Forestry Stewardship Council DRAFT Interim National Standard of Jamaica (2022), shall only use alien species when knowledge and/or experience have shown that any invasive impacts can be controlled.

[lvii] IPM refers to a mix of farmer-driven, ecologically based pest control practices that seeks to reduce reliance on synthetic chemical pesticides. It involves: (a) managing pests (keeping them below economically damaging levels) rather than seeking to eradicate them; (b) relying, to the extent possible, on nonchemical measures to keep pest populations low; and (c) selecting and applying pesticides, when they have to be used, in a way that minimizes adverse effects on beneficial organisms, humans, and the environment (Source: EHS Guidelines)

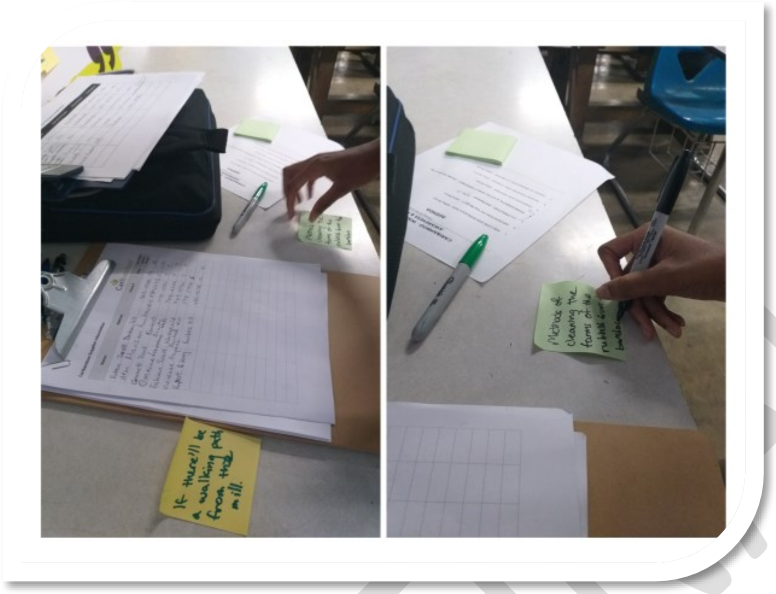
Mitigative measures identified in Section 5.2.2.5 from the Cabarita River Freshwater Assessment are also included below.

Receptors include vegetation, local and protected fauna, nesting birds, ground-fed water courses, nearby ponds and water bodies.

RECOMMENDED MITIGATION MEASURES

- Follow the local guidelines for the establishment and management of Bamboo Plantations set by the BSJ which is the JCP 8: 2021 Jamaican Standard Code of Practice for Bamboo Plantation (2021).
- Ensure BBP operated farms, once finalised, and other farmers supplying the mill abide by the FSC Certification standards and international best practise in cultivating, harvesting, and transporting bamboo from the farms to the mill.
- Develop and implement a Farm Management Plan on all farm sites.
- Consider integrated management strategies for early prevention and control of bamboo expansion including containment with physical barriers, removing unwanted shoots, and using chemical herbicides.
- Avoid planting near waterways and ecologically sensitive areas, to reduce the risk of bamboo invasion via those pathways.
- Maintain a spatial mosaic of land cover by mixing bamboo plantations with other viable-sized forest patches in a large-scale farm design.
- Apply, where possible, apply early-warning mechanisms for pests and diseases (i.e., pest and disease forecasting techniques)
- Consider bio-control organisms—such as insects, birds, mites, and microbial agents—to perform biological control of pests e.g., by maintaining/preserving areas of favourable habitat.
- Consider manual, mechanical weed control, selective weeding and other mechanical controls to kill, relocate or repel pests. Only use pesticides to complement these measures as a last resort.
- If rivers are used for the abstraction of water for farm sites, this must be assessed and approved by the WRA and ensure it does not significantly impact aquatic flora and fauna and terrestrial flora and fauna that depend on the rivers.

8.2.3 SOCIOECONOMIC IMPACTS ASSOCIATED WITH OPERATIONS



The impacts on the human, social, economic and environment stemming from operational activities of the proposed Project include:

- Direct, indirect and induced employment from operational activities. The proposed Project is expected to provide approximately 1000 direct paying jobs and thousands of indirect jobs and boost employment throughout the supply chain (truck drivers and fleets, retailers, community farming cooperatives, restaurants etc.). Education levels will likely impact the availability of jobs to across local community members.
- More community members will gain opportunities to advance their level of education and training required to earn an income.
- Persons interested in farming contracts will receive assistance with acquiring ownership certificates for their land through BBP and government agencies.
- The presence of the mill and BBP through its health and safety requirements and engagement with the communities will promote the health of locals. Additionally, BBP intends to contribute to the improvement of available medical infrastructure and the promotion of vaccination among communities in the development areas.
- Once, operational, some public water facilities (e.g., water pumps and rain catchment tanks), in local communities will be repaired in partnership with the relevant stakeholders to improve the sustainability of public water supply services.
- For maintenance of the property, burning techniques will not be used.
- There is the potential for increased internal migration and the establishment of informal settlements as persons seek employment opportunities.
- Changes in air quality and noise from operations could affect the physical and mental health to those living and working near to the proposed Project site.

- Potential changes in water flow and quality from operations which could affect receptors.
- Change in visual or noise disturbance may affect the well-being of persons in nearby communities
- The overall effect from the operation of the Project on the characteristics and amenities in the wider area. The surrounding communities are marked by limited/degraded social infrastructure which can adversely impact the provision of social services (fire, police, health) or result in an overburden on lacking systems.
- Increased operations-related traffic could have negative impacts on access/route of entries to the proposed Project site. As discussed, the existing road network is in need of upgrading to improve conditions and safety, accommodate daily movement of 300 laden trucks.
- Changes in baseline traffic due to operational activities may affect general road network operations relating to traffic speeds and capacity of road links and network e.g., Martha Brae to Springvale via Wakefield and from Springvale to Montego Bay via Canaan and Adelphi.
- Large heavy goods vehicles (laden trucks) may cause disturbances to local receptors.
- Increased vehicular activity could increase potential risk of accidents and compromise road safety for road users. This is pertinent given the current poor road conditions and lack of safety elements (sidewalks, signage, pedestrian crossings etc.). ***BBP has committed to help reduce this potential impact through lobbying the government for improved law enforcement measures and the implementation of a road safety outreach programme.***
- The potential for improvements in community infrastructure through the establishment of a development fund. ***BBP intends on developing a Community Fund*** towards filling some of the gaps in the government's provision of social and infrastructural purposes. Preliminarily the Community Fund is derived from the tonnes of bamboo harvested and provided to BBP for the mill. The Fund will be held by the BBP. This Fund can be used for the provision of social services for underserved groups and/or the maintenance of heavily used roads most in need of repair as considered necessary.
- There is the potential to foster greater gender diversity, inclusion and equity through the appropriate implementation, management and maintenance of community cooperatives for small farmers (as described in Section 4.3). The International Labour Organisation (ILO) shows that there are strong links between women's involvement in co-operatives and poverty reduction. After becoming involved in co-operatives, women report they perform new and more productive labour activities and earn higher incomes. Women also share that joining co-operatives increases shared caregiving and their decision making in the household, and improves their participation in community affairs (ILO, 2015).

RECOMMENDED MITIGATION MEASURES AND POSITIVE ENHANCEMENTS

- It is recommended that BBP upgrade the current road network from the vicinity of the proposed mill outwards, to accommodate the anticipated weight and number of heavy-duty vehicles associated with operations. Upgrades should include safety infrastructure (sidewalks, pedestrian crossings, safety signs and lighting at minimum). There are also some intersections that would need clear pedestrian crossing with the anticipated increase in vehicular and pedestrian traffic that is brought about by the development.
- BBP should develop a Traffic Management Plan to ensure the health and safety of regular road users and mitigate road accidents. The plan should address the training of any hired fleets or drivers to ensure they are licenced.
- BBP should consider community development initiatives that address the need to upgrade the social infrastructure in the communities of interest to ensure social services can be provided to the Project and community, if needed.
- Consideration should be given to the provision of housing solutions for workers that seek employment from outside of the immediate sphere of influence. This can be done through collaboration with the National Housing Trust who has plans to increase housing solutions. It is also recommended that priority be given to the employment of persons who reside in the immediate sphere of influence. BBP should consider contracting a Labour Officer and supporting office to manage all employment and labour concerns. ***BBP intends to help to increase housing solutions for residents by advocating for the expansion of SCJH Community Regularization Programme and the provision of affordable, temporary housing for select workers for the duration of their respective contracts.***
- BBP should consider the implementation of training, empowerment, maintaining linkages establishing good management and leadership to people involved in cottage and spin-off industries from the pulp mill process. This may include bamboo products such as bamboo utensils, bamboo art, etc. This is important to ensure the maintenance of the proposed cooperatives to incorporate the community into the BBP business model. It is recommended that the Bureau of Standards and the Department of Cooperative and Friendly Societies are fully integrated in the development and sustenance of the cooperatives proposed under this Project. Although there are a few successful cases, Jamaica still has a history of cooperative failing overtime due to clashing personalities, distrust and poor management. It is very important that although self-run, BBP consider supporting these entities and communication lines with the key entities are maintained to facilitate training overtime.
- To improve gender diversity, inclusion and equity, BBP should consider putting measures in place to ensure that both males and females have equal opportunity for employment through declarations at the company policy level as well as through practice. It is important that women are directly engaged in the development of Cooperatives and the Cottage Industry to prevent biases that were not intended to favour one sex over the other. It would also be useful to engage the Bureau of Gender Affairs, which has purview for mainstreaming gender equality across Jamaica is engaged during the

development of the Cottage Industry and the development of Cooperatives to ensure that these entities are not established with inherent gender biases. For an enhanced benefit, it is also recommended that assistance is provided to those persons that have land titling issues are a hinderance. This assistance can come through collaborative relationships with entities such as Land Administration and Management Programme (LAMP)[lviii] that facilitate these processes.

[lviii] The Land Administration and Management Programme (LAMP) is a Government initiative to help all owners of land in Jamaica obtain Certificates of Title for their land and to update the information on existing Land Titles.

9 SUMMARY OF IMPACTS AND MITIGATION MEASURES

Table 9-1 summarizes the potential impacts of the proposed Project on the natural and social environment, and explains the spatial extent, duration and permanence of each. It also shows whether the impact is positive or negative, and the residual impact after mitigation measures have been applied. Not all impacts can be fully mitigated and therefore residual impacts will be experienced by the environmental and social receptors affected by the proposed Project. These are also identified.

Table 9-1: Summary of Major Environmental Impacts and Recommended Mitigation Measures.

RISKS	PROBABILITY OF IMPACT	POTENTIAL IMPACTS	MAGNITUDE	DURATION	DIRECTION	PERMANENCE	SPATIAL EXTENT	PROPOSED MITIGATION MEASURES	RESIDUAL IMPACT
CONSTRUCTION									
AIR EMISSIONS	Likely	• Increase in air pollutants and fugitive particulate matter as a result of: o Vegetation clearing o Improper transport and storage of fine earth materials o Increased vehicular traffic and emissions Adverse health impacts on contractors, employees, residents and properties in surrounding areas	Moderate	Short-term (0-5 years)	Negative	Reversible	Local (Project Area specific)	▪ Construct dust screens around the proposed site ▪ Frequently wet site to reduce fugitive particulate matter (consider every 4-6 hours), particularly in the dry season. ▪ Establish speed limits on and around the site to reduce fugitive dust generation ▪ Phase land clearance activities and minimize cleared areas, re-grass or pave exposed ground as soon as possible ▪ All fine earth material should be covered during transportation to and storage on site; cover or wet construction materials stored on site ▪ Establish a monitoring program during the construction phase to verify effectiveness of the implemented fugitive dust reduction actions as required by the Regulator. ▪ Develop and implement an Environmental Management and Monitoring Plan, which should include a Vehicle Maintenance, Fugitive Dust Management Plan and a Grievance Mechanism	Low
WATER QUALITY	Likely	▪ Vegetation clearance, increase in paved areas, improper storage/disposal of construction materials, improper sewage treatment/disposal and removal/blockage of existing and natural drains may cause: o Increased sediment laden run-off to surface and groundwater o Disruption of natural stormwater runoff o Onsite and downstream flooding o Contamination of water with pathogens/spread of water-borne diseases	Moderate	Short-term (0-5 years)	Negative	Reversible	Local (Project Area specific)	▪ Pave or grass exposed grounds as soon as possible; where possible, unused areas should be left vegetated. ▪ Excavated material should not be stored along drains, gullies, swales or in the path of natural drainage. ▪ Stockpiles should have a berm and should be covered. ▪ Natural drainage should not be blocked without suitably engineered alternatives ▪ Use sediment traps/turbidity barriers where necessary to avoid sedimentation of the nearby waters ▪ Develop a detailed pollution prevention and management plan and solid waste management plan, which should include a scheduled monitoring programme. ▪ Implement an Erosive Process control and monitoring plan ▪ Supervise construction works and ensure it is in compliance with the Environmental, Health and Safety Management and Monitoring Plans	Low

RISKS	PROBABILITY OF IMPACT	POTENTIAL IMPACTS	MAGNITUDE	DURATION	DIRECTION	PERMANENCE	SPATIAL EXTENT	PROPOSED MITIGATION MEASURES	RESIDUAL IMPACT
								▪ Plan the execution of earthworks and land preparation preferably outside of the wet/rainy season. ▪ Apply the best practices in solid waste management in accordance with the law and regulation. ▪ Train operators in the correct disposal of waste ▪ Use certified companies to collect the wastewater from portable toilets (if present on site) and ensure that the wastewater is disposed of in an environmentally sound manner. If chemical baths/other amenities are available, ensure that wastewater generated is treated and disposed of in an environmentally sound manner. ▪ Implement a water quality monitoring programme during construction. ▪ Implement an aquatic community monitoring programme within the vicinity of the mill or as directed by NEPA.	
NOISE AND VIBRATIONS	Likely	▪ Increased vehicular traffic, operation of heavy equipment, etc. will contribute to higher noise levels for local receptors. ▪ Prolonged exposure without the required personal protective equipment (PPE) can result in adverse health impacts.	Moderate	Short-term (0-5 years)	Negative	Reversible	Local (Project Area specific)	▪ Before commencing any works, the Site Manager should notify staff members, visitors and community about planned activities depending on the scale of the work and possible impacts including: o Contact details of the site manager for communications regarding noise issues, o Brief description of works to be performed, o Simplified schedule of the works to be performed ▪ Operate noise-generating equipment during regular working hours (e.g., 7am – 7pm) to minimize potential noise nuisance at night ▪ Position stationary noise sources e.g., generators and compressors as far as possible from sensitive noise receptors ▪ Implement 'soft start' procedures where possible when using HGVs, generators, compressors and other construction equipment ▪ Properly maintain all construction equipment ▪ Equip all workers with appropriate personal protective equipment (PPE) ▪ Erect temporary noise barriers as needed e.g., plywood and other absorbent materials ▪ Prepare a Noise Management Plan and Grievance Mechanism.	Low
SOIL EROSION	Possible	▪ Vegetation clearance may lead to localized soil erosion and increase sedimentation in the Cabarita River.	Minor	Short-term (0-5 years)	Negative	Reversible	Local (Project Area specific)	▪ Phase construction activities. ▪ Maintain/preserve existing vegetation and disturb the minimum amount of land.	Low

RISKS	PROBABILITY OF IMPACT	POTENTIAL IMPACTS	MAGNITUDE	DURATION	DIRECTION	PERMANENCE	SPATIAL EXTENT	PROPOSED MITIGATION MEASURES	RESIDUAL IMPACT
OCCUPATIONAL HEALTH AND SAFETY	Likely	▪ Likelihood of safety incidents and accidents occurring may increase with construction	Minor	Short-term (0-5 years)	Negative	Reversible	Local (Project Area specific)	▪ Ensure staff are properly trained in safety procedures ▪ Have relevant safety signage in place ▪ Ensure staff are equipped with requisite PPE ▪ Monitor and evaluate on an ongoing basis the occupation, health and safety procedures implemented.	Low
TRAFFIC MANAGEMENT	Possible	▪ Increased vehicular activity could increase potential risk of accidents and compromise road safety for road users	Minor	Short-term (0-5 years)	Negative	Reversible	Local (Project Area specific)	▪ Develop and implement a Traffic Management Plan to address internal and external traffic movement	Low
SOLID WASTE MANAGEMENT	Possible	▪ Issues related to improper waste handling, storage and disposal may arise: o Drainage obstruction o Vector breeding o Site aesthetics	Minor	Short-term (0-5 years)	Negative	Reversible	Local (Project Area specific)	▪ Design and implement system for solid waste collection and removal from site by licensed operators to approved disposal site. Apply the best practices in solid waste management in accordance with the law and regulation. ▪ Implement a Solid Waste Management Programme and train operators in the correct disposal of waste.	Low
STORAGE AND TRANSPORT OF RAW MATERIALS	Possible	▪ Raw construction materials for the proposed Project will be stored onsite and there is potential for them to become water or air borne. Stored fuels and the repair of construction equipment have the potential to leak hydraulic fuels, oils, etc.	Moderate	Short-term (0-5 years)	Negative	Reversible	Local (Project Area specific)	▪ A central area (labelled and demarcated) should be designated for the storage of raw materials. This area should be lined in order to prevent the leakage of chemicals into the sediment. o Hazardous waste should be stored in closed containers away from direct sunlight, wind, and rain o Secondary containment systems should be constructed with appropriate materials for the wastes being contained o Conduct periodic inspections of waste storage areas ▪ Raw materials that generate dust should be covered or wetted frequently to prevent them from becoming airborne or waterborne. ▪ Fine grained materials (sand, marl, etc.) will be stockpiled away from drainage channels and low berms will be placed around the piles which themselves will be covered with tarpaulin to prevent them from being eroded and washed away. ▪ Raw material should be placed on hardstands surrounded by berms. ▪ Equipment should be stored on impermeable hard stands surrounded by berms to contain any accidental surface runoff. ▪ Bulk storage of fuels and oils should be in clearly marked containers (tanks/drums etc.) indicating the type and quantity being stored. In addition, these containers should be surrounded by bunds to contain the volume being stored in case of accidental spillage. ▪ Prepare and implement spill response and emergency plans to address accidental releases.	Low

RISKS	PROBABILITY OF IMPACT	POTENTIAL IMPACTS	MAGNITUDE	DURATION	DIRECTION	PERMANENCE	SPATIAL EXTENT	PROPOSED MITIGATION MEASURES	RESIDUAL IMPACT
INTERNAL MIGRATION AND POPULATION GROWTH	Almost Certain	▪ There is the potential for persons to migrate from outside the study area during the construction phase in search of working opportunities.	Significant	Short-term (0-5 years	Neutral	Reversible, Cumulative	Local (Project Area specific) to Regional (Parish Level)	NA	High
EMPLOYMENT OPPORTUNITIES	Almost Certain	▪ Potential for the increased availability of jobs during construction.	Significant	Short-term (0-5 years)	Positive	Reversible	Local (Project Area specific) to Regional (Parish Level)	NA	High
SQUATTING	Likely	▪ Potential for increased squatting as persons migrate for employment opportunities.	Significant	Short-term (0-5 years)	Negative	Reversible	Local (Project Area specific) to Regional (Parish Level)	▪ Considerations should be given for providing housing for migrant workers through collaboration with public and private sector entities such as the NHT, government Ministries, NGO's and private developers. ▪ Prioritize employment of persons who reside in the immediate sphere of influence. ▪ Potentially facilitate developers by working closely with the local municipal corporations to ensure that the needs of any transient workforce are anticipated and planned for accordingly.	Low
LAND CLEARANCE PRIOR TO CONSTRUCTION	Almost Certain	▪ Most sensitive ecosystems on the alluvial plains are freshwater systems, which support the Jamaican Slider Turtle and species which are sensitive to restrictions in water flow and sedimentation. Damage to or loss of aquatic life can result. ▪ Disturbance/loss of foraging habitats and/or modification of commuting routes (including disturbance from lighting) for local fauna. ▪ Damage or disturbance to nesting birds, nests or their young by construction activities	Moderate	Short-term (0-5 years)	Negative	Reversible	Local (Project Area specific) to Regional (Parish Level)	▪ Retain larger trees with a DBH >25cm ▪ Conduct sensitization/awareness sessions on ecology for local workforce. ▪ An environmental management and monitoring plan (EMP) should be prepared before the start of construction. ▪ Vegetation clearance and construction activities should take place outside of the March to September breeding season for birds (where possible). ▪ To control erosion, construction activities should be phased, and existing vegetation should be maintained/preserved where possible, and the minimum amount of land should be disturbed. ▪ Implement the use of sediment traps where necessary ▪ Works should be undertaken as much as possible in the dry season ▪ Conduct wetting of the construction site and materials during construction	Low
ARCHAEOLOGICAL/ CHANCE FIND	Likely	▪ Artefacts of historical or national significance may be found, damaged or destroyed during site clearance or construction	Moderate	Short-term (0-5 years)	Negative	Irreversible	Local (Project Area specific) to National	▪ Notify the JNHT if there are any indications of a chance find and stop working. ▪ The JNHT may perform a Watching Brief, in accordance with the Guidelines for Conducting Archaeological Impact Assessments (2009). In the absence of a Watching Brief, monitoring, if recommended by an Archaeological Impact Assessment, may enable an Archaeological Officer to detect unanticipated, unrecorded exposed cultural features and materials. Depending on the significance and nature of	Medium

RISKS	PROBABILITY OF IMPACT	POTENTIAL IMPACTS	MAGNITUDE	DURATION	DIRECTION	PERMANENCE	SPATIAL EXTENT	PROPOSED MITIGATION MEASURES	RESIDUAL IMPACT
								uncovered resources in such circumstances, an assessment and statement of significance may be necessary. As standard practice, monitoring results must be thoroughly documented in a monitoring report and this report, should guide the next course of action.	

RISKS	PROBABILITY OF IMPACT	▪ POTENTIAL IMPACTS	MAGNITUDE	DURATION	DIRECTION	PERMANENCE	SPATIAL EXTENT	▪ PROPOSED MITIGATION MEASURES	RESIDUAL IMPACT
OPERATIONS									
SEVERE WEATHER	Likely	▪ The proposed Project site is not located in an area that is prone to severe weather. However, severe weather may impact supply chains, export and workforce availability.	Significant	Long-Term (Project lifetime)	Negative	Irreversible, Cumulative	National	▪ Develop and implement a Disaster Management and Emergency Response Plan ▪ Implement standard operating procedures (SOPs) to minimize the potential loss of life, injury, and damage to the environment / property in the event of extreme weather ▪ Monitor daily the possibility of inclement weather, which could affect the Project site. ▪ Have and monitor a National Oceanic Atmospheric Administration (NOAA) weather alert radio to ensure that it is operational and monitored during operating hours.	Medium
DRAINAGE, WATER QUALITY, AQUATIC ENVIRONMENT & SURFACE RUNOFF	Likely	▪ The slow draining soil can result in flooding and /or ponding in some areas of the site, which can impact operations and stored material. This can result in sedimentation of nearby watercourses. ▪ Improper waste disposal, excessive flows, improper effluent treatment and discharge and leaks and chemical spills can result in a change in river water quality and changes in aquatic ecosystem and habitat.	Moderate	Long-Term (Project lifetime)	Negative	Irreversible, Cumulative	Local (Project Area specific)	▪ Buffer zones near to ponds, gullies or other water ways can be established using trees, grass etc. to reduce sediments getting into these systems. ▪ The drainage improvements that form part of the Project design should mitigate against flooding, if appropriately designed and implemented ▪ Stormwater should be separated from process and sanitary wastewater streams to reduce the volume of wastewater to be treated prior to discharge ▪ Runoff from areas with potential sources of contamination should be minimized e.g., limit area of impermeable surfaces. Peak discharge rates should be reduced e.g., using vegetated swales or retention ponds ▪ If possible, stormwater should be managed as a resource (for groundwater recharge or meeting water needs on site) ▪ Oil water separators and grease traps should be installed and maintained around fuel storage and containment areas, refuelling facilities, parking areas.	Low

RISKS	PROBABILITY OF IMPACT	▪ POTENTIAL IMPACTS	MAGNITUDE	DURATION	DIRECTION	PERMANENCE	SPATIAL EXTENT	▪ PROPOSED MITIGATION MEASURES	RESIDUAL IMPACT
								▪ Sludge from stormwater catchments or collection and treatment systems may contain elevated levels of pollutants. This should be disposed of in compliance with NRCA guidelines for the protection of public safety and long-term sustainability of water and land resources. ▪ Implement, monitor and manage a system for the collection and handling of leaks and spills. ▪ Ensure operators are trained in the handling, storage and transportation of chemical products ▪ Implement containment and waterproofing systems surrounding chemical tanks. ▪ Use the best available technologies (BAT) in the production process to minimize the generation of liquid effluents. ▪ Ensure effluent treatment plant constructed is based on the best available practical technology (modern and safe), the activated sludge system and tertiary treatment ▪ Properly operate the effluent treatment plant so that the discharge of treated liquid effluents complies with current legislation ▪ Carry out a periodic inspection of the emissary system and its diffusers ▪ Develop and implement an Effluent Treatment Plant (ETP) Monitoring Program ▪ **Implement a programme to monitor water quality based on stipulated standards to preserve the existing aquatic communities of the Cabarita River within the vicinity of the mill or as directed by the regulator** ▪ Ensure any design plans that alter the natural state of the river are approved and monitored by the regulator. ▪ Monitor the operations of the water and wastewater treatment plants to ensure they are in compliance with the law and regulations	
WASTEWATER	Possible - Likely	▪ Effluent could be high in total suspended solids, biochemical oxygen demand (BOD), chemical oxygen demand (COD), dissolved organic compounds and possible heavy metals if the targeted emissions from the designed WWTP are not met and are not in compliance with the regulations.	Significant	Long (Project lifetime)	Negative	Irreversible, Cumulative	Local (Project Area specific) to Regional (Parish Level)	▪ Utilise tertiary treatment at the facility ▪ Ensure treated effluent discharge is kept to a minimum through water use planning and recycling if possible. ▪ All retention ponds and wastewater treatment facilities should be properly constructed with appropriate buffering zones between these treatment plants/ retention ponds and sensitive receptors (e.g., the Cabarita River, wells, etc.) ▪ Ensure the operator of the WWTP employs continuous quality monitoring and recording of treated effluent before and during release into the Cabarita River.	Minor to Moderate

RISKS	PROBABILITY OF IMPACT	▪ POTENTIAL IMPACTS	MAGNITUDE	DURATION	DIRECTION	PERMANENCE	SPATIAL EXTENT	▪ PROPOSED MITIGATION MEASURES	RESIDUAL IMPACT
AIR EMISSIONS	Almost Certain	▪ Emission of NOx, SOx, PM, Volatile Organic Compounds (VOCs) and greenhouse gases (GHGs). ▪ Emission of malodourous gases to atmosphere can generate discomfort and health issues in sensitive receptors	Significant	Long (Project lifetime)	Negative	Irreversible, Cumulative	Local (Project Area specific)	▪ Project design should incorporate the best available technology to mitigate adverse air emissions (scrubbers, electrostatic precipitators etc.) ▪ Design stacks according to the Good International Industry Practice (GIIP) approach provided by the IFC General EHS Guidelines e.g., a single stack over 100m in height above immediately surrounding land. ▪ Prohibit stockpiling of flammable materials and open burning. Where burning is unavoidable, potential impacts should be identified and weather conditions monitored to schedule burning to minimize impacts. ▪ Burning of solid waste or plant material should not be encouraged or practiced, and if necessary, should be done in a controlled environment under conditions which will prevent the release of any air pollutants. ▪ Develop a preventative maintenance schedule for all equipment on site and for the factory. ▪ Develop an Environmental Management and Monitoring Plan ▪ Continuous and passive monitoring stations will be established as per the requirements of the Regulators in conjunction with the results of the ADM.	High
NOISE AND VIBRATIONS	Likely	▪ Operation of mechanical equipment, transport vehicles and physical activities associated with operations may result in elevated noise levels to receptors adjacent to the proposed Site.	Moderate	Long (Project lifetime)	Negative	Irreversible, Cumulative	Local (Project Area specific)	▪ Buffer zones should be constructed/maintained around areas where there may be loud blow offs. Consider implementing a green belt to leverage natural topography and vegetation of the proposed site. ▪ Equipment with a low noise rating should be considered. Where this is not possible, noise dampeners should be used to attenuate noise. This equipment should be placed in areas downwind of sensitive receptors. ▪ Where possible, limit the hours of operation for mechanical equipment that produce high levels of noise. ▪ Where possible, ensure noise sources are in less sensitive areas (away from sensitive receptors) to take advantage of distancing and shielding. ▪ Develop and implement a Noise Management Plan with Grievance Mechanism. ▪ All equipment and vehicles should be properly maintained.	Low

RISKS	PROBABILITY OF IMPACT	▪ POTENTIAL IMPACTS	MAGNITUDE	DURATION	DIRECTION	PERMANENCE	SPATIAL EXTENT	▪ PROPOSED MITIGATION MEASURES	RESIDUAL IMPACT
RESIDUES AND WASTE	Almost Certain	▪ The proposed project may generate significant quantities of non-hazardous solid waste, with limited hazardous wastes, which can create issues if not properly handled.	Moderate	Long (Project lifetime)	Negative	Irreversible, Cumulative	Local (Project Area specific)	▪ Establishing a Waste Management Plan that considers prevention, reduction, reuse, recovery, recycling, removal, and disposal of wastes. ▪ Prohibit burning of packaging, plastics or other solid waste. ▪ Consider procuring fuels, oils, fertilizers and chemicals in bulk quantities to reduce the volume of waste containers ▪ Institute good housekeeping and operating practices including inventory control to reduce the amount of waste resulting from packaging materials etc. ▪ Inspect storage tanks and components periodically to check for corrosion and structural integrity. ▪ Place skips and bins strategically within the proposed construction site. ▪ Design and cover skips and bins to prevent entry by pests and to minimise odour. ▪ Regularly empty skips and bins to prevent overfilling. ▪ Ensure that hazardous wastes are separated from non-hazardous wastes. ▪ Dispose of solid waste disposal at an approved disposal site.	Low
FARMING *Bambusa vulgaris*[lix]	Almost Certain	▪ Invasive *Bambusa vulgaris* can spread rapidly forming extensive monospecific stands which outcompete native vegetation.[lx] ▪ Bamboo invasion into nearby forests can also reduce the biomass of resident plants and impact habitats for forest specialists.	Major	Long (Project lifetime)	Negative	Irreversible, Cumulative	Local (Project Area specific)	▪ Ensure Bamboo Farms are compliant with local guidelines established by the BSJ, international guidelines from the FSC CoC and international best practice to control and mitigate the spread of this species. ▪ Consider integrated management strategies for early prevention and control of bamboo expansion. ▪ Avoid planting near waterways and ecologically sensitive areas, to reduce the risk of bamboo invasion via those pathways. ▪ Maintain a spatial mosaic of land cover by mixing bamboo plantations with other viable-sized forest patches in a large-scale farm design. ▪ Where possible, apply early-warning mechanisms for pests and diseases (i.e., pest and disease forecasting techniques ▪ Consider bio-control organisms—such as insects, birds, mites, and microbial agents—to perform biological control of pests e.g., by maintaining/preserving areas of favourable habitat. ▪ Consider manual, mechanical weed control, selective weeding and other mechanical controls to kill, relocate or	Medium

[lix] This impact is preliminary and should be fully determined when the farm sites are selected, and the relevant studies have been done to determine the true impact of this risk.

[lx] Defined by the Forestry Department as a deliberately or accidentally introduced species to an area different from its native range. The Forestry Department, through its Forestry Stewardship Council DRAFT Interim National Standard of Jamaica (2022), shall only use alien species when knowledge and/or experience have shown that any invasive impacts can be controlled.

RISKS	PROBABILITY OF IMPACT	▪ POTENTIAL IMPACTS	MAGNITUDE	DURATION	DIRECTION	PERMANENCE	SPATIAL EXTENT	▪ PROPOSED MITIGATION MEASURES	RESIDUAL IMPACT
								repel pests. Only use pesticides to complement these measures as a last resort. ▪ Ensure that cultivation and harvesting of bamboo in the parish owned by BBP and by extension, at other local farms that supply the mill (as best as possible) comply with the local regulations and best practices to facilitate sustainable and managed farms through the development and implementation of a Farm Management Plan.	
SOIL DEGRADATION	Possible	▪ Physical and chemical degradation of soils may result from unsuitable management techniques, such as use of inappropriate machinery or earthworks associated with site preparation and infrastructure development. ▪ Chemical degradation of soil may result from insufficient or inappropriate use of mineral fertilizers, failure to recycle nutrients contained in crop residues, and failure to correct changes in soil pH that result from long-term use of nitrogen fertilizers and excessive use of poor-quality water, resulting in salinization.	Moderate	Long (Project lifetime)	Negative	Reversible	Local (Project Area specific)	▪ Develop and implement a soil monitoring and management plan that includes soil and terrain mapping and erosion risk identification. ▪ Conduct regular surveys to monitor soil structure and chemistry in order to identify areas where remedial action is required. ▪ Implement buffer zones and/or setbacks from water—including "no-treatment" areas along water sources, rivers, streams, ponds, and other surface water bodies—to act as a filter for potential nutrient runoff from the land ▪ Implement regular training and sensitization for the storage, handling and application of all types of chemicals that will be applied to the soil. ▪ Ensure appropriate PPE is provided	Low
OCCUPATIONAL HEALTH AND SAFETY	Likely	▪ Likelihood of safety incidents and accidents occurring may increase from physical, chemical and process-related hazards.	Moderate	Long (Project lifetime)	Negative	Reversible	Local (Project Area specific)	▪ Ensure staff are properly trained in safety procedures. ▪ Ensure the relevant safety signage is in place. ▪ Ensure staff are equipped with requisite PPE. ▪ Monitor and evaluate on an ongoing basis the implemented occupation, health and safety procedures.	Low
INFORMAL AND UNPLANNED SETTLEMENT	Possible	▪ Increased internal migration and the establishment of informal settlements as persons seek employment opportunities.	Moderate	Long (Project lifetime)	Positive	Reversible, Cumulative	Regional (Parish Level)	▪ Consider the provision of housing solutions for migrant workers in collaboration with the relevant public and private sector entities. ▪ It is also recommended that priority be given to the employment of persons who reside in the immediate sphere of influence.	Low

RISKS	PROBABILITY OF IMPACT	▪ POTENTIAL IMPACTS	MAGNITUDE	DURATION	DIRECTION	PERMANENCE	SPATIAL EXTENT	▪ PROPOSED MITIGATION MEASURES	RESIDUAL IMPACT
TRAFFIC (VEHICULAR AND PEDESTRIAN) AND ROAD INFRASTRUCTURE	Almost Certain	▪ Increased operations-related traffic could have negative impacts on access/route of entries to the proposed Project site. As discussed, the existing road network is in need of upgrading to improve conditions and safety, accommodate cumulatively up to 140 truck trips per day, which is anticipated. ▪ Changes in baseline traffic due to operational activities may affect general road network operations relating to traffic speeds and current capacity of road network e.g., Hertford to Flowerhill Road. ▪ Large heavy goods vehicles (laden trucks) may cause disturbances to local receptors. ▪ Increased vehicular activity could increase potential risk of accidents and compromise road safety for road users. This is pertinent given the current poor road conditions and lack of safety elements (sidewalks, signage, pedestrian crossings, etc.)	Significant	Long (Project lifetime)	Negative	Reversible, Cumulative	Local and Regional (Parish Level)	▪ It is recommended that BBP invest in the upgrading the road network in the immediate community to withstand the level of trucking anticipated (cumulatively up to 140 truck trips per day).	Low
SOCIAL INFRASTRUCTURE	Almost Certain	▪ The overall effect from the operation of the Project on the characteristics and amenities in the wider area. The surrounding communities are marked by limited/degraded social infrastructure which can adversely impact the provision of social services (fire, police, health) or result in an overburden on lacking systems.	Significant	Long (Project lifetime)	Negative	Reversible, Cumulative	Regional (Parish Level)	▪ BBP is advised to invest in the upgrading of social services that will facilitate mutual benefit as a part of their Corporate Social Responsibility to the community.	Low
COMMUNITY DEVELOPMENT	Likely	▪ Potential to spur increased investment and development at the parish level as a result of increased economic activity.	Significant	Long (Project lifetime)	Positive	Reversible, Cumulative	Regional (Parish Level)	NA	High

Cumulative impacts are those that result from the successive, incremental, and/or combined effects of an action, project, or activity when added to other existing, planned, and/or reasonably anticipated future actions, projects or activities (IFC 2013). These impacts interact with other effects in a particular place and within a particular time. Thus, the cumulative impacts of an action can be viewed as the total effects of that action on a resource, ecosystem, or human community, and all other activities affecting that resource. Cumulative impacts are also assessed in terms of the incremental effect that acts cumulatively with the effects of other actions, either past, existing, or future. Consideration is given to the activities surrounding the site such as those mentioned in Sections 5.3.7 to 5.3.15. Consideration is also given to the effect of projects planned for the reasonably foreseeable future. The following projects under consideration are those presented in Section 5.3.3:

i. Expansion of housing developments in Westmoreland by the NHT during the next four years.
ii. The expansion of the South Coast Highway
iii. The plans for port expansion at the Montego Bay Free Port
iv. Expansion of the runway at Sangster International Airport in Montego Bay, St. James
v. Expansion of The University of the West indies Western Campus

No other ongoing or planned projects, constructions or developments were indicated by the local authorities at the time of publishing this report.

10.1 ECONOMIC UPLIFTMENT AND RURAL DEVELOPMENT

It is anticipated that there will be a wide range of resulting employment opportunities from the proposed Project due to a large flow of financial and material resources through increased business, trade and commerce, and the service sector. This is likely to occur as there is firsly, employment creation and income generation and secondly there are job and income generating opportunities for the communities in the immediate sphere of influence, termed as multiplier and linkage effects. It is expected that the project will provide approximately 1000 direct paying jobs and thousands of indirect jobs and boost employment throughout the supply chain (truck drivers and fleets, retailers, community farming cooperatives, restaurants etc.). This will result in better economic opportunities available in the area, thus facilitating the well desired rural development envisioned by the WMC. It will not only add to the economic growth, but the project also has a high potential to increase the educational development of people within the area, thus facilitating further economic growth and rural development.

10.2 IMPROVEMENT IN SOCIAL SERVICES/INFRASTRUCTURE IN THE RURAL PROJECT AREA

The increased income generation and increase in the rural population stimulated by the proposed Project can potentially drive improvements in the social services offered in the proposed Project area of interest. BBP's commitment and investment in the rural community will result in improved social services and infrastructure through their Community Development Fund, advocacy, training and investments mentioned in Section 8.2.3.

10.3 WATER QUALITY AND USE OF THE CABARITA RIVER

As the proposed mill intends to extract water from the Cabarita River and release the treated trade effluent into the Cabarita River, the extraction of the surface water and release of the treated effluent may have an impact on the quality and usage of the river. In Section 5.3.11, it was indicated that the nearby communities use the Cabarita River for subsistence and commercial fishing, recreational swimming, bathing, tourism, religious purposes, irrigation and for domestic purposes. There are also other communities to the west and southwest of the project area that the Cabarita River flows through which may also be impacted if there is a change in the water availability and quality.

Regarding the cumulative impact from the extraction of water from the Cabarita River, the hydrological assessment has shown that the requirement of the pulp mill is 12% of the reliable combined flows in the vicinity of the intake structure of the pulp mill site. This result is based on the analysis of the combined flows for the Cabarita River at Grange, and the residual Roaring River flows recorded at the Petersfield gauging station. Thus, based on the reliability assessment and estimated water demand from the WRA, the available water resource at the Cabarita River is adequate to address the mill's demand now and in the future. Additionally, based on the design of the WWTP and its intended use of the BAT and compliance with local and international regulations, treated effluent will be discharged into to the Cabarita River.

With regard to the water quality, components of the project, such as the release of treated effluent, construction and operations of the pulp mill could have an impact of the water quality downstream of the proposed pulp mill. The generation of liquid effluents is minimised by utilising the proposed technology, and will apply Accepted Modern Technology (AMT), Best Practice Environmental Management (BPEM) principles and BAT (will be applied throughout the manufacturing process and the WWTP. Additionally, the effluents generated during the operations at the pulp mill will be treated at the WWTP at the tertiary level. The WWTP is being designed to utilise a clarifier, activated sludge aeration, and treatment through a membrane bioreactor. It is anticipated from the emissions targets for the WWTP design information in Section 4.7 that the effluent produced could increase the COD, pH, Temperature, TOC, BOD, TSS, N_{Tot} and P_{Tot} of the river; however, these should be in compliance with NEPA and international standards as indicated in Table 4-3. However, activities observed during the sampling, site assessments and ecological assessments, specifically downstream of the pulp mill, such as commercial and domestic farming, industrial activities and tourism, have the potential to also impact the quality and flows of the river.

During construction, there is the potential that there could be a change in the water quality of the river due to siltation, from earthworks and civil works as well as the improper management of solid waste, effluents and spills that may be generated or other activities. However, mitigative measures are provided in **Chapters 8 and 9** and in the Water Quality Management Plan in Section 13.4.3. These should assist in minimising the cumulative impacts resulting from construction.

During operations at the mill, there is the potential that there could be a change in the water quality due to the improper disposal of waste and due to leaks and chemical spills that could occur on site. However, mitigative measures that should be complied with are presented in **Chapters 8 and 9** and in the Water Quality Management Plan in Section 13.4.3.

It is expected that no significant change in the flow and quality of the river occurs and if they do occur, they should be short-term and reversible. Additionally, BBP should comply with the requirements in the Water Quality Management Plan presented in Section 13.4.3.

10.4 AIR QUALITY

The Kraft pulp production process, which will be based on the Best Available Techniques and will be using modern technologies, will allow for the reduction, control and monitoring of greenhouse gas emissions. The ANDRITZ HERB Recovery Boiler design, consisting of the symmetrically arranged black liquor and combustion air systems, as well as the use of scrubbers, is designed to ensure optimum combustion control and minimum emissions and carry-over. Based on the results of the Air Dispersion Modelling Assessment in **Chapter 7**, ambient concentrations for pollutants modelled from the proposed Bamboo Pulp Mill using LNG and a Recovery Boiler, plus their background concentration are predicted to meet the Jamaica National Ambient Air Quality Standards (JNAAQS) and guideline concentrations. The pollutants modelled were SO_2, NO_2, PM_{10} and CO. From the results of the ADM, the pulp mill using LNG was not predicted to have a significant impact on the air shed. However, the contribution of the nearby industries led to a prediction that the cumulative concentration of NO_2 for the proposed mill and nearby factory, over a 1-hour period, would exceed the standard for this short-term exposure. This is important to note as the operations of other operators in the air shed will affect short-term exposures.

11 IDENTIFICATION AND ANALYSIS OF ALTERNATIVES

11.1 NO ACTION ALTERNATIVE

The no action alternative is the non-implementation of the proposed Project. This would mean that the community and potentially climate-related benefits that a development such as this could bring would be eliminated. Therefore, the driver of increased employment and income generating opportunities, overall economic upliftment, road improvement, knowledge transfer and training in new skills, development of a new industry, improvement in social infrastructure and services offered and increased removal of CO_2 from the atmosphere would not materialise. The vision for rural development based on the proposed business plan would therefore not become manifest.

11.2 PROJECT SITE AND LAYOUT ALTERNATIVES

11.2.1 ALTERNATIVE SITE FOR PULP MILL

The proposed site in Friendship, Westmoreland was selected from the feasibility and reconnaissance as one of the best locations to site the proposed bamboo pulp mill in Jamaica. Other sites were previously investigated such as in in Springvale, Trelawny. However, the previous site was ecologically sensitive and bordered on a protected area. The site in Friendship is the best site as sensitive ecological habitats are not within proximity to the site and the project site is already on disturbed land. The only other alternative would be to construct and operate the mill in Belize. The option to relocate the mill to Belize was excluded from the EIA process as it is a different jurisdiction with a unique legislative framework and requirements for an EIA.

Regarding environmental impacts, the difference between the proposed site and the alternative was not a part of the scope of this EIA. An alternative location would minimize the disruption and potential contamination of the Cabarita River or spread of bamboo to sensitive ecological areas. However, the vast social and economic benefits outlined above would not directly benefit the list of communities examined (Section 5.3). These benefits would then be transferred to the alternative site.

11.2.2 ALTERNATIVE SITE FOR WATER AND WASTEWATER TREATMENT PLANTS ON SITE

The location of the water and wastewater treatment plants on the site are adjacent to the Cabarita River and could potentially affect the quality and quantity of the river water through primarily affecting the quality and quantity of the available water. Additionally, as the Cabarita River Adventure and Mesopotamia Leisure Farm in Friendship is located approximately 0.5m straight-line distance downstream from the proposed wastewater outlet. This business which is involved in Tourism and Agriculture could be significantly impacted. It was indicated by BBP that the locations of the water treatment and wastewater treatment plants are conceptual at this stage and could be located anywhere on site, within reason. Assurances were also given that if no alternative location is chosen it would be properly engineered and constructed to take full account of ground conditions close to the river, NEPA requirements, as well as flood risks. The potential exists to move it further away from the river; however, further investigations would be required to approve the relocation.

11.3 ALTERNATIVE USES OF THE PROJECT SITE

As the land use of the property before being sold to BBP was used for agricultural purposes, there is a potential that the land could be alternatively used for some other form of agriculture or other development, such as for residential purposes or other industry. Alternative industries would also have tailored investigations of the site for feasibility. However, it is not the intention of BBP, the current owner of the proposed site of the pulp mill, to develop the site for another agricultural or agro-industrial facility or for other residential and/or commercial purposes. Investigations on the alternative uses of the project site by BBP is outside the scope of this EIA. The most likely outcome of an alternative use would be for the non-implementation of the project and sale of the land. This would significantly reduce the potential of the project to improve the socioeconomic conditions of the nearby communities, municipality or rural development.

11.4 PROJECT PULPING PROCESS, EQUIPMENT AND TECHNOLOGY ALTERNATIVES

In the pulp and paper industry and as mentioned in the European BAT Guide there are alternative processing methods available for the conversion of wood and non-wood material to pulp and paper. There are three main types of pulp mills and pulping processes – mechanical, chemical and chemi-mechanical. Chemical pulping is the most common as it uses less energy and yields paper with less strength than fibres that undergoes mechanical pulping. Within chemical pulping there are multiple types of pulping – Kraft (sulfate), acid and alkaline sulfite pulping, neutral sulfite semichemical (NSSC) pulping, and soda pulping which utilise different chemicals. These types of pulping also vary in their economics, are best suited for different types of raw material and yield different emissions and outputs with varying impacts on the environment. The type of process selected is based on the desired final product, wood species and economic factors.[lxi] The Kraft pulping method is the most dominant internationally and this is due to advantages[lxii] such as:

i. It can produce useful pulps from all wood species (hard and soft woods) which includes bamboo, the target raw material for this project;
ii. It readily permits chemical and energy recovery from the spent pulping liquor and was the first pulping process to do so;
iii. The Kraft process is designed to recover the cooking chemicals and heat which means the mill can be self-sufficient and have reduced energy costs and chemical stock;
iv. It regularly produces the highest-strength pulps.

Additionally, as there are varying pulping processes, there are varying equipment, technologies and methodologies that can have multiple variations along either the Pulp Line Process or the Chemical Recovery Processes. Additionally, improvements are being used to enhance sustainability in the industry. ANDRITZ, which will be providing the mill equipment and technology, and SUEZ, the BOO Partner at the pulp mill, have had years of experience developing pulp mills and improving the

[lxi] Cheremisinoff, Nicholas P. (2010). Handbook of Pollution Prevention and Cleaner Production || Sources of air emissions from pulp and paper mills. , (), 179–259. doi:10.1016/B978-0-08-096446-1.10006-1

[lxii] Young, Raymond A. (2003). Encyclopedia of Physical Science and Technology || Pulp and Paper. , (), 249–265. doi:10.1016/b0-12-227410-5/00619-0

technology to enhance sustainability within the industry. Specifications of the WWTP, design of the equipment and quality parameters, use of the TCF bleaching method and considerations of how to recycle and reuse waste generated from the process (**Appendix H**) have been tailored to incorporate sustainability into their operations. One such consideration in the equipment and process being investigated is to develop the wastewater treatment system as a closed-loop system, where all water processed and used in the mill would be recycled for future operations. However, the final decision is at the discretion of BBP and its feasibility. There is the potential that another pulping process, other chemicals and bleaching compounds, and variations in equipment and mill design could be assessed as alternatives, but this is beyond the scope of the EIA and is not the intention of BBP.

12 RISK ASSESSMENT

The following narrative analyses the key risks to human health and ecosystems associated with the proposed Project, specifically pulp mills, that may result from both human activities and natural phenomenon, onsite and off-site.

12.1 IDENTIFICATION OF TYPES OF HAZARDS

12.1.1 PROCESS-RELATED HAZARDS

Table 12-1 presents some of the potential exposures from the various processes in the proposed Project, that should be considered for the construction and operation phases.

Table 12-1: Potential process-related Hazards.

NO.	HAZARDOUS AREAS	HAZARDS
1	Evaporator and Recovery Boiler	Exposure to hazardous chemicals, heat, noise, pinch points and moving equipment, explosion
2	Electrical rooms	Fire and electrocution, explosion
3	Power Transformers	Fire and electrocution, explosion
4	Digester	Exposure to hazardous chemicals, explosion, heat exposure
5	Fuel storage yard	Skidding, Fire, Spills
6	LNG Facility	Fire
7	Raw material storage area	Fire and pest infestation
8	Pulp storage area	Fire, pest control issues/pest infestation
9	Process area	Spillage of caustic soda and black liquor, burns, heat exposure
10	Chemical storage area	Leakage or spills, location of incompatible chemicals, burns, exposure to hazardous chemicals
11	Stack	Uncontrolled air pollution due to failure of air pollution control equipment (APCE), burns, exposure to particulate matter
12	Workspace	Slips, trips and falls, electrocution, fire
13	Wood Yard	Exposure to fugitive dust, fire, heat, noise, pinch points and moving equipment, pest infestation
15	Retention Ponds	Burns, leaks or spills, exposure to hazardous liquid and possible vapours

12.1.2 PHYSICAL HAZARDS

The following are some the common hazards to be considered in the construction and operation of the proposed Project.

12.1.2.1 Operational and Workplace hazards

Some examples of operational and workplace hazards include:

- Slips, trips and falls resulting in sprains, strains and fractures
- Ergonomics hazards from manual handling, lifting weights, or repetitive movements
- Injuries such as cuts from sharp and moving objects in the workplace
- Over-exposure to noise, vibration, and extreme or adverse weather conditions, air quality and poor ventilation and exposure to hazardous liquid waste generated.

12.1.2.2 Machinery and Vehicles

Accidents may occur in the use of machines and vehicles, and these may include:

- Vehicle collisions; vehicle and machinery roll-overs; uncontrolled movement resulting in personal injury (e.g., crushing by moving vehicles); damage or loss of asset; injury, entrapment; entrapment due to unplanned starting, activation, or engagement of equipment (e.g., rollers); or injury during inspection or repair of vehicles (e.g., vehicle lift not secured while personnel working underneath);
- Death due to faulty or unguarded equipment and machinery (e.g., moving parts and pinch points on machinery and vehicles) or improper use of the equipment or not following the HSE guidelines for use of the machinery or equipment;
- Exposure to noise and/or air pollution which may result in injury or death based on exposure, time, concentration and health and age of the individual. These would be due to the operations and/or poor maintenance of the machinery or vehicles
- Fatal accidents associated with crushing by vehicles or equipment.
- Injuries associated with manual, hand-related operations.
- Exposure to noise produced by the machines they operate.

12.1.2.3 Confined and Restricted Space Entry

A serious injury or fatality can result from inadequate preparation when entering a confined space or in attempting a rescue from a confined space. This could result in injuries and fatalities such as:

- Risk of asphyxiation;
- Explosions due to gas, dust, or fumes (e.g., residual petroleum fumes);
- Entrapment or enclosure within the confined space.

12.1.2.4 Fire and Explosion

- Fire and explosions can result from pulping and bleaching operations, during product handling (onsite and off-site), the combustion of chemicals, and in the storing of oil or crop residues.
- The storage of raw material and oil on site and crop residue (for e.g. fine dust could trigger a fire and explosion).
- Faulty electrical equipment/infrastructure and/or the poor maintenance of the electrical infrastructure could trigger a fire and potentially an explosion.

- Improper handling and storage of batteries on site, such as those from the electrical trucks, could trigger a fire on site and potentially an explosion.

12.1.2.5 Noise and Vibration

- Vibration from machinery may affect the whole body and can cause chronic backache or hip and knee pain and can additionally lead to spinal, gastro-intestinal, and urinary tract problems.
- Noise and vibration from hand-held equipment (such as chainsaws, brush cutters, or strimmers) can cause hand/arm problems or hearing loss. This will be based on the length of repeated use of this equipment and not following the required HSE guidelines.

12.1.2.6 Exposure to Natural Hazards/ Weather Elements

- Exposure to extremes of weather, including sustained exposure to the sun or cold, can be harmful. Typical problems include hypo- or hyperthermia dehydration, UV damage to skin or eyes, and heat exhaustion cases.

RECOMMENDED MITIGATION MEASURES

The following recommended measures to eliminate, prevent, minimize and/or control physical hazards should be considered in addition to IFC's Environmental, Health and Safety (EHS) Guidelines – General EHS Guidelines for Occupational Health and Safety.

Machine Safety

- Where applicable, ensure that equipment with moving parts are fitted with safety guards or interlocks
- Power off or power down and lock equipment must be shut off and locked prior to maintenance, repair, or cleaning activities
- Ensure proper training and sensitization for personnel is completed and signed-off before persons are allowed to operate, repair or clean machinery
- Restrict access to areas with heavy machinery in operation and ensure proper signage is present at strategic locations within range of the heavy machinery
- Develop and implement a maintenance and inspection programme for the equipment in keeping with best practices and the manufacturer's guidelines.
- Ensure all staff received the proper training on the use, care and storage of PPE (Personal Protective Equipment) before equipping all personnel with said protective gear.
- Provide workers with the appropriate PPE

Wood Yard Operations

- Create clearly demarcated and controlled transport routes to and within wood yards
- Ensure that raw material stacks should not be higher than a safety height defined by a risk assessment of the specific site conditions and stacking methodology
- Restrict access to wood yards
- Develop and implement a training programme and schedule for team members/staff on Occupational Health and Safety protocols

- Ensure that all the required alarm systems are properly installed, maintained and tested to ensure they are operational. This is to include audible alarms on trucks (e.g. reverse alarms), and other equipment.
- If possible, consider automation of all wood yard activities
- Develop and implement periodic inspection and maintenance of equipment in keeping with manufacturing regulations and industry standards
- Ensure all staff received the proper training on the use, care and storage of the required PPE (Personal Protective Equipment) such steel-capped boots, hardhats, high visibility jackets, etc. before equipping all personnel with said protective gear.
- Provide workers with the appropriate PPE

Dust

- Where possible, ensure that saws, shredders, dusters and chip conveyors should be enclosed with the property safety systems.
- Develop and implement a house-keeping schedule, especially for dust-prone areas.
- Consider using wet sweeping, vacuuming, wash-down methods for the cleaning up in dust-prone areas.
- Ensure people working in these areas are provided with the required PPE.

Heat Exposure

- Control rooms for wood preparation, pulping, bleaching, and paper-making areas have appropriate ventilation and air conditioning systems.
- Develop appropriate working schedules for people working in areas with a high heat hazard to reduce the impact of heat exposure. This includes appropriate rest times, hydration stations where applicable, etc.
- Automate, where possible, aspects of the pulping process with high heat exposure, for example, smelt removal from the chemical recovery boiler
- Ensure a training/sensitisation programme is developed for high risk working areas.
- Implement safety procedures to minimize the potential for smelt/water explosions. Smelt should be transferred at a controlled rate, and recovery boilers maintained to prevent water leaks from the tube walls of the boiler. Chemical recovery boiler operations should be shut down at the first indication of a leak.
- Provide appropriate PPE

Confined Spaces

- Consider reducing the number of confined spaces in the design of the pulp mill
- Ensure all confined spaces are designed according to the required specifications, best practice and required standards
- Complete a Risk Assessment/Action Plan prior to working in confined spaces.
- Confined spaces are restricted areas, as such proper supervision and control must be maintained
- Ensure appropriate PPE and the requisite training is provided before workers enter confined spaces.

Fire and Explosion

Management plans and operating procedures should include comprehensive strategies for the prevention, detection, and suppression of fires within Project perimeters and adjacent properties, including:

- Description of primary detection methods, tools, and protocols
- Ability to communicate with field staff, contractors, and communities
- Measures for reducing fuel loading
- Means to access and contain fires within and approaching the affected site
- Appropriate signate and the proper placement of appropriate fire suppression equipment
- Training of staff, contractors, and communities in fire prevention, suppression and control actions
- All machinery and equipment which have a potential to become a fire hazard should be periodically inspected, maintained and stored.
- Out of use equipment should be properly labelled and stored away. If it cannot be repaired, it should be properly disposed of reused in an appropriate manner
- All flammable/explosive items should be properly handled, stored and transported. The SDS should be readily available and accessible to the relevant team members.

12.1.3 CHEMICAL HAZARDS

Table 12-2 lists some of the major chemicals used or encountered in different processes for a typical kraft pulp mill. It is not intended to be used as a comprehensive reference for all chemicals used in projects of this nature, as specific conditions will vary. Construction crews and operational personnel should obtain and review the Safety Data Sheets (SDSs) for all materials, especially those that are hazardous in nature before use. The SDSs should be made readily available by the BBP operators.

12.1.4 UNPLANNED, UNFORESEEN AND UNAVOIDABLE RISKS

As there are uncertainties with the identification and assessment of risks, there may be the possibility of unforeseen, unplanned and even unavoidable risks occurring. These types of risks may have varying levels of severity, varying durations, be positive or negative, have varying impacts on receptors and have various receptors. These types of risk must be identified without delay and assessed for all possible mitigative, adaptive or even varying levels of tolerance for these types of risks. The appropriate mitigative measures, if available must be implemented and monitored once the risks are identified (See figure with control measures above). Having an experienced and qualified team to conduct robust risk assessments will be key in addressing these risks once they arise. **Section 12.2** addresses response plans to various types of risks that may arise.

Table 12-2: Hazardous process chemicals in pulping processing[lxiii]

CHEMICAL NAME	USES AND CHARACTERISTICS	HAZARDS	MITIGATION MEASURES
Acids: ▪ Sulphurous, H_2SO_3 ▪ Sulphuric, H_2SO_4 ▪ Nitric, HNO_3	▪ In sulphite cooking liquor ▪ Clear and viscous, acrid odour (H_2SO_4) ▪ Used in cleaning evaporators ▪ Yellow colour, acrid odour (HNO_3)	▪ Corrosive burns ▪ Reddening of skin, burning sensation	▪ Maintain updated Safety Data Sheets (SDSs) ▪ Store in the appropriate container, such as a metallic or coated fibre board drum using a strong polyethylene inner package. Container should be locked and dry. ▪ Do not add water to concentrated acids ▪ Use in well ventilated spaces along with the appropriate PPE/respiratory equipment, such as protective clothing, self-contained breathing apparatus and face shields ▪ Incompatible reagents should not be stored together. ▪ Ensure proper ventilation is in place if chemicals are stored in an enclosed area. ▪ Develop and implement a proper training programme for the handling, storage and use of these chemicals and first aid ▪ Develop and implement Hazardous Waste Management Plan ▪ Develop and implement a Spill Management Plan
Black liquor	▪ Liquid alkali, thick and slippery when concentrated ▪ Brown to black watery liquid in weaker concentrations ▪ Slightly pungent smell, with the odour of sulphides (for e.g. 'rotten egg' smell)	▪ Primarily a skin irritant ▪ Corrosive ▪ Toxic if swallowed	▪ Maintain updated Safety Data Sheets (SDSs) for chemicals used in the black liquor ▪ Use appropriate PPE (gloves, clothing, eye, face and respiratory protection) ▪ Use appropriate firefighting equipment (carbon dioxide, foam, sawdust or recommended absorbent material) is recommended. ▪ Eye wash fountain and emergency showers should be present in the event of contact with skin or clothes. ▪ Develop and implement a proper training programme for the handling, storage and use of these chemicals and first aid ▪ Implement Hazardous Waste Management Plan ▪ Develop and implement a Spill Management Plan

[lxiii] https://www.ihsa.ca/rtf/health_safety_manual/pdfs/locations/Paper_Mills.pdf

CHEMICAL NAME	USES AND CHARACTERISTICS	HAZARDS	MITIGATION MEASURES
Green liquor	▪ Alkali ▪ Green colour, no odour ▪ Slippery or soapy feeling	▪ Corrosive burns – less corrosive than white liquor but is scalding hot when handled ▪ Reddening of skin, burning sensation	▪ Maintain updated Safety Data Sheets (SDSs) ▪ Use appropriate PPE (gloves, clothing, eye, face and respiratory protection) ▪ Use appropriate firefighting equipment e.g., fire extinguisher for Class A, B or C fires. ▪ Implement proper, regular training and sensitization on storage, handling and first aid ▪ Implement Hazardous Waste Management Plan
Hydrogen peroxide, H_2O_2	▪ Liquid, clear and colourless ▪ Slightly pungent odour	▪ Strong oxidiser - will react with organic materials and cause fire ▪ Concentrations: mild (3 - 5%) - no danger; moderate (6 - 10%) - minor burns, eye damage; medium (10-50%) - minor burns, eye damage; high (over 70%) – major burns ▪ Explosion risk if mixed with strong acids or caustics	▪ Maintain updated Safety Data Sheets (SDSs) ▪ Store in a cool, well-ventilated area. ▪ Use appropriate PPE (gloves, clothing, eye, face and respiratory protection) ▪ Rinse eyes with wash fountain and emergency showers are recommended ▪ Keep away from incompatible substances ▪ Use appropriate firefighting equipment e.g., fire extinguisher for Class A, B or C fires. ▪ Implement proper, regular training and sensitization on storage, handling and first aid ▪ Implement Hazardous Waste Management Plan
Hydrogen sulphide, H_2S	▪ Colourless, toxic gas, by-product ▪ Rotten-egg odour at low concentrations ▪ Acrid odour	▪ Rotten egg smell at very low concentrations (below 100ppm) ▪ As concentration rises, the sense of smell is rapidly deadened ▪ Nausea, dizziness, and disorientation ▪ Toxic gas at 500 - 700 ppm can be instantly fatal. ▪ Explosive at high concentrations	▪ Use appropriate PPE (gloves, clothing, eye, face and respiratory protection) ▪ Use appropriate firefighting equipment e.g., fire extinguisher for Class A, B or C fires. ▪ Implement proper, regular training and sensitization on storage, handling and first aid ▪ Implement Hazardous Waste Management Plan

CHEMICAL NAME	USES AND CHARACTERISTICS	HAZARDS	MITIGATION MEASURES
Lime: ▪ Quick lime, calcium oxide, CaO ▪ Slaked lime, calcium hydroxide, $Ca(OH)_2$	▪ White powder ▪ Used in sulphite piping	▪ Corrosive alkali burns ▪ Dehydrates skin	▪ Maintain updated Safety Data Sheets (SDSs) ▪ Use appropriate PPE (gloves, clothing, eye, face and respiratory protection) ▪ Keep away from incompatible materials ▪ Use appropriate firefighting equipment e.g., dry chemical fire extinguisher ▪ Implement proper, regular training and sensitization on storage, handling and first aid ▪ Implement Hazardous Waste Management Plan
Methanol, CH_3OH	▪ Methyl alcohol ▪ Colourless ▪ When pure, has slight alcoholic odour; other grades have oily odour	▪ Harmful to inhale vapour or to allow repeated or prolonged skin contact ▪ Affects central nervous system ▪ Signs of poisoning include headache, nausea, vomiting, aimless erratic movement, and dilated pupils ▪ Flammable liquid and vapour air mixture can be explosive	▪ Maintain updated Safety Data Sheets (SDSs) ▪ Store in a cool, well-ventilated area. ▪ Use appropriate PPE (gloves, clothing, eye, face and respiratory protection) ▪ Rinse eyes with wash fountain and emergency showers are recommended ▪ Keep away from incompatible materials ▪ Use appropriate firefighting equipment, e.g., dry chemical fire extinguisher ▪ Implement proper, regular training and sensitisation on storage, handling and first aid ▪ Implement Hazardous Waste Management Plan
Methyl mercaptan, CH_3SH	▪ Colourless gas	▪ Irritating causing watering of eyes and nose ▪ Headaches and nausea ▪ Could be fatal in high concentrations	▪ Use appropriate PPE (gloves, clothing, eye, face and respiratory protection) ▪ Rinse eyes with wash fountain and emergency showers are recommended ▪ Use appropriate firefighting equipment ▪ Implement proper, regular training and sensitisation ▪ Implement Hazardous Waste Management Plan

CHEMICAL NAME	USES AND CHARACTERISTICS	HAZARDS	MITIGATION MEASURES
Sodium carbonate, soda ash, Na_2CO_3	▪ Used in digesting pulp	▪ Primarily irritates eye, nose and throat ▪ Corrosive	▪ Maintain updated Safety Data Sheets (SDSs) ▪ Use appropriate PPE (gloves, clothing, eye, face and respiratory protection) ▪ Rinse eyes with wash fountain and emergency showers are recommended ▪ Use appropriate firefighting equipment ▪ Implement proper, regular training and sensitisation ▪ Implement Hazardous Waste Management Plan
Caustic soda or Sodium hydroxide, NaOH	▪ Used in digesting pulp ▪ Slippery or soapy to touch on skin ▪ Clear to milky white, odourless	▪ Very corrosive material, can cause chemical burns on exposed skin ▪ Can cause irritation of skin, eyes, nose and throat ▪ Overexposure to mists or dusts containing sodium hydroxide can lead to fluid build-up in lungs	▪ Maintain updated Safety Data Sheets (SDSs) ▪ Use appropriate PPE incl. self-contained breathing apparatus, N95 face masks, goggles, gloves (latex, nitrile neoprene) etc. ▪ Keep storage containers in a dry, cool, well-ventilated area ▪ Avoid usage of combustible materials in nearby storage areas ▪ Use appropriate firefighting equipment e.g., fire extinguisher for Class A, B or C fires (do not use water) ▪ Implement proper, regular training and sensitization on storage, handling and first aid ▪ Implement Hazardous Waste Management Plan
Sodium sulphate, Na_2SO_4	▪ Make-up chemical for cooking liquor	▪ Minor irritation of eyes, nose and throat possible	▪ Maintain updated Safety Data Sheets (SDSs) ▪ Use appropriate PPE (gloves, clothing, eye, face and respiratory protection) ▪ Rinse eyes with wash fountain and emergency showers are recommended ▪ Use appropriate firefighting equipment ▪ Implement proper, regular training and sensitization ▪ Implement Hazardous Waste Management Plan
Sodium sulphide, NaS_2	▪ Component of white liquor used in digesting (cooking) pulp in the kraft process	▪ Inhalation of dust can cause irritation of nose, throat, and lungs ▪ Corrosive – can cause skin burns ▪ May react with moisture to release hydrogen sulphide gas ▪ Repeated skin contact may cause allergic skin reaction	▪ Maintain updated Safety Data Sheets (SDSs) ▪ Use appropriate PPE (gloves, clothing, eye, face and respiratory protection) ▪ Rinse eyes with wash fountain and emergency showers are recommended ▪ Use appropriate firefighting equipment ▪ Implement proper, regular training and sensitization ▪ Implement Hazardous Waste Management Plan

CHEMICAL NAME	USES AND CHARACTERISTICS	HAZARDS	MITIGATION MEASURES
Sulphur, S	▪ Yellow solid ▪ Used in some processes to produce sulphur dioxide gas, which is used in digesting pulp	▪ Burns to produce sulphur dioxide	▪ Maintain updated Safety Data Sheets (SDSs) ▪ Use appropriate PPE (gloves, clothing, eye, face and respiratory protection) ▪ Rinse eyes with wash fountain and emergency showers are recommended ▪ Use appropriate firefighting equipment ▪ Implement proper, regular training and sensitization ▪ Implement Hazardous Waste Management Plan
Sulphur dioxide, SO_2	▪ Used in digesting pulp ▪ Clear and odourless gas, acrid odour	▪ Very irritating gas, causes irritation of eyes, nose, and throat ▪ Exposure can cause choking and difficulty breathing ▪ Delayed response to overexposure can result in fluid build-up in lungs	▪ Maintain updated Safety Data Sheets (SDSs) ▪ Use appropriate PPE (gloves, clothing, eye, face and respiratory protection) ▪ Rinse eyes with wash fountain and emergency showers are recommended ▪ Use appropriate firefighting equipment ▪ Implement proper, regular training and sensitization ▪ Implement Hazardous Waste Management Plan
Magnesium Sulphate, $MgSO4$	▪ Used in delignification in the Cooking Process ▪ White granular or in powder form ▪ Odourless ▪ Not flammable	▪ Only toxic in very high dosages and can cause Diarrhoea, Vomiting, Central nervous system depression	▪ Maintain updated Safety Data Sheets (SDSs) ▪ Use appropriate PPE (gloves, clothing, eye, face and respiratory protection) ▪ Rinse eyes with wash fountain and emergency showers are recommended ▪ If swallowed, make victim drink water (two glasses at most). Seek medical attention if the patient is feeling unwell. ▪ Implement proper, regular training and sensitization ▪ Implement Hazardous Waste Management Plan ▪ Do not discharge into the environment
White liquor	▪ Alkali ▪ Golden colour, no odour ▪ Slippery or soapy feeling	▪ Corrosive burns ▪ Reddening of skin, burning sensation like caustic but at higher temperature	▪ Maintain updated Safety Data Sheets (SDSs) ▪ Use appropriate PPE (gloves, clothing, eye, face and respiratory protection) ▪ Use appropriate firefighting equipment e.g., fire extinguisher for Class A, B or C fires. ▪ Implement proper, regular training and sensitization on storage, handling and first aid ▪ Implement Hazardous Waste Management Plan

12.1.5 BIOLOGICAL HAZARDS

Occupational health and safety hazards associated with the construction and operation of the proposed Project include contact with stinging insects, spiders, scorpions, bees and wasps, snakes and disease vectors (e.g., mosquitoes, ticks). If ever required under abnormal operations, the importation of raw material in the form of bamboo chips is required, there is the risk of introducing venomous insects and animals. Microorganisms will develop particularly in closed-loop systems and biological treatment plants for wastewaters, and water-cooling towers.

RECOMMENDED MITIGATION MEASURES

Recommended measures to prevent, minimize, and control exposure to biological agents include:

- Ensure that WWTP has a disinfectant mechanism to prevent the release of effluent with pathogenic organisms.
- Raw material stored on site should be used in a manner that does not facilitate prolonged ponding of water for breeding sites to develop.
- Use biocides in cooling water and in pulping processes to minimize growth of microorganisms.
- Have a robust monitoring programme to test closed-loop water treatment plants and cooling systems for the presence of pathogenic organisms.
- The locations of the treatment plant are in one, where any aerosols produced are not readily released into areas with sensitive receptors.
- Wear appropriate clothing and PPE
- Inspect any clothing, shoes, or equipment (including PPE) before use to ensure there are not animals or insects in them and to ensure they are in good condition.
- Make sure that the necessary sanitation measures are implemented to prevent the contamination of sterile areas.
- Develop and implement a programme for the maintenance of outdoor spaces prevent overgrown vegetation, clutter, unauthorised storage on areas and improper disposal of solid waste to prevent breeding sites, introduction and proliferation of pests, accident-prone areas etc.
- Properly constructed and maintained solid waste storage areas on site.
- Remove or reduce tall grasses, debris, and rubble from around the outdoor work areas.
- Control water accumulation.
- Use insect repellent.
- Ensure availability of onsite first-aid equipment and trained personnel, as well as procedures for emergency evacuation.
- Alert workers as to locations where dangerous animals are spotted and use proper signage to reinforce this information. Also implement a measure to allow for workers to report the sighting of dangerous animals.
- Install fencing and other exclusion methods for larger animals that may present a hazard.
- If bamboo chips are imported for the mill processes, all phytosanitary regulations and requirements must be complied with.

12.2 RISK ASSESSMENT MATRIX

The section below outlines the risk matrix and mitigation measures for various aspects of the proposed Project. The legends for the components of the risk assessment are outlined from Table 12-3 to Table 12-6 below.

Table 12-3: Assessment of Probability.

LEVEL	DESCRIPTION	EXAMPLE
5	**Almost Certain**	Is expected to occur in most circumstances, e.g., once per week
4	**Likely**	Expected to occur in most circumstances, e.g., once per month
3	**Possible**	Will probably occur in most circumstances, e.g., once per year
2	**Unlikely**	Could occur at some time, e.g., once every 10 years
1	**Rare**	May occur only in exceptional circumstances, e.g., once per 100 years

Table 12-4: Assessment of Impacts.

LEVEL	**PERSONNEL INJURY/ILLNESS**	**EXAMPLE DOWN TIME**	**EXAMPLE ENVIRONMENTAL EFFECTS**
5 CATASTROPHIC	Death	>1 month	Long-term environmental damage (project lifetime)
4 CRITICAL	Severe injury or severe occupational illness >2-week hospitalization	1 month to 1 week	Medium-term environmental damage (5-15 years)
3 SIGNIFICANT	Major injury or major occupational illness <2-week hospitalization	3 days to 1 week	Short-term environmental damage (0-5 years)
2 MARGINAL	Minor injury or occupational illness, no hospitalization, day case	1 day to 3 days	Brief (<3 months) environmental damage
1 NEGLIGIBLE	First aid, no injury or illness	<1 day	Minor environmental damage

Table 12-5: Risk Scoring Matrix.

Impact	Catastrophic	5	5	10	15	20	25
	Critical	4	4	8	12	16	20
	Significant	3	3	6	9	12	15
	Marginal	2	2	4	6	8	10
	Negligible	1	1	2	3	4	5
			1	2	3	4	5
			Rare	Unlikely	Possible	Likely	Almost Certain
			Probability				

Table 12-6: Risk Scoring Matrix.

SCORE	RISK	CODE	RESPONSE
≥20	Extreme	E	Urgent action required
11-20	High	H	Action required at the earliest possible moment
6-10	Medium	M	Action required
≤5	Low	L	Continue managing routine practices
	Controlled Risk	CR	Operation may continue with new controls in place

***NA should be used for hazards identified with no consequence**

Control Measures

- ELIMINATE: Eliminate the hazard by removal from the workplace
- SUBSTITUTE: Replace the activity, process, or substance with a less hazardous one
- ISOLATE/ENGINEERING SOLUTIONS: Isolate the hazard from employees, e.g., proper storage of chemicals, firearms, mechanical aids
- ADMINISTRATION: Implement safe workplace practices, procedures, and policies; provide training, adequate supervision
- PERSONAL PROTECTIVE EQUIPMENT: Provide suitable PPE to cover and protect employees

The best method of controlling risk is to eliminate the hazard – it is not always possible to do this immediately. The aim of implementing controls is to get as many controls in place so the risk is reduced to as low as possible. Controls should be selected from as high up on the list as reasonably practical to maximise effectiveness. In many cases a combination of controls may be necessary to reduce the hazard. Table 12-7 presents the risks and considerations for the proposed project.

The current potential risks identified from farming *B. vulgaris* in the parish are also presented in Table 12-7 and will help to inform the SEA and Farm Management Plan once the farming component of the project and the locations of farm sites have been finalised and assessed.

Table 12-7: Risk and Considerations – Proposed Bamboo Market Pulp Mill in Friendship, Westmoreland.

RISKS/ CONSIDERATIONS	LIKELY IMPACTS	PROBABILITY	IMPACT	RISK	POSSIBLE MITIGATIVE/RISK CONTROL MEASURES	Residual Probability	Residual Impact	Residual Risk
OCCUPATIONAL HEALTH AND SAFETY								
OPERATIONAL AND WORKPLACE HAZARDS	▪ Slips, trips and falls resulting in sprains, strains and fractures ▪ Ergonomics hazards from manual handling, lifting weights, or repetitive movements. ▪ Accidents involving sharp and moving objects in the workplace ▪ Over-exposure to noise, vibration, and extreme or adverse weather conditions.	Likely	Significant	High	▪ Implement an Occupational Health, Safety and Environment Management Plan (OHSEMP)and incident management system (Heath Safety and Environmental (HSE) monitor) ▪ Practice good housekeeping, e.g. implements procedures for handling spillages of different kinds ▪ Maintain floors in good condition ▪ Ensure good lighting in all areas ▪ Use appropriate PPE ▪ Install proper signage and demarcation of storage areas ▪ Organize appropriate and frequent training and sensitization	Unlikely	Marginal	CR
MACHINERY AND VEHICLE HAZARDS	▪ Accidents may occur in the use of machines and vehicles including vehicle collisions; vehicle and machinery roll-overs; uncontrolled movement resulting in personal injury (e.g., crushing by moving vehicles); damage or loss of asset; injury, entrapment, or death due to faulty or unguarded equipment and machinery (e.g., moving parts and pinch points on machinery and vehicles); entrapment due to unplanned starting, activation, or engagement of equipment (e.g., rollers); or injury during inspection or repair of vehicles (e.g., vehicle lift not secured while personnel working underneath). ▪ Fatal accidents associated with crushing by vehicles or equipment ▪ Injuries associated with manual, hand-related operations ▪ Exposure to noise produced by the machines while in operation	Likely	Critical	High	▪ Where applicable, ensure that equipment with moving parts are fitted with safety guards or interlocks ▪ Power off or power down and lock equipment prior to maintenance, repair, or cleaning activities ▪ Ensure proper training and sensitisation for personnel is completed and signed-off before persons are allowed to operate, repair or clean machinery ▪ Restrict access to areas with heavy machinery in operation and ensure proper signage is present at strategic locations within range of the heavy machinery. ▪ Develop and implement a maintenance and inspection programme for the equipment in keeping with best practices and the manufacturer's guidelines. ▪ Ensure all staff received the proper training on the use, care and storage of PPE (Personal Protective Equipment) before equipping all personnel with said protective gear.	Unlikely	Marginal	CR
INJURIES AND FATALITIES FROM WORKING AT HEIGHT	▪ Contractors/workers may suffer severe, possibly fatal injuries if they fall from any height e.g., during machinery repair.	Possible	Catastrophic	High	▪ Ensure proper training and sensitisation to use ladders and other scaffolding appropriately ▪ Agree to a safe system of work prior to start ▪ Access and inspect equipment (ladders, scaffolding) before use and store safely after use ▪ Use appropriate PPE	Unlikely	Marginal	CR
NOISE NUISANCE AND VIBRATIONS	▪ Vibration from machinery may affect the whole body and can cause chronic backache or hip and knee pain and can additionally lead to spinal, gastro-intestinal, and urinary tract problems. ▪ Noise and vibration from hand-held equipment (such as chainsaws, brush cutters, or trimmers) can cause hand/arm problems or hearing loss.	Possible	Marginal	Medium	▪ Constructed/maintain buffer zones around areas where there may be loud blow offs. Consider implementing a green belt to leverage natural topography and vegetation of the proposed site ▪ Ensure workers use appropriate PPE ▪ Consider equipment with a low noise rating. Where this is not possible, noise dampeners should be used to attenuate noise. This equipment should be placed in areas downwind of sensitive receptors. ▪ Limit, where possible, the hours of operation for mechanical equipment that produces high levels of noise ▪ Ensure, where possible, that noise sources are in less sensitive areas (away from sensitive receptors) to take advantage of distancing and shielding ▪ Develop and implement a Noise Management Plan with Grievance Mechanism	Rare	Negligible	CR

RISKS/ CONSIDERATIONS	LIKELY IMPACTS	PROBABILITY	IMPACT	RISK	POSSIBLE MITIGATIVE/RISK CONTROL MEASURES	Residual Probability	Residual Impact	Residual Risk
ELECTRICAL SHOCKS	▪ Contractors/workers may suffer shock, burns or fatal injuries from faulty electrical equipment or installation, or improper handling of equipment.	Possible	Catastrophic	High	▪ Implement an Occupational Health, Safety and Environment Management Plan (OHSEMP) and incident management system (HSE monitor) ▪ Discuss electrical safety before tasks to ensure relevant machinery, circuits etc. are isolated and powered off throughout the task ▪ Conduct proper training and sensitisation sessions ▪ Use appropriate PPE ▪ Schedule frequent maintenance and inspection of electrical installations and equipment	Unlikely	Marginal	CR
INJURIES AND FATALITIES WORKING IN CONFINED SPACES	▪ Risk of asphyxiation; explosions due to gas, dust, or fumes (e.g., residual petroleum fumes); and entrapment or enclosure within confined spaces such as stacks, tanks, manholes, etc. ▪ Serious injury or fatality can result from inadequate preparation when entering a confined space or in attempting a rescue from a confined space.	Possible	Catastrophic	High	▪ Design specifications should consider eliminating confined spaces to the greatest extent possible. Where necessary, confined spaces should be designed to accommodate most of the workforce including adjustments for tools and PPE (consult ISO and EN standards). Adjoining areas should have ample room for emergency and rescue operations. ▪ A risk assessment and plan should be completed prior to controlled entry to confined spaces, including ensuring process or feedlines are disconnected, atmospheric testing conducted, etc. The plan should include facilitating ventilation until target safe conditions are met. ▪ Restrict entry to confined spaces, subject to permitted supervision by properly trained personnel ▪ Ensure appropriate PPE and training in same is provided prior to worker entering confined space.	Unlikely	Critical	CR
INJURIES AND FATALITIES FROM HEAT EXPOSURE	▪ Working with heat-related processes associated with the Project may result in injuries (fatal or non-fatal). ▪ Exposure to extremes of weather, including sustained exposure to the sun or cold, can be harmful. Typical problems include hypo- or hyperthermia dehydration, UV damage to skin or eyes, and heat exhaustion cases.	Possible	Significant	Medium	▪ Provide air-conditioned control rooms ▪ Schedule work in hot areas to allow for acclimatisation and rest periods ▪ Automate, where possible, aspects of the pulping process with high heat exposure, e.g., smelt removal from the chemical recovery boiler ▪ Provide appropriate PPE ▪ Implement safety procedures to minimise the potential for smelt/water explosions. Smelt should be transferred at a controlled rate, and recovery boilers maintained to prevent water leaks from the tube walls of the boiler. Chemical recovery boiler operations should be shut down at the first indication of a leak.	Unlikely	Negligible	CR
INJURIES AND FATALITIES FROM FIRE AND EXPLOSION	▪ Fire and explosions can result from operations, during product handling (onsite and off-site), combustion of chemicals, stored oil or crop residues. ▪ Staff or visitors who are trapped could suffer fatal injury from smoke inhalation.	Possible	Catastrophic	High	Include in management plans and operating procedures comprehensive strategies for the prevention, detection, and suppression of fires within the perimeters of the proposed Project site and adjacent properties, including: ▪ Description of primary detection methods, tools, and protocols ▪ Ability to communicate with field staff, contractors, and communities ▪ Measures for reducing fuel loading ▪ Means to access and contain fires within proposed Project site ▪ Proper placement of appropriate fire suppression equipment ▪ Training of staff, contractors, and communities in fire prevention and suppression actions	Unlikely	Catastrophic	CR

RISKS/ CONSIDERATIONS	LIKELY IMPACTS	PROBABILITY	IMPACT	RISK	POSSIBLE MITIGATIVE/RISK CONTROL MEASURES	Residual Probability	Residual Impact	Residual Risk
FUGITIVE DUST NUISANCE AND OTHER EMISSIONS	▪ Staff or visitors may suffer discomfort or respiratory illnesses from exposure to dust and other emissions e.g., releases to air from storage of raw materials or wastes.	Almost Certain	Significant	High	▪ Implement an Occupational Health, Safety and Environment Management Plan (OHSEMP) and incident management system (HSE monitor) ▪ Implement Grievance Mechanism ▪ Usage of appropriate PPE, e.g., N95/FFP masks ▪ Implement dust reduction mechanisms or Dusk Mitigation Plan that includes wetting and covering bare soil, applying dust-retarding products, spreading gravel or mulch to contain fine particles, creating wind breaks, phasing site clearing, and enforcing low speed limits on unpaved roads ▪ Implement a green belt or vegetation buffers around the proposed Project site ▪ Prohibit open burning of waste	Rare	Negligible	CR
INJURIES AND FATALITIES FROM CHEMICAL HAZARDS	Injuries (fatal and non-fatal) may result from: ▪ Dermal contact ▪ Inhalation ▪ Ingestion	Likely	Catastrophic	Extreme	▪ Maintain updated Material Safety Data Sheets (MSDSs) ▪ Use appropriate PPE (gloves, clothing, eye, face and respiratory protection) ▪ Ensure incompatible materials are stored separately ▪ Keep storage containers in a dry, cool, well-ventilated area preferably with secondary containment ▪ Use appropriate firefighting equipment, e.g., dry chemical fire extinguisher, fire extinguisher for Class A, B or C fires, sand, etc. ▪ Implement proper, regular training and sensitisation on storage, handling and first aid ▪ Rinse eyes with wash fountain and emergency showers are recommended ▪ Implement Hazardous Waste Management Plan	Possible	Marginal	CR
INJURIES AND FATALITIES FROM CORROSIVE SPILLAGE	▪ Leakage/leeching or spillage from storage or handling of acid/caustic soda may cay cause dangerous corrosion that could harm the environment or workers/visitors	Possible	Critical	High	▪ Implement an Occupational Health, Safety and Environment Management Plan (OHSEMP) and incident management system (HSE monitor) ▪ Implement strict standard operating procedures (SOPs) incl. material safety data sheets (MSDSs) for all materials ▪ Schedule proper training and sensitisation ▪ Organise proper storage of corrosive materials in suitable labelled containers away from incompatible materials in a cool, dry, well-ventilated area ▪ Ensure corrosive containers are kept closed except when materials are being used ▪ Inspect containers regularly for damage or leaks ▪ Vent acid drums regularly ▪ Keep minimal quantities of corrosive chemicals in work areas ▪ Use appropriate PPE	Rare	Negligible	CR
ODOUR NUISANCE	▪ The sulphur in the cooking process can result in a bad odour. Together with the odour, sulphur compounds can also be an environmental problem since they are released into the atmosphere. If the chemicals become concentrated, e.g., by weather conditions, they can cause eye and breathing irritation for persons nearby. Other symptoms may include nausea and headaches. People with asthma may experience asthma episodes when the odours are strong. People with emphysema or Cardio-pulmonary disease (COPD) may also be at risk.	Almost Certain	Significant	High	▪ Implement Grievance Mechanism ▪ Implement best practices and technologies that achieve 100% odourless operations ▪ Implement international best practices for emission control	Possible	Marginal	CR

RISKS/ CONSIDERATIONS	LIKELY IMPACTS	PROBABILITY	IMPACT	RISK	POSSIBLE MITIGATIVE/RISK CONTROL MEASURES	Residual Probability	Residual Impact	Residual Risk
BIOLOGICAL HAZARDS	▪ Contact with venomous animals, such as stinging insects, spiders, scorpions, snakes and disease vectors (e.g., mosquitoes, ticks). ▪ Microorganisms can develop in wastewater ▪ Introduction of pests and pest infestation from bamboo chips brought to the site.	Possible	Significant	Medium	▪ Design waste treatment plants to minimise the potential for growth of pathogenic organisms ▪ Use biocides in cooling water and in pulping processes to minimise growth of microorganisms ▪ Wear appropriate clothing and PPE ▪ Inspect any clothing, shoes, or equipment (including PPE) before use ▪ Remove or reduce tall grasses, debris, and rubble from around the outdoor work areas ▪ Control water accumulation ▪ Use insect repellent ▪ Ensure availability of onsite first-aid equipment and trained personnel, as well as procedures for emergency evacuation ▪ Use observation and sighting records so workers know areas where there are dangerous animals ▪ Install fencing and other exclusion methods for larger animals that may present a hazard	Rare	Negligible	CR
PHYSICAL								
AIR EMISSIONS/ POLLUTION	▪ Project operations may emit NOx, SOx, PM, Volatile Organic Compounds (VOCs) and greenhouse gases (GHGs). ▪ Emission of malodourous gases to atmosphere can generate discomfort and health issues in sensitive receptors ▪ This could lead to adverse health impacts on contractors, employees, residents and properties in surrounding areas	Almost Certain	Significant	High	▪ Incorporate in project design the best available technology to mitigate adverse air emissions (scrubbers, electrostatic precipitators, etc.) ▪ Design stacks according to the Good International Industry Practice (GIIP) approach provided by the IFC's General EHS Guidelines, e.g., a single stack over 100m in height above immediately surrounding land ▪ Reduce the risk of fire by reducing the build-up of potential fuel sources and controlling weeds and invasive species ▪ Avoid open burning for land preparation, weed control, and post-harvest treatments. Where burning is unavoidable, potential impacts should be identified and weather conditions monitored to schedule burning to minimise impacts. ▪ Burning of solid waste or plant material should not be encouraged or practiced, and if necessary, should be done in a controlled environment under conditions which will prevent the release of any air pollutants. ▪ Develop a preventative maintenance schedule for all equipment on site. ▪ Consider inventory of critical items and equipment parts to ensure speedy remediation of any equipment failures. ▪ Develop an environmental monitoring plan to include checklists for regular inspection of equipment that are critical to the operations of the mill and for pollution abatement (e.g., scrubbers, etc.). ▪ Continuous and passive monitoring stations will be established as per the requirements of the regulators in conjunction with the results of ADM.	Possible	Marginal	CR

RISKS/ CONSIDERATIONS	LIKELY IMPACTS	PROBABILITY	IMPACT	RISK	POSSIBLE MITIGATIVE/RISK CONTROL MEASURES	Residual Probability	Residual Impact	Residual Risk
WATER QUALITY POLLUTION	Vegetation clearance, increase in paved areas, improper storage/disposal of construction materials, improper sewage treatment/disposal and removal/blockage of existing and natural drains may cause: ▪ Increased sediment laden run-off to surface and groundwater ▪ Disruption of natural stormwater runoff ▪ Onsite and downstream flooding ▪ Contamination of water with pathogens/spread of water-borne diseases	Likely	Significant	High	▪ Paving or grassing of exposed grounds as soon as possible; where possible, unused areas should be left vegetated ▪ Excavated material should not be stored along drains, gullies, swales or in the path of natural drainage. ▪ Stockpiles should have a berm and should be covered. ▪ Natural drainage should not be blocked without suitably engineered alternatives ▪ Use sediment traps/turbidity barriers where necessary to avoid sedimentation of the nearby waters ▪ Develop a detailed pollution prevention and management plan, which should include a scheduled monitoring program	Unlikely	Negligible	CR
POLLUTION FROM RESIDUES AND WASTE	▪ Proposed project may generate significant quantities of non-hazardous solid waste, with limited hazardous wastes, which can create issues if not properly handled	Almost Certain	Significant	High	▪ Consider recycling waste products e.g., ash as fill material in construction work, road construction, as a soil conditioning agent, or otherwise landfilled. ***BBP proposes to mix dregs into lime mud and use this for infrastructure and agriculture.*** ▪ Establish a Waste Management Plan that considers prevention, reduction, reuse, recovery, recycling, removal, and disposal of wastes. ▪ Prohibit burning of packaging, plastics or other solid waste. ▪ Consider procuring fuels, oils and chemicals in bulk quantities to reduce the volume of waste containers ▪ Institute good housekeeping and operating practices including inventory control to reduce the amount of waste resulting from packaging materials etc. ▪ Conduct periodic inspections of storage tanks and components to check for corrosion and structural integrity. These should also be subject to structural integrity tests. ▪ Place skips and bins strategically within the proposed construction site ▪ Design and cover adequately skips and bins to prevent entry by pests and to minimise odour ▪ Empty skips and bins regularly to prevent overfilling ▪ Ensure that hazardous wastes are separated from non-hazardous wastes ▪ Ensure that solid waste is disposed of at an approved disposal site	Unlikely	Negligible	CR
SOIL DEGRADATION	▪ Physical and chemical degradation of soils may result from unsuitable management techniques, such as use of inappropriate machinery or earthworks associated with site preparation and infrastructure development. ▪ Chemical degradation of soil may result from insufficient or inappropriate use of mineral fertilizers, failure to recycle nutrients contained in crop residues, and failure to correct changes in soil pH that result from long-term use of nitrogen fertilizers and excessive use of poor-quality water, resulting in salinisation.	Possible	Significant	Medium	▪ Develop and implement a soil monitoring and management plan that includes soil and terrain mapping and erosion risk identification. ▪ Conduct regular surveys to monitor soil structure and chemistry to identify areas where remedial action is required. ▪ Recycle and/or incorporate organic materials (e.g., crop residues, compost, and manures) to replenish soil organic matter and improve soil water-holding capacity. ▪ Minimise the use of pesticides by implementing a pest and disease early warning system, by using biological pest and disease control methods, and by implementing control measures before outbreaks require large-scale control. ▪ Conduct periodic soil analysis to detect changes in soil fertility, inform decisions on fertilizer application rates, and avoid unsustainable nutrient depletion and over-fertilization ▪ Implement buffer zones and/or setbacks from water—including "no-treatment" areas along water sources, rivers, streams, ponds, and other	Unlikely	Marginal	CR

RISKS/ CONSIDERATIONS	LIKELY IMPACTS	PROBABILITY	IMPACT	RISK	POSSIBLE MITIGATIVE/RISK CONTROL MEASURES	Residual Probability	Residual Impact	Residual Risk
					surface water bodies—to act as a filter for potential nutrient runoff from the land			
SEDIMENTATION FROM DRAINAGE & SURFACE RUNOFF	▪ Sediments from areas without vegetation during rainfall periods can result in flooding, infrastructural damage and siltation of surface water and groundwater receptors	Likely	Significant	High	▪ Establish buffer zones near to ponds, gullies or other water ways using trees, grass, etc. to reduce sediments getting into these systems ▪ Design and implement appropriate drainage improvements that form part of the proposed Project design as they should mitigate against flooding ▪ Separate stormwater from process and sanitary wastewater streams to reduce the volume of wastewater to be treated prior to discharge ▪ Minimise runoff from areas with potential sources of contamination, e.g., limit area of impermeable surfaces ▪ Reduce peak discharge rates, e.g., using vegetated swales or retention ponds ▪ Manage stormwater, if possible, as a resource (for meeting water needs on site) ▪ Install and maintain oil water separators and grease traps ed around fuel storage and containment areas, refuelling facilities, parking areas ▪ Dispose of sludge from stormwater catchments or collection and treatment systems in compliance with NRCA guidelines for the protection of public safety and long-term sustainability of water and land resources as the sludge may contain elevated levels of pollutants	Unlikely	Negligible	CR
IMPROPER DISPOSAL OF WASTEWATER RESULTING IN POLLUTION	▪ Effluent from the proposed project is expected to be high in total suspended solids (TSS, mainly from cooking and pulping process screening, washing and bleaching stages, chemical recovery inorganics and fillers), biochemical oxygen demand (BOD), chemical oxygen demand (COD) and dissolved organic compounds mainly from cooking/pulping, screening, washing, bleaching, and chemical recovery plant liquor spills.	Almost Certain	Critical	Extreme	▪ Include in wastewater treatment primary and secondary treatment at minimum (tertiary treatment can be examined depending on effluent characteristics) ▪ Implement extended aeration time to reduce biological sludge formation and help ensure consistently high levels of treatment. ▪ Implement anaerobic biological pre-treatments for effluents high in COD/BOD and low in toxic substances	Unlikely	Marginal	CR
GREENHOUSE GAS (GHG) EMISSIONS	▪ GHG emissions are generated from the combustion of fossil fuels required for raw material production and transportation, wastewater treatment facilities, purchased power.	Almost Certain	Significant	High	▪ Use cleaner fuels e.g., liquid natural gas (LNG) to minimise GHG emissions ▪ Improve energy efficiency using evaporators and recovery boilers ▪ Seek FSC Certification to ensure sustainable practices ▪ Utilise energy saving devices, lighting, and equipment on site ▪ Consider implementing a greenbelt around the proposed Project site, i.e. a band of permanently protected green area designed to promote sustainable use of land	Unlikely	Marginal	CR
NATURAL HAZARDS								
SEVERE WEATHER HALTING PROJECT ACTIVITIES	▪ The proposed project site is not located in an area that is prone to severe weather. However severe weather may impact supply chains, export, and workforce availability.	Possible	Critical	High	▪ Develop and implement an Emergency Preparedness and Response Plan (EPRP) ▪ Implement standard operating procedures (SOPs) implemented to minimise the potential loss of life, injury, and damage to the environment /property in the event of extreme weather ▪ Monitor daily the possibility of inclement weather, which could affect the proposed Project site ▪ Have and monitor a National Oceanic Atmospheric Administration (NOAA) weather alert radio to ensure that it is operational and monitored during operating hours ▪ Ensure shutdown and start-up are done within established procedures if a forced shutdown of all operations is required resulting from severe weather	Possible	Marginal	Medium

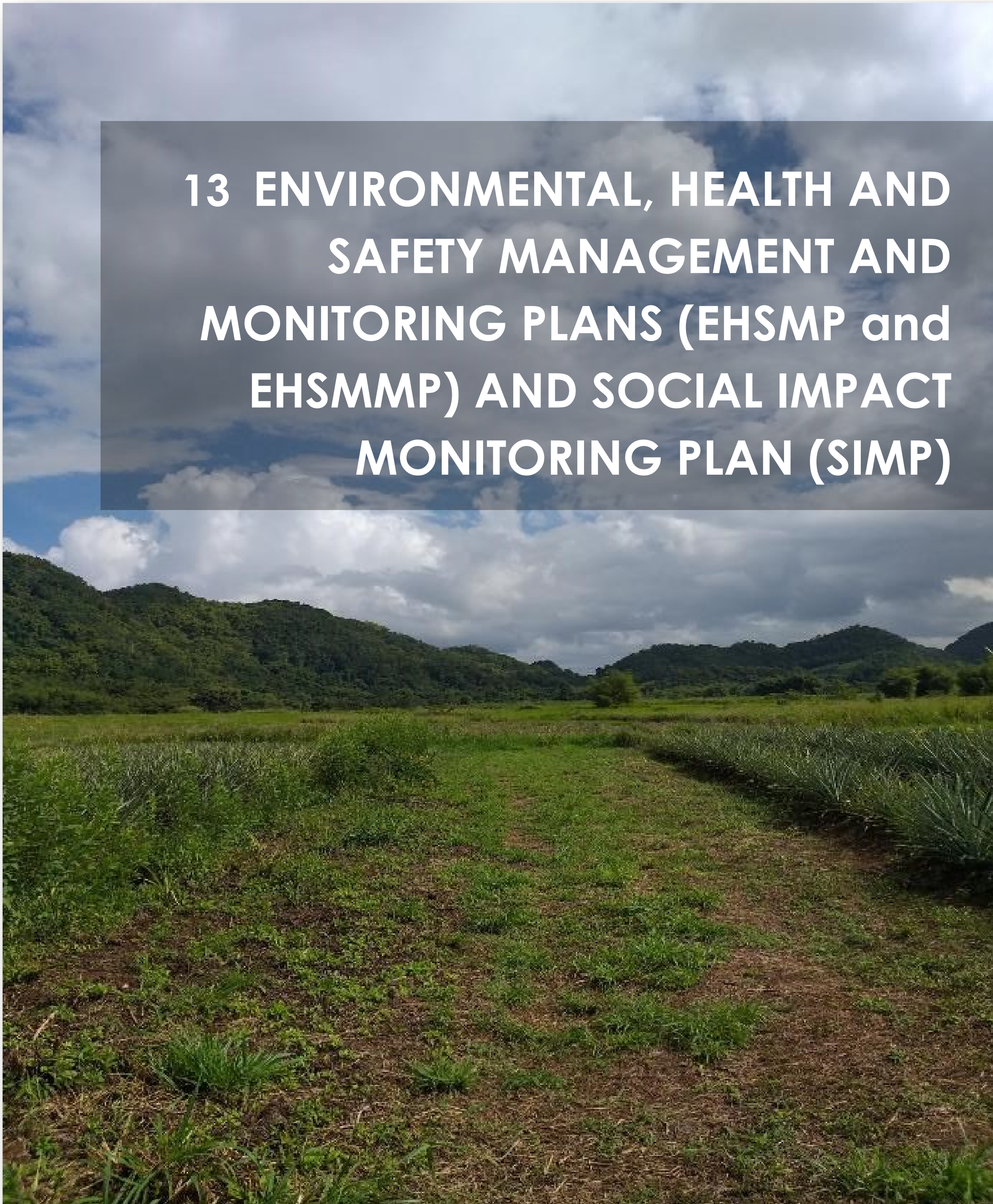
RISKS/ CONSIDERATIONS	LIKELY IMPACTS	PROBABILITY	IMPACT	RISK	POSSIBLE MITIGATIVE/RISK CONTROL MEASURES	Residual Probability	Residual Impact	Residual Risk
				HUMAN AND SOCIAL				
CREATION OF INFORMAL AND UNPLANNED SETTLEMENT	▪ The proposed project may attract workers from outside of the sphere of influence. This could result in the establishment of informal and unplanned settlements as on there are vast areas of unused land in ruinate present in Friendship, Petersfield, Hertford, Amity and the wider sphere of influence.	Possible	Marginal	Medium	▪ Give some consideration to the provision of housing solutions for workers from outside of the immediate sphere of influence who are seeking employment. This can be done through collaboration with the National Housing Trust which has plans to increase housing solutions in Westmoreland. **BBP indicated that temporary housing required will be provided during construction. However, the means to do this have not been finalized. BBP is currently investigating the available options, which include rental properties, hotels, guesthouses, and other forms of accommodations within Westmoreland**. ▪ Give priority, as recommended, to the employment of persons who reside in the immediate sphere of influence	Unlikely	Negligible	CR
POOR COMMUNITY HEALTH AND SAFETY	▪ Potential exposure to pathogens and noxious odours associated with the use of manure ▪ Potential exposure to air emissions from fires, residues, or solid waste (e.g., packaging), malodourous gases ▪ Increased risk of vehicular or machinery injuries on roads and access routes around the community	Possible	Critical	High	▪ Monitor and record all potentially harmful products and activities and manage them to minimize the risk to communities. ▪ Regularly audit and update operating procedures and ensure that personnel are suitably trained. ▪ Ensure that animals and unauthorized people are not present in the areas where potentially harmful products are handled, stored, or applied.	Rare	Negligible	CR
				ECOLOGY				
LAND CLEARANCE DURING CONSTRUCTION	▪ Most sensitive ecosystems on the alluvial plains are freshwater systems, which support the Jamaican Slider Turtle and species which are sensitive to restrictions in water flow and sedimentation. Damage to or loss of aquatic life can result. ▪ Disturbance/loss of foraging habitats and/or modification of commuting routes (including disturbance from lighting) for local fauna. ▪ Damage or disturbance to habitat for protected species including bird species, some of which are endemic, resident and migratory and endemic reptiles. ▪ Damage or disturbance to nesting birds, nests or their young by construction activities	Almost Certain	Significant	High	▪ Retain, if present, larger trees with a DBH >25cm if present ▪ Conduct sensitization/awareness sessions on ecology for local workforce. ▪ Prepare an environmental management and monitoring plan (EMMP) before the start of construction. ▪ Conduct (where possible) vegetation clearance and construction activities outside of the March to September breeding season for birds ▪ Phase construction activities to control erosion and existing vegetation should be maintained/preserved where possible and the minimum amount of land should be disturbed ▪ Implement the use of sediment traps, where necessary ▪ Undertake works as much as possible in the dry season ▪ Wet the construction site and materials during construction	Possible	Marginal	CR

RISKS/ CONSIDERATIONS	LIKELY IMPACTS	PROBABILITY	IMPACT	RISK	POSSIBLE MITIGATIVE/RISK CONTROL MEASURES	Residual Probability	Residual Impact	Residual Risk
FARMING *Bambusa vulgaris* [lxiv]	▪ Invasive *Bambusa vulgaris* can spread rapidly forming extensive monospecific stands which outcompete native vegetation. [lxv] ▪ Bamboo invasion into nearby forests can also reduce the biomass of resident plants and impact habitats for forest specialists.	Almost Certain	Significant	Extreme	▪ Follow the local guidelines for the establishment and management of Bamboo Plantations set by the BSJ. ▪ Ensure BBP operated farms, once finalised, and other farmers supplying the mill abide by the FSC Certification standards and international best practise in cultivating, harvesting, and transporting bamboo from the farms to the mill. ▪ Develop and implement a Farm Management Plan on all farm sites. ▪ Consider integrated management strategies for early prevention and control of bamboo expansion if farms are located within the parish. ▪ Avoid planting near waterways and ecologically sensitive areas, to reduce the risk of bamboo invasion via those pathways. ▪ Maintain a spatial mosaic of land cover by mixing bamboo plantations with other viable-sized forest patches in a large-scale farm design. ▪ Apply, where possible, apply early-warning mechanisms for pests and diseases (i.e., pest and disease forecasting techniques) ▪ Consider bio-control organisms—such as insects, birds, mites, and microbial agents—to perform biological control of pests e.g., by maintaining/preserving areas of favourable habitat. ▪ Consider manual, mechanical weed control, selective weeding and other mechanical controls to kill, relocate or repel pests. Only use pesticides to complement these measures as a last resort.	Possible	Significant	CR
OPERATIONS								
POWER OUTAGE	▪ The proposed project site may experience a power outage (with or without severe weather)	Likely	Negligible	Low	▪ Ensure proposed Project site is equipped with emergency lighting and back-up power sized to allow continued operation of control room, at minimum	Rare	Negligible	CR
ACCIDENTIS DURING LNG UNLOADING TO STORAGE TANKS/FACILITY	▪ With an LNG demand of ~3,800L of LNG per day, impacts from accidental spillage or leakage may occur.	Possible	Significant	Medium	▪ Develop and implement an Emergency Preparedness and Response Plan (EPRP) ▪ Ensure unloading system is equipped with emergency release couplings to shut down LNG flow in case of incomplete connection or premature separation ▪ Install methane detection system to alert relevant personnel of methane release	Unlikely	Negligible	CR
ACCIDENTS DURING FUEL/LNG STORAGE	▪ With an LNG demand of ~3,800L of LNG per day, impacts from accidental spillage or leakage may occur.	Possible	Significant	Medium	▪ Develop and implement an Emergency Preparedness and Response Plan (EPRP) ▪ Ensure fuel storage tanks are equipped with a Safety Instrumental System (SIS) to monitor potential hazards, leaks and initiate shutdown and containment measures ▪ Ensure that storage tanks have secondary containment measures ▪ Ensure tanks are regularly inspected for leakage, corrosion and generally any potential damage to components	Unlikely	Negligible	CR

[lxiv] This impact is preliminary and should be fully determined when the farm sites are selected, and the relevant studies have been done to determine the true impact of this risk.

[lxv] Defined by the Forestry Department as a deliberately or accidentally introduced species to an area different from its native range. The Forestry Department, through its Forestry Stewardship Council DRAFT Interim National Standard of Jamaica (2022), shall only use alien species when knowledge and/or experience have shown that any invasive impacts can be controlled.

13 ENVIRONMENTAL, HEALTH AND SAFETY MANAGEMENT AND MONITORING PLANS (EHSMP and EHSMMP) AND SOCIAL IMPACT MONITORING PLAN (SIMP)



13.1 INTRODUCTION OF THE EHSP

The Environmental, Health and Safety Management and Monitoring Plan (EHSP) outlined in this section presents the environmental management, mitigation, monitoring and institutional measures to be taken in conducting the construction and operational activities of the proposed Bamboo Market Pulp Mill in Friendship, Westmoreland. The focus is to reduce adverse or deleterious environmental and some social effects to acceptable levels and enhance positive effects. This plan provides a framework and requirements/guidance for preparation of a series of sub-plans to be prepared later. It does not present all the individual plans to be implemented. It specifically defines what actions must be taken and who is responsible for incorporating the steps to be taken to reduce adverse operational impacts.

The plan has been developed in accordance with the IFC EHS Guidelines (General, Perennial Crop Production, Paper and Pulp Mills) which contain the performance levels and measures that are normally acceptable to the IFC and that are generally considered to be achievable in new facilities at reasonable costs using existing technology. It is also in compliance with relevant regulations, legislations and policies developed by the Government of Jamaica. A summary of national and international standards for air, water, wastewater and noise is presented in **Appendix E**.

The legally binding obligations regarding monitoring will be outlined in the conditions for the various permits for the Project (if granted). Typically, the permit conditions prescribe that the environmental and social impacts of the Project must be monitored in compliance with the monitoring programmes approved by NEPA according to national standards (or international standards, whichever is more stringent). The monitoring programmes are developed, after obtaining approval, in collaboration with NEPA and the programmes specify the details of the monitoring to be conducted and the reports to be submitted.

13.1.1 OBJECTIVES OF THE EHSP

The development and approval of the EHSP is a necessary pre-condition for the Lenders' approval of the proposed Project The overall objectives of the plan are to:

- Describe the measures required to implement management and mitigation commitments made relative to the construction and operational impacts identified in the EIA;
- Describe specific additional measures required to implement good practice and approval conditions stipulated by NEPA and international funding agencies (IFC, World Bank, SKN etc.);
- Identify the roles and responsibilities of the environmental and social management organisation of the Project;
- Communicate environmental and social expectations and requirements throughout the Project team.

All contractors and subcontractors shall comply with the provisions of the plan, as applicable, to the tasks they are employed to undertake.

13.1.2 SCOPE OF THE EHSP

This section presents the structure of the EHSP, which follows on from the identification of the potential environmental and social impacts and proposed mitigation actions (**Chapter 8**) for the proposed Bamboo Market Pulp Mill in Friendship, Westmoreland.

The EHSP is composed of the Sustainable Management Practices of BBP and specific Environmental Management Plans (EMPs, Table 13-1). The EMP's document the systems and processes that will be implemented by BBP over time to ensure compliance with local and international standards. They define specific action programmes for environmental health and safety, waste management, emergency response and community engagement. BBP will attempt to manage risks by applying accepted and systematic risk management principles combined with routine training. The EMPs will be used by BBP with provisions to be implemented by the selected Contractor; the implementation of standards for other contractors will be the responsibility of BBP.

Table 13-1: Component Environment Management Plans (EMPs) of the Environmental, Health and Safety Plan (EHSP).

	PLANS	DESCRIPTION	RELEVANT IFC PERFORMANCE STANDARDS
1	Environmental Management and Monitoring Plan (EMMP)-	This management plan pays attention to pollution prevention, resource efficiency and environmental health and safety guidelines. The plan should include provisions for the monitoring of air quality, water quality, noise, waste, and health and safety. The plan should include parameters to be monitored and the frequency, monitoring methods to be used (including data quality), monitoring locations, and compliance with local and international standards. It should be completed in detail to include all requirements necessary to monitor the effectiveness of the mitigative measures implemented to reduce adverse impacts from the activities carried out under both aspects of the construction phase. The monitoring plan will extend across all phases of the Project. It is the responsibility of BBP and the selected Contractor. This plan will also meet the requirements of NEPA permits (if granted).	Performance Standard 1 underscores the importance of managing environmental and social performance throughout the life of a project. Performance Standard 3 recognises that increased economic activity and urbanisation often generate increased levels of pollution to air, water, and land, and consume finite resources in a manner that may threaten people and the environment at the local, regional, and global levels.
2	Occupational Health, Safety and Environment Management Plan (OHSEMP)	This plan will outline the action items designed to prevent accidents and occupational other hazards. BBP will assume responsibility and selected Contractors will have specific roles.	Performance Standard 1 underscores the importance of managing environmental and social performance throughout the life of a project. Performance Standard 4 recognises that project activities, equipment, and infrastructure can increase community exposure to risks and impacts

	PLANS	DESCRIPTION	RELEVANT IFC PERFORMANCE STANDARDS
3	**Biodiversity Management Plan (BMP)**	This management plan will focus on protection and conservation of biodiversity and management of invasive species.[lxvi] This plan will contain a series of action items that will ensure that the land clearance and construction activity will have a minimal impact on the surrounding forest, the IUCN Red List vulnerable species and any remaining species from the habitats in the sphere of the project area, and that opportunities for biodiversity maintenance and enhancement are maximised. The development of this plan will be the responsibility of BBP. This plan will also meet the requirements of NEPA permits (if granted).	**Performance Standard 6** recognises that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development.
4	**Emergency Preparedness and Response Plan (EPRP)**	This management plan will seek to identify and encompass all potential hazards associated with the construction phase of the project and will include key components such as communication procedures, evacuation plans, early warning systems, procedures for first responders, emergency supplies and equipment lists, and other contingency provisions. This will be the responsibility of BBP.	**Performance Standard 1** underscores the importance of managing environmental and social performance throughout the life of a project. **Performance Standard 4** recognises that project activities, equipment, and infrastructure can increase community exposure to risks and impacts.
5	**Community Engagement and Development Plan (CEDP)**	This management plan will outline the measures to be used for community and stakeholder engagement, dissemination of project information and grievance management and will be utilised as a key element in all the proposed management, monitoring and mitigation measures outlined in this document. This plan would be the responsibility of BBP, along with the selected Contractor.	**Performance Standard 1** underscores the importance of managing environmental and social performance throughout the life of a project.
6	**Waste Management Plan (WMP)**	This management plan will describe procedures for the compliant management of solid and liquid wastes. This should be developed by the BBP along with the selected Contractor. This plan will also meet the requirements of NEPA permits (if granted).	**Performance Standard 3** recognises that increased economic activity and urbanisation often generate increased levels of pollution to air, water, and land, and consume finite resources in a manner that may threaten people and the environment at the local, regional, and global levels.

[lxvi] Defined by the Forestry Department as a deliberately or accidentally introduced species to an area different from its native range. The Forestry Department, through its Forestry Stewardship Council DRAFT Interim National Standard of Jamaica (2022), shall only use alien species when knowledge and/or experience have shown that any invasive impacts can be controlled.

	PLANS	DESCRIPTION	RELEVANT IFC PERFORMANCE STANDARDS
7	**Traffic Management Plan**	This management plan will outline how traffic will be managed going on and off the site and through the communities. This should be developed by the selected Contractor.	**Performance Standard 1** underscores the importance of managing environmental and social performance throughout the life of a project.
8	**Farm Management Plan (FMP)**	This management plan should outline the strategies for ensuring soil sustainability by mitigating physical and chemical degradation. It should also include soil and terrain mapping and erosion risk identification. It should also include strategies for nutrient management to maintain and/or improve soil fertility and optimise yield while minimising off-site environmental impact (e.g., contamination of groundwater resources and eutrophication of surface water resources from surface runoff and leaching of nutrients). The Plan should also incorporate measures for crop residues, in tandem with nutrient management. It is to be developed by BBP. The plan should cover pest management, water management and sanitation, soil management, nutrient management and farmer training programmes.	**Performance Standard 1** underscores the importance of managing environmental and social performance throughout the life of a project. **Performance Standard 3** recognises that increased economic activity and urbanisation often generate increased levels of pollution to air, water, and land, and consume finite resources in a manner that may threaten people and the environment at the local, regional, and global levels.
9	**Closure Plan**	The Project should develop a plan for the decommissioning of the proposed Project. The plan should include details on how the Project will manage the EHS aspects of the Project (i.e., responsibilities, final destination of the equipment, waste and scraps management, etc.) during the decommissioning phase. This should be developed by BBP.	**Performance Standard 1** underscores the importance of managing environmental and social performance throughout the life of a project.

13.1.3 STRUCTURE OF THE EHSP

The Sustainable Management Practices of BBP will be presented first followed by the Construction and the Operational Phases. The Construction and Operational Phases of the Project are presented as separate sections, as each of the phases has its specific receptors and stressors. Responsibilities for development, implementation and monitoring are clearly defined.

Key potential impacts and the recommended mitigation measures are summarised by parameters of risk. Development of the requisite Management Plans that cover the standards for compliance in the light of the World Bank policy directives and IFC Performance Standards are articulated.

For this EIA report, ESL has developed the EMMP outlined below. It is recommended that the other plans be developed prior to the commencement of proposed Project.

13.2 SUSTAINBLE MANAGEMENT PRACTICES

Sustainable Management Practices in the project are centred around promoting the sustainable production of the raw material (bamboo) and promoting sustainability in the pulp mill operations.

Sustainability at the pulp mill will be done through the resource-efficient production of the pulp and the promotion of environmental sustainability in its production. These include sustainable practices utilised in the use of the raw material, waste reduction, equipment selection for the mill, the bleaching process and in utilities – energy and water. Furthermore, the side-streams of the pulp production process open up a wide variety of opportunities for the extraction, refining and development of new bioproducts from residual biomass including sludge for cementation and road infill.

In the Mill operations, the equipment being used in the processes – the Pulp Line (cooking, washing, drying and bleaching) are being designed to:

i. Optimise the use of raw material
ii. Reduce damage to the fibres in the process
iii. Reduce chemical requirements
iv. Maximise chemical recovery
v. Reduce emissions and energy demand and
vi. Reduce waste.

In the Bleaching process, the use of total chlorine free (TCF) bleaching was selected to ensure minimal damage to the environment from the removal of chlorine in the process.

Sustainability is also being planned for the utilities of energy and water management. The Recovery Boiler is the essential part of the Kraft process of pulping where chemicals for white liquor are recovered, reformed and recycled from black liquor. The Recovery Boiler selected for the BBP mill not only recovers chemicals, but it also generates power efficiently in a safe, reliable and environmentally sound process. Black liquor contains primarily lignin from the previously processed bamboo. The black liquor is burned, generating heat, which is turned into steam and used to make electricity, much as in a conventional steam power plant. Hence, this reduces the need for and use of fossil fuel energy, which is a positive benefit for the environment and fuel required to be imported into Jamaica. The power generated by the mill is more than the mill consumes. It therefore has a small surplus of electricity which BBP intends to use for the benefit of the host community (currently being investigated) and to power the electric trucks used to move materials and finished products between the mill and the Port of Montego Bay. Additionally, BBP are currently looking toward the future onsite production of biofuel pellets and particleboard from residual bamboo waste.

For sustainability in water usage and the treatment of wastewater, equipment at the mill has been designed to utilise water efficiently. According to the International Plant Protection Convention: IPPC (Luciano Oliveira, 2017) and the European BAT Reference Document for the Production of Pulp, Paper and Board, the best world references of water consumption in projects of this nature are in the range of 30 m^3/ADt - 50 m^3/ADt and 20^3 - 90 m^3/ADt (Suhr et. al 2015). BBP estimates a net freshwater requirement for the Project of 20m^3 per tonne of production, in keeping with the lowest water consumption from the European BAT Guidelines. Other water efficiency measures that will be utilized will be based on the water fixtures to be used in the mill, design of the mill layout and in the treatment of wastewater on site. Plumbing fixtures that will be used will be water conserving with sensitisation of staff that use facilities – washrooms, kitchens, pipes etc. sensitised on conserving water. For the wastewater treatment, there will be:

i. Systems for collection and recycling of temporary and accidental discharges from process water spills;
ii. Sufficient and balanced volumes of pulp storage, broke storage and white water storage tanks to avoid or reduce process water discharges;
iii. Recycling of wastewater, with simultaneous recovery of fibres in production;
iv. Separation of contaminated and non- contaminated (clean) wastewaters with collection and reuse of clean non-contact cooling waters and sealing waters;
v. Efficient washing of the pulp ahead of bleaching;
vi. Collection and recycling of spent cooking liquor spills;
vii. Stripping and reuse of evaporation and digester condensates;
viii. Process wastewater (including from all bunded areas where any spillage may occur) will be collected from all process units 'islands' and piped directly to a dedicated wastewater treatment plant at the lower elevation of the site, thus enabling gravity drainage.
ix. Some rainwater will be pumped back to the mill process fresh water supply to supplement river and ground water sources. Surplus rainwater will flow into the Cabarita River after rain and stormwater will be collected via a dedicated system of channels, gullies and pipes, incorporating oil and grease traps where necessary, and collected in an equalisation/surge pond or tank before being treated and then released into the River.

All waste generated from the processes or operation of the mill will be assessed to see if it can be reused and repurposed. Some examples that can be applied relate to the use of dewatered sludge generated from the WWTP. These examples for usage are as follows:

i. Soil quality improvement through soil reclamation or land restoration
ii. Composting for agricultural soil conditioning and improvement
iii. Incineration / combustion with heat recovery to generate power

These are further expounded on below.

Soil Reclamation or Land Restoration

The mill sludge (PMS) could be a valuable soil organic substitute for improving soil quality and potentially for soil reclamation and land restoration. Examples of degraded soils are eroded agriculture sites, oil and gas well sites, bauxite extraction sites, mine tailing sites, abandoned quarries and temporary roads on managed forest sites. Such types of soils lack organic matter, which can be remediated by the high organic content of PMS. Sludge application on degraded soils can also increase its biota by sustaining earthworm communities. Moreover, soil aggregate formation favoured by PMS application can become hotspots for beneficial microbial and faunal activity. Nitrogen content immediately available for plant growth (i.e., mineralised nitrogen) is also increased. Cation exchange capacity of amended degraded soil increases, especially if the PMS is composted prior to their application. As measured for agricultural land, PMS application on degraded soils increases water-holding capacity, which can be an important improvement for coarse textured soils. Therefore, the positive effects of PMS amendments on degraded soil properties decreases its erosion and favours plant growth on reclaimed land.

PMS composting prior to land application

Composting of PMS prior to land application enhances its overall quality as a soil amendment. Composting is a biological process that converts lignocellulosic residues, such as PMS, into a stabilised and non-hazardous material, rich in humic-like substances devoid of pathogens. Composting of primary PMS with other types of nitrogen-rich wastes decreases C:N ratio, prevents soil nitrogen immobilisation and renders the resulting amendment suitable for plant growth. Co-composting of PMS with municipal biosolids, fertilisers, animal manures and chicken broiler floor litter is also effective in creating valuable soil conditioner. As an extension to use of PMS for direct land reclamation, BBP could compost PMS to further enhance its suitability as an excellent soil conditioner for existing humus-poor soils, which could include potential use on BBP's bamboo farmlands once finalised. All these uses will be finalised once their feasibility is assessed.

PMS energy recovery

PMS is a type of biomass that allows a variety of energy recovery practices, thereby reducing the volume that might be otherwise directed to landfilling. The substrates resulting from the energy recovery of PMS, such as ashes and biochar, can also be recycled or reclaimed as soil amendments and/or used in construction materials. Energy recovery can be practiced directly by combustion or indirectly by microbiological and physicochemical processes leading to the production of biogas (through anaerobic digestion) and biofuel (through pyrolysis and bioethanol production). A complete process of PMS to energy recovery typically includes (1) dewatering and (2) drying to increase the effective thermal heat capacity, (3) thermal conversion or recovery of biofuel or direct use of the aqueous phase in which PMS is processed for biofuel production. The intensity of the dewatering and drying processes depend on the technology. Combustion requires dewatering and drying prior to burning, dewatering is also needed for anaerobic digestion for biogas production whereas fermentation for ethanol production can use PMS with low solid content (as low as 20%), reducing energy consumption for pre-treatments. BBP recognises the beneficial qualities of bio-char.

In the longer term (5-10 years) BBP estimates that the pulp mill could generate more baseload renewable electricity and when BBP's farming operations are producing a surplus of bamboo biomass. BBP is considering the potential to export this excess electricity to JPS Co. As well as using excess bamboo biomass for this purpose, BBP intends to use dried PMS as another 100% renewable fuel source for electricity generation. As mentioned above, all these potential measures of how to reuse the dewatered sludge generated from the WWTP are being assessed. Once assessments are completed and the abovementioned options are found feasible and practicable, the necessary permits and testing will be done and applied for with the relevant Regulators.

Even though this EIA does not cover the farm sites, BBP has provided sustainable management practices that will be used on the farm sites as a part of their overall sustainable management practices. BBP has indicated that the sustainable production of the bamboo will be promoted on farms owned by BBP as well as those operated by contracted Jamaican farmers. This also includes using the raw material to support other local industries in Jamaica. The sustainable production of the raw material would be guided by international best practice, local guidelines and the FSC Certification. Tests are currently being done to determine the best and most efficient growing and harvesting conditions for the *B. vulgaris* in Jamaica and once these are complete, more information will be provided. Additionally, prior to processing the bamboo, residual twigs and branches from the harvesting could be used to support a Jamaican cottage industry that produces straws and stirrers.

13.3 IDENTIFICATION OF PROPOSED MITIGATION MEASURES AND RELEVANT ENVIRONMENTAL MANAGEMENT PLANS

13.3.1 CONSTRUCTION PHASE

The potential impacts during the construction phase would be largely transient in nature. The impacts and mitigation therefore relate to:

- Water quality
- Air Quality
- Noise
- Alteration to the current habitat zones
- Socio-economic Aspects
- Drainage alterations
- Storage of Hazardous Materials
- Site Security
- Migrant Labourers
- Worker Health and Safety
- Traffic management
- Emergency Preparedness and Response
- Facilities to be provided by Labour Contractor
    - Potable Water
    - Sanitary Facilities
    - Canteen

The EHSP for the construction phase includes the following plans to guide compliance with standards and policies as discussed above.

1. Environmental Management and Monitoring Plan (EMMP)
2. Occupational Health, Safety and Environment Management Plan (OHSEMP)
3. Biodiversity Management Plan (BMP)
4. Emergency preparedness and response plan (EPRP)
5. Community Engagement and Development Plan (CEDP)
6. Waste management plan (WMP)
7. Traffic Management Plan (TMP)

13.3.2 OPERATIONS PHASE

During the operational phase of the development, the areas of concern relate to the operational systems of the proposed Project. Considerations include:

- Air quality management
- Water and wastewater management
- Noise management
- Solid waste management
- Management of hazardous chemicals
- Traffic Management
- Workforce management
- Labour Issues
- Staffing and Support Facilities

The ESMP for the operations phase of the proposed Project includes the following plans, in addition to some of the plans previously discussed above:

1. Environmental Management and Monitoring Plan (EMMP)
2. Occupational Health, Safety and Environment Management Plan (OHSEMP)
3. Community Engagement and Development Plan (CEDP)
4. Biodiversity Management Plan (BMP)
5. Farm Management Plan (FMP)
6. Emergency Preparedness and Response Plan (EPRP)
7. Traffic Management Plan (TMP)
8. Closure Plan (CP)

13.4 THE EHS MANAGEMENT AND MONITORING PLAN

13.4.1 AIR QUALITY MANAGEMENT PLAN

13.4.1.1 Monitoring Standards

The relevant NEPA and international standards (where local standards do not exist) standards will be used for the environmental monitoring of this Project during the construction and operations phases. Table 13-2 and Table 13-3 outlines the relevant local and international standards monitored data for comparison.

Table 13-2: Ambient Air Quality Standards of NEPA and the World Health Organisation (WHO).

Ambient Air Quality	Average Timing	NRCA (NEPA) Standard (Max Concentration in µgm^{3})	WHO Ambient Air Quality Standard (µgm^{-3}) [(a)]
$PM_{2.5}$	Annual	-	35 (Interim target-1) 25 (Interim target-2) 15 (Interim target-3) 10 (Interim Target 4) 5 (Guideline)
	24-hour	-	75 (Interim target-1) 50 (Interim target-2) 37.5 (Interim target-3) 25 (Interim Target 4) 15 (Guideline)[(b)]
PM_{10}	Annual	50	70 (Interim target-1) 50 (Interim target-2) 30 (Interim target-3) 20 (Interim Target 4) 15 (Guideline)[(b)]
	24 hours	150	150 (Interim target-1) 100 (Interim target-2) 75 (Interim target-3) 50 (Interim Target 4) 45 (Guideline)[(b)]
Sulphur Dioxide	Annual	80 Primary; 60 Secondary	-
	24- hour	365 Primary; 280 Secondary	125 (Interim target-1) 50 (Interim target-2) 40 (Guideline)[(b)]
	1 hour	700	-
	10 minutes	-	500 (Guideline)
	Annual	100	40 (Interim Target 1)

Ambient Air Quality	Average Timing	NRCA (NEPA) Standard (Max Concentration in μgm^3)	WHO Ambient Air Quality Standard (μgm^{-3}) (a)
Nitrogen Dioxide			30 (Interim Target 2) 20 (Interim Target 3) 10 (Guideline)
	24- hour	-	120 (Interim Target 1) 50 (Interim Target 2) 40 (Guideline)(b)
	1 hour	-	200 (Guideline)
Ozone	1 hour	235	-
	8-hour daily max.	-	160 (Interim target-1) 100 (guideline)
Notes for WHO Standards: (a) Concentrations referenced at 0ºC and 1 atm (b) 99th percentile (i.e. 3-4 exceedance days per year)			

Source: NEPA; WHO (2020)

Table 13-3: Emission guideline for Pulp and Paper Facilities – Kraft, Bleached

PARAMETER	GUIDELINE VALUE (kg/ADt)
SO_2 as S	0.4
NOx as NO_2	2.0 for softwood pulp
Total Suspended Particulates (TSP)	0.5
Total Reduced Sulphur Compounds (TRS)	0.2

**Source*: European Commission, 2001; Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques in the Pulp and Paper Industry, December 2001; and U.S. EPA National Emission Standards for Hazardous Air Pollutants for Source Categories, 40 CFR Part 63.

Through monitoring of the ambient air quality, Bamboo Bioproducts will ensure that both they and their sub-contractors comply with all emission limits in the NEPA standards and the World Health Organisation (WHO) ambient air quality standards.

13.4.1.2 Monitoring Equipment and Stations

Samples for particulate matter should be collected using calibrated pumps. The sampling plan should be designed and implemented in accordance with the NRCA Ambient Air Quality Guideline Document (2006). The data obtained from the analyses of the filter should be expressed as the exposure levels of particulate matter (PM_{10}) over a 24-hr period or as prescribed in the NRCA Ambient Air Quality Guideline Document (2006).

SO_x, NO_x, H_2S

In the absence of an active method, a suitable and approved passive monitor should be used to collect this data. These monitors rely on the natural diffusion of a gas pollutant down a gradient set up by having an efficient absorber at one end of a tube that is effectively opened to the atmosphere at the other end. Passive monitors should be exposed continuously for a 4-week period or as per the manufacturer's guidelines after which the monitors will be collected and analysed using an approved method.

The results at the end of the sampling period should be compared with the Jamaica National Ambient Air Quality Standards.

Stations

Monitoring stations should be selected as stipulated by the regulatory agency and could be guided by the ADM presented in **Chapter 7**. The sampling sites, when chosen, may be based on the closest sensitive human receptors and the direction of the prevailing winds. The location of these monitoring stations will be outlined in the regulator's permit to operate the facility. PM_{10}, SO_x, NO_x and H_2S should be monitored during both the construction (where PM_{10} should be the main air quality parameter assessed) and operational phases of the project or as specified by the regulatory agency.

13.4.1.3 Monitoring Frequency

This will involve continuous monitoring for a 24-hour period along the length of the proposed site. Monitoring should be conducted as stipulated by the permit issued by NEPA.

During the operational phase, monitoring should be conducted as stipulated by NEPA. If the analyses of the data obtained indicate pollution levels are well controlled or consistently compliant with the relevant standards, Bamboo Bioproducts can consider having discussions with NEPA to determine if monitoring frequencies can be reduced.

13.4.1.4 Management and Mitigation Measures

Bamboo Bioproducts is encouraged to establish a baseline for all the air pollutants relevant to operations. The baseline sampling exercise should be conducted prior to the commencement of any work on the Project Site and this will be guided by the local regulator. If there are temporal restrictions in determining the baseline, discussions with the regulator need to be held to determine suitable alternatives. The baseline measurements are critical to differentiate between existing ambient conditions and project related impacts. Once the baseline is established it will be the responsibility of the contractor to ensure that pollution levels on the site (whether from a source on the site or off) are within the relevant guidelines. Measures which should be implemented to ensure compliance with the relevant standards include:

- Maintain emissions of NOx and SOx within the limits established by NRCA by:
    - Using low-sulphur fuels where possible
    - Ensuring all equipment are properly maintained

  - Vehicle fleet, where necessary, should be upgraded with less-polluting trucks and vehicles, and using alternative fuels and fuel mixtures. If electric trucks are used, the client should ensure the proper tyres are used on the trucks to prevent early tyre wear.
  - Ensuring that all emitting sources of NO_x and SO_x are outfitted with approved scrubbing technologies

- Reduce engine idling during on- and off-loading activities should be encouraged

- Minimise the generation of fugitive dust:

  - Ensuring all unpaved areas are with paved or grassed
  - Reduce the speed limit of vehicles used in the park
  - Wash dusty paved surfaces when necessary
  - Ensure dust screens are used for any activities which will generate fugitive dust

- Reduce emission at source during operations
  - Sufficient stack height to be provided as per NRCA guidelines for wider dispersal of pollutants
  - Bamboo Bioproducts should consider incorporating a biophilic design of all components, the development and maintenance of a greenbelt[lxvii] around the Project area and local vegetation along internal roads within the premises

13.4.1.5 Roles and Responsibilities

All members within the chain of command for the proposed Project are identified in Table 13-4, along with their roles and responsibilities. Regulatory oversight is performed by NEPA.

It is the responsibility of the Contractor to ensure that all mitigation measures are carried out and that monitoring reports are prepared. The Contractor should ensure that an EHS Manager is employed to oversee the specific requirements of this plan.

The Implementing Agency is responsible for monitoring the contractor to ensure that monitoring is being undertaken and mitigation measures are being enforced. The frequency of submission and review of monitoring reports will be determined by NEPA.

[lxvii] A greenbelt is a policy and land use zone designation used in land use planning to retain areas of largely undeveloped, wild, or agricultural land surrounding or neighbouring urban/industrial areas

Table 13-4: Air Quality - Roles and Responsibilities.

POSITION	ROLE/ RESPONSIBILITY
BBP	Implementing Agency
NEPA, Enforcement Branch	Monitoring reports are submitted to the Enforcement Branch to be at a frequency determined by NEPA.
Operations Manager	Generally responsible for reviewing the monitoring reports, the coordination of response and supporting the EHS (Environment, Health and Safety) Manager.
Facility Manager	Generally responsible for ensuring the mitigation measures are implemented and machinery are properly maintained to reduce potential impacts.
Environmental Health and Safety (EHS) Manager	The overall implementation responsibility of the Operations Environmental Monitoring Plan lies with the EHS Manager. In addition, the EHS Manager is responsible for the review of all monitoring reports and ensuring that any corrective actions needed are put in place. The EHS is also responsible for ensuring that the staff to conduct the sampling are adequately trained and that the staff/ contractors receive a site-specific induction course.
Environmental Specialist (internal or external) and Environmental Monitor	The environmental Specialist will be responsible for: • Conduction of the Air Quality and Noise Assessments • Conduction of the Wastewater and water quality assessments • Analysis of the results • Identifying any correction measures needed • Generating a report for review.

The EHS Manager is responsible for the EHSP and is supported by a team of technical professionals (Environmental Monitors) who carry out specific environmental programs to include sampling needed for each monitoring programme. The EHS Manager is also responsible for periodically updating this EHSP.

13.4.1.6 Key Performance Indicators

Table 13-5 identifies the KPIs.

Table 13-5: Air Quality - Key Performance Indicators.

NO.	KEY PERFORMANCE INDICATORS	MONITORING AND MEASURING METHODS	RESPONSIBILITY
1	Equipment maintenance log and schedule	Review and inspection of documentation	Contractor Results to be presented to the Implementing Agency
2	Notices to stakeholders	Review and inspection of documentation	Contractor Results to be presented to the Implementing Agency
3	Air quality parameters within NEPA standards	Results certificates	Contractor Results to be presented to the Implementing Agency
4	Log of wetting frequency	Review and inspection of documentation	Contractor Results to be presented to the Implementing Agency
5	Use of personal equipment gear	Review and inspection of documentation	Contractor Results to be presented to the Implementing Agency
6	COVID-19 Protocols and logbook	Review and inspection of documentation	Contractor Results to be presented to the Implementing Agency

13.4.1.7 Data Analysis and Reporting

All samples collected during the monitoring exercise will be analysed using verified/validated analytical methods at an Environmental Health Unit (EHU) approved laboratory and internationally accredited laboratory. The Certificate of Analysis (COA) obtained from the laboratory should contain at least the following information:

i. Sample identification/information and description
ii. Sample collection date and time
iii. Sample submitting information (temperature and condition of sample, time and date of submission)
iv. Analysis date
v. Test results with units of measurement
vi. Test methods
vii. Notes regarding anomalous tests results
viii. Applicable standard

ix. QA/QC documentation
x. Signature of authorized persons

The data obtained from the certificate of analysis will be analysed, taking into consideration statutory requirements and operational standards as well public health and safety. These reports will be prepared by the environmental specialist (internal/ external) and submitted to the EHS Manager who will then review and take necessary actions and report to the relevant regulatory agencies according in the reporting frequency in their License). The structure of the report should include but not be limited to the following:

- Introduction
- Project Background
- Sampling locations (including GPS locations) and description
- Approach/Methods
- Results
- Discussion
- Recommendations based on finding
- Monitoring Summary

13.4.2 NOISE MANAGEMENT PLAN

The NRCA (NEPA) Standards are presented in the Table 13-6. The relevant NEPA permit will stipulate the frequency with which monitoring should take place during the construction and operations phase. Noise level readings, wind direction and any unusual local noise sources should be recorded. Measurements will be taken using approved and calibrated sound level meters. The frequency spectrum of the noise will be measured.

The results at the end of the sampling period will be compared with NEPA standards. Through monitoring of the Noise, BBP will ensure that both they and their sub-contractors comply with NEPA guidelines for Industrial areas.

Table 13-6: Local Noise Standards.

	NRCA (NEPA) Standard	
	Day (7am – 10pm)	Night (10pm – 7am)
Residential	55dBA	50dBA
Commercial	65dBA	60dBA
Industrial	75dBA	70dBA

13.4.2.1 Monitoring Equipment and Stations

Ambient noise measurements should be conducted continuously over a three-day period at least six sites. Four of these sites should be along the perimeter of the proposed project area, one of these sites should be upwind of the project site while one should be downwind of the project site. The upwind and downwind sites should be within a 100-metre radius from the proposed project location. This is to establish a baseline to distinguish which noise impacts are from the proposed project and which already exist. Once this is established, discussions can be held with NEPA to determine the frequency of noise assessments. Important to note, however, that a baseline should be re-established if there any changes to the operations and/or installation and commissioning of new equipment.

Siting and assessments should be done as prescribed in the relevant permit issued by NEPA. The monitoring equipment should be located approximately 1.5 m above the ground and no closer than 3m to any reflecting surface (e.g., walls). The noise level readings should be taken over a minimum period of 24 hours and the average (geometric mean) noise level recorded in decibels (dBA). In general, the noise level limit is represented by the background or ambient noise levels that would be present in the absence of the Project or noise source(s) under investigation. In addition, before and after the survey, the instrument should be checked with a calibrator, which is factory calibrated.

13.4.2.2 Monitoring Frequency

The noise level readings will be taken over a minimum period of 24 hours or as stipulated by the NEPA permit and the average (geometric mean) noise level recorded in decibels (dBA).

13.4.2.3 Management and Mitigation Measures

In addition to the monitoring procedures, The Contractor should ensure the following noise reduction options are implemented where necessary.

- Workers must be properly protected from noise above 90dBA using the appropriate protective gear (according to US OSHA Permissible Noise Exposure Limits). The exposure limit for occupational noise exposure recommended by the National Institute for Occupational Safety (NIOSH) is 85dBA for an 8 Hour shift.
- The area should be classified as an industrial area and as such noise levels should not exceed 75dBA.
- All pneumatic tools to be used in close proximity to residential properties should be fitted with an air exhaust silencer.
- Noise mitigation measures should be utilised (including the construction of bunds, metal sheet walls) in order to limit noise levels at sensitive receptors.
- Ensure that equipment to be used meets industry best standard in relation to noise attenuation.
- Ensure that construction works are only undertaken in defined working hours (weekdays 8h00 – 17h00 and weekends 8h00 – 13h00). In the event that noisy activities are undertaken outside of the specified working hours, all noise receptors should be informed of such activities in advance.
- Assess and manage all noise complaints.
- Undertake noise monitoring at locations with persistent noise complaints.
- Vehicle speeds should be limited to 20km/h on unpaved surfaces
- Develop and maintain a maintenance schedule for all equipment and vehicles.

13.4.2.4 Key Performance Indicators

The following KPIs in Table 13-7 have been selected in order to evaluate the effectiveness of the noise monitoring system.

Table 13-7: Noise – Key Performance Indicators

NO.	KEY PERFORMANCE INDICATORS	MONITORING AND MEASURING METHODS	RESPONSIBILITY
1	Equipment maintenance log and schedule	Review and inspection of documentation	Contractor Results to be presented to the Implementing Agency
2	Notices to stakeholders	Review and inspection of documentation	Contractor Results to be presented to the Implementing Agency
3	Noise parameters within NEPA standards	Results certificates submitted at a frequency prescribed by NEPA	Contractor Results to be presented to the Implementing Agency
4	Log of complaints	Review and inspection of documentation	Contractor Results to be presented to the Implementing Agency
5	Use of personal equipment gear	Review and inspection of documentation	Contractor Results to be presented to the Implementing Agency

13.4.2.5 Roles and Responsibilities

It is the responsibility of the Contractor to ensure that all mitigation measures are carried out and that monitoring reports are prepared. The Contractor should ensure that an EHS Manager is employed to oversee the specific requirements of this plan.

The Implementing Agency (BBP) is responsible for monitoring the Contractor to ensure that monitoring is being undertaken and mitigation measures are being enforced.

13.4.2.6 Data Analysis and Reporting

The results from the sampling exercise will be compared to NEPA noise pollution standards and included in the environmental monitoring report prepared and submitted to NEPA at the prescribed frequency. If there are any exceedances, this should be reported immediately to the EHS Manager to allow for management strategies to be changed according to the results.

13.4.3 WATER QUALITY MANAGEMENT PLAN

13.4.3.1 Monitoring Standards

Monitoring of water quality for the proposed Project will mostly consider environmental and public health impacts during both the construction phase and operational phase. The parameters to be monitored during construction to ensure protection of the aquatic environment will be stipulated by NEPA in the relevant license (if granted) and the sampling protocol used will meet at a minimum, the Ministry of Health & Wellness (MoHW) Environmental Health Laboratory Sampling and Field Measurements Protocol. Nevertheless, standards for ambient water quality stipulated by NEPA are given in the Table 13-8.

Table 13-8: Jamaica National Ambient Water Quality Standards – Freshwater (NEPA)

Parameters (units)	Standard Range
Total Dissolved Solids (mg/L)	120.0 - 300
pH (pH units)	7.00 – 8.40
Conductivity (mS/cm)	150.0 - 600
Calcium (mg Ca/L)	40.0 – 101.0
Chloride (mg Cl^-/L)	5.0 – 20.0
Magnesium (mg Mg/L)	3.6 - 27.0
Nitrate (mg NO_3^-/L)	0.1 – 7.5
Phosphate (mg PO_4^{3-}/L)	0.01 – 0.8
Sodium (mg Na/L)	4.5 – 12.0
Sulfate (mg SO_4^{2-}/L)	3.0 – 10.0
Hardness (mg $CaCO_3$/L)	127.0 – 381.0
Biochemical Oxygen Demand (mg O_2/L)	0.8 – 1.7
Potassium (mg K/L)	0.74 – 5.0
Silica (mg SiO_2/L)	5.0 – 39.0

The IFC has Effluents and Emissions Guidelines/Resource Use Benchmarks for Pulp and Paper Facilities - Bleached Kraft Mill, Integrated. These are presented in the Table 13-9.

Table 13-9: Effluents and Emissions Guidelines/Resource Use Benchmarks for Pulp and Paper Facilities -Bleached Kraft Mill, Integrated. Source: IFC (2007).

PARAMETERS	UNITS	GUIDELINE
Flow	m^3/ADt	50
pH	-	6-9
TSS	kg/ADt	1.5
COD	kg/ADt	20
BOD	kg/ADt	1
AOX	kg/ADt	0.25
Total N	kg/ADt	0.2
Total P	kg/ADt	0.03

13.4.3.2 Monitoring Equipment, Stations and Frequency

Monitoring should be carried out by an entity approved for regulatory sampling and testing according to the frequency that is stipulated in the NEPA Permit.

13.4.3.3 Management and Mitigation Measures

Once parameters are determined to be non-compliant with the regulatory stipulations or process requirements, corrective actions should be taken to bring the parameters back into compliance. Investigations into the cause(s) of the non-compliance should be done as soon as possible once results are obtained to ensure swift and adequate corrective measures are implemented.

13.4.3.4 Key Performance Indicators

The following KPI's, in Table 13-10, have been selected to evaluate the effectiveness of the water quality management program.

Table 13-10: Water Quality - Key Performance Indicators.

NO.	KEY PERFORMANCE INDICATOR	HOW WILL IT BE MONITORED AND MEASURED	RESPONSIBILITY
1	Sediment traps	Site Inspection	Contractor. Results to be presented to the Implementing Agency
2	Logs indicating when any incidents and when work was halted	Review and inspection of documentation	Contractor. Results to be presented to the Implementing Agency
3	Water Quality Results from a certified lab.	Review and inspection of documentation- certificate results to be presented to NEPA at a prescribed frequency.	Contractor. Results to be presented to the Implementing Agency
4	Spot Checks/ Self Audits	Review and inspection of documentation/ processes	Contractor. Results should be used as preventative measures.

13.4.3.5 Data Analysis and Reporting

All samples collected during the monitoring exercise should be analysed using verified/validated analytical methods at an EHU approved laboratory. The Certificate of Analysis (COA) obtained from the laboratory should contain at least the following information:

i. Sample identification/information and description
ii. Sample collection date and time
iii. Sample submitting information (temperature and condition of sample, time and date of submission)
iv. Analysis date
v. Test results with units of measurement
vi. Test methods
vii. Notes regarding anomalous tests results

viii. Applicable standard
ix. QA/QC documentation
x. Signature of authorized persons

The data obtained from the certificate of analysis will be analysed, taking into consideration statutory requirements and operational standards as well public health and safety. These reports will be prepared by the environmental specialists (internal/ external) and submitted to the EHS Manager who will then review and take necessary actions and report to the relevant regulatory (agencies according to the reporting frequency in their License).

13.4.3.6 Roles and Responsibilities

It is the responsibility of the Contractor to ensure that the management and mitigation measures for water quality are clearly understood by all workers and that they are carried out and relevant monitoring reports are prepared. The Implementing Agency is responsible for monitoring the contractor to ensure that monitoring is being undertaken and mitigation measures are being enforced.

13.4.3.7 Data Analysis and Reporting

If there are any violations, this will be reported immediately to the EHS Manager to allow for management strategies to be changed according to the results.

13.4.4 FLORA AND FAUNA MANAGEMENT PLAN

13.4.4.1 Monitoring Standards

The works will be monitored by the Contractor based on adherence to the NEPA environmental permit.

13.4.4.2 Monitoring Frequency

Monitoring will be carried out by the Contractor (via a qualified environmental specialist) according to the frequency that is stipulated in the NEPA Permit.

13.4.4.3 Management and Mitigation Measures

The Contractor will ensure that the following measures are put in place to manage the flora and fauna in the construction area:

- Efforts should be made to retain some of the larger trees at each site (i.e., with a diameter at breast height (DBH) greater than 25cm). Locations for tree retention should be selected deliberately with trees falling along the boundaries of each plot. Additionally, replanting of trees should be considered along the boundaries of each plot to supplement natural/native vegetation.
- NEPA should be contacted if there is a sighting of any species of concern and this should be fully communicated to all workers. Workers should be properly advised on the presence of species of concerns.
- Where possible, vegetation clearance and construction activities should take place outside of the March to September breeding season for birds. Where construction must proceed during this period, activities that could disturb or destroy nests should be avoided, adapted, rescheduled or relocated.

- Contractors should consider sensitivity/awareness training on local and migrant avifauna to mitigate risks. Additionally:
  - Active nest searching is not recommended as the ability to detect nests is very low while the risk of disturbing or damaging active nests is high
  - If an active nest is encountered during construction activities, all activities should be halted in the nesting area and persons should move away as quickly and quietly as possible. Appropriate setback should be established (species dependent) and a qualified ecologist ecologist/NEPA consulted. If the status of the nest cannot be confirmed, or if a nest is found outside of the breeding season, an appropriate setback distance should be implemented until such time that the nest status can be confirmed.
- Cleared vegetation should be disposed of in a suitable manner. Burning should not be permitted.
- Proper storage and disposal of construction waste and the management of stockpiles to minimize/avoid sedimentation of waterways and surface water bodies at each site should be practiced.

13.4.4.4 Key Performance Indicators

The following KPIs in Table 13-11 have been selected in order to evaluate the effectiveness of the community access.

Table 13-11: Ecology - Key Performance Indicators.

NO.	KEY PERFORMANCE INDICATOR	HOW WILL IT BE MONITORED AND MEASURED	RESPONSIBILITY
1	No major losses of priority species	Review and inspection of documentation	Contractor. Results to be presented to the Implementing Agency
2	Signage	Inspection of the site	Contractor. Results to be presented to the Implementing Agency
3	Number of Training and Awareness sessions	Review and inspection of documentation	Contractor. Results to be presented to the Implementing Agency

13.4.4.5 Roles and Responsibilities

It is the responsibility of the Contractor to ensure all workers are made aware of the importance of following the management and mitigation and that monitoring reports are prepared.

The Implementing Agency is responsible for monitoring the contractor to ensure that monitoring is being undertaken and mitigation measures are being enforced.

13.4.4.6 Data Analysis and Reporting

If there are any violations, this will be reported immediately to the EHS Manager to allow for management strategies to be changed according to the results.

13.4.5 WASTE MANAGEMENT PLAN

The administration and oversight of solid waste management is primarily to be carried out by the EHS Manager. Below is the definition used in the management of solid waste:

Solid (Non-Hazardous) Waste

The International Finance Corporation (IFC) General Environment, Health and Safety (EHS) Guidelines define solid (non-hazardous) waste as generally any garbage refuse including domestic trash, inert construction/demolition materials, refuse such as scrap metal and empty containers. Solid waste that is likely to be generated in this Project will primarily be construction waste (piping material, dirt, old pavement, etc).

Hazardous Material/Waste

The International Finance Corporation (IFC) General Environment, Health and Safety (EHS) Guidelines define hazardous waste as Substances that possess at least one of four characteristics; ignitability, corrosivity, reactivity, or toxicity - or appear on special lists.

The International Finance Corporation (IFC) General Environment, Health and Safety (EHS) Guidelines define hazardous material as materials that represent a risk to human health, property, or the environment due to their physical or chemical characteristics. They can be classified according to the hazard as explosives; compressed gases, including toxic or flammable gases; flammable liquids; flammable solids; oxidizing substances; toxic materials; radioactive material; and corrosive substances.

13.4.5.1 Monitoring Frequency

Monitoring of waste should be done twice per month or as per the frequency with which material is being removed and transported from the site to ensure that all measures are being implemented and followed.

13.4.5.2 Management and Mitigation Measures

To reduce the possible negative impacts of improper waste disposal and management, the EHS Manager or Operations Manager will ensure that during operations, every effort is made to adhere to the following mitigation measures:

- Potential hazardous material should be identified and stored in designated locations, ideally not in the same space as processing or packaging
- All non-hazardous waste generated should be disposed of using approved methods. Waste should only be collected by the NSWMA, or a contractor approved by NSWMA and transported to an approved disposal facility
- Burning or burying of any kind of waste is prohibited
- Any hazardous material, such as waste oil, asbestos-containing material and contaminated soil, should be disposed of via approved contractors in locations approved by NEPA. A special permit for removal and transportation is a requirement of NEPA.

- A schedule for collection of waste and disposal must be developed and must be adhered to throughout the duration of the proposed Project.
- Recycling of compost can be done, where feasible.
- In the event of leaks/spills, they should be cleaned up immediately, NEPA/ODPEM consulted, and the waste disposed of at an approved dump site.
- Portable toilets, if used, must only be transported by approved contractors. NEPA permits may be required.
- Hazardous materials shall be stored in properly bunded areas to contain any leaks, and drip trays shall be in place under all fuel bowsers.
- Workers handling hazardous waste (e.g. chemicals) should be properly equipped with personal, protective equipment (PPE), that is, masks, gloves, hard hats, hard boots, etc.
- Appropriate spill kits must be available in areas of proximity to watercourses and drains.
- All wastewater that is contaminated with hazardous substances shall be collected in a container, allowed to evaporate, and the sludge disposed of as hazardous waste.
- All personnel shall be trained and educated during induction on the safe handling of hazardous substances.
- Sufficient weather and scavenger-proof bins (with lids to prevent the escape of litter) shall be provided and be accessible at all points where waste is generated.
- The proposed Project area should be kept clean and free of litter and no litter from the site shall be allowed to disperse to surrounding areas.
- All personnel shall be instructed to dispose of all wastes in a proper manner.
- During any repair, maintenance or renovation activities, all construction materials should be suitably stored and protected so that they do not become damaged and unusable.

13.4.5.3 Key Performance Indicators

The following KPIs in Table 13-12 have been selected to evaluate the effectiveness of the solid waste management system:

Table 13-12 Waste Management – Key Performance Indicators.

NO.	KEY PERFORMANCE INDICATOR	HOW WILL IT BE MONITORED AND MEASURED	RESPONSIBILITY
1	No waste deposited in the active roadway, waterways, ponds or pedestrian walkways	Location of a storage site away from roadway, waterways, ponds or pedestrian walkways for construction waste	Contractor, EHS Manager. Results to be presented to the Implementing Agency
2	No leakages or spills	Monitor possible spills. Inspection of the site by the Contractor	Contractor, EHS Manager Results to be presented to the Implementing Agency
3	Limited sediment laden run-off during heavy rain	Monitor nearby/downstream wells and water bodies during operation for significant sediment deposits	Contractor, EHS Manager Results to be presented to the Implementing Agency
4	Reuse of waste (construction, organic etc) where possible	Less waste being delivered to the disposal site	Contractor, EHS Manager Results to be presented to the Implementing Agency
5	Approved Contractors	Inspection of licenses and documentation	Contractor. Results to be presented to the Implementing Agency

KPIs will be reviewed occasionally to determine areas for improvement. Specific KPIs will need to be developed for the additional Environmental Management Plans (EMPs).

13.4.5.4 Roles and Responsibilities

The Implementing Agency is responsible for monitoring the selected Contractor or EHS Manager (and team) to ensure that monitoring is being undertaken and mitigation measures are being enforced.

13.4.5.5 Data Analysis and Reporting

If there are any exceedances, these will be reported immediately to the EHS Manager to allow for management strategies to be changed according to the results.

13.4.6 HEALTH AND SAFETY MANAGEMENT PLAN

This section relates to both worker health and safety as well as the general community.

13.4.6.1 Monitoring Frequency

Monitoring will be carried out by the Contractor daily to minimize possible incidents.

13.4.6.2 Management and Mitigation Measures

The Contractor will ensure that the following mitigation measures are followed during construction to reduce the possible negative impacts of workers and surrounding residential areas:

- The Contractor must have a health and safety policy that is known and understood by all workers. It must also be visible to the workers on site.
- Construction areas should be clearly demarcated with safety signs and barriers to prevent possible incidents.
- Workers should be properly equipped with health and safety equipment and trained in the proper use of construction equipment.
- All workers must be trained in the proper use of all health and safety equipment.
- All workers must be trained in the proper handling and management/ disposal of all types of waste.
- The contractor EHS Manager/ Officer shall maintain a register of all EHS related incidents that have occurred as a result of the activities associated with the contract. EHS incidents that should be recorded include fires, accidents, spills of hazardous materials that contaminate soil or water resources, stop-order notices issued by NEPA, the WMC or any other relevant agency, non-compliance with this EMP.
- Each EHS related incident will be investigated by the client's EHS Officer and an incident report forwarded to the contractor. An incident report will be presented within five working days.
- EHS incident reports will include as a minimum, a description of the incident, actions taken to contain any damage to the environment, personnel or the public, and the corrective actions to repair/remediate any damage.
- All construction plant and equipment, tanks and machinery shall be maintained in a good state of repair throughout the construction period
- Equipment maintenance will be carried out on an impermeable surface
- Leakage from equipment will be prevented by regular inspection and repair
- Areas under construction should be clearly demarcated.
- Emergency medical supplies must be available and easily accessible in the case of an incident.
- In the event that the onsite medical supplies are not adequate, the incident needs to be escalated to the hospital.
- If a worker is exposed to hazardous material, they should immediately be taken for medical attention.

13.4.6.3 Key Performance Indicators

The following KPIs in Table 13-13 have been selected to evaluate the effectiveness of the health and safety management system.

Table 13-13: Health and Safety - Key Performance Indicators.

NO.	KEY PERFORMANCE INDICATOR	HOW WILL IT BE MONITORED AND MEASURED	RESPONSIBILITY
1	Health and Safety Policy	Review and inspection of documentation	Contractor. Results to be presented to the Implementing Agency
2	Health and Safety Signs	Inspection of the site	Contractor. Results to be presented to the Implementing Agency
3	Training log and schedule	Review and inspection of documentation	Contractor. Results to be presented to the Implementing Agency
4	Register of all EHS related incidents	Review and inspection of documentation	Contractor. Results to be presented to the Implementing Agency
5	Equipment maintenance log and schedule	Review and inspection of documentation	Contractor. Results to be presented to the Implementing Agency
6	Emergency Kit	Inspection of site office	Contractor. Results to be presented to the Implementing Agency

13.4.6.4 Roles and Responsibilities

It is the responsibility of the Contractor to ensure that the health and safety management policy is clearly understood by all workers and that all mitigation measures are carried out and that monitoring reports are prepared.

It is the responsibility of the workers to ensure that they understand the health and safety requirements and that they abide by them.

The Implementing Agency is responsible for monitoring the contractor to ensure that monitoring is being undertaken and mitigation measures are being enforced.

13.4.6.5 Data Analysis and Reporting

If there are any violations, this will be reported immediately to the EHS Manager to allow for management strategies to be changed according to the results.

13.4.7 EMERGENCY RESPONSE PLAN

13.4.7.1 Monitoring Standards

The works will be monitored by the Contractor.

13.4.7.2 Monitoring Frequency

Monitoring will be carried out by the Contractor monthly.

13.4.7.3 Management and Mitigation Measures

The Contractor will ensure that the following measures are put in place for effective emergency response:

- In the event of a fire- there should be sufficient, available and well-maintained firefighting equipment.

- If the fire is too large, the Jamaica Fire Brigade shall be called to extinguish it.
- In the event of pending heavy rainfall, all equipment should be removed so that it is not damaged.
- Workers should not be allowed to work during periods of heavy rainfall or lightening events.
- First Aid Kits should be readily available at the Construction Site Office.

13.4.7.4 Key Performance Indicators

The following KPIs in Table 13-14 have been selected in order to evaluate the effectiveness of the emergency response measures.

Table 13-14: Emergency Response - Key Performance Indicators.

NO.	KEY PERFORMANCE INDICATOR	HOW WILL IT BE MONITORED AND MEASURED	RESPONSIBILITY
1	Maintenance log	Review and inspection of documentation	Contractor. Results to be presented to the Implementing Agency
2	Incident log	Review and inspection of documentation	Contractor. Results to be presented to the Implementing Agency

13.4.7.5 Roles and Responsibilities

It is the responsibility of the Contractor to ensure that the emergency response measures are clearly understood by all workers and that all management and mitigation measures are carried out and that monitoring reports are prepared.

The Implementing Agency is responsible for monitoring the contractor to ensure that monitoring is being undertaken and mitigation measures are being enforced.

13.4.7.6 Data Analysis and Reporting

If there are any violations, this will be reported immediately to the EHS Manager to allow for management strategies to be changed according to the results.

13.4.8 CONSULTATION PLAN AND GRIEVANCE MECHANISM

The purpose of this section is to outline the measures to be used for stakeholder engagement, dissemination of project information and grievance management.

This strategy is key to facilitate inclusive, two-way communication between the project proponents and the persons who are directly or indirectly impacted by the activities to be undertaken. These include communication with stakeholders who are both internal and external to project implementation.

The plan includes provisions for managing the following:

- Stakeholder mapping
- Consultation plan including time schedule
- Grievance modalities and mitigation procedures

- Reporting

Implementation of this strategy will be the responsibility of the Implementing Agency for the Project, BBP.

13.4.8.1 Consultation Plan

13.4.8.1.1.1 Stakeholder Identification and Analysis

This section presents a summary of the stakeholder identification (see Table 13-15). While some stakeholders may have more critical or direct roles on the project, all stakeholders are considered as participants in the planned implementation of the Project in some capacity. A summary of the implied order of functional involvement is presented by the following ranks:

Medium Interest Stakeholders (MI)

Their roles may be based on a specific administrative mandate and capability/capacity which is a standard engagement for them (e.g. JPS Co.)

Stakeholders with Important Interests (II)

These stakeholders have important information or specific action-based deliverables on which project implementation is contingent. The Stakeholder Consultation process will not qualify as robust if these entities are not consulted.

Critical Stakeholders (CI)

These stakeholders are critical engines of project development both in relation to conceptual planning and actual resource deployment and must be consulted. This list also includes affected parties who will be impacted by this program.

Participatory roles can be characterised as (but not limited to):

- ✓ Implementing Agency
- ✓ Regulatory
- ✓ Facilitating
- ✓ Procurement
- ✓ Affected Communities

Table 13-15: Stakeholder Identification.

STAKEHOLDERS WITH A PARTICIPATORY ROLE IN THE PROJECTS PLANNED IMPLEMENTATION	PARTICIPATORY ROLE	CURRENT INTEREST FOCUS	CURRENT INTEREST RATING
National Environment and Planning Agency	Regulatory	Environmental permits/ licences	**Medium Interest Stakeholders**
Ministry of Science, Energy and Technology	Facilitating	Technology Input	
Bureau of Standards	Regulatory	Standards, technology and training Input	
Jamaica National Heritage Trust	Regulatory	Guidance on changes to sites with key heritage features	
Forestry Department	Facilitating	Forestry Inputs, Protected Area Management	
Environmental Health Unit, The Ministry of Health and Wellness	Facilitating	Health Management	
Jamaica Constabulary Force	Facilitating	Crime and Community Safety Management	
JPS Co.	Facilitating and Procurement	Electricity supply	
National Land Agency	Facilitating	Land ownership and titles	
Independent Lawyers	Procurement and Facilitating	Support land ownership changes	
Sub-contractors	Facilitating & Procurement	The details of the involvement of these subcontractors is yet to be determined. They will perform contracted functions whether on the engineering aspects of the project or the environmental health and safety aspects. Or as to be determined	
Contract workers	Facilitating	These will likely comprise the workforce of the subcontractors	
Equipment suppliers	Procurement	As likely determined by Sub contractors	
Contract Service Providers	Procurement and Facilitating	As likely determined by Sub contractors and Client	

STAKEHOLDERS WITH A PARTICIPATORY ROLE IN THE PROJECTS PLANNED IMPLEMENTATION	PARTICIPATORY ROLE	CURRENT INTEREST FOCUS	CURRENT INTEREST RATING
Stakeholders Influencing the Project			
BBP	Implementing Agency	Overarching	Critical Stakeholders
Ministry of Economic Growth and Job Creation	Facilitation & Planning	Government inputs	
Ministry of Industry, Commerce, Agriculture and Fisheries	Facilitation & Planning	Government inputs	
SJC Holdings	Procurement and Facilitating	Land management	
Municipal Corporations (SJMC, TMC)	Facilitation & Planning	Local Government Inputs – Possible interactions with the Inter-Agency Committee, Parish Disaster Committee, Parish Development Committee	
Jamaica Fire Brigade	Facilitation & Planning	Local Government Inputs – Possible interactions with the Inter-Agency Committee, Parish Disaster Committee, Parish Development Committee	
National Works Agency (NWA)	Procurement	Structural works	
Social Development Commission (SDC)	Facilitating	Social Environment	
National Solid Waste Management Authority (NSWMA)	Procurement & Facilitating	Waste Management	
Facilitators of the Project			
National Water Commission	Facilitating and Procurement	Water supply	Stakeholders with Important Interests
National Land Agency	Facilitating	Land acquisitions and titles	
Water Resources Authority	Regulatory	Licence for well drilling, abstraction and monitoring	
Affected stakeholder			
Communities surrounding the proposed Project site	Surrounding community	Impacts negative or positive	Critical Stakeholders
Community groups/associations	Surrounding community	Impacts negative or positive	

STAKEHOLDERS WITH A PARTICIPATORY ROLE IN THE PROJECTS PLANNED IMPLEMENTATION	PARTICIPATORY ROLE	CURRENT INTEREST FOCUS	CURRENT INTEREST RATING
Environment groups/associations	Surrounding community	Impacts negative or positive	Stakeholders with Important Interests
Stakeholders able to affect project			
Port Authority of Jamaica	Facilitating	Export facility	Critical Stakeholders

Stakeholder Mapping

Table 13-16 presents the mapped stakeholders and the level of engagement needed.

Table 13-16: Stakeholder Mapping.

STAKEHOLDERS	LEVEL OF ENGAGEMENT	PARTICIPATION /NEEDS
Residential stakeholders (primarily those identified in Section 5.3) Commercial/Industrial/Agricultural stakeholders present within the Project Footprint	Consult, Involve, Collaborate	Awareness - messages to inform stakeholder on activities Two-way consultation to guide project understanding, and likely out turns of the EIA and EHSP, also mitigation responses to negative impacts or on beneficial activities Participation ranges across: ✓ Regulatory bodies that provide guidelines to be followed, the requisite permits and monitoring. ✓ Collaboration to ensure relevant agencies and authorities are engaged.
Stakeholders that are involved in the Project's development and planned implementation, irrespective of current interest rating.	Consult, Involve, Collaborate	
Stakeholders who can influence Project Implementation	Consult, Involve, Collaborate	Project understanding, and likely out turns of the EIA and EHSP, also mitigation responses to negative impacts or on beneficial activities
Internal Stakeholders		
Contractor	Transact, Consult, Involve	Training and sensitization on lender requirements for completing contracted work
Servicing company/ companies	Transact, Consult	
Construction and utility work Contractors	Transact, Consult, Involve	

STAKEHOLDERS	LEVEL OF ENGAGEMENT	PARTICIPATION /NEEDS
Services and facilities suppliers	Transact, Consult	Collaboration to ensure two-way communication regarding any issues, mitigation measures or positive impacts
Security agencies	Transact, Consult	Collaboration regarding security issues or breaches.
Media Outlets	Monitor Inform	To inform message for awareness

13.4.8.1.1.2 Consultation Schedule

A schedule has been developed for the consultations intended to facilitate disclosure of information on the Project. It is anticipated that engagement will help to build and maintain over time a constructive relationship with all stakeholders.

Pre-construction Phase

The Table 13-17 illustrates the Project consultation schedule presented for the pre-construction phase of the Project and shows the various types of communication strategies recommended for each type of stakeholder identified.

Table 13-17: Proposed Pre-Construction Consultation Schedule.

PROJECT PHASE	STAKEHOLDER	TIMING	METHOD OF COMMUNICATION
EIA phase	Key implementing Agencies and other interested stakeholders Residents from within communities: **Westmoreland** (Friendship Cross, Hertford, Frome, Barham, Friendship, Petersfield, Amity, Savanna-la-Mar)	At the start of Project- site reconnaissance	Community meetings and rapid interviews with selected stakeholders to gain understanding of the main issues and to introduce them to the Project.
		During the EIA before the Draft Report	Questionnaire survey to introduce stakeholders to the Project, to gain understanding of the general socio-economic setting, and understanding of risk profile.
	Key implementing Agencies and other interested stakeholders Residents from within the above communities Wider communities in Trelawny and St. James	Towards the end of the EIA, after the Draft Final Report has been reviewed and approved by the NEPA.	Public Consultation to present the Project, and its components, the findings of the assessments, to gain feedback and solicit buy-in.

PROJECT PHASE	STAKEHOLDER	TIMING	METHOD OF COMMUNICATION
Post EIA Phase	Key Institutions involved in development and implementation of project: ✓ WMC ✓ MICAF ✓ NWA ✓ NWC ✓ NIC ✓ NEPA	After the submission of the Draft EIA and EHSP.	Focused interviews on their mandate, strengths and weaknesses to determine institutional recommendations. Focused meetings to fully develop Project components and activities
Post EIA Phase	Key institutions may need to be consulted prior to construction to determine permit and approval needs: ✓ NEPA ✓ NWA ✓ WRA ✓ WMC	Once project has been finalised and funding approved	Meetings
Post EIA Phase	All stakeholders identified in Table 13-15		Meetings Media Launch

Construction Phase

Table 13-18 shows the details for communication required during the construction stage. It outlines the communication needs, timing and method for the stakeholders relevant for each management plan.

Table 13-18: Stakeholder Consultations during any construction phase for the Project.

#	PLAN	COMMUNICATION NEEDS	TIMING	METHOD
1	Construction Management Plan/ Occupational Health, Safety and Environment Management Plan (OHSEMP)	Training of employees about health and safety procedures and personal protective gear that need to be worn during construction activities.	Before and periodically during the Works	Sensitisation sessions with contract workers on site. Bulletins - notice board on site as reminders, safety signs.
3	Waste Management Plan	Communication to solid waste collectors to receive and remove solid and hazardous	Prior to the start of construction	Collectors to be advised via letter and telephone conversation.

		waste offsite to appropriate off-site disposal. Communication to workers about the procedures for handling and disposing of solid and hazardous waste material.		Worker sensitisation sessions
4	Traffic Management Plan	Communication to all potentially affected stakeholders	Prior to and periodically during construction	Notices and signs along the affected route

Operations Phase

There may still be the need to communicate with key stakeholders once the construction phase has been completed, particularly those with regulatory obligations relevant to ongoing monitoring.

13.4.8.1.1.3 Reporting

The results of engagement activities conducted throughout the Project will be presented; at the end of each phase/major milestone, the subsequent results will be appended. Engagement activity summaries will include the following information:

- Stakeholder engaged (name and contact details)
- Date and location of meeting (photo if possible)
- Topic of meeting
- Feedback received from stakeholder
- Answers from Implementing Agency
- If the Implementing Agency commits to something, the commitment should be recorded as part of a commitment register identifying a responsible entities/person, and a deadline as appropriate.

13.4.9 GRIEVANCE MECHANISM

A grievance mechanism will have to be in place prior to the start of construction. This mechanism will allow for concerns/ complaints to be received and to facilitate resolutions of the affected individuals. It will require the Project proponent and/or the contractor to respond within a specified time. This mechanism offers the Implementing Agency and the affected communities/ stakeholders an alternative to external dispute resolution processes.

It will be the responsibility of the Implementing Agency to update and modify this procedure or complaint mechanism as the full contours of the final Project are known and agreed.

The grievance process outlined below covers both the construction and operation phase. The Implementing Agency will receive complaints and facilitate resolution of the affected communities' or individual members concerns and grievances about the environmental and/or social performance. The grievance mechanism is scaled to the risks and adverse potential impacts of the Project. It facilitates the prompt address of concerns using an understandable and transparent process that is appropriate based on the Jamaican scenario and readily accessible to all segments of the affected communities.

The mechanism is at no cost and is without retribution. The mechanism will not impede access to judicial or administrative remedies. The Implementing Agency will inform the affected communities about the mechanism during its community engagement process and as appropriate to safeguard the interests of the Project. The recommended approach below is specific to internal stakeholders and external stakeholders.

Internal and External Stakeholders

Both internal and external stakeholders will place any complaint through the mechanism proposed. A temporary office may need to be set up for the Project and as such complaints can be received at this location.

Step 1
The process of accepting grievances is the first step which can take on varying levels of formality as outlined in Table 13-19. The following section outlines the Grievance Collection Form that complainants will first need to complete. Grievance can be recorded at the temporary facility. Grievances can also be logged anonymously based on the nature of the problem.

Table 13-19: Methods for Grievance Receipt, from Least to most formal.

LEVEL OF FORMALIZATION	EXAMPLES
Least formal: Oral complaints received face to face	Staff charged with collection of grievances writes down complaints at group or individual meetings, during field visits, or at designated locations.
Somewhat formalised: Oral complaints received through remote-access methods	Staff accepts grievances through a designated telephone line.
More formalised: Written compaints received face-to-face	Staff accepts written submissions from an individual or a group at groups or individual meetings, during site visits, or at designated locations.
Most formalised: Written complaints recevied through remote access me thods	Complaints come in via regular mail, internet, or grievance collection boxes (consider having multiple locations). Complainants submit written grienvances to third parties (to be forwarded to the company or the thrid party designated to administer the company grievance mechanism

While oral complaints are accepted from both internal and external stakeholders, a grievance collection form provided in the following section should be completed by the stakeholder following oral face to face or remote communication. This form will be made available at the temporary office.

Step 2

The logging of complaints rests with the local Project coordinator. Following the logging of a complaint, the grievance will be addressed. A response must be prepared for the grievant.

Should the grievant not be satisfied with the response provided, they move on to step 3.

Step 3

Grievances that cannot be handled in Step 2 will be taken to the designated authority within Implementing Agency. A further root cause analysis should be done to identify another appropriate corrective action and complete the Grievance Monitoring Form in the following section.

The complainant will then be informed in writing the decision to correct the action within a forty (40) working day period.

Step 4

If the complainant does not feel that the grievance has been adequately addressed, they would go to court if the complainant so desires.

13.4.9.1 Grievance Collection Form

(Used by Stakeholder)

Case No. ______________________________

Applicant's Name ___________________________________

□ I wish to submit complaint anonymously

□ I demand that my personal details not be disclosed without my consent

Address:____

____

Telephone: ______________________________________

Email: ____

Description of Comment/Complaint: *(Subject of case, when did it occur, location, who is involved, effects of situation)*

____

____

____

____

____

Date of Incident: ___________________________________

□ One-time incident/complaint (date______________________)

□ Happened more than once (indicate how many times: ________________________)

□ Ongoing (a currently existing problem)

According to the applicant, what measures would provide solution to the problem?

____

____

____

____

____

____

Signature: ___________________________________

Date: _______________________________________

Note: Please forward this form to: Project Office- Implementing Agency , Jamaica

Telephone: ____________________

Email: _________________________

13.4.9.2 Grievance Monitoring Form

(Used by Grievance Manager)

This Form is the responsibility of the Grievance Officer.

Case No. ______________________________

Applicant's Name ___________________________________

Address:____

____

Telephone: ______________________________________

Email: ____

Complaint

____
____
____
____
____
____

Root Cause Analysis

- List all the possible contributing factors
- Identify most probable reason

____
____
____
____
____

Corrective Action

____
____
____
____
____

Preventative Action if problem can re-occur

____
____
____
____
____

13.4.10 SUMMARY OF MONITORING FREQUENCY

Table 13-20 summarises the monitoring frequency required for each area described previously.

Table 13-20: Summary – Monitoring Frequency for each parameter.

PARAMETER	FREQUENCY
Air Quality	Twice per month or as stipulated by NEPA
Noise	Twice per month or as stipulated by NEPA
Water Quality	Monthly or as stipulated by NEPA
Health and Safety Management	Daily
Flora and Fauna	Weekly
Emergency Response	Monthly
Waste Management	Twice per month

13.4.11 COST ESTIMATES

The estimated costs are currently being developed and may potentially be included in the final report.

13.5 INTRODUCTION OF THE SIMP

The Social Impact Management Plan (SIMP) outlined in this section presents the predictions and potentially planned responses for certain common and specific social impacts that may occur throughout the operations activities of the Project. The following sections are extracted from the complete SIMP Report presented in **Appendix P.** The SIMP will specifically focus on the impact of BBP and the proposed pulp mill on the local economy, education & training opportunities and local social infrastructure as well as on the public perceptions & acceptance of the mill.

13.5.1 OBJECTIVES OF THE SIMP

The purpose of the SIMP is to identify and define the potential roles of BBP, the government and the community in the mitigation and management of social impacts throughout construction and operation of the Project. The SIMP also aims to promote an active and on-going role for communities, local authorities and government throughout the life of the revised Project.

13.5.2 SCOPE AND STRUCTURE OF THE SIMP

The SIMP is required to address the:

- Assignment of accountability and resources;
- Updates on activities and commitments made by BBP;
- Mechanisms to respond to public enquiries and complaints;

- Mechanisms to resolve disputes with stakeholders;
- Periodic evaluation of the effectiveness of community engagement processes;
- Practical mechanisms to monitor and adjust mitigation strategies and action plans; and
- Action plans to implement mitigation strategies and measures.

This section also presents the structure of the SIMP for the proposed Bamboo Market Pulp Mill in Friendship, Westmoreland, extracted from the complete SIMP report in **Appendix P.**

- Impact Identification and Management
- Monitoring and Reporting
- Stakeholder Engagement Strategy
- Complaint Resolution

13.5.3 IDENTIFICATION OF PROPOSED MITIGATION MEASURES AND RELEVANT ENVIRONMENTAL MANAGEMENT PLANS

BBP undertook a comprehensive stakeholder engagement process within the immediate and surrounding to inform the identification of key issues and impacts associated with the Project. Impacts were assessed according to their nature, duration, extent, severity and likelihood. This was used to generate and calculate a significance rating, ranked from low to very high.

An evaluation of the potential impacts was undertaken that considered both the impacts before and after the application of mitigation measures. Each identified impact was assessed according to:

- Project Phase (construction, operation, decommissioning)
- Affected Stakeholder Groups
- Nature of Impact (positive, negative or neutral)
- Consequence
- Probability
- Mitigation and Enhancement Measures

Evaluations were undertaken considering the results of stakeholder consultation, and with consideration of the cumulative impacts that may be experienced in the proposed project area. The results of this evaluation were summarised according to the overall significance of each impact before the application of mitigation measures, as shown in Table 1, and has included both real and perceived issues identified by stakeholders.

Mitigation and management strategies for the key social benefits and impacts identified were developed by BBP. Action plans were developed according to three (3) categories - Education/Training, Local Economy and Social Infrastructure. The Action Plans were also broken down into:

- Impact Management Plan
- Mitigation and Management Activities
- Indicators for Monitoring and Evaluation

13.6 THE SIMP

13.6.1 EDUCATION/TRAINING ACTION PLAN

It was found that most of the survey respondents from the SIA (**Appendix O** and **Appendix P**), at the very least, had a secondary level school education and admitted to undergoing only informal apprenticeships. Although, this can be an effective avenue for training, the ultimate lack of certification does not meet BBP's needs to maintain a uniformed, industry standard of quality at the proposed pulp mill.

BBP has already established plans to broker a partnership between the University of West Indies and the University of Maine, USA to create a 'Center of Excellence' for the industry and an exchange graduate course scheme. Additionally, BBP intends to liaise with academic and training institutions such as The Human Employment and Resource Training Trust/National Service Training Agency (HEART Trust NSTA), regarding partnership opportunities (e.g., summer internships/trainee programmes, additions to curricula, BBP sponsored after-school clubs).

The Impact Management Plan for Education/Training is presented in Table 13-21. The corresponding Mitigation and Management Activities Plan is presented in Table 13-22 and the Indicators that can be used in the monitoring is presented in Table 13-23. All mention of farm sites below refer to farm sites that could potentially be located in the parish of Westmoreland; however, the location of farm sites has not been finalised to date.

Table 13-21: Education/Training Impact Management Plan.

OBJECTIVE	**Enhance employability of the labour force to ensure that mill workers meet world-class industry standards**
Potential impacts/ Outcomes	• Increased community knowledge of areas of work/study which are relevant to the mill's operations • Increased skill level among local labour force • Higher rates of local employment • Increased quality of work • Influx of students (both local and new to LDAs/ farm sites), to educational institutions that are BBP partners • Reduced rate of migration from LDAs and/or farm sites • Increased income earned among locals
Monitoring & Reporting	Monitoring will depend on the submission of reports from BBP HR department and partnering schools concerning the following: • Summer internships/trainee programmes • After-school clubs • The progress of scholarship recipients • The introduction of new modules and/or courses of study at secondary and post-secondary institutions

Table 13-22: Mitigation and Management Activities for Education/Training.

Action	Parties Engaged in Action	Timeframe
Develop a listing of skills and academic qualifications needed from local labour force to work for BBP.	BBP technical team	Q1
Map local academic & vocational skills training institutions in LDAs and farm sites.	BBP Social Development team	Q1
Meet with academic and training institutions regarding partnership opportunities (e.g., summer internships/trainee programmes, additions to curricula, BBP sponsored after-school clubs).	BBP Social Development team Mapped academic and training institutions	Q1
Meet with local secondary schools to advocate for the inclusion of more vocational skills components (i.e., for BBP-related skills), into their curriculum Meet with government stakeholders to advocate for the inclusion of more vocational skills components (i.e., for BBP-related skills), into the national high school curriculum.	BBP Social Development team Representatives from local secondary schools Representatives from the Ministry of Education, Youth and Information (MoEYI)	Q1-Q3
Allocate a portion of the **BBP Community fund** to provide sponsorship for the development of after-school clubs in local high schools which concentrate on imparting certain technical skills.	BBP Social Development team Representatives from local secondary schools	Q2-Q4
Partner with the Montego Bay Community College (MCC) to develop additional courses and/or replicate courses solely taught at the Montego Bay campus that focus on the attainment of knowledge & skills needed by mill. Meet with MCC stakeholders to identify courses for development/ replication based on established criteria such as associated costs, estimated demand among students, level of need for specific skills at BBP and in wider industries. Allocate BBP Community funds to help to offset some of the costs associated with the hiring of new teaching staff; -procurement of programmatic materials needed to facilitate/enhance learning and the provision of scholarships to select students.	BBP Social Development team Representatives from the MCC	Q1-Q3
Develop a BBP scholarship programme to provide full/partial scholarships for BBP-related courses/ degree programmes (e.g., engineering, construction, agriculture etc.) for tertiary/post-secondary students. Allocate a portion of the BBP Community fund to go towards the scholarships Invite other stakeholders (e.g., private and public sector entities), to contribute to the scholarship fund Create criteria with partnering institutions (e.g., level of economic need, academic qualifications, quotas for academic category, disability type, gender etc.)	BBP Social Development team Representatives from local tertiary institutions Potential donors from private and public sectors	Q3-Q6
Develop a BBP internship/trainee programme which allows participants to work at the mill temporarily. Identify clear areas in the mill's operations in which participants could work/be trained. Collaborate with partners (e.g., HEART Trust NSTA), to include the BBP internship as a component in their skills training programmes.	BBP Social Development team BBP heads of departments Local academic institutions Local vocational skills training institutions	Q8-12

Action	Parties Engaged in Action	Timeframe
Partner with academic institutions and youth development stakeholders to promote the programme among students and unattached youth/young adults	Local youth development stakeholders	
Collaborate with local academic institutions to sponsor and implement seasonal child and adult literacy programmes.	BBP Social Development team Local academic institutions	Q5

Table 13-23: Indicators to be used in the monitoring and evaluation of the Education/Training Plan

Outcome	Indicator
Increased skill level among labour force	# of people who have successfully completed BBP-sponsored training programmes % of locals in occupations requiring a medium/high level of skill in a skillset(s) related to BBP operations # of job applications from skilled workers to BBP 5 years following the start of the company's skills training activities
Higher rates of local employment	% of employed residents from LDAs and farm sites
Influx of students to educational institutions that are BBP partners	# of students at partnering educational institutions
Reduced rate of migration from LDAs and/or farm sites	# of residents in LDAs and farm sites
Increased income earned among locals	% of senior management team comprising of local hires in 3 years % of middle management team comprising of local hires in 3 years
Increased community knowledge of areas of work/study which are relevant to the mill's operations	% of students enrolled in relevant degree programmes at local tertiary institutions % of participants enrolled in relevant skills training programmes at local training institutions % of locals in occupations related to BBP operations # of BBP sponsored after-school clubs established # of local secondary schools which include vocational skills components (which are relevant to BBP operations), in curricula

13.6.2 LOCAL ECONOMY ACTION PLAN

Generally, in rural Jamaica, the economic development of many LDAs and farming areas have been stunted for many years, thus having a direct negative economic impact on the lives of locals. The economy in most of these locations is heavily dependent on agriculture. However, the loss in appeal of entering this industry, the national decline of the Sugar Industry and praedial larceny have made a declining industry. Nowadays, most of the LDAs and farming areas have low levels of economic opportunities. There is a possibility that BBP could fill these economic gaps through the pulp mill's employment of locals, partnerships with contracted farmers, and the implementation of technical skills training programmes. The project can add value to the local economy through using local employment, partnerships with individuals through Farmer Contracts and partnerships with business and individuals.

The Impact Management Plan for the Local Economy is presented in Table 13-24Table 13-21. The corresponding Mitigation and Management Activities Plan is presented in Table 13-25 and the Indicators that can be used in the monitoring is presented in Table 13-26.

Table 13-24: The Local Economy Impact Management Plan.

Objective	**Improve local economic prospects through the creation of jobs and business partnerships.**
Potential impacts/ Outcomes	• Increased local employment levels • Increased employment opportunities for diverse population groups • Renewed interest in farming as a viable means of income generation for land-owning locals • Increased formalisation of land ownership

Table 13-25:Potential Mitigation and Management Activities for the Local Economy.

Action	Parties Engaged in Action	Timeframe
Bamboo Farming Contracts		
Create framework for bamboo farming agreement Draft a model contract that sets out mutual expectations of BBP and suppliers that also conforms with local and international requirements for the establishment of bamboo plantations. Amongst other important factors will be treatment of workforce and community.	BBP team	Q1
Promote the opportunity for local farmers to become contracted BBP bamboo suppliers, once all the standards and certifications can be met, among LDAs and farm sites Use traditional and digital media to invite potential suppliers to register online their interest to farm bamboo as a BBP contractor. Partner with key community stakeholders to put on community information sessions (preferably in each LDA), in order to explain what opportunities are available for local contractors, the anticipated timelines, and to invite potential suppliers to express their interest to farm bamboo as a BBP contractor. Include information on the typical services that the constructor is looking to source, the general terms of reference of the contract and any pre-tender requirements. At the end of each contract cycle, search for new contractors via a new round of media promotions and community information sessions. Develop a model for independent bamboo contract farming as cooperatives alongside RADA to help farmers access farming contracts to deliver bamboo to BBP.	BBP team: Media & Communications Officer Community Benevolent Associations Media outlets Rural Agricultural Development Authority (RADA)	Q1-Q4
Increase the capability of locals to become BBP suppliers.	BBP team	Q1-Q2

Action	Parties Engaged in Action	Timeframe
Design and implement a series of free workshops training landowners who have me the required standards, in sustainable, eco-friendly bamboo farming techniques. Evaluations should be held at the end of the training to certify farmers as being ready to formally start bamboo farming for BBP and ensure they are sensitised on how to conform with local and international requirements.	Land-owning residents of LDAs and farm sites. Trainers Certifying bodies	
Recruitment strategies		
Increase employment opportunities for diverse population groups, such as people with disabilities, school leavers and people that were previously unemployed. Map a wide variety of public and civil society stakeholders through which job postings can be advertised to a diverse cross section of the local workforce and arrange with local academic institutions to promote job opportunities among final year students/incumbent university graduates. Partner with educational institutions for the inclusion of BBP related fields within curriculum and degree modules. Partner with social impact groups, community groups and public sector agencies to promote and make job opportunities accessible to vulnerable groups (e.g., persons with disabilities, unattached youth, those who have been unemployed long-term etc.). Advertise current job postings via traditional and digital media (e.g., newspapers, social media etc.).	BBP team - Media & Communications Officer Local academic and vocational training institutions e.g. UWI, MCC, HEART NSTA Community Benevolent Associations Government agencies Media outlets	Q2 – engagement with stakeholder organisations Q8 – mill opening: advertising job listings
Develop and adopt employee management strategies which facilitate the continued support of a diverse workforce and keeps turnover low. Partner with social impact groups, community groups and public sector agencies to assess the needs of each segment of the workforce (e.g., vulnerable populations), and use findings to inform the development of the employee management plans. Ensure mill design provides disability accessible (i.e., the installation of ramps). Allocate space in budget to make workplace more disability accessible (e.g., the training of customer service employees in Jamaican Sign Language, etc.) Develop plans to continue the practice of up-skilling and training staff to progress to new positions.	BBP team Disability organisations (e.g., Combined Disability Association) Community Benevolent Associations Government agencies	Q8
Business Partnerships		
Map businesses in and around the LDAs and at BBP farm sites (once finalised). Register BBP to be part of the Westmoreland Chamber of Commerce to gain access to their extensive network of local enterprises. Liaise with relevant local businesses to propose partnership opportunities.	BBP team WCC Local businesses	Q2-Q6

Table 13-26:Indicators in the monitoring and evaluation of the Local Economy Plan.

Outcome	Indicator	Means of Verification
Increased local employment levels	% of local population employed in each LDA and at BBP farm sites	Reports from the Statistical Institute of Jamaica and/or the Social Development Commission BBP-sponsored surveys
Increased influx of persons from external areas	# of persons hired by BBP who resided in LDAs prior to hiring versus # of those who resided in LDAs upon/after hiring # of persons hired by BBP who commute from outside communities	Employee records
Increased employment opportunities for diverse population groups	% of BBP employees who live with disabilities % of BBP employees which constitute unskilled labour # of unattached youth who became BBP hires after participating in the BBP internship programme	Employee records Employment contracts BBP internship programme certifications
Renewed interest in farming as a viable means of income generation for land-owning locals	# of contracted farmers per contract cycle # of local population working in the agricultural sector	BBP Farming contracts Reports from the Statistical Institute of Jamaica and/or the Social Development Commission BBP-sponsored surveys
Increased formalisation of land ownership	% of contracted farmers who received land titles since the commencement of BBP's partnership with SCHJ	Dated land titles

13.6.3 SOCIAL INFRASTRUCTURE ACTION PLAN

The Social Infrastructure Action Plan was generated by considering factors such as the:

- Traffic and Road Safety
- Medical Services
- Land Acquisition & Involuntary Resettlement
- Water Supply
- Pollution
- Social Nets
- Crime

The Impact Management Plan for the Social Infrastructure is presented in Table 13-27. The corresponding Mitigation and Management Activities Plan is presented in Table 13-28 and the Indicators that can be used in the monitoring is presented in Table 13-26.

Table 13-27: Social Infrastructure Impact Management Plan.

Objective	**Ensure that improved social services are provided so that the needs of the mill and the residents are properly met.**
Potential impacts/ Outcomes	• Improved/more sustainable access to water in targeted communities • Increased access to quality yet affordable housing • Increased levels of health among locals • Reduction in traffic accidents across LDAs • Greater adoption of eco-friendly farming practices among local farmers in conformance with local and international standards and best practices. • Reduced risk of deforestation, flooding etc. due to harmful farming methods • Greater levels of socioeconomic advancement and social inclusion among vulnerable groups • Increased citizen security in LDAs • Increased disaster preparedness • Increased awareness and positive perceptions of BBP among the general public • Increased economic activity along coastal towns

Table 13-28: Mitigation and Management Activities for the Social Infrastructure.

Action	Parties Engaged in Action	Timeframe
Social Nets		
General		
Create a Community Fund in which a certain value of the harvested green bamboo will be allocated for each parish and will be held by BBP. Map and liaise with local development stakeholders to identify partnership opportunities, especially groups which target At-risk children; the elderly; people with disabilities; the economically disadvantaged. Develop a Community Development Fund Framework which includes stakeholder involvement and ownership, along with areas for focus. Create a mechanism to incentivize workers to participate in the delivery of various community outreach interventions spearheaded by partnering organisations or BBP itself.	BBP Social Development team Local community development stakeholders	Q5 - ongoing
Poverty		
Promote the reduction of poverty in local communities. Map organisations which specialize in meeting the needs of the impoverished. Partner with poverty-reduction stakeholders to assess the needs of people living in poverty in LDAs.	BBP Social Development team Local poverty-reduction organisations	Q5 - ongoing
Establish a community-run social enterprise (with branches in each LDAs), which sells bamboo straws and other BBP products and employs members of vulnerable populations. Develop and submit a proposal for the Community Enterprise Model to partners (e.g., HEART Trust NSTA), and key community stakeholders to gain feedback and consensus. Partner with local businesses and academic institutions to design and implement programmes for impoverished persons which focus on financial literacy, entrepreneurial training, job readiness, and job placement.	BBP Social Development team Local stakeholder organisations (including the HEART Trust NSTA, churches and non-profit organisations) Local businesses Local academic institutions	Q5 - ongoing

Action	Parties Engaged in Action	Timeframe
Collaborate with local schools to sponsor and implement child and adult literacy programmes. Donate small conditional and unconditional grants to local non-profit organisations and the outreach ministries of local churches.		
People Living with Disabilities		
Serve the needs of the local disabled population. Map organisations which specialize in meeting the needs of people living with disabilities. Partner with disability stakeholders to assess the needs of people living with disabilities in LDAs.	BBP Social Development team Local disability-related stakeholder organisations	Q5 - ongoing
Promote disability accessibility in the design of the mill via the inclusion of important physical infrastructure (e.g., ramps). Sponsor the delivery of disability accessibility training sessions to BBP staff, and to local schools, local businesses and local government bodies in partnership with the stakeholder agencies. Meet with local government bodies to advocate for increased disability accessibility in local public buildings – also through the installation of certain physical infrastructure.	BBP team Local disability-related stakeholder organisations Local government bodies (e.g., Ministry of Labour and Social Security)	Q1-ongoing
At-risk Children		
Serve the needs of children in local development areas. Partner with academic and child welfare stakeholders to assess the needs of at-risk children in LDAs.	BBP Social Development team Local academic and child welfare stakeholders	Q5 - ongoing
Partner with local schools to sponsor school feeding programmes (e.g., partially sponsoring the PATH programme's delivery at local schools) Make contributions (e.g., cash donations, sweat equity from volunteer BBP construction workers etc.), to local schools towards the maintenance of buildings, and the procurement of equipment and supplies. Sponsor homework assistance programmes carried out by local community centres/outreach organisations (the Source Savanna-La-Mar, the Petersfield branch of the Westmoreland Parish Library etc.).	BBP Social Development team Local schools BBP workers Local community centres/outreach organisations (e.g., the Source, Parish Library etc.)	Q9 - ongoing
The Elderly		
Serve the needs of the local elderly population. Map organisations which specialize in meeting the needs of the elderly. Partner with key stakeholders to assess the needs of the elderly in LDAs and farm sites	BBP Social Development team Local stakeholder organisations that target elderly beneficiaries	Q5 - ongoing
Make donations to local elderly care facilities (e.g., the DCS Nursing Home in Amity) towards the maintenance of buildings, and the procurement of beds and equipment. Create a private pension and health insurance scheme for BBP worker. Advocate on behalf of the elderly populations in LDAs and farm sites to the National Council for Senior Citizens.	BBP Social Development team Local elderly care facilities National Council for Senior Citizens	Q4 - ongoing
Water		

Action	Parties Engaged in Action	Timeframe
Improve community access to water in targeted communities. Partner with the National Water Commission and the WMC to identify problems and develop strategies to improve the sustainability of public water supply services (e.g., fixing/ replacing broken public water facilities)	BBP team National Water Commission Westmoreland Municipal Corporation	Q3-ongoing
Roads		
BBP could help to **implement safety measures which have the power to either reduce or prevent crashes** across LDAs and Farm sites. Develop a Traffic and Road Management Plan Lobby the National Works Agency (NWA), regarding the repair of sections of heavily used roads most in LDAs and farm sites Meet with local police force to advocate for improved road law enforcement measures in LDAs (especially in Friendship) - e.g., the increased presence of traffic control officers in certain areas. Meet with representatives from the National Road Safety Council to discuss the possible scaling of its Motorcycle Outreach to all 6 LDAs.	BBP team National Works Agency Local police force National Road Safety Council	Q3-ongoing
To complement public sector interventions, make contributions from the BBP Community fund towards the maintenance of heavily used sections of roads most in need of repair. These roads are: Petersfield: Shrewsbury and Petersfield main road; Hertford: Hertford main road; Friendship: Friendship main road; Savanna-la-Mar: Great Georges Street and Frome: Frome main road. Partner with the Jamaica Automobile Association (JAA) to increase the opportunities for mill workers to participate in driving lessons. Prior to proposing this to JAA, assess the demand for such an initiative among workers. Offer to partially sponsor the initiative so that lessons can be offered at discounted rates to employees. Sponsor certain aspects of the National Disaster Risk Management programme and recovery efforts for adverse hydrometeorological events (e.g., flooding), which has the potential to damage roads, houses and other property/infrastructure	Westmoreland Municipal Corporation Jamaica Automobile Association Office of Disaster Preparedness and Emergency Management (ODPEM)	Q4 - ongoing
Health		
Help to increase levels of health among local workforce and communities. Partner with local community clinics to assess their infrastructural needs. Register BBP in the Private Sector Vaccine Initiative (PSVI) which will facilitate the company's purchase of vaccines for staff and their dependents Allocate money from the BBP Community fund to help upgrade community clinics with the most pressing needs	BBP Social Development team Local community clinics Representatives of the Private Sector Vaccine Initiative	Q8 - Needs assessment
Housing		
Help to increase access to quality yet affordable housing. Meet with representatives from SCJH to advocate for the expansion of their Community Regularization Programme to all LDAs. Establish a set of criteria to inform the selection process of which employees qualify for BBP housing. Partner with locally-based developers and architects to find ways of designing and constructing affordable but quality houses.	BBP team Representatives from SCJH Housing developers	Q1-ongoing
Pollution		

Action	Parties Engaged in Action	Timeframe
Minimize the risk of fluid waste from the mill contaminating local waterbodies (e.g., local revenue generators like the Cabarita River). Channel fluid waste through to a water treatment plant on a continuous basis in order to recover 85% of the chemicals used. Use residual bamboo waste (e.g., lime sludge) to produce bioproducts (e.g., cementation, road infill, biofuel pellets, particleboard, Syngas, ethanol etc.), onsite.	BBP team Environmental Solutions Limited	Q1-ongoing
Reduce the mill's overall dust emissions. Develop an advanced dust collection system through which dust can be filtered, causing the dust emissions to be kept at a minimum.	BBP team Environmental Solutions Limited	Q1-Q2
Discourage the use of harmful farming practices (e.g., the slash and burn method) by doing the following: Use traditional & digital media and community sensitization sessions to carry out public educational campaigns which highlight the negative economic, environmental and health effects of each practice. Establish a company mandate to refuse the purchase of burnt bamboo from local growers as part of company policy. Ensure all farmers are sensitised on the local and international standards and best practices for farming as well as developing, implementing and monitoring a Farm Management Plan to ensure the FSC Certification remains valid during the operations	BBP team Rural Agricultural Development Authority Bureau of Standards Jamaica Forestry Department	Q3-ongoing
Crime		
Reduce and/or **mitigate the effects of the rising crime rates** in LDAs and farm sites. Meet with local public-sector entities to advocate for the improvement of infrastructure in hot spot/volatile communities in Savanna-la-Mar. Build a strong relationship with the local police in each LDA and farm sites through periodic meetings. Allocate money in BBP budget to establish increased security around BBP Resources in Savanna-la-Mar, Lacovia and Little London. Proving ongoing community engagement strategies to ensure community support for BBP. Contract with a security company to cover security matters related to company personnel, contractors, visitors, farm lands, mill infrastructure and assets.	BBP team Local police force Local public-sector entities (e.g., Ministry of Labour and Social Security)	Q1 - ongoing
Disaster Risk Management		
Ensure that a disaster risk management business continuity plan is developed in accordance with the guidelines of the Office of Disaster Preparedness and Emergency Management (ODPEM). Partner with the Westmoreland Municipal Corporation to sponsor drain cleaning programmes leading up to the rainy season as drainage systems are inadequately maintained leading to flooding during rainy season.	BBP Social Development team Westmoreland Municipal Corporation ODPEM	Q2-ongoing

Table 13-29:Indicators in the monitoring and evaluation of the Social Infrastructure Plan.

Outcome	Indicator	Means of Verification
Improved/more sustainable access to water in targeted communities	# of impaired public water facilities which are fixed/replaced due to BBP's collaboration with NWC	BBP reports
Increased access to quality yet affordable housing	# of BBP housing units leased by workers Level of certification awarded to BBP housing	Lease agreements Quality assessment results and certifications
Increased levels of health among locals	# of pieces of equipment donated by or purchased as a result of BBP # of in each LDA/farm site who have been vaccinated under BBP's collaboration with PSVI	Invoices, receipts and photographs of donated items and money to beneficiary organisations PSVI reports
Reduction in traffic accidents across LDAs and Farm sites	# of accidents on local roads # of new/reformed law enforcement measures implemented in LDAs # of LDAs in which the National Road Safety Council's Motorcycle Outreach was replicated # of motorcyclists in each LDA who have successfully completed the Motorcycle Outreach programme # of BBP employees who receive driver's licenses after the commencement BBP's partnership with the JAA # of BBP-sponsored road repairs	National Road Safety Council reports Jamaica Automobile Association reports and registration documents BBP reports
Greater adoption of eco-friendly farming practices among local farmers	% of chemicals recovered # of bioproducts produced onsite # of attendees at community sensitization sessions	BBP mill operations reports BBP records for community sensitization sessions
Greater levels of socioeconomic advancement and social inclusion among vulnerable groups	*<u>General</u>* # of branches of the community-run social enterprise established # of branches of the community-run social enterprise which have turned profitable within first 3-5 years of operation # of persons who complete BBP-sponsored financial literacy training sessions # of persons who operate a profitable business 3 years after completing BBP-sponsored entrepreneurial training sessions # of persons who are employed within one year of completing the BBP-sponsored job readiness programme # of persons who are successfully matched with jobs via BBP-sponsored job placement programme	*<u>General</u>* Registration certificates for each branch of the community-run social enterprise Financial reports for each branch of the community-run social enterprise BBP reports for financial literacy training programme BBP reports for entrepreneurial training programme BBP reports for job readiness programme BBP reports for job placement programme BBP reports for adult literacy training programme

Outcome	Indicator	Means of Verification
	# of persons who complete BBP-sponsored adult literacy training sessions # of local non-profit organisations and the outreach ministries of local churches who received BBP funding	BBP financial records and contracts regarding the awarding of grants to beneficiary organisations
	Elderly # of pieces of equipment donated by or purchased as a result of BBP # of BBP employees on private pension and health insurance scheme	*Elderly* Invoices, receipts and photographs of donated items and money to beneficiary organisations BBP insurance and pension scheme records
	Children # of students in LDAs/children of employees working on farm sites registered for local BBP-sponsored school feeding programmes # of pieces of equipment donated by or purchased as a result of BBP to local schools $X donated by BBP to local schools # of volunteers from BBP staff worked towards the maintenance of schools # of BBP sponsored homework assistance programmes	*Children* BBP records for school feeding programmes Invoices, receipts and photographs of donated items and money to beneficiary organisations BBP records for sponsored school maintenance projects BBP records for sponsored homework assistance programmes
	Disabled Persons # of infrastructural modifications to design of the mill to facilitate disability accessibility # of BBP-sponsored disability accessibility training sessions # of persons who complete BBP-sponsored disability accessibility training sessions	*Disabled Persons* Architectural plans for design of the mill BBP records for sponsored disability accessibility training sessions
Increases citizen security in LDAs and farm sites	# of meetings held with the local police in each LDA and at farm sites	Minutes from meetings held with the local police in each LDA and at farm sites
Increased disaster preparedness	The production of one Disaster risk management business continuity plan # of completed BBP-sponsored drain cleaning activities	Disaster risk management business continuity plan Site reports
Increased awareness and perceptions of BBP among the public	# of Followers on social media # people attending BBP community events	Official BBP social media analytics

13.7 COMMUNITY INVESTMENT AND PARTNERSHIPS

In order to successfully implement the management plans outlined above, BBP intends to implement a number of key mechanisms or tools, including:

- A Community Investment Fund (The BBP Community Fund) to channel financial resources into the Community
- Key Partnerships with Government Agencies and Non-Government Organisations in the
- local community; and

- On-going provision of a Community Liaison Officer to provide information to the public and deal with stakeholder issues and grievances.

Further information on each of these implementation measures is provided in **Appendix P.**

13.7.1 KEY PARTNERSHIPS

13.7.1.1 Private sector

The private sector should be engaged primarily via BBP's linkages with local businesses; several of which may become suppliers of materials needed in both the construction and operation of the mill, as well as in areas dealing with shipping, fleet management, security etc. Beyond this, the BBP intends to join local private sector bodies such as the Jamaica Chamber of Commerce Westmoreland Chapter, the Jamaica Manufacturing and Exporters Association and the Private Sector Organisation of Jamaica, the umbrella group for private sector in Jamaica.

13.7.1.2 Civil society

One of BBP's goals is to partner with local academic institutions which can feed their graduates into a larger pipeline of local mill workers. The company's social development team has already met with the HEART Trust NSTA to discuss their provision of training opportunities for relevant skill sets required by BBP. They have responded favourably to the project and its implications for the local work force, as they already offer some training in bamboo shoot harvesting, cultivation and pre-processing operations etc. As was previously mentioned, BBP has already established plans to create a 'Center of Excellence' for the industry and an exchange graduate course scheme with the University of West Indies and the University of Maine, USA. The Montego Bay Community College has also expressed a level of openness to BBP's proposal to replicate or develop degree programmes which are relevant to mill operations at their Frome campus. Furthermore, BBP intends to collaborate with academic and training institutions regarding the development of summer internships/trainee programmes, additions to curricula, BBP sponsored after-school clubs etc.

BBP intends to partner with Community Clinics to assess the health needs of the communities as well as to evaluate their own infrastructural needs so that BBP can provide assistance with their upgrade and, ultimately, with the improvement of community health. BBP is also seeking to approach churches, non-profit organisations and community outreach groups (e.g., the Source Savanna-La-Mar), with various opportunities to have a partnership in the provision of needs for local vulnerable populations. Concerning the proposed mill's environmental impact, Environmental Solutions Limited (an established BBP partner), will continue be engaged with regards to the development of systems by which dust from the mill can be filtered and fluid waste can be treated on a continuous basis. On another note, media outlets will be reached out to for the publicization of public education campaigns and job opportunities.

13.7.1.3 Public sector

BBP will seek to form partnerships with various public sector stakeholders, mainly in the interest of ensuring that adequate social services are provided at a high quality so that the needs of the proposed mill and the residents are properly met. The WMC, will be consulted, lobbied and/or partnered with on a variety of issues and activities in the parish including the company's endeavour to sponsor drain cleaning programmes leading up to the rainy season as drainage systems are inadequately maintained leading to flooding during rainy season. To improve community access to water in targeted communities, the company plans to partner with both the NWC and the WMC to identify problems and develop strategies to improve the sustainability of public water supply services (e.g., fixing/ replacing broken public water facilities). Additionally, BBP aims to increase the opportunities for the mill workers to participate in driving lessons through a long-standing collaboration with the JAA, and RADA will be asked to collaborate on the design of BBP's public education campaigns which highlight the negative economic, environmental and health effects of certain farming practices (e.g., 'slash-and-burn').

Plans are also in place to engage other public sector entities, mainly for advocacy needs such as:

i. The NWA. BBP intends to engage the NWA regarding the repair of sections of heavily used roads in communities surrounding the mill and farm sites.

ii. The National Road Safety Council. BBP intends to engage the NWA to encourage them replicate their Motorcycle Outreach in all of the LDAs surrounding the mill site.

iii. SCJH Housing Developers. There is a plan to seek an audience with representatives from the company to advocate for the expansion of their Community Regularization Programme to all LDAs.

iv. The Ministry of Education, Youth and Information will be engaged to advocate for the inclusion of more vocational skills components (i.e., for BBP-related skills), into the national high school curriculum.

v. Finally, the local police force should be continually engaged, so as to form a good relationship with them throughout the mill's development and operation, as well as to advocate for improved road law enforcement measures in LDAs.

13.7.1.4 Dedicated Community Information Office and Liaison Officer

A Community Information Office will be established to facilitate transparent and regular communication with BBP and the surrounding local communities. The office should supply a range of information materials for interested stakeholders. Plans are in place for the Opening hours to be scheduled with consideration to normal working hours, as well as shift work patterns.

The Office is to be staffed by a dedicated Community Liaison Officer, who should be available to deal with stakeholder issues, concerns and suggestions. The Community Liaison Officer is also responsible for documenting community issues, as well as ensuring the satisfactory resolution of issues received through the community grievance mechanism as discussed further in Section 13.4.9.

13.8 MONITORING AND REPORTING

This Section describes the specific measures that will be taken to manage the social performance of the Project. The monitoring, review and reporting mechanisms presented could help to ensure that the SIMP responds appropriately to internal and external changes for the duration of the Project.

13.8.1 MONITORING AND EVALUATION

The monitoring and evaluation of social management measures are necessary to assess how individual programmes are tracking against the overall Project objectives. This will allow BBP to respond to both internal project changes and external community feedback. Robust monitoring and evaluation should allow for the:

- Identification and response to issues at an early stage
- Effective forward planning
- Recording of programme inputs, outputs, outcomes and impacts
- Understanding and justification of whether a programme is meeting initial objectives
- Increased accountability by staff and teams
- Understanding whether community and stakeholder expectations are being met, and
- Increased levels of transparency

Detailed monitoring plans have been outlined for each of the aforementioned action plans. These plans provide a framework for performance targets, data sources, data collection mechanisms and frequency of data collection. The action plans will be reviewed on an annual basis. The key monitoring mechanisms proposed in these action plans are summarised in Table 13-30.

Table 13-30: Summary of Key Monitoring Mechanisms.

Monitoring Mechanism	Data Type	Purpose
Employment records	Quantitative	Monitor employment diversity.
Procurement spend reports	Quantitative	Monitor project spend on goods and services with local and regional providers.
Project safety reporting	Quantitative	Monitor safety incidents and near misses that may impact on workforce health and wellbeing, as well as on the general community.
Training records	Quantitative	Reflect workforce and community participation in education programmes, training, induction and safety sessions.
Environmental monitoring reports	Quantitative	Report on results of dust, noise and air quality monitoring to evaluate potential impacts on amenities.
Community grievance mechanism	Qualitative	Monitor specific community complaints, issues, suggestions and comments regarding the revised Project.
Social Impact Report	Qualitative & quantitative	Quarterly report which reports on the SIMP and its indicators, along with report on Community Fund, Community Enterprise and Community relations. (To include energy & climate targets to be determined).

13.8.2 REPORTING

Communicating the findings of the monitoring process is important for providing key stakeholders with information on how social management activities are progressing. Internally, for BBP, it shows how funds are being used to achieve key objectives. Additionally, the findings generate knowledge of what works, what does not work and why; helping the project team to appropriately manage impacts.

It is planned, that the internal reporting on this SIMP should be undertaken regularly throughout construction and operation, through middle management meetings, community updates and stakeholder reporting. Where appropriate, summary and quarterly reports would also be discussed at Senior Management Team meetings and should be incorporated in the company's annual reports. External reporting during construction and operation should take place through providing a summary of performance and progress via website and social media postings, as well as a regular community newsletter and WhatsApp group broadcasts and in person community and stakeholder update sessions.

Reporting on performance against mitigation and management activities and indicators outlined in the SIMP is required on an annual basis. A reporting template is included in **Section 13.10.** The indicators for each of the objectives will be monitored to assess BBP's progress. The results should be reported to higher management, along with any recommendations regarding necessary changes to the indicators. The results may also be made publicly available. Where adverse effects are identified, any mitigating action(s) should also be reported.

13.9 STAKEHOLDER ENGAGEMENT STRATEGY

This Section provides an overview of the range of stakeholder groups that may be affected by or interested in the Project. It also outlines the specific mechanisms that will be used to ensure that stakeholders continue to be involved throughout the life of the Project.

13.9.1 ENGAGEMENT PRINCIPLES AND STRATEGY

BBP will seek to involve the community during the planning, construction, operation and decommissioning of the proposed mil. BBP will seek to engage with stakeholders via a diverse set of mechanisms (e.g., in-person or digital public forums, direct contact with past survey respondents, small meetings with community groups/organisations, the BBP website & social media pages etc.), and give transparent and consistent reports on the mill's development progress, activities and, ultimately, its economic and social impact (according to pre-established Key Performance Indicators).

The implementation of stakeholder engagement was in general guided by IFC Performance Standard 1 Requirements: Assessment and Management of Social Risks, Impacts and Opportunities.

13.9.2 STAKEHOLDER ENGAGEMENT MECHANISMS

Table 13-31 presents the range of engagement mechanisms that will be used in the project. The stakeholder engagement strategy should be reviewed and revised internally on an ongoing basis.

Table 13-31: Key Stakeholder Engagement Mechanisms.

Stakeholder Group	Primary Interest	Engagement Mechanisms
Community	Local Labour Market Training opportunities Farming Contracts Social infrastructure Crime	BBP website BBP social media BBP WhatsApp group BBP newsletter Community stakeholder meetings
Local Government	Local Labour Market Training opportunities Farming Contracts Social infrastructure Crime	Government stakeholder meetings Community stakeholder meeting
Business owners	Local Labour Market Training opportunities Social infrastructure Crime	Private sector stakeholder meetings
Land owners (potential suppliers)	Farming Contracts	BBP website Direct outreach BBP WhatsApp Group BBP newsletter Community stakeholder meetings
Agricultural Stakeholders	Farming Contracts Social infrastructure	BBP Website BBP Newsletter BBP WhatsApp Group Agricultural Stakeholder meetings Direct outreach

13.9.3 COMMUNITY ENGAGEMENT EVALUATION

Continually monitoring and evaluating the effectiveness of the communication and engagement programme with the local stakeholders are necessary to ensure that the impacts and concerns raised are considered and acted upon, where appropriate. The communication and engagement programme will be reviewed on an annual basis. See Section 13.10.1 for the Instructions on Completing the Annual Monitoring Reports.

13.9.4 EVALUATION METHODS

The range of methods that will be used to evaluate the effectiveness of the engagement programme with local stakeholders include:

i. **Database records:** Database records with an analysis of feedback forms submitted, website hits, telephone calls, incoming emails, tone of enquiries and key issues raised.

ii. **Benchmarking activities:** Benchmarking activities will be undertaken using questions on any feedback forms and activities to determine changes in local community attitude, knowledge and behaviours.

iii. **Informal feedback:** All significant informal feedback received from local stakeholders regarding consultation activities will be recorded in the revised Project database and reported and analysed.

iv. **Observations:** Team members will record their observations during local stakeholder engagement activities. These observations will detail what happened during the activity, who was involved and how they reacted. Team members will also record 'stand out moments' and quotes.

v. **Media analysis:** Analysis of negative versus positive media coverage.

13.9.5 EVALUATION CRITERIA

The evaluation criteria for each objective are identified in Table 13-32.

Table 13-32: Evaluation Criteria for Community Engagement.

Objective	Method of evaluation	Key indicators
1. Inform the local stakeholders about revised Project benefits and opportunities	Database records Benchmarking activities Informal feedback Observations	Level of local stakeholder awareness of the revised Project Information disseminated as per this strategy
2. Provide open, honest and timely communication with local stakeholders	Database records Benchmarking activities Informal feedback	Amount of communication with local stakeholders and its effectiveness Local stakeholders' satisfaction levels with the revised Project communication Response times to local stakeholder enquiries
3. Engage local stakeholders to capture their views and ensure they are understood by the Project team and considered in decision making where possible	Database records Benchmarking activities Informal feedback Observations	Amount of feedback received and how it has been acted upon How and if local stakeholder feedback is successfully communicated to the revised Project team
4. Ensure early identification of potential local stakeholder issues and implementation of appropriate mitigation strategies	Database records Benchmarking activities Observations	How feedback has been acted upon How local stakeholders have influenced Project decisions and mitigation measures

13.9.6 ADJUSTING MITIGATION STRATEGIES AND ACTION PLANS

The community engagement feedback should be used to monitor the effectiveness of the Project's mitigation strategies and action plans. If feedback indicates a need to adjust the mitigation strategies and action plans the following process will be followed:

- Community feedback on the mitigation measure will be reviewed further to better understand the issue;

- The feedback will be investigated further through discussions with stakeholders, community members, government agencies and other groups, field investigations, further technical monitoring or data collection as required; and
- Following the investigation, recommendations will be made to BBP regarding the appropriate course of action. If necessary, action plans will be updated as needed and communicated to the relevant BBP staff for implementation.

13.10 COMPLAINT RESOLUTION

To facilitate open communication and active complaint resolution, it is important that local stakeholders are able to raise issues and complaints in a formal way. Local stakeholders can raise issues and concerns relating to the project with the dedicated Community Liaison Officer. The Community Liaison Officer should be available to receive complaints and could be contacted either in person at the Community Information Centre, by email or telephone. The Community Liaison Officer should ensure that all issues are conveyed to the appropriate divisions of BBP, including management, in the event an issue relates to operational issues.

The following are key principles that should be adhered to by BBP in responding to issues or concerns raised by local stakeholders:

- **Timeliness** – complaints will be dealt with in a timely and efficient manner;
- **Sensitivity** – ensure that both parties feelings and perspectives are respected;
- **Fairness and Impartiality** – both parties will be afforded substantive and procedural fairness in the resolution process; and
- **Confidentiality** – only parties directly involved in the complaint or those involved in decision making about outcomes will have access to information about the complaint.

13.10.1 INSTRUCTIONS FOR COMPLETING ANNUAL MONITORING REPORTS

The following outlines a template for completing annual monitoring reports.

Template Preparation

Enter the reporting year on the front page and in any other themes stating „[Year]".
Wherever possible, it is recommended that the annual reports build on previous years reports, particularly with regard to indicators to enable tracking over time. Therefore, it is recommended that new columns are added in the indicator data tables with additional data added annually.

Results Summary

Summarise, at the highest level, the key achievements, challenges and any other detail that BBP wishes to highlight across the year.
In particular, it is recommended that BBP provides details on actions that cut across multiple themes e.g. the Stakeholder Engagement Plan, the Road and Traffic Management Plan, the Community Fund, the Community Enterprise et al.

Mitigation and Management Actions - Progress Summary

Enter a summary of progress with expected completion date and next steps, including noting whether the action is:

- Scheduled
- In progress
- Complete, or
- Overdue

If additional management actions are initiated during the year enter these at the bottom of the table.

Indicators

- Data [Year] - Enter data available for each indicator. Where data is not available, state as such with a reason and anticipated first year in which the data will be reported.
- Comment - Detail notes of trends and causes where material changes are seen (if known).
- If additional indicators are identified during the year enter these at the bottom of the table.

Summary

Discussion - Detail the key achievements, challenges and any other information you wish to highlight across the year for each theme.

Compliance - Provide summary results of relevant compliance activities that are reported through other mechanisms and that relate to the theme.

14 CONCLUSION

Bamboo Bioproducts Limited (BBP) proposes to construct the first, world-class, non-integrated Bleached Kraft Pulp Mill in Friendship, Westmoreland. In conducting the environmental and social assessment of this proposed mill, it is our professional opinion, that based on the information provided, the mill will have minimal to moderate impact on the surrounding physical environment and a positive impact on the social environment once mitigation measures have been successfully implemented.

Some key positive impacts identified in an assessment of the Project included:

i. Economic upliftment and rural development,
ii. Improvement in social services/infrastructure in rural areas, and
iii. Carbon sequestration.

However, potentially negative impacts and risks were identified with their corresponding mitigative measures addressed in the report. Some of these included:

1. **Significant impacts identified during the construction**
    - Internal migration and population growth
    - Employment opportunities
    - Squatting

2. **Significant impacts identified during operations**
    - Severe weather
    - Wastewater
    - Air emissions
    - Traffic
    - Social infrastructure
    - Community development
    - The potential impact of the *Bambusa vulgaris* on biodiversity
    - The potential impact of the mill's use of the Cabarita River on its water quality and usage downstream from the proposed mill.

Additional assessments such as a Hydrology Assessment and Air Dispersion Modelling Assessment indicated that the water requirements and potential emissions would comply with the water resource availability and local regulations respectively. The Climate Vulnerability and Risk Assessment presented the climate-related hazards that could affect the project site and the surrounding communities. Pluvial flooding, storm surge and hurricanes/tropical storms posed the highest risk to these areas. Several risks were identified during the construction and operation phases of the project. The only risk identified with the highest residual risk, after the implementation of mitigative/risk control measures recommended, was severe weather halting project activities.

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APPENDICES

Appendix ATerms of Reference

TERMS OF REFERENCE for an ENVIRONMENTAL IMPACT ASSESSMENT for the

PROPOSED BAMBOO MARKET PULP MILL in Friendship, Westmoreland

By

Bamboo Bioproducts Limited

APPLICATION SECRETARIAT BRANCH
08 2022
NEPA

Prepared by:	**The National Environment and Planning Agency**
Date submitted:	December 14, 2021
Revision 1:	December 24, 2021
Revision 2:	March 25, 2022
Revision 3:	November 25, 2022

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Environmental Impact Assessment Report for the construction and operation of Proposed Bamboo Market Pulp Mill in Friendship, Westmoreland by Bamboo Bioproducts International LLC.

The Technical Report should include but not be limited to the following:

1) Executive Summary
2) Introduction
3) Policy, Legislation and Regulatory Consideration
4) Methodology and Approach
5) Project Description
6) Description of the Environment
7) Public Participation
8) Impact Identification and Analysis
9) Mitigation
10) Risk Assessment
11) Identification and Analysis of Alternatives
12) Environmental Management and Monitoring Plan
13) Conclusion and Recommendations
14) List of References
15) Appendices

The purpose of this document is to establish the Terms of Reference (TOR) for the Environmental Impact Assessment (EIA) for Bamboo Bioproducts International LLC. An EIA seeks to identify the impacts the proposed project is likely to have on the area and community in which the physical development will be carried out as well as the impact of the environment on the proposed development. It also outlines mitigation measures necessary to reduce the negative impacts of the project. The EIA will be prepared using a participatory approach involving key stakeholders. This TOR is specific to works that is to be conducted within the terrestrial environment.

The EIA report must be produced in accordance with the agreed TOR issued by the National Environment and Planning Agency (NEPA) to Bamboo Bioproducts International LLC.

Where the need arises to modify the TOR, the required amendments/modifications are to be made and submitted to the Agency. Approval for the TOR must be obtained from the Agency, in writing, prior to the commencement of the EIA study.

The National Environment and Planning Agency and the Natural Resources Conservation Authority (NRCA) reserves the right to reproduce, transfer and disclose any and all contents contained in the submitted environmental impact assessment report without the written consent of the proponent, consultants and/or its agents.

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The Terms of Reference to conduct the Environmental Impact Assessment (EIA) are as follows:

Executive Summary

Provide a brief statement on the content of the EIA report. The executive summary should provide a comprehensive overview and objectives of the project proposal, natural resources, justification for the project, etc. In addition, it should include relevant background information and provide a summary of the main findings, including but not limited to main impacts and mitigation measures, analyses and conclusions in the report.

INTRODUCTION

The introduction should provide a background and seek to explain the need for and the context of the project and the EIA. It should also provide the delineation and justification of the boundary of the study area, general methodology, assumptions and constraints of the study. Additionally, a profile of the project proponent, implementing organization, project consultants, etc. should also be provided. The study area shall include at least the area within a 2 km radius of the boundaries of the proposed project area, except for air dispersion models which require up to 10km radius.

POLICY, LEGISLATION AND REGULATORY CONSIDERATION

This section should provide details of the pertinent regulations, standards, policies and legislations governing environmental quality, safety and health, cultural significant finds, protection of sensitive areas, protection of endangered species, siting and land use control at the local and national levels. The examination of the legislation should include at a minimum the Natural Resources Conservation Authority Act 1991; Natural Resources Conservation Regulations 1996, amended 2015; Natural Resources Conservation (Wastewater and Sludge) Regulations, 2013; Wild Life Protection Act; the Town and Country Planning Act 1957; National Solid Waste Management Authority Act; The Water Resources Act; Jamaica National Heritage Trust Act; Building Act and Codes and Standards promulgated there under, Town and Country Planning (Westmoreland) Provisional Development Order, 2018; Natural Resources Conservation Authority & Town and Country Planning Authority Guidelines for Developing a Natural Gas Sector Regulatory Framework 2015; The Public Health Act; Planning Guidelines, and **all** appropriate international convention/protocol/treaty where applicable. Describe traditional land use and advise of any prescriptive rights including public access rights.

METHODOLOGY & APPROACH

Clearly outline the methodologies and approaches in conducting the study including collecting and analyzing data, stakeholder consultation, dates on which surveys were conducted etc. ***The study area shall include at least the area within a 2 km radius of the boundaries of the proposed project area, except for air dispersion models which require up to 10km radius.*** *Additionally,* ***data should be collected in both the wet and dry seasons.***

PROJECT DESCRIPTION

This section should provide a comprehensive description of the overall project concept and specify the different components. It should include the following:

- History and background of the project
- A location map at a scale of 1:12,500 (or an appropriate scale)
- A detailed site survey at a scale of 1:12,500 showing all existing buildings, structures and ground levels (above Ordinance datum)
- The total area of the site
- Existing site and its characteristics
- Description of the surrounding areas
- Site maps illustrating areas to be impacted and areas to be preserved in their existing state.
- A master site layout plan showing the various components and design elements of the proposed development
- A comprehensive description of all components and the various design elements of the project inclusive of project objectives and phases (where applicable), all applicable timelines for the various aspects of the project (from pre to post development). The description should also provide details of the design concept, design components, material(s) to be used, designated parking areas, total number and design of access (ingress/egress points) to the development from the main road; setbacks (from property boundaries, main road etc.), safety and security and supporting services. This should be supported using maps, schematic plans, diagrams and other visual aids where appropriate.
- Details of proposed access(es) to the site to be used for pre-construction, construction and operational phases
- Details on infrastructure development including design plans for all components of the development including the proposed wastewater/sewage treatment system and disposal of treated effluent must be clearly outlined.
- Details of a scheme for firefighting and emergency operations including:
    - Active protection (such as fire detection systems, sprinkler systems, automatic smoke extraction systems, etc.)
    - Passive protection (the nature construction material used)
    - The means of escape
    - Emergency lighting and warning signs
    - Evacuation
    - Dedicated Emergency access ways for the fire fighting and emergency.
- A comprehensive drainage assessment. This assessment should take into consideration existing natural drainage channels, proposed man-made drainage/water features or any proposed changes in topography. Potential issues of increased surface runoff and sediment loading must also be addressed. Special emphasis should also be placed on the stormwater run-off, drainage patterns, characteristics of the aquifer, including the level and status of the groundwater.

In addition, plans for providing utilities, particularly details relating to the source of potable water and electricity generation, roads and other services should be clearly stated.

- A Waste Management Plan which clearly outlines expected types and quantities of construction waste during the construction phase, general waste arising from material consumption of the workforce, as well as, the expected waste during the operational phase should be completed. Details should also be provided for any central disposal area(s) being considered to serve the proposed development
- Details of equipment and machinery to be involved in the project, how these will be mobilized and areas to be used for storage of machinery and material should be clearly indicated.
- Details of workforce, including proposals for mobilization and accommodation should be indicated.
- All phases of the project should be clearly defined, the relevant time schedules provided, and phased maps, diagrams and appropriate visual aids included in the Environmental Impact Assessment Report.
- The study area should be clearly delineated and referenced. Taking into account the types of resources located in the area and the magnitude of the associated impacts, the study area should be large enough to include all valued resources that might be significantly affected by the project.

Details of any required decommissioning of the works and/or facilities.

Specific consideration must be given to:

- ***Details of the species of bamboo to be planted***
- ***Source of the planting material to be used in the cultivation***
- ***Details of proposed collection, treatment and disposal or reuse of any wastewater (trade effluent) to be generated by the operation of the facility***
- ***Details of the source and volume of water required***
- ***Plan for the control and management against the spread of the invasive alien species. The plan should contain site specific control measures.***

DESCRIPTION OF THE ENVIRONMENT

A survey of the proposed development site should be conducted; taking into account the types of resources located in this area and the magnitude of the associated impacts. The study area should be large enough to include all valued resources that might be significantly affected by the project. The study area should be clearly delineated and referenced and the survey should be conducted for both the wet and dry seasons. This information will form the basis upon which impacts of the project will be assessed. The following aspects should be described in this section:

Physical Environment

This section should provide a complete description of the study area including geographical boundaries and methodologies used for the collection of data. The description should include the following aspects of the environment:

- Topography, soil type, climate, drainage, geology (including but not limited to seismicity and faults), geomorphology of the site and hazard vulnerability including impacts on current landscape, aesthetic appeal and hydrology should be examined. Special emphasis should be placed on stormwater runoff, drainage patterns. Percolation tests should also be conducted within the proposed study area.

- Water quality for any surface water feature in the vicinity of the development. Quality Indicators should include but not be limited to Nitrate, Phosphate, Faecal Coliform, Salinity and Total Suspended Solids.
- Description of air quality including the results of an Air Dispersion Model to be conducted for the proposed project and its cumulative impact. All Air Dispersion Models should be developed in accordance with the guidance provided in the NRCA (Air Quality) guideline document.
- All ambient air quality monitoring shall be conducted in accordance with the Natural Resources Conservation Authority (Air Quality) Regulations, 2006 and the NRCA (Air Quality) guideline document.
- Detailed hydrological assessment to include specific references to discharge, exceedance values and estimation of peak flows under the 10-, 25-, 50- and 100-year return periods. Models to be included to demonstrate impact of the proposed development on the hydrological regime of the river.
- Climatic conditions and air quality in the area of influence including particulates
- Noise levels of the existing site and the ambient noise in the area of influence.
- Sources of existing pollution and extent of contamination.
- Availability of solid waste management facilities.
- Surrounding land uses.

Biological Environment

Description of terrestrial habitats, existing vegetation, flora and fauna surveys inclusive of a species list; commentary on the ecological health, function and value in the project area, threats and conservation significance. This should include:

- A detailed qualitative and quantitative assessment of terrestrial habitats in and around the proposed project sites and the areas of impact. This must also include flora and fauna surveys and should include species lists.
- A species list should be generated with special emphasis placed on rare, endemic, threatened, protected, endangered, invasive and economically or nationally important species. Migratory species should also be considered. There may be the need to incorporate micro-organisms to obtain an accurate assessment. Identification and description of the different ecosystem types and structure including species dominance, species dependence, habitats/niche specificity, community structure and diversity, possible biological loss or habitat fragmentation ought to be considered. The assessment must be done according to internationally (scientific) acceptable standards and the provision of photographic inventory is preferred.

  The field data collected should include, but not be limited to:
  - Vegetation profile
  - Species lists must be provided for each community
  - A habitat map of the area
- A detailed assessment of the riverine system including ecology, minimum ecological flow, socioeconomic activities, etc. extending downstream to the entrance to the marine environment.
- Water quality indicators to include an assessment of macroinvertebrates.

- An assessment of fish species and populations.

Natural Hazards

A risk assessment of the development in relation to the following must be undertaken

1. Tropical Storms, Hurricanes, Earthquakes
2. Natural hazard risk assessment should take in account climate change projections.

Heritage

An assessment of artifacts, archaeological, and cultural features of the site should be undertaken. Where there is a need, this should be conducted in collaboration with the Jamaica National Heritage Trust.

Socio-economic Environment

This section should provide details on the demography, regional setting, location assessment, current and potential land-use patterns (of neighbouring properties); description of existing infrastructure such as should be explored; and other material assets of the area. There should also be an assessment of the present and proposed uses of the site and surrounding areas including any land acquisition needs, any prescriptive or public access rights, and impacts on current users of the area during and post development. Effects on socio-economic status such as changes to public access and recreational use, impacts on existing and potential economic activities, public perception, contribution of development to national economy and development of surrounding communities.

A socio-economic survey to determine public perception of the project (both negative and positive) should also be completed and this should include but not be limited to potential impacts on social, aesthetic and historical/cultural values. This assessment may vary with community structure and may take multiple forms such as public meetings or questionnaires. The methodology for conducting the survey should be included as the EIA report.

PUBLIC PARTICIPATION

This section should detail the results public perception surveys conducted. It should summarize the issues identified during the public participation process and how these have been addressed or incorporated in the Environmental Impact Assessment Report.

It should describe the public participation methods, timing, type of information provided and collected from public and stakeholder target groups. The sampling methodology employed must be appropriate for the population size and distribution, and must be weighted towards the communities/interest groups in closest proximity to the proposed development. The instrument used to collect the information must be included in the appendix. Stakeholder meetings should also be held to inform the public of the proposed development and the possible impacts and gauge the feeling/response of the public toward the development.

The issues identified during the public participation process should be summarized and public input that has been incorporated or addressed in the EIA should be outlined.

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Public Meeting(s) should be held in accordance with the Guidelines for Conducting Public Presentation at a time and location signed off by the National Environment and Planning Agency (NEPA). A public meeting will be held to present the findings of the EIA once completed and submitted for consideration. All relevant documents are required to be made available to the public. In addition, any material change to the design of the project will require a further public meeting to be undertaken by the developer and all changes made to the document and project should be clearly outlined to the public.

IMPACT IDENTIFICATION AND ANALYSIS

A detailed analysis of the project components should be done in order to identify major potential environmental, health and safety impacts of the project. This section shall seek to distinguish between levels of impact, significance of impact (a ranking from major to minor/significant to insignificant should be developed), positive and negative impacts, duration of impacts (long term or short term or immediate), direct and indirect and impacts, reversible or irreversible impacts, long term and immediate impacts and identify avoidable impacts.

Cumulative impacts should also be evaluated taking into account previous developments and any proposed development immediately adjacent to the subject development. The major concerns surrounding environmental, health, and safety issues should be noted and their relative importance to the design and implementation of the project indicated.

The extent and quality of the available data should be characterized, explaining significant information deficiencies and any uncertainties associated with the predictions of impacts. A major environmental issue is determined after examining the impact (positive and negative) on the environment and having the negative impact significantly outweigh the positive. It is also determined by the number and magnitude of mitigation strategies which need to be employed to reduce the risk(s) introduced to the environment. Project activities and impacts should then be ranked as major, moderate or minor, and presented in separate matrices for all the phases of the project (i.e. preconstruction, construction, operational, and decommissioning/closure). The potential impacts may be subdivided into Physical Impacts, Biological Impacts and Socio-economic and Cultural Impacts.

All impacts should be listed, ranked and assessed, preferably in a single table.
The impacts to be assessed should include but not be limited to the following:

Physical Environment

- Impacts of construction activities such as site clearance, earthworks, geotechnical and engineering requirements and spoil disposal.
- Impacts of spills (such as oil and chemical spills)
- Impacts on Air Quality inclusive of malodours
- Impacts on Water Quality (pollution of potable, coastal, surface and ground water)
- Impacts on/of Climate Change
- Demands/requirements of the following must be quantified
  - Water Supply

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- Sewage Treatment and Disposal - Empirical data must be provided to show that the proposed sewage treatment facility has the capacity to remove the nutrients to meet the National Sewage Effluent Standards;
- Wastewater Disposal
- Trade Effluent Discharges
- Solid Waste Disposal
- Electrical Power (fossil fuels, wind, sun)
- Communications and other utility requirements
- Transport Systems and supporting infrastructure required

- Operation and maintenance – waste disposal, site drainage, sewage treatment and disposal solution, and air quality;
- Impacts on visual aesthetics and landscape
- Noise
- Change in drainage pattern

Biological Environment

This should include an assessment of the direct and indirect impacts of the project on the ecology of the terrestrial and aquatic environments with emphasis being placed on rare, endemic, threatened, protected, endangered, invasive, and economically important species found. This should include habitat loss and fragmentation, loss of species and natural features due to construction and operation, and the impact of noise and vibration on fauna.

Natural Hazards

Potential impact of natural hazards (including hurricanes and earthquakes) and flooding potential.

Heritage

Loss of and damage to artifacts, archaeological, geological and paleontological features. An assessment of artifacts, archaeological, geological, paleontological and cultural features should be undertaken. Where there is a need, this should be conducted in collaboration with the Jamaica National Heritage Trust.

Socio-economic Environment

This should include effects on socio-economic status including changes in resource use, public access and recreational use; impacts on existing and potential economic activities; public perception; and the contribution of development to the national economy and development of surrounding communities. Socio-economic and cultural impacts to include land use/resource effects.

Specific consideration must be given to the impact of the construction of the pulp mill.

MITIGATION

This section should provide mitigation measures which should endeavor to avoid, reduce or remedy the potential negative impacts identified, while enhancing the positive impacts identified. Mitigation and abatement measures should be developed for each potential negative impact identified. Full details of the methods proposed to be employed in the implementation of these measures should be provided, including details on the scheduling/timelines, source of materials, location and responsible parties, where appropriate. Maps and diagrams should also be used to illustrate areas where mitigation measures are proposed to be implemented.

RISK ASSESSMENT

This section should include an assessment of the risks associated with introduction of the specific species and the suitability for introduction.

IDENTIFICATION AND ANAYSIS OF ALTERNATIVES

Alternatives to the proposed development or specific components and the potential environmental consequences of each proposed alternative, including the no-action alternative should be examined. These should be assessed according to the physical, ecological and socio-economic parameters of the site including the effects of climate change.

Specific consideration should be given to:

- ***Location of bamboo plantations/farms***
- ***Sources of bamboo (input material)***
- ***Disposal of wastewater generated***
- ***Source of water for operation***
- ***Transportation of input materials***

ENVIRONMENTAL MANAGEMENT AND MONITORING

Environmental Management Plan

An Environmental Management Plan should be developed which will detail the requirements for the construction and operational phases of the project. This should include, but not be limited to the requirements for operational activities, training and other recommendations to ensure that the implementation of mitigation measures and long-term minimization of negative impacts.

Environmental Monitoring Plan

A draft Environmental Monitoring Plan should be included in the EIA. At the minimum the draft monitoring plan should include:

i. The locations selected for monitoring
ii. The mitigation measures to be implemented and the parameters and activities which will be monitored for each activity
iii. The proposed methodology to be employed for the monitoring of the various parameters and the frequency of the monitoring
iv. The proposed format that the monitoring reports should take
v. The frequency of the submission of the monitoring reports
vi. The responsible parties for the monitoring
vii. Details for special monitoring of birds and/or other protected species during and after the proposed works if required.

Specific consideration must be given to:

- ***Details of any proposed training programme to be implemented for farmers***
- ***Details of proposed monitoring programme to ensure there is no spread of the bamboo from cultivation***

Conclusion and Recommendations

List of References

Appendices

The appendices should include but not be limited to the following documents:

i. Reference documents
ii. Photographs/ maps
iii. Data Tables
iv. Glossary of Technical Terms used
v. Final Terms of Reference
vi. Profile of the project proponent and implementing organization
vii. Composition of the consulting team, team that undertook the study/assessment, including name, qualification and roles of team members
viii. Notes of Public Consultation sessions
ix. Instruments used in community surveys

All findings must be presented in the EIA report and must reflect the headings in the body of the TORs, as well as references. GIS references should be provided where applicable. One hard copy and an electronic copy must be submitted to NEPA for review after which the Agency will indicate the number of hard copies along with an electronic copy of the report to be submitted. One copy of the document should be perfect bound.

The report should include appendices with items such as maps, site plans, proposed streetscapes, the study team and their individual qualifications, photographs, and other relevant information. All of the foregoing should be properly sourced and credited

Appendix B Environmental Permit and Licence Applications Process

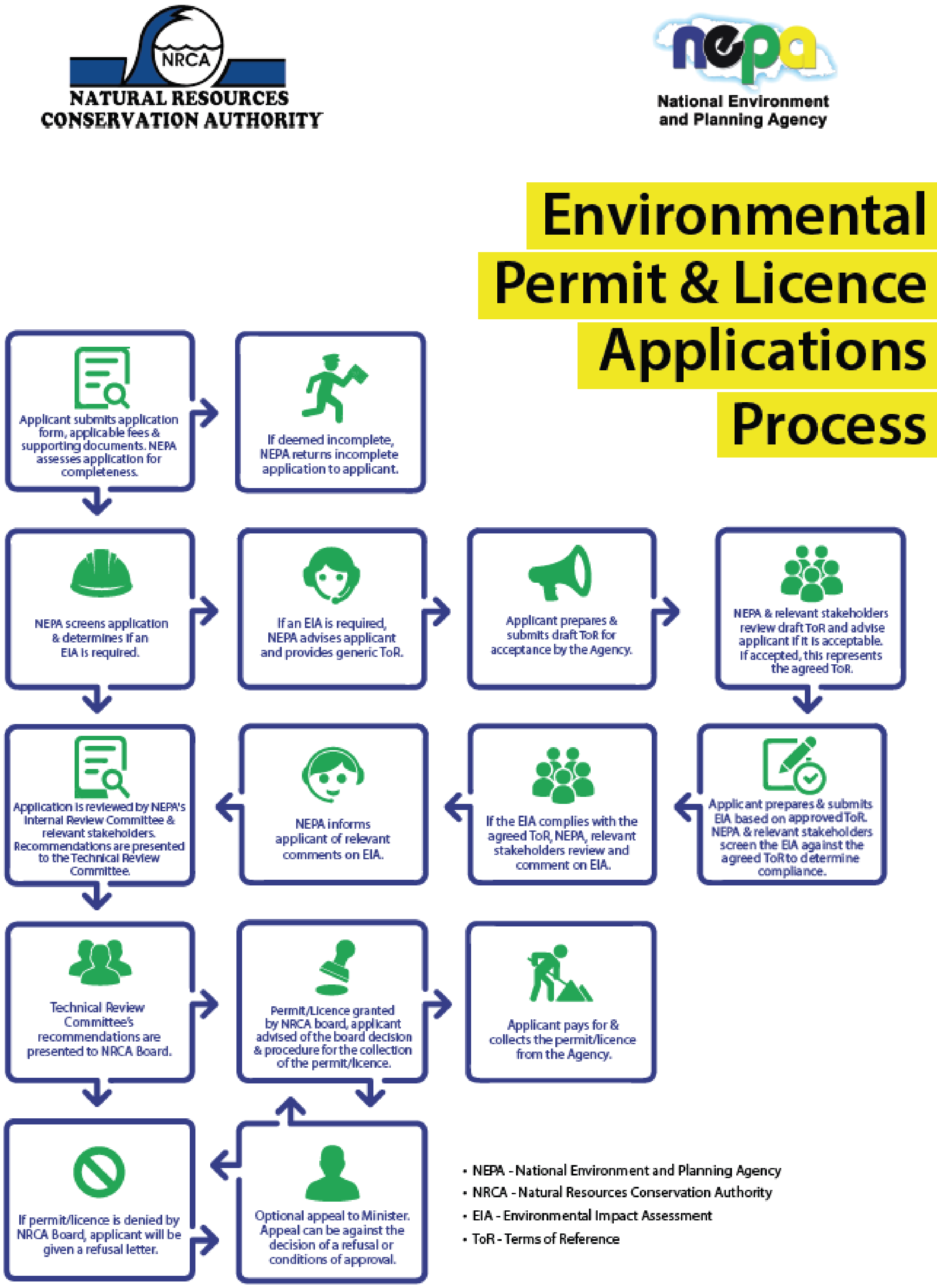


Figure 0-1: Environmental permit and licence application process (Source: National Environment and Planning Agency, NEPA 2019)

Appendix C Legislation

Table C-1: Draft Detailed Legal and Regulatory Framework and relevance to the proposed Project.

Name	Content	Relationship to the Project
Relationship of the Project to the environmental protection legislation and regulations currently in force		
The Natural Resources Conservation Authority (NRCA) Act (1991	The Natural Resources Conservation Authority Act was passed in the Jamaican Parliament in 1991 and provided the basis for the establishment of the Natural Resources Conservation Authority (NRCA) with primary responsibility for ensuring sustainable development in Jamaica through the protection and management of Jamaica's natural resources and control of pollution. Sections 9 and 10 of the NRCA Act stipulate that an Environmental Impact Assessment (EIA) may be required for new projects and existing projects undergoing expansion. The NRCA Act binds the Crown and as such supersedes all other legislation relating to environmental issues. The Minister is empowered to request an Environmental Impact Statement (EIS) in relation to certain major projects.	Communication with NEPA indicated that an EIA is required for this development, as such, this EIA is being done to meet the requirements of this NRCA Act and support permit applications.
The Natural Resources Conservation (Permits and Licences) (Amendment) Regulations, 2015	These regulations, developed in 2013, require the application for the grant of a permit to undertake an enterprise, construction or development of a prescribed description or category in a prescribed area as set out in Form 1 in the First Schedule. The Jamaica Public Service (JPS) and an LNG Provider (to be determined) will also be operating on site to produce power and store Liquid Natural Gas (LNG) respectively. These BBP business partners will also be required to and responsible for preparing and submitting the necessary documentation for permits and licences.	BBP is required to apply for a permit for the following: • Construction and operation of a Market Pulp Mill at Friendship, Westmoreland. • Construction and operation of a Wastewater Treatment Plant at Friendship, Westmoreland to support the development • Discharge of effluent wastewater The LNG Provider operating on site will also be required to and be responsible for preparing and submitting the necessary Environmental Permit (EP) applications for proposed construction and operation activities.

Name	Content	Relationship to the Project
The Natural Resources Conservation (Wastewater and Sludge) Regulations, 2013	Jamaica has prepared and enacted regulations governing the quality of the effluent discharged from facilities to public sewers and surface water systems. The regulation requires that the facility meet the outlined trade effluent and sewage quality standards set by the NRCA. The requisite permits and licences are required for the installation and operation of sewage treatment facilities and wastewater treatment systems. According to Sections 5, 6, and 7 the following apply for wastewater treatment plants: • Licence to construct a wastewater treatment plant • Licence to operate a wastewater treatment plant • Licence to a discharge effluent from wastewater treatment plant	BBP will require a licence for each activity. Following receipt of a permit, the developer would be required to monitor the effluent quality based on the frequency outlined in the terms and conditions of the licence and submit monitoring reports accordingly.
The Natural Resources Conservation Authority (Air Quality) Regulations, 2002	Part I of this Act stipulates license requirements and states that every owner of a major facility or a significant facility shall apply for an air pollutant discharge license. Part II speaks to the stack emission targets, standards and guidelines. The Act states that no person shall emit or cause to be emitted from any air pollutant source at a new facility, any visible air pollutants the opacity or pollutant amount of which exceeds the standards. Every owner of a facility with one or more air pollutant source or activity shall employ such control measures and operating procedures as are necessary to minimize fugitive emissions into the atmosphere, and such owner shall use available practical methods which are technologically feasible and economical, and which reduce, prevent or control fugitive emissions to facilitate the achievement of the maximum practical degree of air purity. The stack emission standards specified in the Twelfth Schedule shall apply to all new facilities with air pollutant sources. The	BBP will be required to employ emission control measures to minimize fugitive emissions from any stack.

Name	Content	Relationship to the Project
	regulations also define primary and secondary ambient air quality standards.	
The Town and Country Planning Act (1999)	Empowers the designated Minister to appoint the Town and Country Planning Authority and outlines its functions thereunder. There are also provisions which outline the conditions for the authorization of developments. Section 5 of the Act grants the Town and Country Planning Authority, subject to consultation with any local body, the authorization to prepare the provisional development orders for any land in urban or rural areas, to control the development of land in the prescribed area. Additionally, the Act provides for the objection to development by any person on specified grounds. Further, it stipulates for guidance, what must be included in development orders and the conditions by which the applications will be approved. The Act establishes area-specific standards for land use, density and zoning.	The Act and the Westmoreland Development Order will guide the land use and planning for the Project.
The Wild Life Protection Act (1945) ***Amended 1991***	Primarily concerned with the protection of specified species of fauna and precludes the hunting of any protected species. The Act also stipulates the periods for hunting; prescribes the conditions for such activities and the penalties for going in contravention of these provisions. The Act prohibits the removal, sale, or possession of protected animals and the use of dynamite, poison or other noxious material to kill or injure fish. It also prohibits the discharge of trade effluent or industrial waste into any harbour, stream, river canal etc. However, it has been superseded by the NRCA Act which provides for permits or licenses for the discharge of trade effluent into waters. There is also Draft Trade Effluent and Sewage Regulations promulgated under the NRCA Act and these regulations incorporate trade effluent standards which specify limits for discharges of trade effluent and draft ambient water quality Standards.	The construction and operation phases of the Project will impact biodiversity of the Site and the ecosystem services provided through elements such as vegetation clearance, stack emissions, wastewater discharge etc.

Name	Content	Relationship to the Project
Factories Act (1943) Amended 2009	Makes provision for the registration and supervision of factories, and for the safety of workers employed. It is accompanied by the Factories Regulations (1961), and The Building and Operations of Works of Engineering Construction (1968) BOWEC. The Industrial Safety Section of the Ministry of Labour and Social Security is responsible for monitoring and enforcing the requirements of the Factories Act and its accompanying Regulations for occupational safety and health in Jamaica. There is also a draft Occupational Health and Safety Act 2004, being updated for legislation. This new legislation will include requirements for every workplace to have an occupational health and safety policy and will supersede the Factories Act and its various Regulations.	During construction and operation of the pulp mill, occupational health and safety of workers, visitors and the surrounding community must be paramount to remain compliant with the Act.
Public Health Act (1976)	The Public Health (Air, Soil and Water Pollution) Regulations 1976, aim at controlling, reducing, removing or preventing air, soil and water pollution in all possible forms. Under the regulations given: • No individual or corporation can emit, deposit, issue or discharge into the environment from any source. • Whoever is responsible for the accidental presence in the environment of a contaminant must advise the Environmental Control Division of the Ministry of Health and Environmental Control, without delay. • Any person or organization that conducts activities which release air contaminants such as dust and other particulates is required to institute measures to reduce or eliminate the presence of such contaminants. • • No industrial waste should be discharged into any water body which will result in the deterioration of the quality of the water.	The excavation and construction work and use of heavy machinery and equipment may result in the temporary generation of fugitive dust. Proper care and standard best practices for the construction industry should be applied to minimize public health risks

Name	Content	Relationship to the Project
The National Solid Waste Management Authority Act, 2000	The National Solid Waste Management Authority Act (2001) is "an act to provide for the regulation and management of solid waste; to establish a body to be called the National Solid Waste Management Authority (NSWMA) and for matters connected therewith or incidental thereto". NSWMA is to take all steps as necessary for the effective management of solid waste in Jamaica to safeguard public health, ensure that waste is collected, sorted, transported, recycled, reused or disposed of, in an environmentally sound manner and to promote safety standards in relation to such waste. The NSWMA also has responsibility for the promotion of public awareness of the importance of efficient solid waste management, to advise the Minister on matters of general policy and to perform other functions pertaining to solid waste management.	Solid waste management will be essential in the construction phase and will require the removal and proper disposal of vegetative matter, soil and construction rubble. The NSWMA should be contacted regarding an approved disposal site.
Water Resources Act (1996)	The Water Resources Act established the Water Resources Authority (WRA). This Authority is mandated to regulate, allocate, conserve and manage the water resources of the island.	BBP may be desirous of digging wells at the proposed project site in Friendship for abstraction.
Watersheds Protection Act (1963)	This Act provides for the protection of watersheds to include areas adjoining watersheds and the conservation of water resources for Jamaica.	The proposed project site, Friendship falls within the Cabarita River Watershed Management Unit, which encompasses several residential communities, which depend on the watershed and its services to maintain their livelihoods.
Noise Abatement Act (1997	The Noise Abatement Act was incorporated on 1997. It has a narrow focus and only includes noise from musical or noisy instruments and noise produced by a loudspeaker, microphone or any other device for the amplification of sound in both private and public places. The Act outlines the distance from the source, the vicinity and time of day for which noise is to be considered a nuisance. The process for applying for a permit to operate equipment where the sound will be reasonably capable of disturbing any person is also described.	World Bank guidelines have been adopted by the National Environment and Planning Agency (NEPA) and are used for benchmarking purposes along with the draft National Noise Standards that are being prepared. Hence BBP will need to comply in construction and operations phase.

Name	Content	Relationship to the Project
Disaster Risk Management Act (2015)	The Disaster Preparedness and Emergency Act established the Office of Disaster Preparedness and Emergency Management (ODPEM) which is responsible for carrying out the provisions of the Act.	Given Jamaica's susceptibility to natural hazards and more recently, the outbreak of COVID-19, BBP should remain cognizant of changes mandated by the Act for business continuity purposes and the safety of all employees.
The Access to Information Act (2002)	It gives citizens and other persons a general legal right of access to official government documents which would otherwise be inaccessible. This allows for informed knowledge of the functioning of government	All documents pertinent to the EIA process for BBP will be accessible to the general public.
Relationship of project to national plans, programmes and policies		
Vision 2030 Jamaica - National Development Plan (2009)	Vision 2030 Jamaica aims at enabling Jamaica to achieve developed country status by 2030. The Plan has four National Goals that are mapped into 15 National Outcomes, which in turn will be pursued through National Strategies. • Goal 1: Jamaicans are empowered to achieve their fullest potential • Goal 2: The Jamaican society is safe, cohesive and just • Goal 3: Jamaica's economy is prosperous • Goal 4: Jamaica has a healthy natural environment	National Outcomes 12, 13 and 15 of the Vision 2030 are integral to this development being proposed. These are as follows: **Outcome 12 and Strategies– Internationally Competitive Industry Structures** • Develop company sophistication and productivity • Develop economic linkages and clusters • Develop economies of scale and scope through collaboration among enterprises in the region • Enhance the framework for competition among enterprises • Promote eco-efficiency **Related BBP Aspects:** • Letters of intent (LOI) in place with leading Consumer Tissue and Personal Hygiene Producers, as they look to increasingly replace stock consumption with non-wood fibres.

Name	Content	Relationship to the Project
		Outcome 13 and Strategies- Sustainable Management and Use of Environmental and Natural Resources • Integrate environmental issues in economic and social decision-making policies and processes • Develop and implement mechanisms for biodiversity conservation and ecosystems management • Develop efficient and effective governance structures for environmental management • Manage all forms of waste effectively **Related BBP Aspects:** • The project concept is based on the first and last strategies and is an excellent illustration of environmental underpinning in agro-ecological industrial models and design. • BBP's design has integrated a recovery boiler to supplement power to the mill and maximize energy efficiency • Establishment of cottage industry in local rural communities utilising bamboo by-products as straws, stirrers etc. **Outcome 15 and Strategies - Sustainable Urban and Rural Development** • Create a comprehensive and efficient planning system • Create an appropriate framework for sustainability planning • Create sustainable urban centres, including urban renewal and upgrading • Create vibrant and diversified rural areas

Name	Content	Relationship to the Project
		• Ensure safe, sanitary and affordable shelter for all **Related BBP Aspects:** • All aspects of this development are geared towards sustainable rural development.
The National Land Policy (1996)	The goals and objectives of this Policy are to ensure the sustainable, productive and equitable development, use and management of the country's natural resources.	Chapter 3 of the National Land Policy includes rural development and the protection of watershed and fragile areas and crop and production, all relevant to the construction and operation of the proposed bamboo market pulp mill and potential farming locations.

Appendix D Development Order Policies that Apply to the Project

Upon request from the NEPA, Table D-1 below lists the development order policies in the *Town and Country Planning (Westmoreland Area) Confirmed Development Order 20121* that apply to the proposed pulp Mill in Friendship, Westmoreland.

Table D-1: Development Policies that apply to the project taken from the documents, the Town and Country Planning (Westmoreland Area) Provisional Development Order 2018 and the Town and Country Planning (Westmoreland Area) Development Order (Confirmation) Notification, 2021.

Name of Policy	Description	How it Applies to the Project	Policy Page No.
GENERAL DEVELOPMENT POLICIES			
POLICY GD2	The planning authorities will not give approvals for major residential or commercial development: iv. which by virtue of any process generates smell, fumes and/or noise and would be a nuisance to existing and proposed development in the area in which it is to be located.	This is well understood and BBP is seeking to keep smells, fumes and noise within local and international guidelines, whichever is more stringent.	404[187]
POLICY GD3	The planning authorities will refuse planning permission for development likely to result in damage to or the loss of trees which makes a significant contribution to character and appearance of an area except in extra ordinary circumstances in which case the site would have to be landscaped to the satisfaction of the local planning authority.	None on property. However, we will be guided by the local authority.	404[187]
POLICY GD13	There will be a general presumption against new development or the intensification of existing ones in areas which are at risk from flooding unless the necessary acceptable mitigating measures can be taken.	Flooding was investigated in a hydrology assessment in the EIA and will be addressed.	404[189]
POLICY GD14	The planning authorities will ensure that flood risk and sea level rise are properly taken into account in the location of new development and that appropriate measures are taken to reduce the risk of flooding.	This was considered and is presented in the EIA	404[189]
POLICY GD20	Planning permission will not be granted for any development which would have a significant adverse effect upon the amenity and privacy of adjoining properties.	This is being considered.	404[191]
POLICY GD23	The provision of car parking and parking bays should be in accordance with the standards indicated in the Appendix 7 and no development will be approved that is not in conformity except in extraordinary circumstances.	This will comply with the regulations.	404[192]

Name of Policy	Description	How it Applies to the Project	Policy Page No.
POLICY GD26	All new developments will be required to be designed and located in relation to the existing road network, and to provide satisfactory vehicular access, egress, and crossover and where appropriate, circulation within the site.	This already applies to the project and will be incorporated in the designs	404[192]
POLICY GD31	Pervious parking lot techniques will generally be preferred where it is considered necessary and/or practical to minimize surface runoff from a development.	This was considered.	404[193]
POLICY GD33	During the construction stage of a development all possible source of fugitive dust generation should be sprinkled to avoid the dispersion to surrounding areas. Trucks transporting construction materials are to be covered.	This will apply to the project during the construction phase and is already mentioned in the EIA.	404[194]
POLICY GD45	Any development which is likely to have significant effect on the environment by virtue of its nature, size and location may require an Environmental Impact Assessment.	An Environmental Impact Assessment was completed.	404[196]
Policy GD54	The local planning authority will seek to minimize light pollution that causes sky glow, glare and light trespass by ensuring the scheme proposed demonstrate that what is submitted with the planning application is the minimum required to undertake the task.	This could possibly apply. More information on the designs would be needed to clarify this.	404[199]
RURAL AREA POLICIES			
POLICY RAP2	Development which will cause a loss of productive agricultural land or reduce the viability of farm buildings will not be permitted unless it can be demonstrated that the need for the development overrides agricultural considerations and no alternative site on non-agricultural land is available.	This development would override agricultural considerations as it intends on boosting the industry island-wide. Alternative lands were already looked at and were rejected based on feasibility.	404[210]
POLICY RAP3	The local planning authority will attach major importance to the need to safeguard agricultural land for production in considering development applications in the rural areas and refuse planning permission for development involving the subdivision of agricultural land into unproductive units. This consideration will be informed in part by food security considerations occasioned by climate change.	This would need to be guided by the relevant agency.	404[210]
POLICY RAP8	Any development in the countryside (including agriculture for which permission is needed) will be required to be sited and designed in such a way that any adverse impact on farming, the landscape, archaeological sites, historic features, mineral extraction or on public enjoyment of the country side is kept to a minimum.	This was considered. No major adverse impact anticipated for the siting on the mill on farming, the landscape, etc.	404[211]

Name of Policy	Description	How it Applies to the Project	Policy Page No.
TRANSPORTATION			
POLICY SP T1	Planning permission will not normally be given for development which would require direct access/egress on to or have an adverse impact on a main road or highway	The mill will not be located in a place that will have an adverse impact on a highway. It is also some distance from the main road of Hertford to Flowerhill.	404[126]
POLICY SP T2	The laying out or material widening of a means of access will be permitted only where it does not constitute a hazard to pedestrians and other users of the highway and where it is possible for vehicles to enter and leave the premises in a forward gear.	It is not anticipated that this would cause a hazard.	404[127]
POLICY SP T3	All road reservations should be in accordance with the requirements set out in the Appendix 6 of this Order and no development will be permitted which would conflict with these reservations.	This will be noted in the development plans	404[127]
POLICY SP T4	New and improved roads will be required to comply with the provisions set out in the Schedule of Road Standards and with such other details of construction and design as required by the relevant road authority.	This will be noted in the project and applied when we reach that stage.	404[127]
POLICY SP T6	Planning permission will not normally be granted for any development which would result in significant hazard to road users or which would reduce the free flow of the traffic on a primary distribution road.	The mill does not directly go through a primary distribution road. No significant hazard to road users is anticipated.	404[127]
POLICY SP T7	The planning authorities will seek to ensure that all developments adhere to the required setback from the main road improvement line as outlined by the relevant road authority.	This may potentially apply to the project and the mill will comply with this.	404[128]
POLICY SP T17	The planning authorities will support the implementation of traffic management and engineering measures to improve local road safety and protect the environment especially in residential areas at nights.	The project will comply with this directive as best as possible. Noise quality assessments were done and the mill intends to comply with protecting the nearby residential environments with respect to noise.	404[130]
POLICY SP T20	Where large developments are being undertaken the planning authority will encourage development proposals and road designs where adequate provisions are made for mass transit including public transportation.	The planning authority would have to guide us on this.	404[130]
POLICY SP T21	The local planning authority will encourage the use of mass transit including public transportation as a means of reducing traffic congestion and will seek to ensure that the necessary provisions are made to widen the service delivery network to make it attractive for all commuters.	This will be noted for the future staff of the proposed mill.	404[130]

Name of Policy	Description	How it Applies to the Project	Policy Page No.
POLICY SP T22	Priority will be given to coordinating land use changes with transport provision so as to minimize the need to travel by means of private automobiles and improve walkability of areas	This will be noted for the future staff of the proposed mill.	404[131]
POLICY SP T25	Developers will be required to provide parking facilities within the curtilage of the site being developed for new and extended developments and all change of uses in accordance with the requirements set out in Appendix 7 and the design standards in Appendix 9 and Figures 2, 3 and 5 of this Order.	This will be noted for construction. Plans and layout already in place to include parking facilities on site.	404[131]
POLICY SP T26	A standard allowance of approximately 30 square metres of parking area in practical shape (inclusive of manoeuvring space) should be made for each car parking space.	This will be considered in the designs.	404[132]
POLICY SP T27	Where a development is to be occupied by several users, each having its own space permanently, the number of parking spaces required will be calculated separately for each planning unit.	This will be incorporated in the designs. However, this development will not be occupied by several users; just by staff.	404[132]
POLICY SP T29	Where a building is divided by permanent construction into more than one use and occupancy, the number of parking bays required shall be calculated separately for each use and occupancy.	This will be incorporated in the designs.	404[132]
POLICY SP T34	New developments will be required to provide adequate parking facilities for people with disabilities in such a position that it enables safe and convenient access to the development.	This will be included in the designs.	404[133]
POLICY SP T43	Developers will be required to provide vehicle loading and off-loading bays within the curtilage of the site to be developed as set out in Appendix 7.	This will be included in the designs.	404[135]
POLICY SP T51	The planning authority will not approve applications for the development of transportation centres and car parks unless the proposals are accompanied by plans showing the layout and design of adequate lighting, landscaping and security features.	Designs of the mill are currently in development and will include all these features.	404[136]

Name of Policy	Description	How it Applies to the Project	Policy Page No.
CONSERVATION OF THE NATURAL ENVIRONMENT			
POLICY SP C1	The planning authority will not normally support any development that will have a detrimental effect on conservation areas and sites of ecological and aesthetic value.	This development does not infringe on conservation areas and sites of ecological and aesthetic value.	404[143]
POLICY SP C3	The planning authority will resist the destruction of trees/clusters of trees and woodlands where they are of amenity value and will if necessary, encourage the Local Authority to place Tree Preservation Orders on such trees to ensure their protection.	This development does not involve the destruction of trees etc. where they are of amenity value.	404[143]
POLICY SP C4	The planning authority will ensure that environmentally sensitive or vulnerable areas are reserved as natural areas and greenbelt reserves for wildlife and recreation whenever possible and used as natural buffers between incompatible land uses.	This is noted. EIA did not identify any areas for greenbelt reserves, wildlife and recreation or reserved areas.	404[143]
POLICY SP C6	The planning authority will normally grant permission for new developments only if there is an acceptable standard of landscaping provided. Details at the planning application stage should accurately identify planting area, including details of plant species, their size and densities in each location.	The Planning authority will have to guide us on this.	404[144]
POLICY SP C7	The planning authority will not consider applications for development which do not show all vegetation, ponds, streams, rivers and ditches which are to be retained during construction with details for their protection during the period.	This will be noted and submitted to the Planning Authority.	404[144]
POLICY SP C8	Planning permission will not normally be granted for any development which infringes directly or indirectly through felling, lopping, topping, pruning, changes to drainage patterns or ground levels, severance or compaction of roads, upon conservation areas, as identified on the land use proposal map.	No conservation areas on or within the 2km buffer zone of the site.	404[144]
POLICY SP C10	The planning authority will ensure that natural drainage features including sink holes are not blocked during or after development activities.	The only natural drainage feature on site is the Cabarita River and there are no plans to alter/train the river, only extract water from it.	404[144]
POLICY SP C12	Hard and soft landscaping is to be provided to the satisfaction of the planning authority as an integral part of any development proposals, where it is necessary to enhance the environment and the siting of a new building or otherwise help integrate that development into its surroundings.	This would apply to the design/Design Phase. From preliminary drawings, a combination is anticipated.	404[145]

Name of Policy	Description	How it Applies to the Project	Policy Page No.
POLICY SP C14	Lands in these watersheds may be used for agricultural purposes but should adhere to guidelines set by the appropriate agencies and should be properly managed to reduce the effects of soil erosion.	This was identified as a potential area of concern during construction and operations. The EIA identifies mitigative measures to reduce the effects of soil erosion.	404[145]
POLICY SP C16	The planning authority will not encourage development within the aquifer recharge area that threatens to undermine or is in conflict with the natural functions of this area.	This is understood. Hydrological assessment does not anticipate that it would undermine or is in conflict with the aquifer recharge process.	404[145]
POLICY SP C21	The planning authority will not grant planning permission for any development proposals which could lead to unacceptable levels of environmental pollution and in dealing with such applications will take into consideration site location and environmental safeguards.	This is understood. An EIA was completed and the relevant mitigative measures have been identified to ensure the levels of environmental pollution predicted are within acceptable levels or is minimal.	404[146]
POLICY SP C22	Development proposals which would lead to unacceptable levels of noise nuisance to nearby existing or future occupants will not be granted permission by the planning authority.	The mill intends to comply with both local and international requirements for noise, whichever is more stringent.	404[146]
POLICY SP C33	No development shall take place above, or in close proximity to caves or caverns unless these have been adequately explored or investigated to ensure safety of the development.	No caves or caverns have been identified on or within the 2km buffer zone of the mill site.	404[149]
POLICY SP C36	Development sites that put risk on the ground water resources shall not be permitted.	The EIA investigated this the current information and via a hydrology assessment and a geotechnical investigation and there is no identified concern about the impact on groundwater.	404[149]
POLICY SP C50	In areas suspected to have archaeological significance, developers will be required to undertake an Archaeological Impact Assessment.	This could apply to the project. Area not designated as having archaeological significance from correspondence with the JNHT.	404[152]

Name of Policy	Description	How it Applies to the Project	Policy Page No.
URBAN ECONOMY			
POLICY SP UE21	Hazardous industrial processes or storage facilities will only be permitted in locations where they will have no adverse impacts on the site to be developed or on neighbouring sites or developments in the area.	This could apply to the project. More information needed on the design of the mill to determine if it applies.	404[159]
POLICY SP UE22	Development proposals for any use which would result in a significant number of people living or working in close proximity of any hazardous industry or storage site will not normally be permitted.	This could potentially apply to the project, but measures will be put in place to address this.	404[159]
POLICY SP UE24	Permission will not be granted for un-neighbourly industrial activities, or other uses likely to be detrimental to the amenity of a locality or pollute the natural environment and the local planning authority will seek the relocation of business places which are so inclined.	This could potentially apply to the project. An EIA is being submitted to NEPA with the findings, but no adverse effect anticipated.	404[160]
RURAL ECONOMY			
POLICY SP RE1	Land of agricultural potential (Class I–III) will be preserved and conserved for productive agricultural use and priority will be given to agricultural uses over other planning considerations.	The planning authority would have to guide us on this.	404[160]
POLICY SP RE3	There will be adequate setbacks put in place to protect riverine areas from contamination from agricultural lands and to protect life and livelihoods from flooding in line with climate change considerations.	This will be considered in the project.	404[161]
POLICY SP RE9	Any development which is allowed in the rural areas (including agricultural and horticultural building for which planning permission is required) will have to be designed and sited in such a way that any adverse effect on farming or public enjoyment of these areas is kept to a minimum.	This will be considered in the project.	404[162]
POLICY SP RE19	The planning authorities will normally support the establishment of agro industries where they strengthen the rural economy, as long as they are not located on good agricultural land, will not compromise the character of the area, or impact adversely on the environment or have a deleterious effect on surrounding uses.	The project will strengthen the rural economy. It is not anticipated that the project will impact adversely on the environment and have a deleterious effect on surrounded uses.	404[164]
POLICY SP RE20	The planning authorities will normally support proposals for the improvement of industries or the establishment of new ones where they strengthen the rural economy, as long as they will not compromise the character of the area, or impact adversely on the environment or have a negative effect on surrounding uses.	A new industry will be established and will strengthen the rural economy. It is not anticipated that the project will impact adversely on the environment and have a deleterious effect on surrounded uses.	404[164]

Name of Policy	Description	How it Applies to the Project	Policy Page No.
POLICY SP RE22	Dwellings of a temporary nature for special agricultural workers outside existing settlements and in particular location and agricultural buildings where it is of a type and size appropriate to its purpose may be allowed on good agricultural land in extenuating circumstances only.	This may potentially apply to the project and will be considered.	404[165]
POLICY SP RE23	Development essential for agricultural production outside the urban fence will normally be permitted provided that there is no conflict with other important rural area resources and no adverse impact on the appearance of the surrounding area.	This may not apply but needs to be clarified.	404[165]
POLICY SP RE29	Planning permission for development of lands of agricultural significance within the local planning area will be granted provided the land is urgently needed for development and the proposal do not prejudice the existing residential and visual amenity of the area and the necessary infrastructural being available.	The land for the project site is not within a local planning area.	404[167]
WATER SUPPLY			
POLICY SP WS1	The planning authority will seek to facilitate the development of or improvements to the potable water distribution system including pump and lift stations and reservoirs where appropriate within the order area.	The mill's intention is not to improve the accessibility to potable water in nearby community; only to supply the mill's operations.	404[170]
POLICY SP WS2	The planning authority, in consultation with the National Water Commission or private water supply entities, will seek to locate and secure lands/easements for the accommodation of infrastructure to support the water distribution system.	None (water infrastructure) detected in the immediate area.	404[170]
POLICY SP WS3	Permission will normally be given for design, location and construction of water treatment facilities to the satisfaction of the planning authority, and other regulatory bodies.	A water treatment facility to extract and treat water from the Cabarita River will be constructed. This water will only be used by the mill.	404[171]
Policy SP WS6	The planning authority will not grant permission for any development which does not provide suitable and adequate water supply. This may take the form of a catchment tank or other facility to satisfy water supply requirements.	Adequate water supply from the Cabarita River has been assessed and it is predicted that it will not compromise the water levels in the river.	404[171]
POLICY SP WS7	The planning authority will encourage the use of harvested rainwater and recycled grey water for non-potable uses and will ensure that provision is made for this in new development proposals.	This will be reviewed as an option in the design of the mill	404[171]
POLICY SP WS9	The planning authority will seek to develop planning incentives to encourage the incorporation of water conservation and recycling devices and technology.	This may apply to the project, but is dependent on the designs which are currently in development.	404[172]

Name of Policy	Description	How it Applies to the Project	Policy Page No.
WASTE TREATMENT AND DISPOSAL			
POLICY SP WT2	Planning authorities will seek to encourage the development of or improvements to pumping stations and sewage transportation and treatment facilities within the Order Area.	This somewhat applies to the project. A tertiary level wastewater treatment plant and aeration pond will be located on the site to treat the mill's waste.	404[172]
POLICY SP WT8	There should be a minimum vertical distance of one meter between the bottom of a tile field and the maximum elevation of the ground water table or any layer of rock or impervious material.	This will be rectified by elevating areas of the property. So far, the groundwater encountered is presumed a perched water table.	404[173]
POLICY SP WT9	The collection and use of rainwater and recycled grey water for some secondary uses in buildings will be encouraged and provision should be made for this in development proposals.	This will be reviewed as an option in the design of the mill	404[174]
POLICY SP WT13	Existing and proposed civic amenity waste sites and transfer stations should have satisfactory access to and from the site and not be detrimental to environmentally sensitive areas and the activity should in no way be a nuisance to adjoining uses.	There are no nearby civic amenity waste site.	404[174]
POLICY SP WT16	Solid waste should be disposed of in landfill sites where possible and these should be located in areas where there will be no detrimental effect on surface or underground water resources.	The company intends to use a reputable and registered company to dispose of solid waste. We presume that these guidelines will be followed.	404[175]
POLICY SP WT20	The planning authority will give special attention to the creation of special hazardous waste disposal sites where and when necessary for the safe disposal of hazardous materials.	This will be considered, however, the designs and material list are still in development.	404[176]

Name of Policy	Description	How it Applies to the Project	Policy Page No.
ENERGY CONSERVATION AND GENERATION			
POLICY SP E1	The planning authority will be mindful of energy conservation in assessing the design of development applications especially as it relates to the use of natural lighting and conservation techniques.	This may possibly apply, but is dependent on the design which are still under development.	404[176]
POLICY SP E3	The planning authority will support the design and layout of developments that employ green development and energy efficiency standards.	The designs are currently under development but this will be considered.	404[176]
POLICY SP E8	The planning authority will encourage the undergrounding of utility wires and cables, appropriate markers must be installed to identify the routes.	This may possibly apply, but is dependent on the design which is still under development.	404[177]
POLICY SP E9	The planning authority will consider the development of alternative energy sources provided the process, including ancillary buildings and facilities, that will not cause negative impacts on the ecology of the area or disturbance to any receiving or transmitting system in the area.	Most of the energy will be provided by the recovery boiler which is still being designed. Final checks/investigations on its impacts on receiving or transmitting systems will be done. No identified negative impact on the ecology based on the current information.	404[177]
POLICY SP E11	The planning authority will encourage the use of acceptable renewable sources for energy in building and site design.	The mill intends to generate most of its energy renewably from the recovery boiler that will use the bamboo pulp as a raw material. They also intend to use LNG/LPG as a back-up fuel for start-ups. Local energy supplier, the JPS Co. may be used during construction and early operations.	404[177]

FROME LOCAL DEVELOPMENT AREA			
Frome/Blackness is drained by the Cabarita River and is a flood-prone area during periods of heavy rain. It is imperative that existing flood risks are either reduced or addressed so that new developments do not individually or cumulatively increase flood risks. Hence, appropriate structural measures, to effectively address surface water drainage and the cumulative impact of altered drainage patterns, in these sensitive areas should be implemented.			
HOUSING			
POLICY FB H6	The local planning authority will not support development in flood areas except where the necessary infrastructures are in place.	Area to be potentially impacted by flooding was identified and will be elevated.	404[287]
POLICY FB H7	The local planning authority shall establish a "no-build zone" along the Cabarita River.	Need more information on this. This would apply to worker homes if the company is looking to provide this.	404[287]
POLICY FB H8	In areas of steep slopes or unstable geology or in areas of conservation or environmental importance where low density accommodation or residential development is contemplated development will be prescribed to strict stipulations or conditions and must adhere to the recommendations of the relevant Planning Authorities.	Will apply if housing is provided for workers, but not considered at this stage.	404[287]
CONSERVATION OF THE BUILT AND NATURAL ENVIRONMENT			
POLICY FB C1	The Planning Authorities will encourage developmental activities that will ensure sustainable use of water resources as well as the preservation of ecosystems and the aquatic environment throughout the planning area.	Understood. We will indicate how this will be done.	404[291]
POLICY FB C2	The local planning authority will not grant planning permission for any developments which will result in the large-scale removal of flora and fauna or cause any contamination of the water supply.	Understood. Only sugar cane will be removed, and the water supply will be somewhat protected via the wastewater treatment plant	404[291]
POLICY FB C3	The planning authority will not normally encourage development within the aquifer recharge and watershed area that threatens to undermine or is in conflict with the natural functions of this area.	Understood.	404[291]
POLICY FB UE4	In areas where development is permitted adjacent to the ponds and other water bodies, the setback shall be a minimum of 30 metres from the edge or banks and may be varied by the Planning Authorities or other relevant agency.	This will be considered in the design	404[291] - 404[292]

Appendix E National and International Standards – Air, Noise and Water

Table E-1: Jamaica National Ambient Water Quality Standards – Freshwater (NEPA, 2014)

Parameters (units)	Standard Range
Total Dissolved Solids (mg/L)	120.0 - 300
pH (pH units)	7.00 – 8.40
Conductivity (mS/cm)	150.0 - 600
Calcium (mg Ca/L)	40.0 – 101.0
Chloride (mg Cl^-/L)	5.0 – 20.0
Magnesium (mg Mg/L)	3.6 - 27.0
Nitrate (mg NO_3^-/L)	0.1 – 7.5
Phosphate (mg PO_4^{3-}/L)	0.01 – 0.8
Sodium (mg Na/L)	4.5 – 12.0
Sulfate (mg SO_4^{2-}/L)	3.0 – 10.0
Hardness (mg $CaCO_3$/L)	127.0 – 381.0
Biochemical Oxygen Demand (mg O_2/L)	0.8 – 1.7
Potassium (mg K/L)	0.74 – 5.0
Silica (mg SiO_2/L)	5.0 – 39.0

Table E-2: Effluents and Emissions Guidelines/Resource Use Benchmarks for Pulp and Paper Facilities - Bleached Kraft Mill, Integrated. (Source: World Bank Group EHS Guidelines- Pulp and Paper Mills)

PARAMETERS	UNITS	GUIDELINE
Flow	m^3/Adt	50
pH	-	6-9
TSS	kg/Adt	1.5
COD	kg/Adt	20
BOD	kg/Adt	1
AOX	kg/Adt	0.25
Total N	kg/Adt	0.2
Total P	kg/Adt	0.03

Table E-3: Sewage Effluent Standards (applied to discharges from sewage treatment systems built after 1997)

PARAMETERS	EFFLUENT LIMIT
BOD	20 mg/L
TSS	20 mg/L
Nitrates (as Nitrogen)	10 mg/L
Phosphates	4 mg/L
COD	100 mg/L
pH	6-9
Faecal Coliform	200 MPN/100 ml
Residual Chlorine	1.5 mg/L

Table E-4: NRCA Jamaican National Trade Effluent Standards, 1995

PARAMETERS	EFFLUENT LIMIT
Ammonia/Ammonium	1.0 mg/L
Barium	5.0 mg/L
Beryllium	0.5 mg/L
Boron	5.0 mg/L
Calcium	No Standard
Chloride	300 mg/L
Colour	100 TCU
Detergent	15 mg/L or <0.015kg/1000kg product
Fluoride	3.0 mg/L
Iron	3.0 mg/L
Magnesium	No Standard
Manganese	1.0 mg/L
Nitrate (as Nitrate and Nitrite)	10 mg/L
Oil and Grease	10 mg/L or <0.01kg/1000kg product
pH	6.5 - 85
Phenols	0.1 mg/L
Phosphate	5.0 mg/L
Sodium	100mg/L
Sulphate	250 mg/L
Sulphide	0.2 mg/L
TDS	100 mg/L

PARAMETERS	EFFLUENT LIMIT
TSS	All times <150 mg/L Monthly average 50 mg/L
HEAVY METALS	
Arsenic	0.5 mg/L
Cadmium	0.1 mg/L
Chromium	1.0 mg/L
Copper	0.1 mg/L
Cyanide Free CN, Total CN	 0.1 mg/L 0.2 mg/L
Lead	0.1 mg/L
Mercury	0.02 mg/L
Nickel	1.0 mg/L
Selenium	0.5 mg/L
Silver	0.1 mg/L
Tin	No standard
Zinc	1.5 mg/L
Total Heavy Metals	2.0 mg/L
STREAM LOADING	
BOD	<30 mg/L
COD	<100mg/L or <0.1kg/1000kg product
DO	>4 mg/L
BACTERIOLOGY	
Total Coliform	<500 MPN/100ml
Faecal Coliform	<100 MPN/100ml

Table E-5: Ambient Air Quality Standards of NEPA and the WHO.

Ambient Air Quality	Average Timing	NRCA (NEPA) Standard (Max Concentration in µgm^{3})	WHO Ambient Air Quality Standard (µgm^{-3}) [(a)]
PM $_{2.5}$	Annual	-	35 (Interim target-1) 25 (Interim target-2) 15 (Interim target-3) 10 (Interim Target 4) 5 (Guideline)
	24-hour	-	75 (Interim target-1) 50 (Interim target-2) 37.5 (Interim target-3) 25 (Interim Target 4) 15 (Guideline)[(b)]
PM $_{10}$	Annual	50	70 (Interim target-1) 50 (Interim target-2) 30 (Interim target-3) 20 (Interim Target 4) 15 (Guideline)[(b)]
	24 hours	150	150 (Interim target-1) 100 (Interim target-2) 75 (Interim target-3) 50 (Interim Target 4) 45 (Guideline)[(b)]
Sulphur Dioxide	Annual	80 Primary; 60 Secondary	-
	24- hour	365 Primary; 280 Secondary	125 (Interim target-1) 50 (Interim target-2) 40 (Guideline)[(b)]
	1 hour	700	-
	10 minutes	-	500 (Guideline)
Nitrogen Dioxide	Annual	100	40 (Interim Target 1) 30 (Interim Target 2) 20 (Interim Target 3) 10 (Guideline)
	24- hour	-	120 (Interim Target 1) 50 (Interim Target 2) 40 (Guideline)[(b)]
	1 hour	-	200 (Guideline)

Ambient Air Quality	Average Timing	NRCA (NEPA) Standard (Max Concentration in µgm^3)	WHO Ambient Air Quality Standard (µgm^{-3}) [(a)]
Ozone	1 hour	235	-
	8-hour daily max.	-	160 (Interim target-1) 100 (guideline)
Notes for WHO Standards: (a) Concentrations referenced at 0ºC and 1 atm (b) 99th percentile (i.e. 3-4 exceedance days per year)			

Source: NEPA; WHO (2020)

Table E-6: Emission guideline for Pulp and Paper Facilities – Kraft, Bleached

PARAMETER	GUIDELINE VALUE (kg/Adt)
SO_2 as S	0.4
NOx as NO_2	2.0 for softwood pulp
Total Suspended Particulates (TSP)	0.5
Total Reduced Sulphur Compounds (TRS)	0.2

Source: European Commission, 2001; Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques in the Pulp and Paper Industry, December 2001; and U.S. EPA National Emission Standards for Hazardous Air Pollutants For Source Categories, 40 CFR Part 63.)

Table E-7: Noise Standards for Jamaica.

	NRCA (NEPA) STANDARD	
	Day (7am – 10pm)	Night (10pm – 7am)
Residential	55dBA	50dBA
Commercial	65dBA	60dBA
Industrial	75dBA	70dBA

Appendix F JCP 8: 2021 Jamaican Standard Code of Practice for Bamboo Plantation that will guide Bamboo Cultivation and Harvesting

The JCP 8: 2021 Jamaican Standard Code of Practice for Bamboo Plantation provides recommendations for the cultivation and harvesting of all types of bamboo found in Jamaica. These standards will assist in managing the *B. vulgaris* that is the raw material for the project.

Bamboo Growing Conditions

Recommendations for the growing conditions of B. vulgaris is presented in below (**Table F-1**).

Table F-1: Growing conditions recommended for B. vulgaris as found in the JCP 8: 2021 Jamaican Standard Code of Practice for Bamboo Plantation (BSJ, 2021).

VARIABLES	RECOMMENDED CONDITIONS
Altitude	Grown on plains and up to altitudes of 1500m
Soil Type	Is best on moist alluvial soil and well-drained sandy and clayey soils. The plant is tolerant to salinity and water logging

Bamboo Cultivation

For the establishment of the bamboo farm, the proposed site will need to be cleared and ploughed with some retention of natural trees as partial shade for beneficial bamboo growth. The recommended spacing for high productivity bamboo cultivation is currently being investigated. Trials are currently underway at a Nursery site based on 6 variations of land preparation, planting and maintenance. The recommended stand density for this species is 700 clumps per hectares, with each clump containing 10 – 20 culms at 1 – 3 years of age. Additionally, the Standard provides recommendations for soil/water conservation and managing established clumps. An example of managed and controlled cultivation is presented in **Figure F-1**. The recommended measures for cultivation are presented in **Table F-2**.

Figure F-1: Illustration of controlled, cultivated bamboo

Table F-2: Cultivation recommendations for B. vulgaris as found in the JCP 8: 2021 Jamaican Standard Code of Practice for Bamboo Plantation (BSJ, 2021)

VARIABLES	RECOMMENDED CONDITIONS
Planting Material	Vegetative propagation is very easy in this species and culm or branch cuttings root easily and even without use of rooting hormones throughout the year. This species rarely flowers and seeds are not viable. Clumps after flowering may die completely but some may survive.
Soil/water Conservation	Moisture/water harvesting trenches (60 cm x 45 cm x 30 cm) are to be dug along the interspaces in the alternate rows of planting when planted in 6 m x 6 m spacing.
Manging Clumps	***Cultural practices*** – All dead and dying culms to be cut and removed from the third year of establishment preferably during the dry season before the new growth of culms. ***Fertilisation*** – To be carried out as per the advice of an expert after testing the soil once the clumps have established. Responds well to NPK and organic fertilizers like compost, vermi-compost and dried farmyard manure. Organic fertilizers recommended if grown for edible shoots. ***Irrigation*** – Responds well to irrigation however essential only during the first two years to ensure better establishment and quicker culm production. If grown for edible shoots watering ensures enhanced sprout production. Moisture retention through trenches should also be practiced. ***Plant protection measure s***- If managed properly with routine pruning, thinning and cleaning, (cultural practices) Bamboo usually escapes pest infestations. Proper sanitation measures should also be adopted for the control of fungal infections.

VARIABLES	RECOMMENDED CONDITIONS
	Thinning – Regular thinning and cleaning should be carried out from the 4th year of clump establishment. All dry, dead and drying culms are to be removed from the clump so as to create sufficient space in the clump for new sprouts to grow up straight. As a regular practice these operations are to be carried out every year probably prior to the wet season.

BBP will provide information on the farming method and fertilizers and/or herbicides that will be used once their ongoing tests are complete. This may be provided in the SEA to be submitted to NEPA.

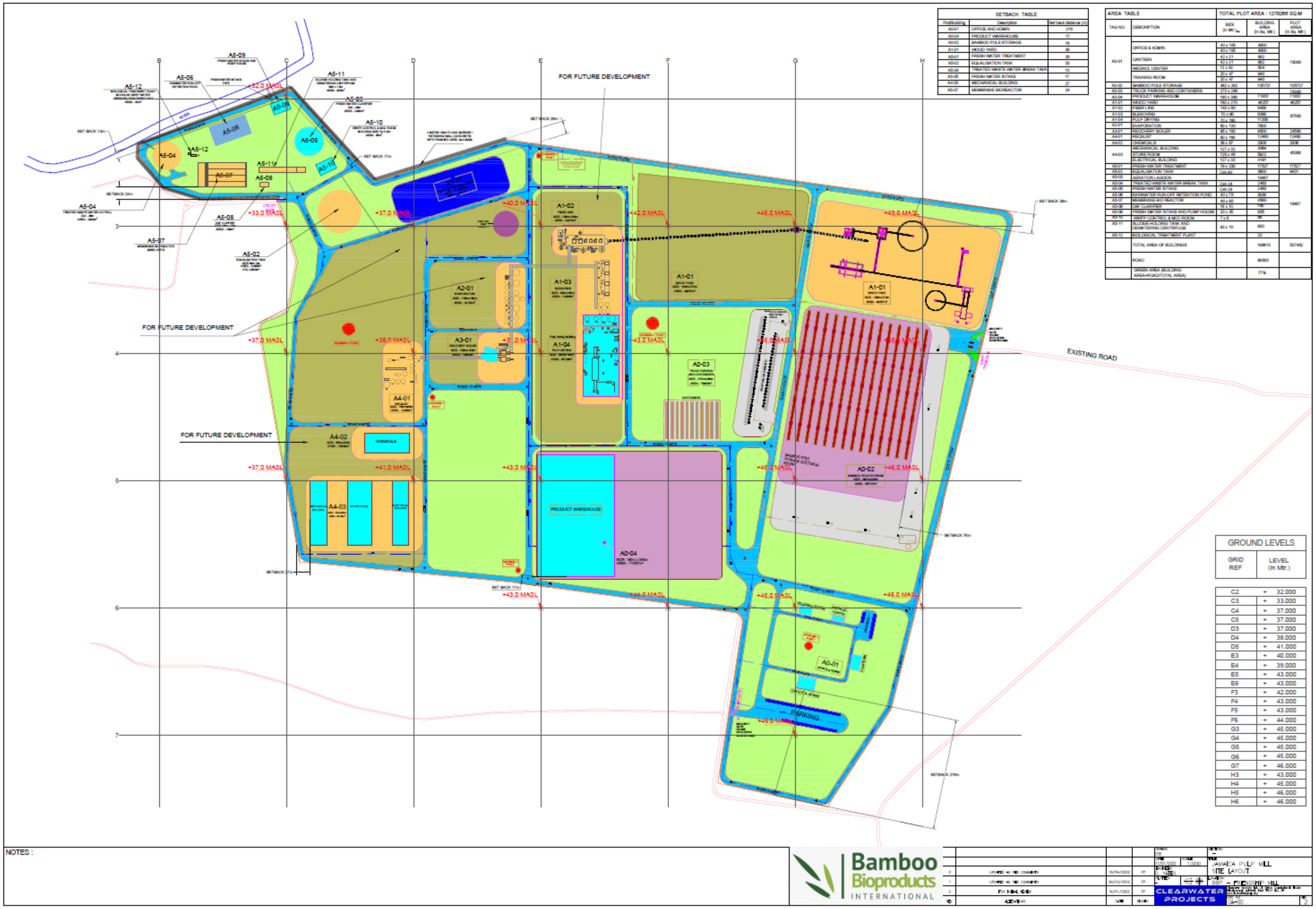
Bamboo Harvesting

Once the bamboo culm reaches one year, the maximum fibre content is generally achieved. Further, the lignin and silicon content increase with the age of the bamboo, as such the culms for pulping will be harvested when they are young. As *B. vulgaris* is a sympodial bamboo, this means harvesting at approximately 3 years. Recommendations from the JCP 8: 2021 Jamaican Standard Code of Practice for Bamboo Plantation (BSJ, 2021) for harvesting are presented in **Table F-3**.

Table F-3: Harvesting recommendations for B. vulgaris as found in the JCP 8: 2021 Jamaican Standard Code of Practice for Bamboo Plantation (BSJ, 2021)

VARIABLES	RECOMMENDED CONDITIONS
Harvesting	Culms (for timber) should be harvested only during non-rainy months. No current year culms are to be cut. For propagation about 20% of two-year-old culms can be selectively cut from all portions of the clumps which can be used for vegetative propagation through rooting of culm cuttings. About 60% of the 3-year-old culms and almost all of the 4th year culms can be cut and removed. However, it is always better to retain a few older culms in the clump to serve as support for the younger newly emerging culms.

Appendix G Site Layout



Appendix H Kraft Pulping Process and Expected Quality Parameters

The Kraft pulping process relevant to this project has 4 main steps: raw material preparation, pulp manufacturing, chemical recovery and pulp bleaching. **Figure H-1** shows a simplified overview of the kraft pulping process which will be used at the proposed pulp mill, while **Figure H-2** shows the Kraft Process cycle that will be used at the proposed mill.

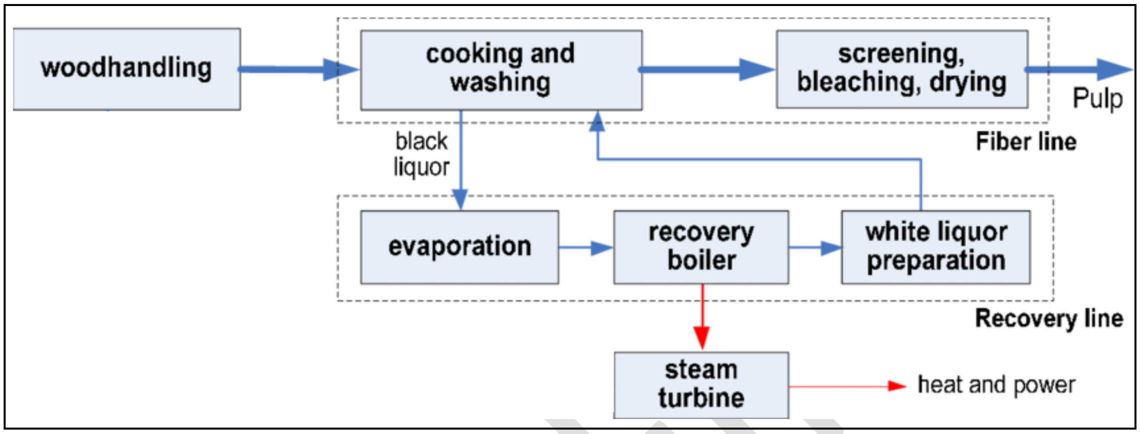


Figure H-1: Simplified diagram of the kraft pulp process modified for the bamboo pulp mill. Source: Hamaguchi et al, (2012).

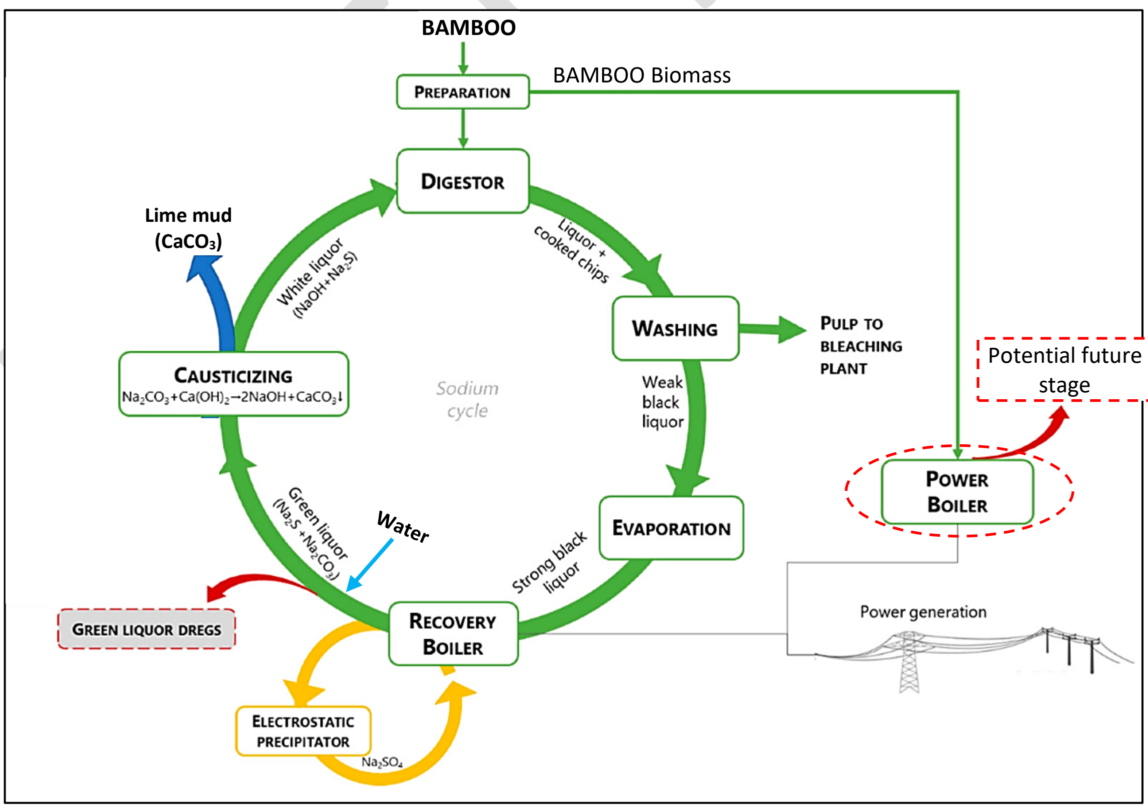


Figure H-2: Simplified diagram of the kraft pulp process cycle for the bamboo pulp mill (BBP, 2022).

In the following sections, the pulping process will be described in two main parts:

iii. **The PULP LINE** (**The Fiberline**) – Raw Material Handling, Cooking and Delignification, Washing and Screening, Bleaching and Drying

iv. **The CHEMICAL RECOVERY** – Evaporation, Recovery Boiler, Reausticizing

The machines and equipment for the Kraft Process of the pulp mill will be supplied by ANDRITZ.

THE PULP LINE

Raw material handling

This involves the reception and storage of raw bamboo material, wood chipping and screening. BBP proposes to receive bamboo as culms directly from farms and transported to the mill by enclosed trucks. The current business plan for BBP does includes a personal fleet of electric-powered trucks, for the transport of raw material to the proposed mill, and they will also need to contract local trucking companies for transportation.

For the kraft process, the bamboo logs will be reduced to chips in a chipper to form uniform-sized chips for the better pulp product. The more uniform the chips after the chipper, the lower the raw material consumption. Chips will be screened for thickness, to ensure optimal size and uniformity for the process. Oversized chips or foreign materials can interfere with or damage the operation of the equipment. The material removed in the screening operation can be sold for other purposes or burnt in a solid fuel boiler with heat recovery together with bark/sludge from the wastewater treatment plant.

The preliminary quality parameters are provided below and the final Quality Parameters for the pulp mill will be provided by BBP once finalised.

BBP Preliminary Quality Parameters

- Wood species: Bamboo, *Bambusa vulgaris* (100%)
- Average wood density: 200 BD kg/m^3
- Average wood moisture: 45 – 50%
- Yield: 50%
- Chips size distribution requirements
    - oversize (> Ø 45 mm) = ≤ 2.2%
    - accept = > 85%
    - pins (> 3 mm) = ≤ 7.5%
    - sawdust (< Ø 3 mm) = ≤ 2.3%

Cooking and Delignification

In the kraft process, the bamboo fibres are liberated in the cooking plant by dissolving the lignin and part of the hemicellulose in the cooking chemical solution (white liquor), which contains sodium hydroxide (NaOH) and sodium sulphide (Na_2S) as active chemicals. Continuous digesting/cooking will be used. The Cooking is based on three-row digester proceeded by a TurboFeed chip feed and black liquor treatment with Reboiler. This is known as Lo-Solids cooking provided by ANDRITZ. For Lo-Solids cooking, the primary objective is to minimize the concentration of dissolved organics throughout the bulk phase of delignification while maintaining, as with other forms of modified cooking, an "even" alkali profile, minimal cooking temperatures, and minimal concentrations of dissolved lignin at the end of the cook.

In order to achieve these, multiple extractions, split white liquor additions and split filtrate additions are utilized. The cooking profiles of dissolved organic, alkali, and sulphide concentrations are manipulated by altering the relative flows of extraction and of filtrate additions. The selected cooking method will remove more lignin from the bamboo without reducing yield or causing extended cellulose degradation, thereby reducing the organic load caused by pulp bleaching (third step in the kraft process). This reduces the requirements for any subsequent bleaching chemicals, and effluent discharges from the bleaching plant are decreased.

The bamboo chips will be fed by an Air Lock Screw Conveyor to the Diamondback Chip Bin with atmospheric steaming (**Figure H-3**). While passing through the Diamondback Chip Bin, the chips are heated to a temperature of approximately 100°C by low pressure steam. This assures that all chips are properly heated and conditioned prior to the addition of white liquor / impregnation cooking liquor. This is done by exposing all of the chips to a steam environment that causes the air to diffuse out of the chips and saturates them with moisture. This excellent steaming allows the incoming chips to become uniformly impregnated by cooking liquor and results in the low levels of rejects during cooking.

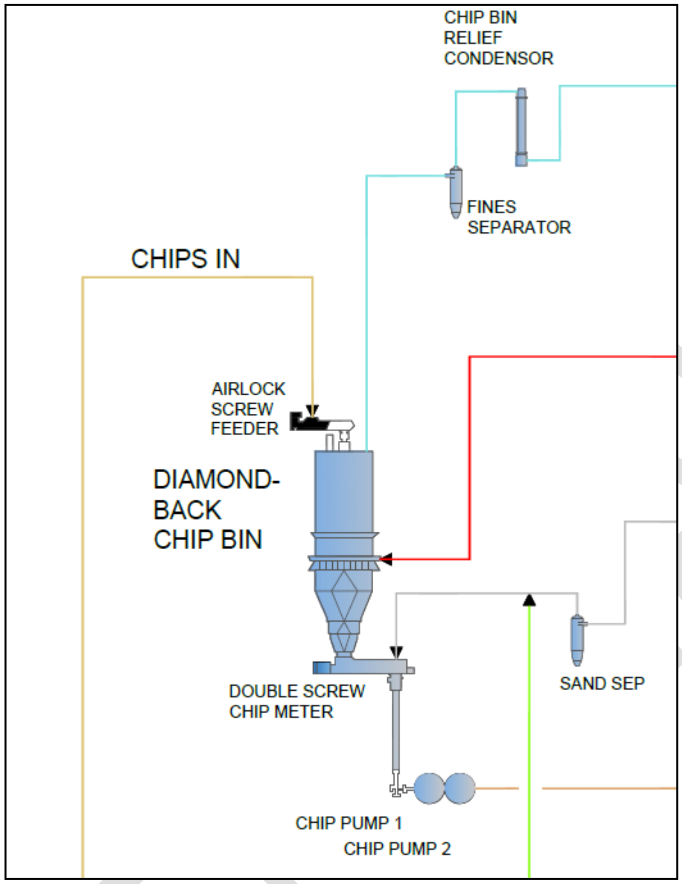


Figure H-3: Process Flow of sending chips to the sand separator.

The chips are uniformly discharged from the Chip Bin with the help of the Double Screw Chip Meter. From the Chip Meter, the chips are discharged into the Chip Tube to be mixed with the cooking liquor. The liquor from Digester goes through a Sand Separator that removes sand from the feed circulation return flow. Liquor enters the separator tangentially, and centrifugal forces created by the tangential entry carry the sand to the periphery, away from the outlet nozzle, thus allowing the sand to settle to the bottom. The chip and sluice liquor flow homogeneously out from the chip tube to the suction of the first TurboFeed Chip Pump. A series of specially designed Chip Pumps (TurboFeed) deliver the chip slurry to the top of the Digester Vessel. Chips enter the first cooking zone of the Digester through the Inverted Top Separator (ITS) unit consisting of a cylindrical slotted screen basket and a screw conveyor (**Figure H-4**). The chips are conveyed up the ITS by a screw conveyor mounted within the screen basket and with the aid of upflowing liquor. At the same time, the screw conveyor wipes the screen basket to keep the screen from plugging.

Figure 0-2: Downflow Lo-Solids Digester (ANDRITZ, 2022)

Medium pressure steam is added to the top of the Digester (**Figure H-4; Figure H-5**) to heat the chips to correct temperature required for hard wood. Having passed this zone, the chips enter the extraction screen. Here liquor is extracted from the Lo-Solids extraction screens (upper most set of Digester screens), taking away from the system a high load of cooking side-products that are not beneficial for cooking. Next the chips meet the fresh liquor from the cooking circulation (second row of upper set of Digester screens). This liquor heats the chips to the cooking stage temperature.

White liquor and wash liquor are combined and pre-heated by extracted black liquor before being added to the digester cooking circulation. This liquor displaces the liquor from the first cooking zone. A portion of this liquor flows upward to counter currently heat the chips. The remainder of the liquor flows together with the chips downward to the digester second cooking zone. After the second cooking zone the rest of the liquor is extracted from the digester at the digester wash screens.

Washing in the Digester is accomplished by passing wash liquor in the counter-current direction through the pulp in the Digester bottom wash zone. The Cold Blow Pump injects wash liquor into the Digester bottom (**Figure H-5)**. This filtrate is first cooled in the Cold Blow Cooler prior to addition to the Digester. This liquor passes upwards in the pulp column and is continuously extracted through the digester wash screens. Adding a portion of the cold blow filtrate into the radial wash central pipe further enhances washing. This filtrate radially displaces the black liquor in the pulp at the end of the cooking zone.

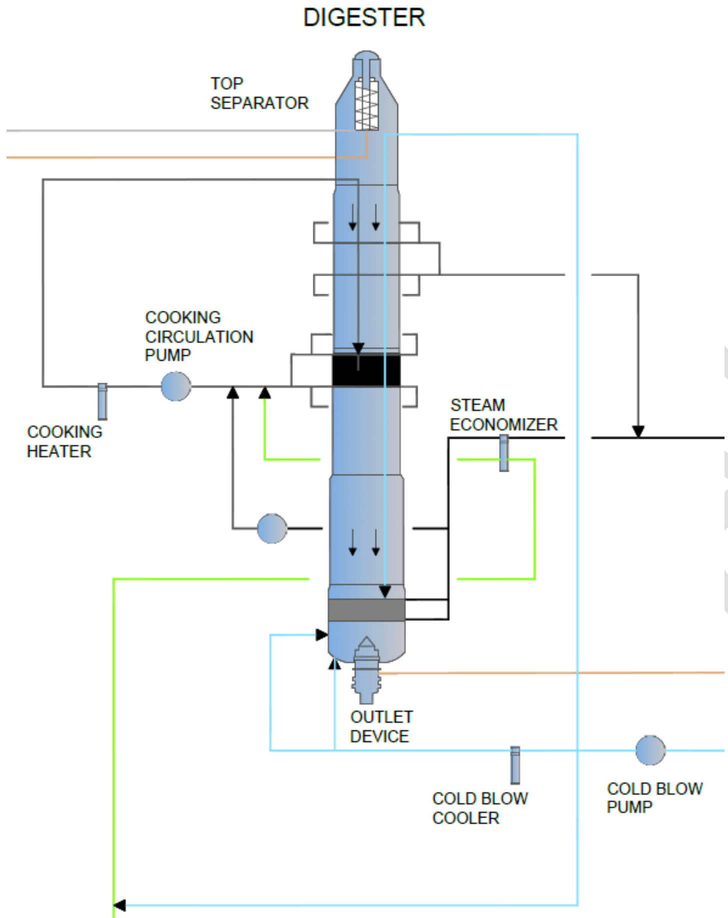


Figure 0-3: Process flows within the Digester (BBP, 2022).

Pulp from the Digester is homogeneously blown to the Blow Tank with the help of a Digester Outlet Device. The consistency of the chip column as it moves past the lower extraction screens is too high to be blown from the Digester. For this reason, another function of the wash filtrate is diluting the chip mass to the desired consistency. The pulp consistency is approximately 10 – 11 % when blown from the Digester. The Outlet Device motor load and pressure differential across the Outlet Device are a good indication of the blow consistency.

Extracted liquor from the digester is passed into a reboiler (**Figure H-6**) where it is cooled to approximately 110°-115°C. Heat from the extracted liquor is used to generate fresh steam from condensate which is added to the reboiler body. The black liquor leaving the reboiler is further cooled and then filtered before being transferred to the Evaporator area. The use of the reboiler allows digester pressure to be used for transferring the liquor and eliminates the requirement for a pump. The liquor to the reboiler flows through tubes very similar to a standard shell and tube heat exchanger. Energy is transferred from the liquor through the tubes into the shell side fluid.

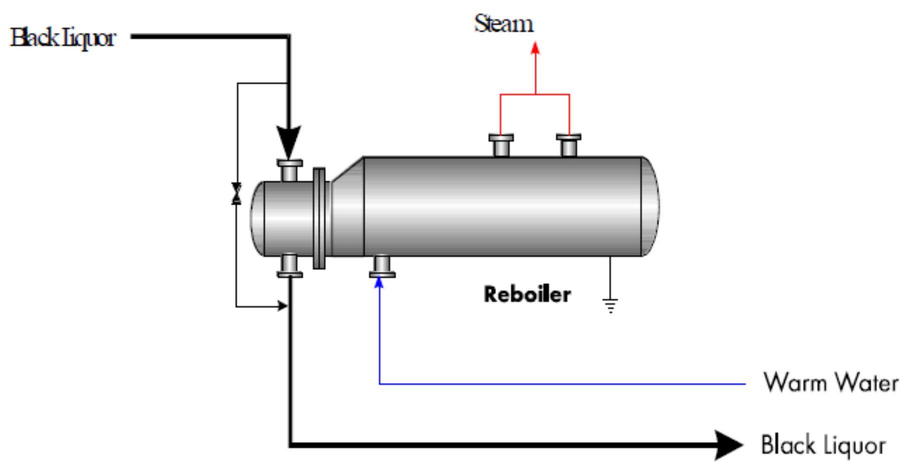


Figure 0-4: Reboiler (ANDRITZ, 2022)

The black liquor is filtered in the black liquor filter. In the filter most of the fibres are separated from the black liquor into a minor reject flow. Accepted, fibre-free black liquor is finally transferred to the Evaporation area, and the reject flow is returned to the Fiberline. The black liquor filter rejects are passed back to Digester. The black liquor filter reject flow remote setpoint is proportional to sum of extraction flows. Pressure difference for filter is calculated between the feed and accept pressure. High pressure difference indicates plugging of the black liquor filter screen and increases the reject flow controller setpoint of corresponding filter. The bypass valve opens in case the filter experiences high pressure difference or needs maintenance. Digester wash liquor bypass is connected to the fibre filter feed. The Bypass is normally closed, but if for some reason all wash liquor from the brown stock washing does not fit into cooking, wash liquor can be let directly to fibre filtration.

The preliminary quality parameters are provided below and the final quality parameters for the pulp mill will be provided by BBP once finalised.

BBP Preliminary Quality Parameters for Cooking only

- Target capacity at the blow line (min): 810 ADt/d
- Alkali charge (max): 21 %EA as NaOH
- Concentration of EA in white liquor: 110-115 g NaOH/l
- White Liquor Sulfidity: 20-25%
- White Liquor temperature (min): 90°C
- Design kappa from cooking: 16-20 kappa
- Black Liquor to evaporation (temp): 95°C
- Black Liquor to evaporation (fibre content): ≤ 40 mg/l
- Equipment Retention Times
    - Digester = 200 min
    - Blow Tank = 90 min

Washing and Screening

Washing and Screening in the project include 4 processes: Brownstock Washing, Oxygen Delignification, Screening and Post Oxygen Washing. The pulp coming from the Digester will contain both fibres and spent cooking liquor (black liquor), the latter of which contains inorganic chemicals and a large amount of organic substances and this needs to be removed. The black liquor will be removed from the pulp in the washing step and led to the chemical recovery system, where cooking chemicals and energy will be recovered. The dissolved organic substances and the spent cooking chemicals will be recovered from the cellulose fibres in the brown stock washing stages that will run counter-currently. The four processes will be described below.

Brownstock Washing

Pulp from the Blow Tank is discharged to the Standpipe and pumped with its consistency regulated at approximately 10% to the Brownstock Washing Drum Displacer (DD) Washer (**Figure H-7**). The Brownstock, Post-O2 Washing and Bleaching is based on DD Washer technology. Advantages of this DDW Washer technology include a high washing efficiency, high availability of the equipment, reduced energy operation, homogeneous pulp, minimum fibre damage and low emissions.

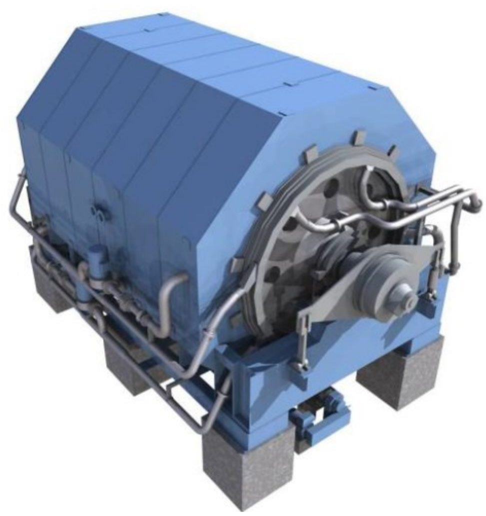


Figure 0-5: ANDRITZ Drum Displacer Washer. (ANDRITZ, 2022)

The surface of the rotating drum is divided into pockets. The casing to which sealing elements are attached surrounds the drum. The sealing elements separate the different washing zones from each other and have minimal clearance to the pockets edges. The distribution valve connects the drum channels and filtrate piping for filtrate removal and counter-current washing. The distribution valves located at both ends of the drum are divided into sectors corresponding to the washing stages. Hence the filtrates are not mixed. The DD Washer unique feature is, that it has flexible amount of washing zones. The pulp is washed upstream as displacement washing according to the counter-current principle (**Figure H-8**). In addition, the washer has a feed zone and a discharge zone. Pulp is removed below the discharge zone by a discharge screw. The pressurized pulp is dewatered in the feed zone on the surface of the perforated plate of the drum and fills the drum "U-type" pocket each at the time.

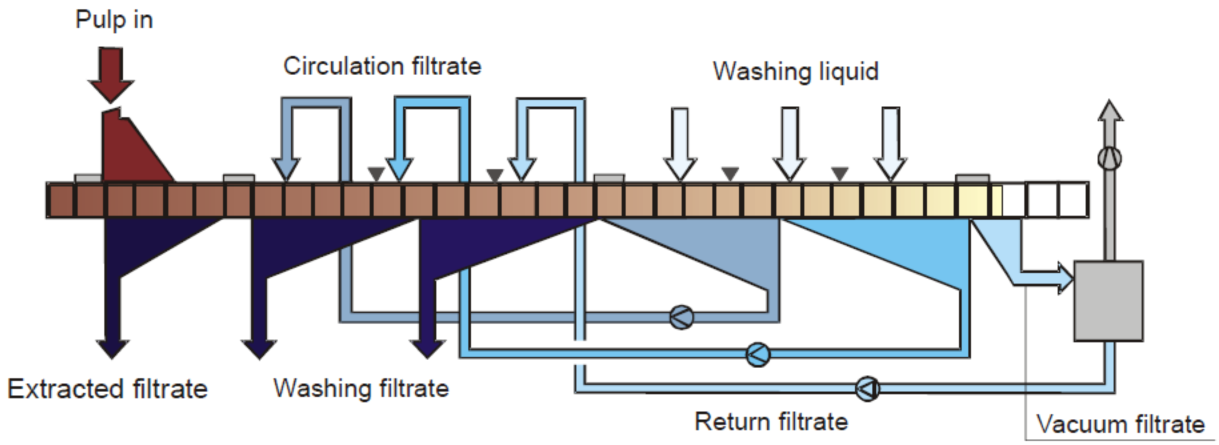


Figure 0-6: Operational Principle of a multi-stage DD Washer. (ANDRITZ, 2022)

From the feed zone, the pulp enters the 1st washing zone at constant thickness and consistency (10-12%). In each washing stage, the liquor present in the pulp cake is displaced by the filtrate of the next washing stage. With the circulating filtrate pumps introduced between the washing stages, the filtrate pressure of each washing stage is increased. The complete washing and filtrate circulation is pressurized by the wash water pressure and intermediate filtrate pumps. This prevents air from being mixed with pulp.

From the last washing stage, the pulp enters the discharge stage. A pressurized air impulse led below the perforated plates loosens the pulp cake from the drum pocket and makes the pulp drop onto the discharge screw. A higher outlet consistency is achieved by the vacuum system before the discharge stage. The vacuum system includes vacuum tank and a vacuum pump common with post oxygen DD-Washer, as well. As soon as the pulp has been discharged, the showers of the perforated plate wash pipe wash the perforated plate of the drum. The pulp is released from the drum to discharge conveyor by blowing pressurised air into the drum channels. From Browstock Washing DD Washer discharge conveyor the pulp drops directly to O2 Feed standpipe.

The Brownstock Fiberline process area requires a system for handling spill liquors from cooking and Brownstock process areas, system essentially including sump pumps centrifugal cleaner for cleaning spill from small impurities.

Oxygen Delignification Stage

The Oxygen Delignification Stage comprises two oxygen reactors, which depending on the wood species, allow for about 40% to 60% kappa reduction. From the oxygen stage feed standpipes, the pulp is pumped at 11-12% consistency by MC-pump to through the Oxygen Feeder and Oxygen Mixer to the first reactor. The retention time of the 1st Oxygen Reactor is 15 min, operating temperature approximately 95°C and operating pressure at the top of the reactor approximately 8 bar(g). Approximately two-thirds (2/3) of the total dose of oxygen (O_2) and oxidized white liquor is charged in the first Oxygen Reactor. From the 1st Oxygen Reactor, the pulp is discharged by the Reactor 1 Discharge Scraper, equipped with gas removal, and is heated up to 98 °C with indirect contact steam feeder to the pulp.

The hot pulp is led through the Oxygen Feeder and Oxygen Mixer to the 2nd Oxygen Reactor. The retention time in 2nd Oxygen Reactor is 60 min, operating temperature approximately 100°C, and operating pressure at the top of the reactor approximately 5.0 bar(g). From the 2nd Oxygen Reactor, the pulp is discharged with the Reactor 2 Discharger and sent to the Oxygen Delignification Blow Tank, where the pulp is diluted and then pumped to the Knot Separator.

Screening

In the Knot Separator (**Figure H-9**) the pulp is fed tangentially to the upper section of the screen, outside the rotating screen cylinder of the knot separator. Accept pulp flows through the ø8 mm holes of the screen cylinder into the accept space. Knots and other heavy impurities drift to the outer rim of the screening space outside the knot screen cylinder and are discharged out of the knot separator to the reject pipe, to which dilution liquor is fed according to the ejector principle (pulp is not diluted inside the unit). In the reject pipe, the knot reject is diluted to approximately 1% consistency and fed to the Knot Washer. The Knot Separators rejects are treated in the Knot Washer, in which the fibers are washed off from the knots fed into the unit. The incoming flow is fed to the bottom section of the screen where heavy rejects, such as junk and stones, sink to the bottom and are discharged. The washing liquor is fed from the outside of the screen basket to wash the fibers loose from the knots and the vertical screw lifts dry knots to the upper section of the screen, from which they are discharged at 25 – 30% consistency.

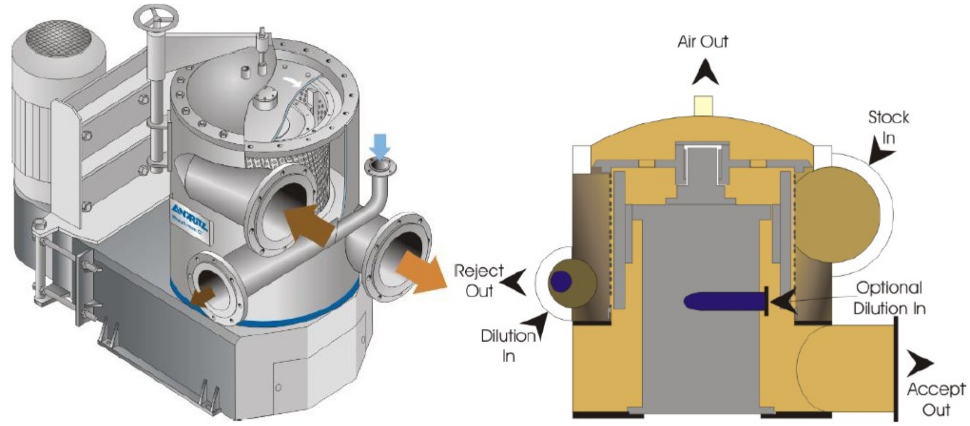


Figure 0-7: Knot Separator. (ANDRITZ, 2022)

Once diluted with white liquor or black liquor filter rejects, the knot reject is pumped to the cooking plant by an open-impeller process pump. Accepted pulp (primary and secondary) flows through the holes in the screen cylinder to the accept space, and from there it is pumped to the suction side of Screen Feed Tank bottom dilution pump. The knot reject can also be taken out from the system. The Knot Separators accepts are fed to the feed pump of the primary MODUscreens which are operated in parallel. Primary stage accept is fed to the Pressure Thickener and the rejects are pumped to the feed of the secondary stage MODUscreen at approximately 2.5% consistency. Secondary stage accepts are fed to the primary stage and the rejects are pumped to the feed of the tertiary stage MODUscreen at approximately 1.5% consistency.

The accepts from the tertiary screen are returned to the feed side of the secondary stage screen feed pump and the rejects flow into the Shive Cleaner. From Shive Cleaner the accepts flows to the Reject Washer. The rejects from the Shive Cleaners are taken to oxygen stage feed or out from the system. The reject of the Reject Washer is discharged from the screen at 10 – 15% consistency and is fed to the oxygen stage feed standpipe or to cooking or is purged out from the system.

Post Oxygen Washing

The Primary stage accepts are fed to Pressure Thickener, from which the thickened pulp is fed to the Post Oxygen (O_2) stage DD Washer. The Pressure Thickener filtrate is fed to the suction side of the screening dilution pump.

The preliminary quality parameters are provided below and the final Quality Parameters for the pulp mill will be provided by BBP once finalised.

BBP Quality Parameters

- Dilution factor at the last post O_2 washer: 2.5 m^3/ADmt
- COD to Bleaching: < 11 COD/kg

Bleaching

The purpose of bleaching chemical pulp is to obtain certain pulp quality criteria with respect to brightness, brightness stability, cleanliness, and strength. Cooking and delignification do not remove all the lignin, as such to achieve the required brightness, it is necessary to remove or oxidise the remaining lignin and impurities in the pulp.

Chlorine-free pulp is an environmentally preferable alternative to pulp bleached with chlorine. Chlorine and its derivatives (such as chlorine dioxide)—the most common bleaching agents used by the pulp and paper industry—are quite harmful to the environment, particularly the aquatic environment.

Chlorine-free paper is categorized as either *Totally Chlorine Free* (TCF) or *Elemental Chlorine-Free* (ECF). The process proposed by BBP will use TCF bleaching, meaning pulp will be bleached without any type of chlorine. TCF bleaching, an established technique, uses oxygen, ozone or peracetic acid and peroxide with alkali from lignin extraction.

TCF bleaching is the environmentally preferable alternative to ECF bleaching because chlorine derivatives—while less harmful to the environment than elemental chlorine—still produce toxic chlorinated organic compounds, including chloroform, a known carcinogen. These compounds are released into waterways as effluent from the bleaching process, where they produce environmental damage. Oxygen (O_2), ozone (O_3), and hydrogen peroxide are some bleaching alternatives to chlorine and chlorine derivatives.

The bleach plant will consist of a sequence of separate bleaching stages with different chemicals added. Each bleaching stage will comprise:

- Devices for mixing chemicals and pulp
- A bleaching reactor (upflow or downflow towers) designed with a suitable residence time for chemical reactions
- Washing equipment for separation of used chemicals, removed lignin and other dissolved material from the pulp (drum washer, wash presses or diffuser washer)

The bleaching will be carried out in four bleaching stages with a pre- and post-oxygen DD Washer after each bleaching stage. The bleaching stages are designated using symbolic shorthand for the type of bleaching agent applied. BBP process will be based on the sequence O-O-Q1-EOP-Z/Q2-P or Q1-EOP-Z/Q2-P. The sequence as illustrated below (**Figure H-10**) where:

i. **O** = Oxygen stages of 15 minutes (at 95°C) and 60 minutes (at 100°C) respectively in 2 Oxygen Reactors. The pulp from Post Oxygen DD Washer is pumped with MC Pump to the Brownstock HD Storage/Q1 Tower
ii. **Q1** = First Bleaching stage. This will be done in the Brownstock Storage Tower. Here the pulp is discharged with ADS Discharge Scraper to the mQ1 Stage DD Washer. The ADS Discharge Scraper is used for 120 minutes. From the Q1-stage DD Washer, the pulp drops into the Standpipe, and

is pumped further by an MC-pump to the EOP stage atmospheric upflow reaction tower at approximately 11 - 12% consistency.

iii. **EOP** = At 11-12% consistency, Peroxide (H_2O_2) and sodium hydroxide (NaOH) are dosed to the EOP-stage feed pump that feeds the EOP upflow tower. Oxygen is added via Oxygen Mixer. In the EOP tower the retention time is 90 min and temperature approximately 95°C. From the EOP Tower, the pulp is discharged by a Top Scraper and directed to the EOP-stage DD Washer to ensure uniform pulp flow. The washing liquor used in the EOP Washer is White Water/Hot Water and as a dilution, Z/Q2-stage filtrate is used.

iv. **Z/Q2** = From the EOP-stage DD Washer, the pulp drops into the Standpipe of the MC pump feeding the Z/Q2-stage and is furthered by pumping through the two Ozone mixer to the Ozone Reactor (Z) at 11 – 12% consistency. From the Ozone Reactor, pulp is discharged with a Reactor Discharger to the Q2 Blowtube.

v. **P** = Alkaline stage. From the Z/Q2-stage DD Washer, the pulp drops into the Standpipe, and is pumped further by an MC-pump to the P-stage Reactor at approximately 11 - 12% consistency. Peroxide (H_2O_2) and sodium hydroxide NaOH are dosed to the P-stage feed pump that feeds the P-Reactor. In the P-Reactor the retention time is 120 min and temperature approximately 100°C. From the P-Reactor, the pulp is discharged by a Reactor Discharger and sent to P-stage DD Washer. White Water/Hot Water is used as washing liquor and as a dilution liquor. After P-stage DD Washer pulp is pumped into Bleached Pulp Storage Tower.

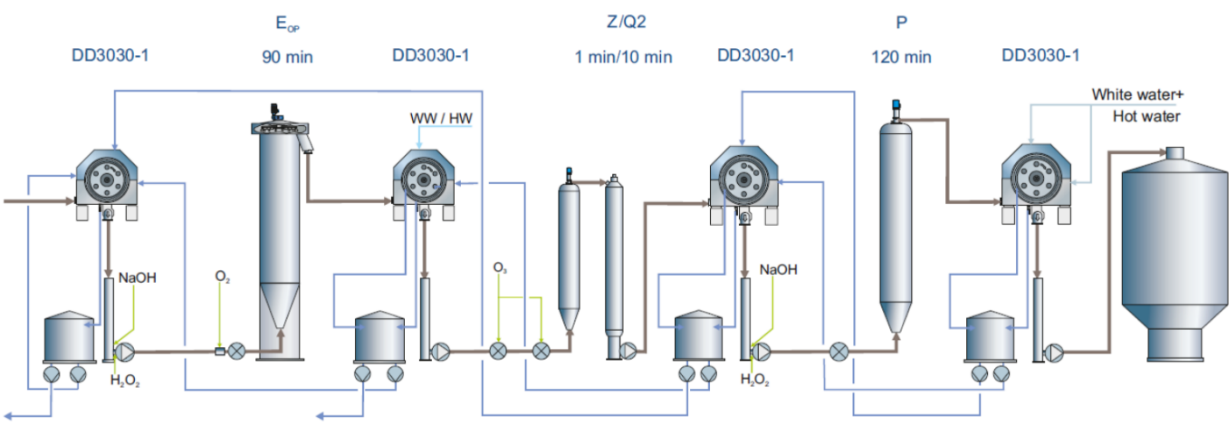


Figure H-10: Illustration of the proposed stages of bleaching for the pulp mill (Source: ANDRITZ, 2022).

The preliminary quality parameters are provided below and the final Quality Parameters for the pulp mill will be provided by BBP once finalised.

BBP Preliminary Quality Parameters

- Capacity bleached pulp: 790 Admt/d
- Sequence: O-O-Q1-EOP-Z/Q2-P
- Dilution factor in bleaching washers: 1.5 m^3/ADt
- COD after last washer: < 2 COD/kg

- Final brightness: ≥ 85% ISO
- Equipment Retention Times
  - 1st Oxygen Reactor = 15 min
  - 2nd Oxygen Reactor = 60 min
  - Brownstock Storage Tower / Q1-Stage = 120 min
  - EOP-Tower = 90 min
  - Z-Reactor = 1 min
  - Q2 Blow Tube = 10 min
  - P-Reactor

The utility requirements of the Fiberline (Cooking to Bleaching) are provided below and the final utility requirements for the pulp mill will be provided by BBP once finalised.

BBP Preliminary Utility Requirements for the Fiberline – Cooking, Brownstock Washing, O2 Delignification, Screening and Post Oxygen Washing and Bleaching

- Mill/Cooling water:
  - Temperature = 32 °C
  - Pressure, min = 3 bar(g)
- Hot Water
  - Temperature = 75-80 °C
  - Pressure, min = 3 bar(g)
- Warm Water
  - Temperature = 45 °C
  - Pressure, min = 3 bar(g)
- Sealing water purity requirement
  - Suspended solids content, max. = 2 mg/l
  - Particle size, max. = 50 µm
  - Permanganate number, max. = 30
  - Fe content, max. = 1 mg/l
  - Total hardness, max. = 10 dH
  - Humus free
- Low Pressure Steam
  - Pressure = 6 bar(g)
  - Temperature = 180 C
- Middle Pressure Steam
  - Pressure = 12 bar(g)
  - Temperature = 220 °C
- Power supply nominal voltage:
  - High Voltage = 110 kV
  - Middle Voltage = 10.5 kV
  - Low Voltage = 400/230 V
  - Power Supply nominal frequency = 50 Hz
- Compressed air

- Process air Pressure = 6 bar(g)
- Instrument air Pressure = 5.5 bar(g)
- Instrument air Oil content = < 10 mg/m^3
- Instrument air Dust content = 0.5-3 µm

Drying

The drying process will involve the screening and cleaning of the pulp, followed by pulp being dewatered in a press and then dried (**Figure H-11**). Once the bleached pulp is dried it will be cut and rolled into bales, the final product, which will be prepared for shipment.

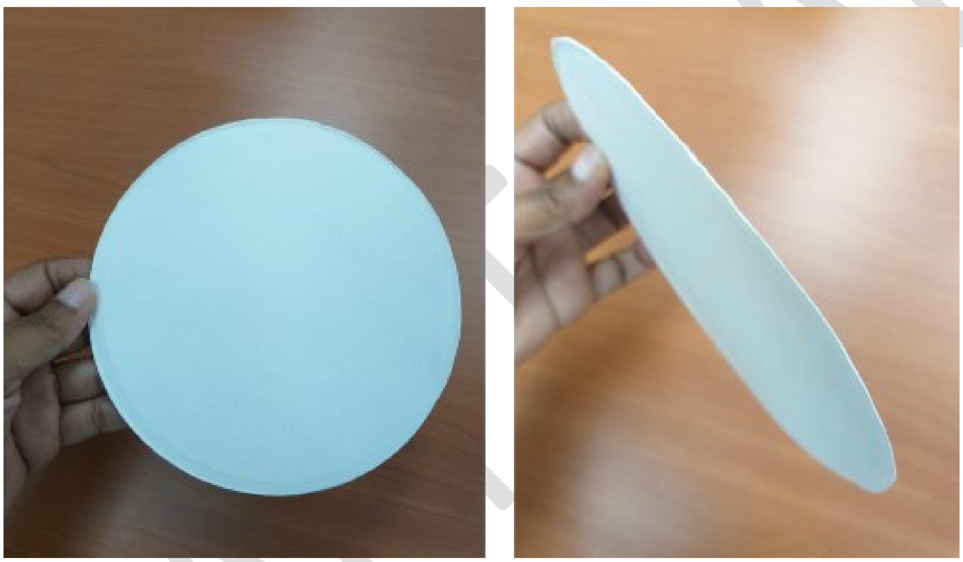


Figure H-11: Final product sample.

The preliminary quality parameters are provided below and the final Quality Parameters for the pulp mill will be provided by BBP once finalised.

BBP Quality Parameters

- Steam pressure before control valve: 0.35 MPa (g)
- Final pulp sheet dryness: 90 % BD
- Sheet width at cutter: 4200 mm
- Number and size of Bales at cutter: (6) 700 slit x 840 cut mm
- Bale weight: approx. 250 kg

THE CHEMICAL RECOVERY LINE

Evaporation

The Evaporation plant is a part of the Chemical Recovery process at the Kraft Pulp Mill. The Evaporation Plant converts weak black liquor to a stable, high-solids black liquor stream for efficient combustion in the recovery boiler. It also processes various side streams for combustion in the recovery boiler. A diagram of the process flow of the Evaporation Plant is presented in (**Figure H-12**) Processes in the Evaporation Plant involve:

i. Liquor, steam and vapour flows
ii. Condensate flows and segregation
iii. Condensate stripping and washing
iv. Methanol Liquefaction
v. Treatment of DNCG and CNCG gases

Liquor, Steam and Vapour Flows

Black liquor is concentrated in the Evaporation Plant whereby the Feed black liquor (from the Reboiler from Cooking) is fed to separate flash sections where the flash vapours are utilized for evaporation and where the liquor is concentrated. These sections are called effects and are labelled as effects 1A-1D, 2A, 2B, 3, 4, 5 and 6 (**Figure H-12**). The sequence of travel along the effects is 4-5-6-5-4-3-2A/2B. The Liquor is further concentrated in effects 1A, 1B, 1C and 1D. Low Pressure live steam is fed to effects of 1A to 1D with the liquor; secondary vapour generated are used as a heating medium. Clean primary condensates generated from effects 1A to 1D are then collected together and flash cooled. The flash vapor is condensed in a separate element section, which results as return rate of 100%.

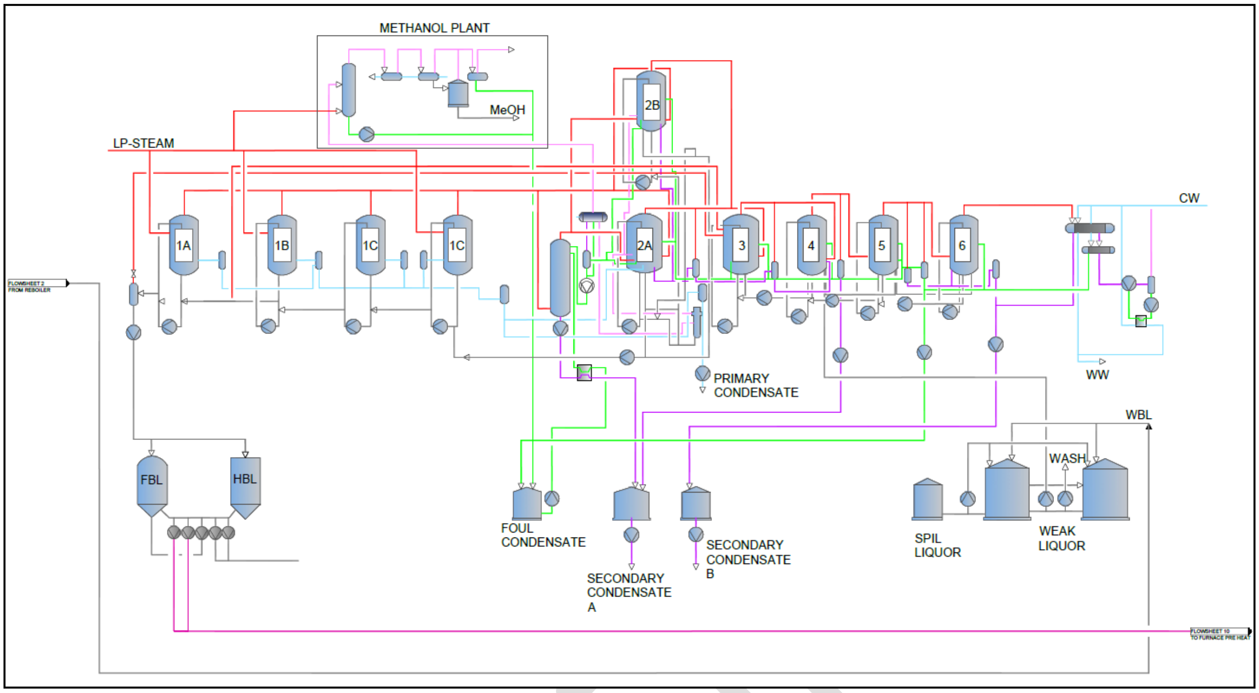


Figure H-12: Process flow of the Evaporation Plant (BBP, 2022).

Condensate Flows and Segregation

The secondary condensates from the Evaporator effects are expanded to the very next effect. The total flow of process condensate is divided in three different fractions: prime quality condensate (A), intermediate quality condensate (B) and a fraction that will have a high methanol content (Foul). The condensate that is high in MeOH-content is called "foul" condensate and will require stripping before reuse.

The elements in effects 2, 3, 4, 5 and 6 are equipped with an internal methanol concentration system (**Figure H-12**). The vapor is fed to the bottom of the element where the vapor will flow upwards counter-currently to the condensate. In a way, the element works as an "internal stripper". The counter-current flow as well as the good vapor liquid contact, assures maximum purification. The foul condensate is withdrawn from a separated section on the top of the plate. The gases from the surface condenser are vented with an ejector system and transported to the Non-condensable Gas System (NCG-system) for destruction.

Condensate Stripping and Washing

The foul condensate from the Digester area and the Evaporation Plant area are pumped to the foul condensate tank (**Figure H-12**). From there the foul condensate is fed to the stripping column through a condensate filter to avoid plugging of the stripper with fibers and other material. The double filter is arranged so that one filter is in use and the other is on stand-by. A simplified flowsheet of stripping system is shown in **Figure H-13** below.

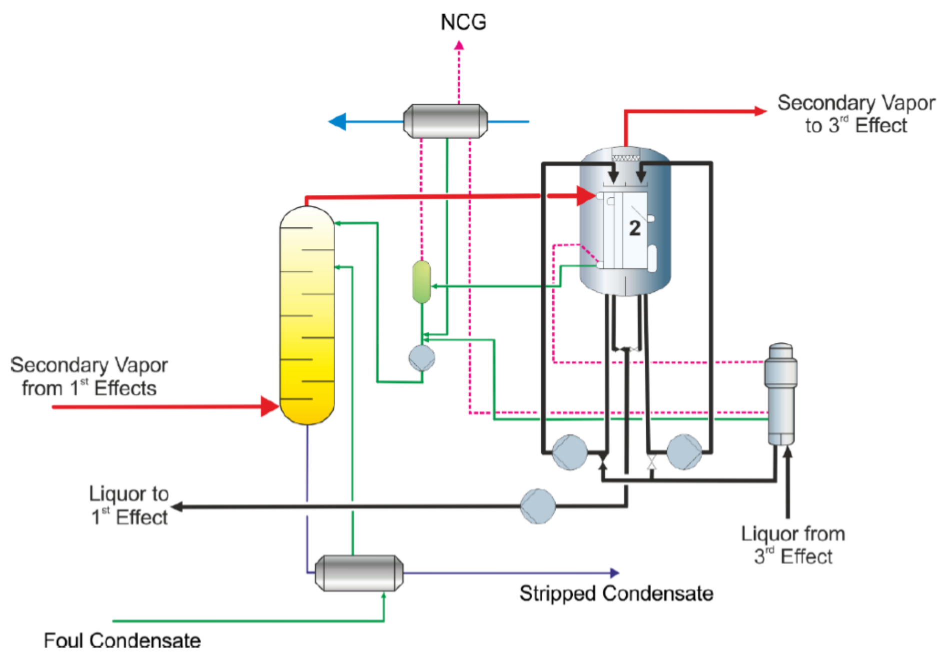


Figure H-13: ***Simplified flowsheet of stripping system (ANDRITZ, 2022)***

The foul condensate coming from tank farm is preheated in a foul condensate pre-heater before entering the stripping column. The stripping media is secondary vapor from the effect 1A, 1B, 1C and 1D (**Figure H-12**). The stripper overhead vapours are condensed primarily in a dedicated lamella package in the second effect and secondly in a tubular type preheater, top condenser, utilizing black liquor coming from effect 3 as a cooling media. The vapor from the top condenser is fed to a trim condenser where the stripper gas concentration can be adjusted before it is led to the methanol liquefaction system. The stripped condensate coming from the stripping column is fed through a foul condensate pre-heater where it operates as a heating medium. After the pre-heater, stripped condensate is mixed with the prime quality process condensate for reuse.

The Evaporation Plant shall deliver a proper amount of firing liquor to the Recovery Boiler during wash sequences. The recommended wash media is weak liquor, but the wash liquor piping will be arranged so that process condensate, warm water or also with caustic can be used as wash media, should this be needed. Washed liquor shall be pumped out through the circulation pump to the wash liquor flash tank. From the wash liquor flash tank, liquor goes to Spill liquor tank and finally to weak liquor tank.

Methanol Liquefaction

The stripper gas coming from trim condenser is led to a rectifying Methanol column where the methanol rich gas is concentrated and finally condensed to a liquid methanol fuel (**Figure H-12**). A simplified flowsheet of the methanol liquefaction system is shown in **Figure H-14** below. A small amount (~ 20 % of the gas amount) of live steam is fed to the bottom of the rectifying column to maintain operating pressure and temperature. The top vapor product is first condensed partially in a methanol column top condenser and after that in a methanol condenser. The condensate exiting from the column bottom will be returned to the foul condensate tank.

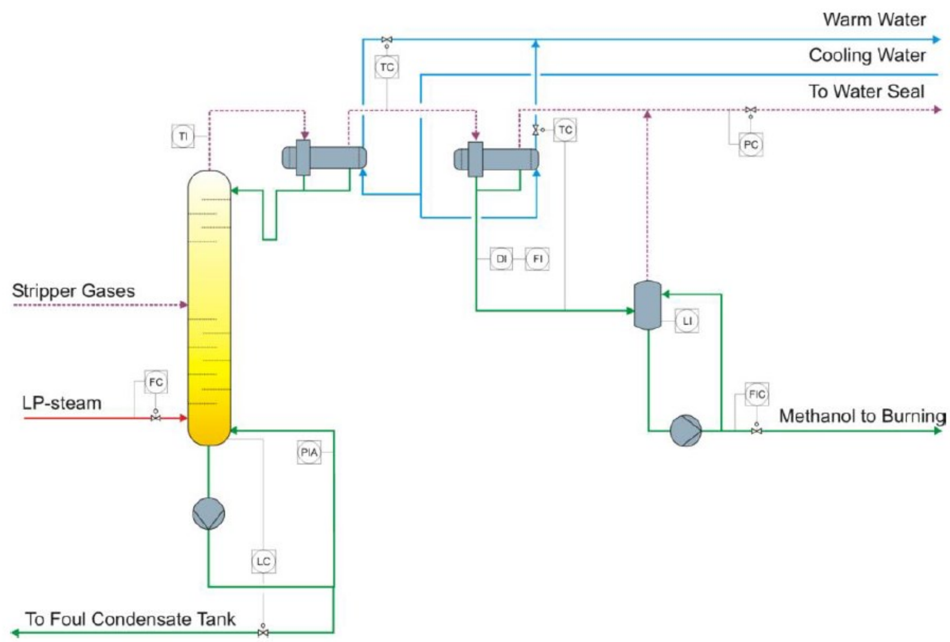


Figure H-14: Simplified flowsheet of the methanol liquefaction system (ANDRITZ, 2022)

The Quality Parameters for the Evaporator Plant will be provided by BBP once finalised.

Recovery Boiler

The main processes in the chemical recovery system are the evaporation of the black liquor (cooking liquor and counter-current washing liquor), incineration of the evaporated liquors and causticizing (including lime regeneration). The chemical recovery boiler is an essential part of the pulp production process as it recovers and regenerates cooking liquors. The concentrated black liquor is burnt in the recovery boiler to recover the sodium and sulphur content in a suitable chemical form to regenerate the pulping chemicals and recover energy from the flue-gases. The fuel value of recoverable black liquor is normally enough to make kraft pulp mills more than self-sufficient in heat and electrical energy.

BBP proposes to implement a recovery boiler, which will have three main functions:

i. Recovery of inorganic pulping chemicals
ii. Incineration of the dissolved organic material and the recovery of the energy content as process steam and electrical power
iii. Prevention and control of pollution (a significant reduction of the wastewater load discharged to the wastewater treatment plant and an extensive reduction of emissions to air)

ANDRITZ is the world´s leading supplier of recovery boilers and will be supplying a ANDRITZ HERB™ Recovery Boiler for the project (**Figure H-15**). This Recovery Boiler for kraft mills is designed to achieve a high power-to-heat ratio to maximize both chemical recovery and energy generation from the recovery process. **Figure H-16** presents the process flow of the Recovery Boiler at the proposed pulp mill.

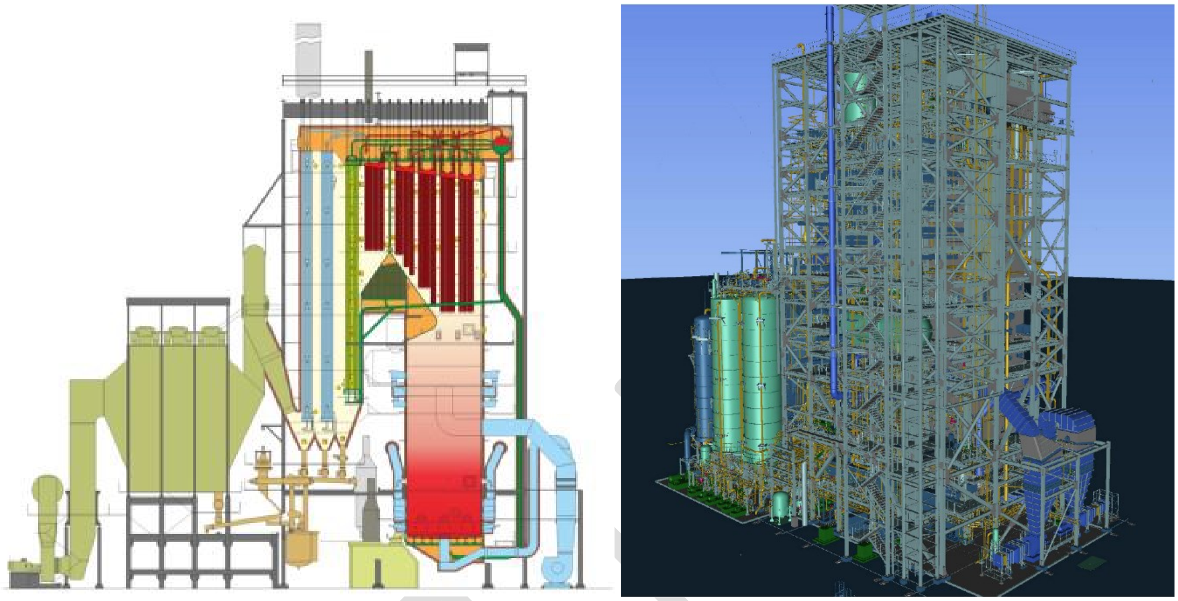


Figure H-15: typical layout of HERB recovery boiler that will be used at the mill. (ANDRITZ, 2022)

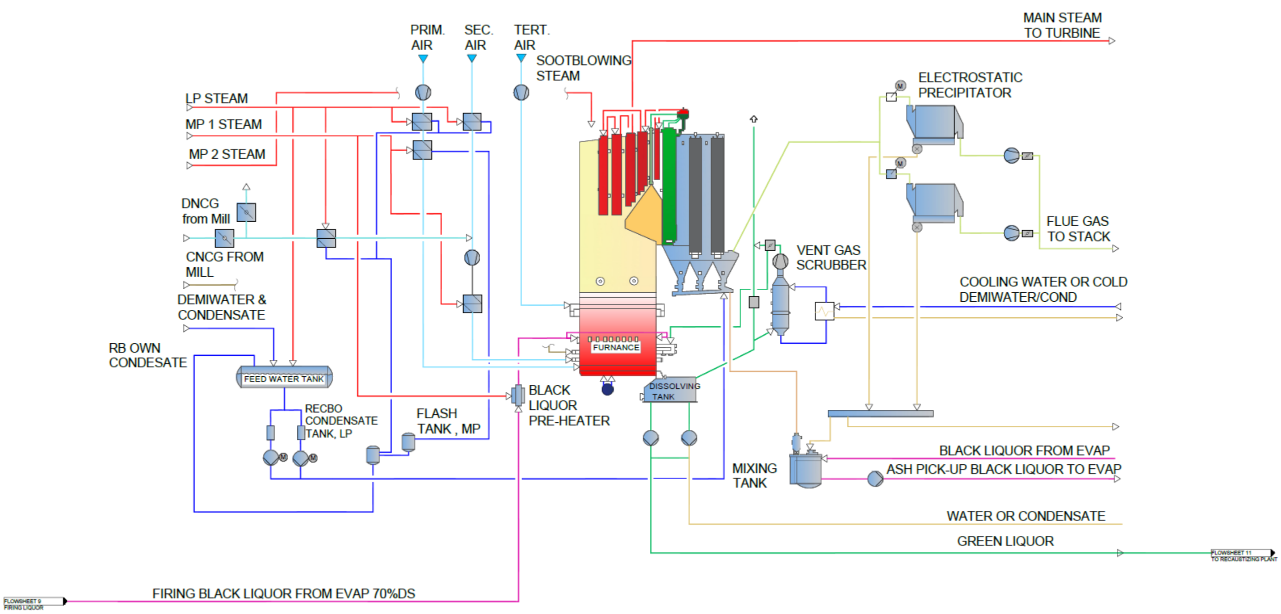


Figure H-16: Illustration of Recovery Boiler (Source: BBP, 2022).

The spent liquor from the digesting plant goes first to the evaporation plant where the dry solids content of the liquor is increased. Then the evaporated liquor comes to the recovery boiler plant (**Figure H-16**). Fly ash from electrostatic precipitators is mixed into the black liquor. After additional concentration of the black liquor in the evaporation plant the liquor is burned in the combustion chamber of the boiler. Feed water is pumped first to the economizers where it is preheated by flue gas. The water then enters the water circulation system of the boiler. During combustion of the black liquor, high pressure steam is generated in the boiler. The superheated steam flows from the boiler to a turbine generator plant. The hot smelt flow of the regenerated chemicals is drained from the furnace floor to the dissolving tank (**Figure H-16**). The chemicals are dissolved into weak white liquor and returned to a Recausticizing Plant for further processing.

The smelt from the recovery boiler will be dissolved in water or weak white liquor to produce 'green liquor' which consists mainly of sodium sulphide (Na_2S) and sodium carbonate (Na_2Co_3). The green liquor will be filtered and causticized with lime in the Reacusticizing Plant and sodium carbonate is converted into sodium hydroxide (NaOH) to produce 'white liquor' for pulping. Ash residues and other impurities are removed from the process as green liquor dregs.

The handling of black liquor with a high sulphur content may release sulphur-containing gases into the air as sulphur dioxide after incineration and as malodorous gases containing reduced sulphur compounds e.g. hydrogen sulfide (H_2S), methyl mercaptan (CH_3SH), dimethylsulphide (CH_3SCH_3) and dimethyldisulphide (CH_3SSC_3). The recovery boiler BBP is planning to use is composed of a top-supported, gas-tight membrane construction furnace with a decanting type floor construction, a panel type superheater section protected by a large nose arch, a singlepass, long flow type generating section (boiler bank) and a single-pass, long flow type economizer. The symmetrically arranged black liquor and combustion air systems are designed to ensure optimum combustion control and minimum emissions.

Strong, malodorous gases will be collected and burnt in the recovery boiler, a common practice in European pulp mills. The BBP concept will incorporate this, and all safety measures with special care for burner design and air distribution to eliminate explosive conditions. The unit is composed of a top-supported, gas-tight membrane construction furnace with a decanting type floor construction, a four stage superheater section protected by a large nose arch, a single-pass, long flow type generating section (boiler bank) and a single-pass, long flow type economizers. The symmetrically arranged black liquor and combustion air systems are designed to ensure optimum combustion control and minimum emissions and carry-over. Scrubbers will be used to treat flue-gases from dedicated burners for heat recovery and the removal of sulphur dioxide (SO_2). The scrubber water will be led back to the chemical recovery system.

BBP Preliminary Quality Parameters (ANDRITZ, 2022)

The ANDRITZ HERB Recovery Boiler design parameters are:

- Virgin black liquor firing capacity: 1250 tDs/d
- Dry solids concentration: 79%

- Steam parameters at Superheater outlet
  - Temperature = 440°C
  - Pressure = 40 bar (a)
- Steam Capacity: 190 t/h

Recausticizing Plant

The recausticizing process is the final stage in the chemical recovery in a pulp mill. The goal is to achieve an efficient and controlled reaction between green liquor and lime to produce as much strong and clean white liquor (NaOH) as possible with high purity (minimum amount of unreactive chemicals) for the cooking process. It also provides excellent lime mud filtration properties. A diagram of the process flow from the Recovery Boiler and through the Recausticizing Plant to the Digester is shown in **Figure H-17**.

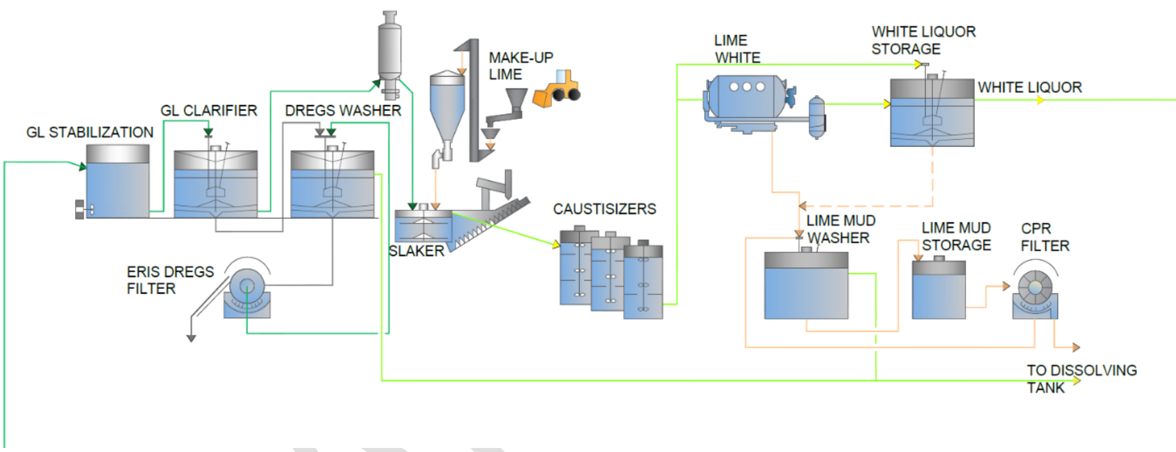


Figure H-17: Process flow of the Recausticizing Plant. Inflows of the green liquor come from the Recovery Boiler to the Green Liquor Stabilisation Tank (GL Stabilisation). Once Recausticizing is complete, the white liquor is pumped back into the Digester (ANDRITZ, 2022).

Green Liquor Handling

The purpose of Green Liquor Handling is to filter green liquor coming from the Recovery Boiler so that it can be suitable for Recausticizing. The green liquor is pumped from the Recovery Boiler's dissolving tank to the green liquor stabilization tank, where the variations of green liquor flow and density are balanced (**Figure H-17**). The purpose of the green liquor stabilisation tank is to stabilize the concentration, temperature and flow fluctuations of incoming green liquor. It also acts as a storage tank between the Recovery Boiler and the Green Liquor Filter. From the stabilization tank, green liquor is fed flow-controlled to the green liquor clarifier (**Figure H-17**). The green liquor clarifier consists of the clarifying section (lower part) and the storage section (upper part). Green liquor is fed to the lower part of the clarifier, the clarifying section, by the feeding pipe. In the clarifying section, green liquor dregs are separated from green liquor and it sinks to the bottom of the clarifier. The clarifier raking mechanism in the bottom collects the dregs to the pumping chute, from where the dregs is pumped to the dregs filter for washing and drying. Dry and clean dregs are removed from the process.

Clarified clean green liquor rises from the clarification section to the upper section that operates as storage for clarified green liquor. From the storage, the green liquor is pumped to a Lime Slaker (**Figure H-17**). Optionally the green liquor can be cooled prior to feeding to a slaker as the cooling of the liquor will optimize the operation of the slaker, maximize causticizing reaction and prevent boiling problems in the slaker. In the cooling process, clean, hot green liquor from a green liquor filter or clarification system is pumped into to a vacuum operated flash-tank, where a part of the liquor vaporizes. The vapor is led to a separate condenser, where the energy of the hot vapor is transmitted into cooling water.

Non-condensable gases (NCGs) are removed by small vacuum pump. By controlling the outlet temperature of the cooling water, it is possible to precisely cool the green liquor to ensure that the temperature of the causticized liquor exiting the slaker is maintained at a constant temperature and slightly below boiling. The heat from the green liquor can be used to produce hot water in the condenser. The green liquor does not pass through the condenser, which eliminates the problems of heat exchanger fouling, normally experienced with normal tube and shell green liquor coolers. The Condensate is returned back to the green liquor flow fed to the Lime slaker.

The Andritz EIRS Dregs Filter is a rotary vacuum precoat filter and consists of a rotating drum, vat with agitator, hood with wash sprays and an automatic continuously advance/retract scraper blade system (**Figure H-17**). The Dregs Filter dewaters, washes and dries concentrated green liquor dregs from the green liquor filter. The Dregs Filter has a precoat of freely filtering lime mud built on the media that helps with the filtration. The dregs are filtered on the surface of the precoat, washed with hot water, dried and then removed by an automatic, continuously advancing scraper blade.

Limeslaking and Causticizing

The slaking process is an important unit operation within the White Liquor Plant and occurs in the Lime Slaker (**Figure H-17**). The ANDRITZ LimeSlake has raking arms and is designed to create the optimum lime mud particle size, which improves the white liquor filtration process. Lime and green liquor are mixed under the slaker liquid level with feed cyclone. Constant lime/green liquor ratio can be maintained in the slaker by controlling the rotation speed of the lime feeder regardless of changes in green liquor feed flow or quality. Lime, which is slaked in the two (2) compartment LimeSlake, creates larger lime mud particles, which filter more easily on pressurized white liquor disc filters, resulting in increased capacity, longer intervals between acid washing and less frequent filter bag replacement. Lime milk is overflown from the slaker to the series of causticizers.

ANDRITZ causticizer system is designed for operating the system with optimum reaction yield, whereby their purpose is to give lime milk sufficient retention time to complete the reaction to obtain white liquor filtration. The ANDRITZ LimeWhite is a pressurized disc filter, which performs both white liquor filtration and lime mud washing and because of the high discharged mud solids it is an ideal selection for mills with tight water balances (**Figure H-17**). The LimeWhite system consists of a horizontal pressurized filter vessel with integrated lime mud agitator, a filtrate vessel and filtration and booster compressors with separators. Channels, located inside the shaft transfer white liquor from the discs through the shaft and filtrate valve to the filtrate vessel, where gases and white liquor are separated and white liquor is pumped to white liquor storage. A pressure difference of approximately 1.2 bars causes the lime mud to form a cake on the filter media and forces white liquor into the sectors.

White liquor flows from the sectors through the channels inside the central shaft and into the filtrate vessel. Lime mud, which is separated from white liquor, stays on the surface of the rotating filtering discs. Hot water showers wash soda from the lime mud cake, which is further dewatered prior to discharge. A precoat of lime mud is maintained on the discs and the outer layer of lime mud is scraped from the discs by scraper blades into the lime mud chutes, where it is diluted.

The ANDRITZ CPR Lime Mud Precoat Filter dewaters and washes lime mud. The ANDRITZ CPR Lime Mud Filter is a rotary vacuum precoat filter and consists of a rotating drum, vat with oscillating rake type agitator, hood with wash sprays, scraper assembly. Pre-washed lime mud from the lime mud storage tank is diluted to approximately 25% solids and then pumped to the lime mud filter vat. Additional wash water is added to the vat to maintain a constant vat level, which ensures an even cake formation on the drum. The lime mud solids are retained on the surface of the precoat layer. The lime mud is washed by spraying with hot water, dried and then discharged from the filter by a stationary scraper on to the conveyor. The liquor and air pass through the drainage sections, internal valve and suction valve to the vacuum receiver, where the air and filtrate are separated, and the filtrate is pumped to weak wash storage.

The BBP concept does not include a lime kiln and propose that the produced lime mud be used outside the mill, either as part of raw material in the cement industry or as soil improvement material (both fertilizers and/or correction of densities).

The Quality Parameters for the Recausticizing Plant will be provided by BBP once finalised.

Appendix I Wastewater Treatment Plant Factsheet for the Bamboo Pulp Mill from SUEZ

Water Technologies & Solutions
fact sheet

Z-MOD* S (AG) packaged plants

pre-engineered above ground packaged plants are cost effective, compact solutions for wastewater treatment

Base system

- ZeeWeed* 500 reinforced ultrafiltration membranes produce superior effluent quality while operating in a high solid wastewater environment
- Complete systems incorporate screening, biological equipment, filtration equipment, and disinfection
- Epoxy coated carbon steel tank with anoxic chamber with mixing, aerobic chamber with diffusers and membrane chambers
- Aeration blowers, permeate pumps, back pulse pumps, back pulse tank, control panel, recirculation pump, GE Fanuc PLC, and HMI interface mounted on the equipment skid
- Plant start-up and operator training

Equipment material

- Epoxy coated carbon steel or 316SS Frame
- SCH 80 PVC Piping
- Epoxy coated carbon steel or 316SS Membrane tank
- High density polyethylene backpulse tank
- 316SS air header

Application dependent options

Biological equipment includes screening, enhanced nitrogen removal systems, and grinder pumps

Chemical systems for enhanced coagulation, pH control, and membrane cleaning

Effluent systems including turbidity measurement and UV disinfection

- Maintenance packages including shelf spares, spare parts, service contracts, and process tracking software
- Acoustic blower enclosures
- 24/7 technical support
- InSight* proprietary data analysis and tracking system

Table I-1 below shows the data sheet for the water treatment system being designed for the Pulp Mill.

Table I-1: Data sheet for the Z-MOD S4 System of the Water Treatment Solution SUEZ is designing for use at the Pulp Mill.

	Value	Unit
Design Flow Rates		
Average Flow	20,000	gpd
Peak Flow	40,000	gpd
Permeate Discharge Design		
Design Flow Rate	15	gpm
Max TDH Required	6.7	psig
Available TDH	22	psig
Discharge Pressure	15.3	psig
Cassette Configuration Type of Membrane:	500	A
Number of Trains:	2	
Number of Cassettes per Train:	1	
Number of Modules per Cassette:	2	
Standard Equipment		
Blowers for Process & Membrane Aeration	2	
Aerobic Diffusers	1 Lot	
Anoxic Mixing	1 Lot	
Membrane Modules	4	
Recirculation Pumps	2	
Permeate Pumps	2	
Backpulse Pumps	2	
Backpulse Tank	1	
Control Panel	1	
PLC	1	
HMI	1	
Biological Tank	1	
Equipment Skid	1	
Tie points Connections		
Influent Piping	2"	inch
Effluent Piping	2"	inch
Recirculation Piping	2"	inch
Equipment Footprint		
Skid Installation Length	11	ft
Skid Installation Width	12	ft
Skid Installation Height	72	inch

	Value	Unit
Biological Footprint		
Membrane & Biological Tank Diameter	12	ft
Maximum Length Per Tank	47	ft
Minimum Tank Length (with Membranes)	16	ft
Typical Number of Tanks	1	#
Typical Total Tank Length	20-30	ft
Required Height to Hoist Hook for Membrane Removal	TBD	ft
Low Strength Approx. Aeration Design		
Membrane	114	scfm
Process Air Low Strength	57	scfm
Blower Output	200	scfm
High Strength Aeration Design		scfm
Membrane	114	
Process Air High Strength	135	scfm
Blower Output	250	scfm
All information is provided based on typical characteristics and may vary depending influent characteristics *Low Strength Wastewater is 250 mg/L BOD, 250 mg/L TSS, 45 mg/L TKN* *High Strength Wastewater is 500 mg/L BOD, 500 mg/L TSS, 90 mg/L TKN*		

Appendix J Water Quality Survey Site Descriptions

Table J-1: Description of Water Quality Sampling Locations

Water Quality (November 2021)		
Site	**GPS (Latitude, Longitude)**	**Observations**
WQ1	18°18’05.82”N, 78°04’05.49”W	The sample was taken from an area of the river under the bridge of a partially paved main road. The water at this location was fast flowing and vegetation along the river banks consisted of cane-like and other water loving plants.  No algal growth was seen in the water. Stones were seen at the bottom of the river. Plastic bottles were seen alongside the river bank. Canefields were seen along either side of river where the sample was taken. A pump house with two large white drums on top of it was also seen. On the opposite side of the bridge, a papaya farm which was being reaped was observed.

Water Quality (November 2021)		
Site	GPS (Latitude, Longitude)	Observations
		  This site was a tributary of the Cabarita River located upstream of the project location. Environmental Conditions: Slightly cloudy, cool, humid, light NE winds

Water Quality (November 2021)		
Site	**GPS (Latitude, Longitude)**	**Observations**
WQ3	18°17’52.22”N, 78°05’15.94”W	The water at this sampling location was fast flowing and deep. It was noted that the water became faster flowing and shallower as the river progressed. The widest portion of the water body was ~100 ft wide. The vegetation along the banks of the river consisted of large-trunked trees and cane like plants.  No algal growth was seen in the waterway; however, algae was observed on rocks and concrete structures. The roadway above the sampling location had both paved and unpaved areas.  Plant debris was observed in the river. Bamboo debris and trash was seen forming a dam under the bridge. A cane field was observed to the right of the river. A metal and concrete bridge was seen above the river. The metal part of the bridge had peeled paint and some amount of rusting and erosion was seen.

Water Quality (November 2021)		
Site	GPS (Latitude, Longitude)	Observations
		 Trash was seen along the riverbed. The middle of the river had a small island with grass-like vegetation.  This site was upstream of the project location. Environmental Conditions: Slightly cloudy, cool, humid, light NE winds

<table>
<tr><th colspan="3">Water Quality (November 2021)</th></tr>
<tr><th>Site</th><th>GPS (Latitude, Longitude)</th><th>Observations</th></tr>
<tr><td>WQ4</td><td>18°17’53.26”N,
78°05’41.15”W</td><td>The water at this sampling location appeared cloudy and brown. The sample was taken in medium-fast flowing water at a location which was ~8ft wide. Algal growth was seen on rocks in the water. The river bank was heavily vegetated and consisted mainly of cane-like plants and narrow trunked trees, however, some exposed areas were observed along the bank.


A flat bridge made from concrete and stone passed over the sample point.The roadway consisted of exposed rocks and gravel. Vast lands of canefield were seen on either side of the river.</td></tr>
</table>

Water Quality (November 2021)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		 This site was a tributary of the Cabarita River upstream of project location. Environmental Conditions: Slightly cloudy, cool, humid, light NE winds

Water Quality (November 2021)		
Site	**GPS (Latitude, Longitude)**	**Observations**
WQ5	18°17’37.42”N, 78°06’35.94”W	The sample was taken from an area of the river ~30ft wide under the bridge of the fully paved main road. The bridge was made from metal and concrete where some areas of the metal structure were observed to be rusting. Cane fields were observed on either side of the river.  A rope assumed to be used for swinging into the river was observed at this location.  The river was observed to be fast flowing and deep. The vegetation along the river bank were observed to be mainly cane-like plants. *Elodea canadensis* was observed close to the banks of the river where the velocity of the water was a lot gentler.

Water Quality (November 2021)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		 This sampling point was downstream of the project location. Environmental Conditions: Overcast, cool, thunder heard in background, light NE winds
WQ6	18°18’11.74” N, 78°04’22.39” W	The sample was taken an area of the river that appeared to be ~20ft wide. Large stone(s) were seen at the bottom of the river. Plant debris was seen in water. A bridge passes over this sampling point.  The roadway on either side of the bridge appeared to be fully paved. The vegetation along the banks of the river appeared to be medium-trunked trees, ferns and cane-like plants, however, some parts of the river bank were devoid of vegetation. Canefields were observed to be prevalent on either side of the river. A greenhouse (not in use) was also observed close to the sampling location.

<table>
<tr><th colspan="3">Water Quality (November 2021)</th></tr>
<tr><th>Site</th><th>GPS (Latitude, Longitude)</th><th>Observations</th></tr>
<tr><td></td><td></td><td>
No algal growth was observed in the water, however, some amount of growth was seen on stones and the bridge. Some garbage was seen on the river bank.

This sampling point was upstream of project site.

Environmental Conditions: Slightly cloudy, cool, humid, light NE winds</td></tr>
<tr><td>WQ7</td><td>18°17’30.54” N,
78°06’05.71” W</td><td>The sample was taken from a point along the river that seemed to be an anabranch of the main river. The anabranch was not as fast flowing as the main river, however, rocks were seen at the bottom of the stream also. A bank in the river separated the anabranch and the main river. The sand bank was vegetated with mainly cane-like plants, as well as medium and small trunked trees.
</td></tr>
</table>

Water Quality (November 2021)		
Site	GPS (Latitude, Longitude)	Observations
		 Birds were heard chirping in the distance at this location. Algal growth was seen on large rocks. The river banks were partially exposed in some areas and other areas consisted of overgrown cane plants.  This sampling site was close to the proposed water intake point. Environmental Conditions: Overcast, cool, humid, light NE winds

Water Quality (November 2021)		
Site	**GPS (Latitude, Longitude)**	**Observations**
WQ8	18°17’35.96” N, 78°05’48.51” W	This sample site was heavily vegetated and ~60 feet wide. Cane like plants were seen growing predominantly along the banks of the waterway, however, there were sections of the bank that were partially exposed. The water at this sampling point was fast flowing.  

Water Quality (November 2021)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		 This sampling site was close to the proposed discharge point. Environmental Conditions: Moderate rainfall, overcast, light NE winds, humid

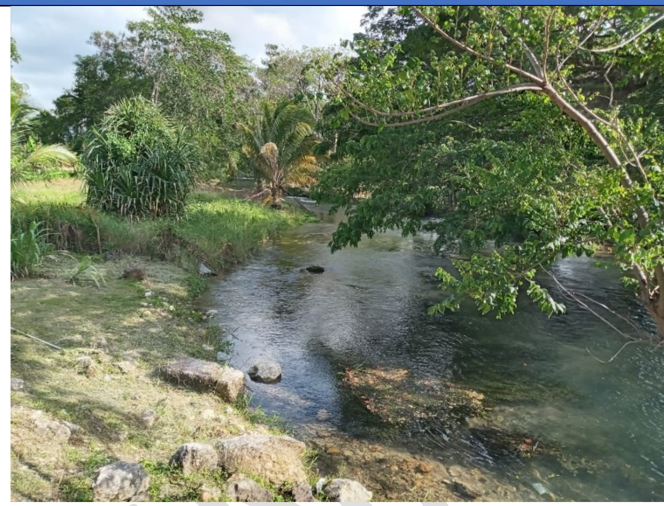
Water Quality (November 2021)		
Site	**GPS (Latitude, Longitude)**	**Observations**
WQ9	18°16’60.00” N, 78°04’55.00” W	The sample was taken from a canal close to the main road. The canal contained lily pads, other plant material and small fishes.  Coconut, dasheen and banana plants were seen growing on the banking. Debris was seen in the water. The water was slow moving at this sample point.  Environmental Conditions: Sunny, partially cloudy, little to no wind

<table>
<tr><th colspan="3">Water Quality (March 2022)</th></tr>
<tr><th>Site</th><th>GPS (Latitude, Longitude)</th><th>Observations</th></tr>
<tr><td>WQ1</td><td>18°18’05.53”N, 78°04’06.38”W</td><td>The stream the sample was taken from ranged from ~3ft to 6.5 ft in width. A cow was observed drinking water downstream of the sampling location. Rocks with moss growth were seen along the river banking. The banking also had some exposed areas along with grass-like vegetation and other water loving plants. The river had a rocky bottom and dead vegetative debris was observed on the surface of the water. Both sides of the river had small, medium and large trees.

Domestic garbage was observed along the banking and in the stream.

Cane fields were observed to the east and west of the sampling location. The roadway observed towards the north of the sampling location was partially paved. A papaya farm was seen</td></tr>
</table>

Water Quality (March 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		nearby to the sampling location. Woodpeckers were heard and cows were seen in the general vicinity of the sampling area. This site was upstream of the project location. **Environmental Conditions: Cool, overcast, light winds**
WQ2	18°17'46.04"N, 78°04'8.12"W	This sample was taken from the Roaring River which had a moderate flow at the time of sampling. The point at which the sample was taken from was a built-up area which appeared to cater to recreational activities along the river.  The banks of the river were grassed with some overhanging mature trees. A large number of aquatic plants and very small fish were observed in the water.

Water Quality (March 2022)		
Site	GPS (Latitude, Longitude)	Observations
		 A bridge and main roadway were observed to the close to the sampling area.  This site was upstream of the project location. **Environmental Conditions: Cool, overcast, light winds**

Water Quality (March 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
WQ3	18°17’52.07”N, 78°05’16.37”W	A small banking comprised of river stones was upstream of the sampling location. Small yellow and black, as well as bottom feeding fish were seen nearby to the sampling location. Natural debris was seen on the surface of the water. Vegetation along the banking included large trunked and medium trunked trees, grass-like plants and other water loving vegetation. Some areas of exposed banking were observed. The bottom of the river that was visible had stones and natural debris such as sticks. A small amount of garbage was seen in the river. The river depth ranged from ~2ft to over 6ft.  

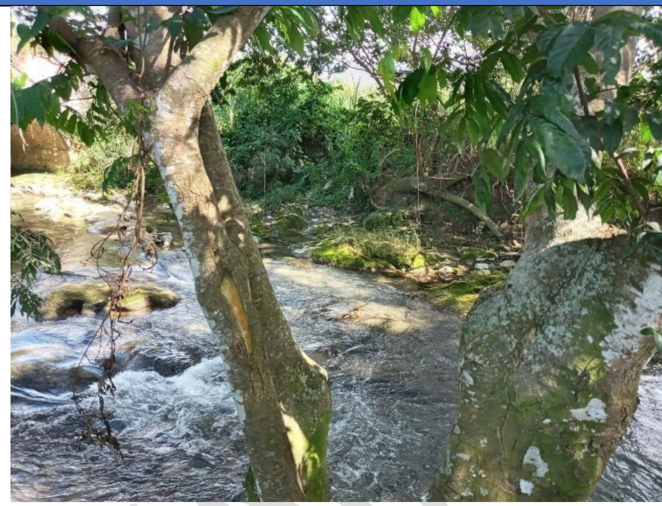
Water Quality (March 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		 A concrete and rusting metal bridge was located at this sampling point with moss observed growing on the concrete section of the bridge. Some of the paint on the bridge was peeling.  Natural debris in the area downstream of the sampling location, on the opposite side of the bridge, created a dam-like structure.

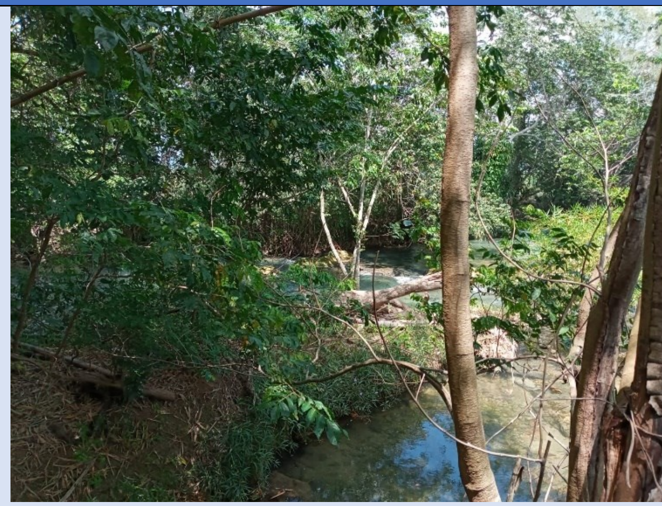
Water Quality (March 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		 The road close to the bridge had some paved and some unpaved sections. This site was upstream of the project location. **Environmental Conditions: Cool, sunny, slightly cloudy, light winds**
WQ4	18°17’53.90”N, 78°05’41.17”W	This sample was taken from a narrow stream whose banking was overgrown with grass-like vegetation and narrow and medium trunked trees. Some exposed areas banking was seen. At the bottom of the river some rocks were observed that had a white, brown, black, grey or red hue. Cane fields were seen on either side of the river. The nearby roadway had paved and unpaved sections. The waterway upstream, on the opposite site of the roadway, of the sampling location was more densely vegetated. Small, dark coloured fish were seen in the waterway.

Water Quality (March 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		 This site was upstream of the project location. **Environmental Conditions: Cool, overcast, light winds**
WQ5	18°17’36.88”N, 78°06’36.25”W	This sampling location was notably shallower than when the location was visited in the wet season assessment. It was observed that more exposed areas of the river bed which comprised of piles of river stones. The flow of the river was fairly fast.  Some large rocks with moss growth were seen upsteam of the sampling location under the bridge at this location.

Water Quality (March 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		 The vegetation along the river banking included medium trunked trees, tall, grass-like vegetation and other water loving plants. The bottom of the river could be clearly seen with rocks and *elodea canadensis*. Small to medium sized fish and plant debris were seen. The depth of the water ranged from ~2ft to over 4ft.  This sampling point was downstream of the project location. **Environmental Conditions: Cool, sunny, light winds**

Water Quality (March 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
WQ6	18°18'11.74" N, 78°04'22.39" W	The stream at this sampling point was fairly fast flowing. The sampling location was located to the west of a bridge. The rocks along the river banking and in the river had moss growing on them.   Large and medium trunked trees, as well as fern-like plants were seen along the banking along with some grass-like vegetation. Some areas of exposed banking was seen.

Water Quality (March 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		 Cane fields were observed on either side of the river. A soap-like residue was seen on the surface of the water. A patch of snails were seen on the surface of a rock. Several small canines were also seen in the area. This sampling point was upstream of project site. **Environmental Conditions: Cool, sunny, few clouds overhead**
WQ7	18°17’30.45” N, 78°06’07.07” W	The sample was taken from an anabranch of the main river; this sampling area was noted to be a point along the river that persons in the community use to catch fish and bathe. Persons upstream of the sampling location were observed to be fishing and swimming. The water flowed at a moderate rate at this location. Some debris (leaves and garbage) were seen. The banking of the river had dry grass-like material, bamboo and other medium-large trunked trees. Some dark coloured fish were seen in this area of the river as well as some macroinvertebrates. The bottom of the river was clearly seen. The depth of the river at this point was ~2.5 ft.

<table>
<tr><th colspan="3">Water Quality (March 2022)</th></tr>
<tr><th>Site</th><th>GPS (Latitude, Longitude)</th><th>Observations</th></tr>
<tr><td></td><td></td><td>

Sampling site downstream of proposed discharge point.

Environmental Conditions: Cool, sunny, light winds</td></tr>
<tr><td>WQ8</td><td>18°17’35.94” N,
78°05’48.52” W</td><td>Small tan coloured fish with stripes were seen at this sampling location. The banking at this location had vegetation that comprised of mainly grass-like plants. Small trunked trees were also observed at ths location. This area of the river had a width of ~50ft. The river had a moderate flow at this point. The rocks at the bottom of the river were clearly seen. Patches of elodea canadensis was present at this location. There was natural debris seen on the surface of the water.</td></tr>
</table>

Water Quality (March 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		  The area in which the sample was taken from was ~6ft deep while other sections of the river were shallower. This sampling area was also wider that the sections of the river upstream and downstream. This sampling location was ~200ft from an unpaved roadway. Sampling site downstream of the proposed intake point. **Environmental Conditions: Light winds, cloudy**

<table>
<tr><th colspan="3">Water Quality (March 2022)</th></tr>
<tr><th>Site</th><th>GPS (Latitude, Longitude)</th><th>Observations</th></tr>
<tr><td>WQ9</td><td>18°16’59.89” N,
78°04’55.21” W</td><td>The sample was taken from a canal/ drain filled with water that had a very low flow. The water surface was covered with lillies and other plant debris; some algal growth was observed. Small pockets of bubbles were seen coming to the surface of the water. The river banking had both concrete and natural elements such as grass. There were houses close by that could be seen to have edible vegetation.


Environmental Conditions: Very cool, overcast, light winds</td></tr>
</table>

Water Quality (March 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
WQ10	18°17’54.96” N, 78°07’51.54” W	This sampling location had a concrete banking with some amount of moss growth. The width of the waterway at this sampling location was ~40ft wide. The waterway was fairly shallow and fast moving. *Elodea canadensis* could be seen in the water at this location.   The vegetation on the banking comprised grass-like vegetation, small trunked trees and water loving plants. The rocks in the river had red – white colouring. Few debris was visible on the water surface.

Water Quality (March 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		 A concrete bridge with broken and rusting metal railings was observed at this sampling location. A concrete structure under this bridge created a small waterfall downstream of the sampling location. The water downstream of the sampling point was ~150ft wide and had a deeper depth.  Cane fields were seen on either side of the river. Medium sized fish were observed in the river. The roadway above the sampling area was unpaved. Persons were observed to have been swimming downstream of the sampling site. Sampling site downstream of project location. **Environmental Conditions: Cool, sunny**

<table>
<tr><th colspan="3">Water Quality (March 2022)</th></tr>
<tr><th>Site</th><th>GPS (Latitude, Longitude)</th><th>Observations</th></tr>
<tr><td>WQ11</td><td>18°18’00.22” N, 78°09’09.06” W</td><td>This sample was taken from a point in the river where small, light and dark coloured fish were seen. Small translucent shrimp were also seen in the river while small snails were seen along the banking. The banking of the river comprised of grass-like and water loving plants with some areas of exposed dirt. The bottom of the river could clearly be seen and rocks and elodea canadensis were observed in the river. The river was fairly fast flowing. The area of the river that the sample was taken from was ~30-35ft wide. Few bubbles and plant debris were seen on the surface of the water.


A large tree with a rope used to swing into the river was also seen at this point.</td></tr>
</table>

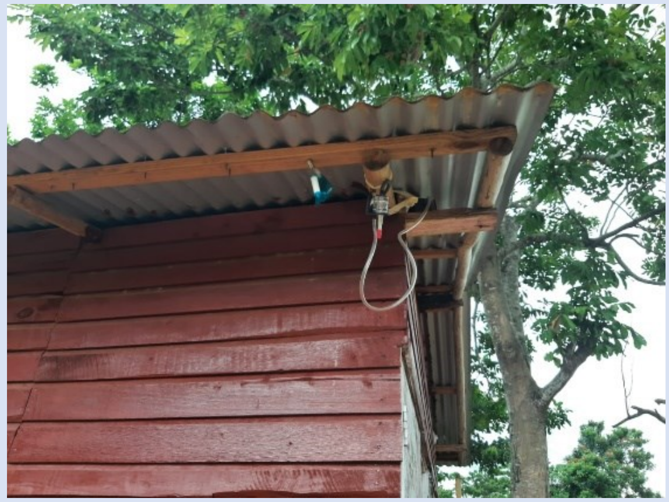
Water Quality (March 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		 There was a bridge to the west of the sampling point which had vehicles that traversed along it frequently. Other small tunked trees were seen to the north of the sampling location. A track coming from the main road was used to access this sampling location. Sampling site downstream of project location. **Environmental Conditions: Few clouds, light winds, sunny**

Water Quality (March 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
WQ12	18°16’41.89” N, 78°10’23.28” W	This sample was taken from an area of the river that had a 20-30ft wide banking. Large branches were seen in the river. The banking had a lot of vegetation. An iron and concrete bridge was located ~20ft above the sampling point.   Sampling site downstream of project location. **Environmental Conditions: Sunny, partially cloudy, little to no winds**

Appendix K Air Quality Survey Site Descriptions

Table K-1: Description of Air Monitoring Sites

Air Quality (November 2-3, 2021)		
Site	**GPS (Latitude, Longitude)**	**Observations**
AQ1	18°15’28.95”N, 78°06’51.11”W	The pump was placed on the veranda of a house ~25 feet from the main road (fully paved). The pump was placed ~6 feet above ground with the intake point facing the road. The veranda is ~2-3 feet above the ground, which was grassed. However, some partially exposed areas on the ground were seen. The vegetation at this site mainly comprised of shrubs and the ground was wet at the time of pump placement. Renovations on a home were observed adjacent (to the right side) of the monitoring site during the assessment. An open field with grass like vegetation was seen across the main road. Sporadic vehicle use was observed at this site. This site was downwind of the project location based on prevailing wind direction. **Environmental Conditions: Slight NW winds, cloudy, cool, dusk starting to approach**
AQ2	18°15’47.98”N, 78°05’18.11”W	The pump was placed on a column of an open veranda of a wooden house ~4-5 feet higher than the paved main road. The veranda was located ~18 feet west of the main road. The ground was fully grassed, and vegetation mainly consisted of shrubs, however, fruit trees and flowering plants were also. The ground was also wet due to consistent rainfall in the afternoons. This site was downwind of the project location based on prevailing wind direction. **Environmental conditions: Slight NW winds, cloudy, cool, dusk starting to approach**

Air Quality (November 2-3, 2021)		
Site	**GPS (Latitude, Longitude)**	**Observations**
AQ3	18°18’22.76”N, 78°04’51.38”W	The pump was placed under the rafters of a small wooden structure with a zinc roof which was ~2ft east of the paved main road.  The yard surrounding this structure was a combination of paved and unpaved areas with the unpaved areas having loose gravel and dirt. Few large trees were seen close to the building. A large open field was seen directly across the main road. This open field was mainly comprised of grass-like vegetation; however, a cluster of large trees was observed in the area.  This site was upwind of the project location based on prevailing wind direction. **Environmental Conditions: Slight NW winds, cool, overcast, very light rainfall**

Air Quality (November 2-3, 2021)		
Site	**GPS (Latitude, Longitude)**	**Observations**
AQ4	18°17’49.56”N, 78°06’10.22”W	The pump was placed on the south side of the building on louvred window (of a bathroom) located ~19 feet to the east and ~2-3 ft above the main road. The pump was sheltered by the rafters of the building.  The area was free from trash and large trees, however, natural debris such as leaves and gravel were observed on the ground. The ground was also grassed and damp.  The land across the main road was heavily vegetated and goats were seen traversing the main road.

Air Quality (November 2-3, 2021)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		 This site was upwind of the project location based on the prevailing wind direction. **Environmental Conditions: Slight NW winds, very light rainfall, overcast**

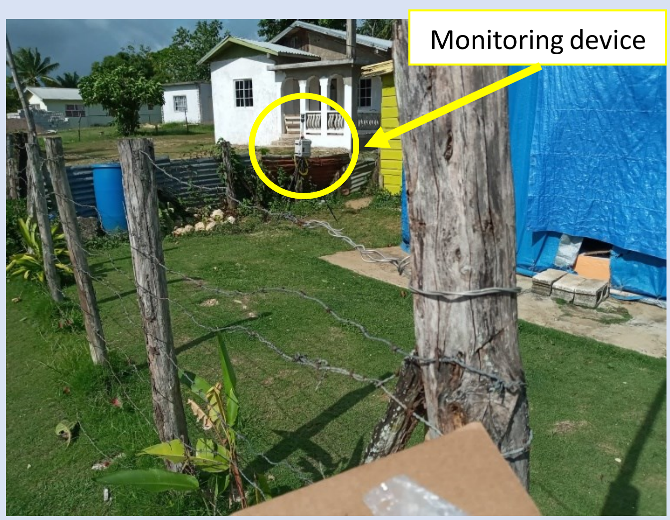
Air Quality (November 2-3, 2021)		
Site	**GPS (Latitude, Longitude)**	**Observations**
AQ5	18°17'07.24"N, 78°06'46.56"W	The pump was placed on the grill of a concrete house located ~15ft to the east of the main road (paved). 

Air Quality (November 2-3, 2021)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		 There was no debris on the grassy ground, however there were some exposed areas of dirt and loose gravel. The vegetation consisted of shrubs and few large trees. Goats and cars were seen sporadically on the main road. A cane field was observed directly across the main road.

Air Quality (November 2-3, 2021)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		 This site was WSW of proposed project location. **Environmental Conditions: Rainbow seen, rainy and slightly cloudy, slight NW winds**
AQ6	18°15’36.55” N, 78°05’25.02” W	The pump was placed on a local store that sells lumber, blocks, hardware and electrical fixtures facing the roadway. This store was located east of a busy main road. Many houses and other structures seen in the vicinity of the area. The site was not heavily vegetated but a few large trees such as palm trees and grass-like plants were seen. Exposed gravel and dirt/ dust were observed also. 

Air Quality (November 2-3, 2021)		
Site	GPS (Latitude, Longitude)	Observations
		  This sampling position was downwind of project site based on prevailing wind direction. **Environmental Conditions: Slight NW winds, overcast, humid**

Air Quality (November 2-3, 2021)		
Site	**GPS (Latitude, Longitude)**	**Observations**
AQ7	18°16’53.04” N, 78°05’02.54” W	The pump was placed on the grill of a garage of a house ~30ft east from the paved main road. Some sections of the road had some loose gravel. The yard space was free from debris, the ground was grassed and vegetation consisted of mainly flowering plants and shrubs. Few cars and kids on bicycles were seen travelling along the main road at the time of pump placement. Sampling position to the ESE of proposed project location. **Environmental Conditions: Slight NW winds, heavy rainfall, overcast skies**

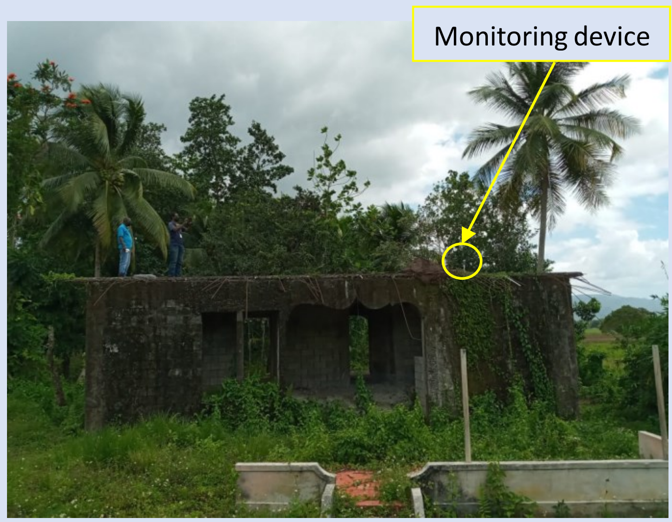
Air Quality (March 31 – April 1, 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
AQ1	18°15’34.20” N, 78°06’51.50” W	The pump was placed approximately 10 feet east of a paved main road on the open lawns of a residential home made of cement and board. The assessment area was grassed with areas of loose gravel. Vehicles traversed the roadway frequently. The pump was placed several meters away from any structure which may restrict airflow around the pump.  This site was downwind of the project location. **Environmental Conditions: Sunny, windy**

<table>
<tr><th colspan="3">Air Quality (March 31 – April 1, 2022)</th></tr>
<tr><th>Site</th><th>GPS (Latitude, Longitude)</th><th>Observations</th></tr>
<tr><td>AQ2</td><td>18°16’5.12” N, 78°05’09.94” W</td><td>The pump placed on top of a metal container inside of a block and marl yard. This site was approximately 55 feet east of a busy main roadway.

The site location contained cement blocks, marl and other stone heaps that were 30-60 ft away from the container that the pump was placed on, containers containing cement bags and pallets located on top of containers. The block and marl yard was unpaved and had tractors and other large equipment within it. No trees were seen on compound. Vehicles traversed the roadway frequently.

This site was downwind of the project location.

Environmental conditions: Cloudy, windy</td></tr>
</table>

Air Quality (March 31 – April 1, 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
AQ3	18°18’26.28” N, 78°04’48.92” W	The pump was on top of the flat roof (decking) of an abandoned house with approximately 40 feet west of a paved roadway. Areas of settled water were observed on the decking along with some amount of exposed steel. The area surrounding the house was heavily vegetated inclusive of two coconut trees in the yard. Sporadic vehicle movement at this location.  This site was upwind of the project location. **Environmental Conditions: Windy, overcast**
AQ4	18°17’48.88” N, 78°06’09.87” W	The pump was placed on a light post approximately 25ft east of a paved main roadway.  The area was free from trash, however, natural debris such as leaves and gravel were observed on the ground. The area across the main road was heavily

Air Quality (March 31 – April 1, 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		vegetated. Few trees such as palm trees were observed on the compound. Sporadic vehicle movement seen at this location.  This site was upwind of the project location. **Environmental Conditions: Overcast, windy**
AQ5	18°17’22.33” N, 78°06’39.46” W	The pump was placed on the roof of a concrete house located ~15ft from the main road (paved). There was no debris on the grassy ground, however there were sections of exposed dirt and loose gravel. The vegetation consisted of shrubs and few large trees. Goats and cars were seen sporadically on the main road.  A cane field was observed directly across the main road. Frequent vehicle movement at this location.

Air Quality (March 31 – April 1, 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		 This site was WSW of the project location. **Environmental Conditions: Windy, sunny, partially cloudy**
AQ6	18°15’36.72” N, 78°05’26.34” W	The pump was placed on the roof of an old house located south west of a lumber/hardware store and approximately 20ft west of a paved main road. Exposed steel and gravel was seen on the roof.  The area was not heavily vegetated however, there were several large trees such as naseberry, pear, guinep and breadfruit situated north of the pump location. Exposed gravel and dirt was seen on the ground leading towards the house. Vehicles traverse the main road frequently. An unpaved roadway was located to the north of the assesment location.

Air Quality (March 31 – April 1, 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
		 This sampling position was downwind of project site. **Environmental Conditions: Windy, cloudy**

Air Quality (March 31 – April 1, 2022)		
Site	GPS (Latitude, Longitude)	Observations
AQ7	18°16’52.80” N, 78°05’02.50” W	The pump was placed on the open lawns of a residential home ~10ft from the paved main road. Some sections of the road had some loose gravel. The yard space was free from debris, the ground was grassed and vegetation consisted of mainly flowering plants and shrubs. Vehicles traversed the main road frequently.   Sampling position ESE of the proposed project site. **Environmental Conditions: Windy, cloudy**

Appendix L Noise Survey Site Descriptions

Table L-1: Description of Noise Survey Locations (November 2021)

Noise (November 2021)		
Site	**GPS (Latitude, Longitude)**	**Notes**
AQ1	18°15'28.95"N, 78°06'51.11"W	On the first day of taking the noise readings, construction noises, such as hammering could be heard. Distant chatter, goats bleating, birds chirping, chickens clucking, and ducks quacking were also heard at the time of assessment. Noise was heard from cars passing sporadically as well. **Environmental Conditions: Slight NW winds, cloudy, cool, dusk starting to approach** On the second day of taking the noise readings, noise could be heard from construction activities adjacent to the site, animal noises similar to those heard on day 1, chatter and cars passing frequently. **Environmental Conditions: Very light rainfall, slight overcast, light NE winds**
AQ2	18°15'47.98"N, 78°05'18.11"W	On the first day of taking the noise readings, intermittent construction sounds, vehicular noise, distant music and cars passing with loud music were heard. **Environmental conditions: Slight NW winds, cloudy, cool, dusk starting to approach** On the second day of taking the noise readings, vehicular noises from passing cars and a motor running, barking dogs, distant chatter and birds chirping were heard. **Environmental conditions: Overcast, humid, light NE winds**
AQ3	18°18'22.76"N, 78°04'51.38"W	On the first day of taking the noise readings, noise was heard from vehicles passing sporadically, birds chirping and knocking sounds. **Environmental Conditions: Slight NW winds, cool, overcast, very light rainfall** On the second day of taking the noise readings, vehicular noises from cars passing sporadically and a motor running, light chatter, noise from a radio

Noise (November 2021)		
Site	**GPS (Latitude, Longitude)**	**Notes**
		and sounds from nature such as birds chirping, and leaves rustling were heard. **Environmental Conditions: Sunny, hot, scattered clouds, light NE winds**
AQ4	18°17'49.56"N, 78°06'10.22"W	On the first day of taking the noise reading, noise was heard from vehicles passing and rustling leaves. **Environmental Conditions: Slight NW winds, very light rainfall, overcast** On the second day of taking the noise readings, noise was heard from cows mooing, birds chirping, goats bleating, light chatter, vehicular noises from cars passing sporadically, car horns and a motor running were heard. **Environmental Conditions: Sunny, hot, scattered cluds, light NE winds**
AQ5	18°17'07.24"N, 78°06'46.56"W	On the first and second day of taking the noise reading, noise was heard from vehicles passing along the main road sporadically. **Environmental Conditions: Rainbow seen, rainy and slightly cloudy, slight NW winds** On the second day of taking noise readings, noise was heard from the cars and trucks passing sporadically and distant background chatter. **Environmental Conditions: Rainy, overcast, light NE winds**
AQ6	18°15'36.55" N, 78°05'25.02" W	On the first day of taking the noise reading, noise was heard from cars frequenting the main road. **Environmental Conditions: Slight NW winds, overcast, humid** On the second day of taking the noise readings, noise was heard from vehicles passing, birds chirping and rustling leaves. **Environmental Conditions: Warm, humid, overcast, light NE winds**
AQ7	18°16'53.04" N, 78°05'02.54" W	On the first day of taking the noise readings, noise was heard from vehicles passing sporadically and from a mobile 'Craven A' truck playing music at a local store in the area.

Noise (November 2021)		
Site	**GPS (Latitude, Longitude)**	**Notes**
		Environmental Conditions: Light NW winds, heavy rainfall, overcast skies On the second day of taking noise readings, noise was heard from cars passing with music, bikes and other motor vehicles, distant chatter and a motor running. **Environmental Conditions: Warm, humid, overcast, light NE winds**

Table L-2: Description of Noise Survey Locations (May 2022)

Noise (May 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
NS1	18°15’34.20” N, 78°06’51.50” W	Noise readings were taken along the Truro Gate to Locust Tree Road in front of an occupied house. This site was east of a busy main roadway. At the time of the assessment, noise (inclusive of horns blowing) was heard from vehicles such as cars, vans and motorbikes frequently traversing the roadway, as well as from birds and distant sounds of chatter and children playing. **Environmental Conditions: cool, bright, light winds**
NS2	18°16’5.12” N, 78°05’09.94” W	Noise readings were taken along the Hertford to Flowerhill road in front of a block and marl yard. This site was east of a busy main roadway. At the time of the assessment, noise (inclusive of horns blowing) was heard from vehicles such as cars, turcks and motorbikes frequently traversing the roadway, cars trottling as well as from distant sounds of birds, dogs, cats and chatter. The site location contained cement blocks, marl and other stone heaps, containers containing cement bags and pallets located on top of containers. The block and marl yard was unpaved and had tractors and other large equipment within it. **Environmental Conditions: cool, slightly cloudy**

Noise (May 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
NS3	18°18’26.28” N, 78°04’48.92” W	Noise readings were taken along a road in the Friendship community north of the proposed project location in front of a partially constructed abandoned house. Thick vegetation was observed to the back of this house. This site was west of a paved roadway. At the time of the assessment, noise was heard from vehicles such as cars that traversed the roadway sporadically, an idle car as well as from dogs, birds (a woodpecker was heard pecking), music, goats bleating and distant sounds of chatter. This site location was overgrown with grassy plants and mounds of dry grass observed at the location. **Environmental Conditions: sunny, light winds, slightly cloudy**
NS4	18°17’48.88” N, 78°06’09.87” W	Noise readings were taken along a road in the Friendship community north of the proposed project location in front of a primary school. Thick vegetation was observed to the west of this noise assessment area. This site was east of a paved roadway. At the time of the assessment, noise was heard from vehicles such as cars that traversed the roadway sporadically, an idle car as well as from birds and distant sounds of chatter. **Environmental Conditions: sunny, light winds, slightly cloudy**
NS5	18°17’22.33” N, 78°06’39.46” W	Noise readings were taken along the Truro Gate to Locust Tree Road in front of a residential home. Open cane lands were observed to the east of the assessment site. This site was west of a busy paved main roadway. At the time of the assessment, noise was heard from vehicles such as cars frequently traversing the roadway, cars trottling, birds as well as from distant sounds of chatter. **Environmental Conditions: sunny, light winds, slightly cloudy**

Noise (May 2022)		
Site	**GPS (Latitude, Longitude)**	**Observations**
NS6	18°15’36.72” N, 78°05’26.34” W	Noise readings were taken along the Hertford to Flowerhill road in front of an abandoned house. This site was west of a busy main roadway and southwest of a lumber store. At the time of the assessment, noise (inclusive of horns blowing) was heard from vehicles such as cars and motorbikes frequently traversing the roadway, as well as from distant sounds of birds and thunder rolling. Dogs were seen in the area and an unpaved roadway was seen to north of the assessment location. **Environmental Conditions: light rain and winds, cool, overcast**
NS7	18°16’52.80” N, 78°05’02.50” W	Noise readings were taken along the Hertford to Flowerhill road in front of a residential home. This site was east of a busy paved main roadway. At the time of the assessment, noise (inclusive of horns blowing) was heard from vehicles such as cars, turcks and motorbikes frequently traversing the roadway, cars idling as well as from distant sounds of ducks, dogs, chickens, birds and chatter. **Environmental Conditions: cool, slightly cloudy**

Appendix M Results Certificate and Information on Sampling Equipment Used

Please see the attached results certificates or PDF documents attached in the order as printed below.

Report/ Document
Water Quality Certificate of Sample Analysis (November 2021)
Water Quality Certificate of Sample Analysis (March 2022)
PM_{10} and Noise Certificate of Sample Analysis (November 2021)
PM_{10} Particulate Survey Report (March 2022)
Noise Certificate of Sample Analysis (May 2022)
H_2S Report of Laboratory Analysis (November 2021)
NO_x and SO_x Report of Laboratory Analysis (November 2021)
H_2S, NO_x and SO_x Report of Laboratory Analysis (March 2022)
Modular Impactor and SKC Legacy Pump (Used in the November 2021 AQ Sampling Exercise)
NOx and SOx Passive Sampler Information
H_2S Passive Sampler Information

ESL QUALITY & ENVIRONMENTAL HEALTH LABORATORY

A division of

ISO 17025 ACCREDITED LABORATORY

7 Hillview Avenue,
Kingston 10, Jamaica
Tel: (876) 978-9519, 978-6297, 978-5902
Fax: (876) 946-3745
E-mail: envirsol@cwjamaica.com

Certificate of Sample Analysis

CSA#: ESL 21110401-08

Attention:

Mrs. Jaidene Webster-Jones
Environmental Solutions Limited
7 Hillview Avenue
Kingston 10

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The ISO/IEC 17025 accreditation only applies to the tests identified in the Results of Sample Analysis.

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Sample(s) Information

Job Number:	**21110401-08**
SPN:	**-**
Date of Report:	20/12/2021
Revision Date:	**Not Applicable**
Sample(s) Collected:	03/11/2021
Sample(s) Submitted:	04/11/2021
Temperature on Arrival:	0.8ºC
Number of Samples:	8
Analysis Started:	03/11/2021
Analysis Completed:	02/12/2021
Prepared By:	**Tara-Lee Hylton, Technical Assistant**

Verified By ……… K. Williams ………………

Kivonna Williams,
Anlayst

Approved By……S. Ellis……….

Shadain Ellis,
Senior Analyst

Results of Sample Analysis

Sample ID (Matrix) - Qualifier: BB-WQ8 (Surface Water) **-☐C(B) ☐C(C) ☒C(L)**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Freshwater Standard
pH (pH units)	DR	7.75 @ 25.0ºC	c	**7.00- 8.40**
Dissolved Oxygen (mg O_2/L)	DR	6.73 @ 25.0ºC	c	
Conductivity (mS/cm)	DR	0.324 @ 25.0ºC	c	**0.15- 0.6**
Salinity (ppt)	DR	0.15 @ 25.0ºC	c	
Total Dissolved Solids (mg/L)	DR	210.69 @ 25.0ºC	c	**120.0- 300.0**
Nitrate as Nitrogen (mg NO_3^--N/L)	H-8039	0.4	P(1)	**-**
Nitrate (mg NO_3^-/L)		1.8		**0.1 -7.5**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.10	-	**0.01- 0.8**
Sulfate (mg SO_4^{2-}/L)	H -8051	2	E(M1)	**3.0 -10.0**
Faecal Coliform (MPN/100ml)	SM-9221	540	-	**-**
E. coli **(MPN/100ml)**	SM-9221	350	-	**-**
Chemical Oxygen Demand (mg O_2/L)	H-8000	10	P(P)	**-**
Total Suspended Solids (mg /L)	SM-2540 D	6.0	-	**-**
Chloride (mg Cl^-/L)	SM-4500 Cl^- B	3.2	-	**5.0 -20.0**
Total Nitrogen (mg N/ L)	H-10071	<2.2	UMR, P(P), P(1)	**-**
Total Phosphorous (mg P/ L)	SM-4500 B5 & H-8048	0.06	-	**-**
Phenol (mg C_6H_5OH/ L)	H-8047	<0.002	UMR	**-**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Freshwater Standard
Biochemical Oxygen Demand ($mg\ O_2/L$)	H-8043	1.3	-	-
Total Alkalinity ($mg\ CaCO_3/\ L$)	SM-2320 B	184.3	-	-
Total Hardness ($mg\ CaCO_3/\ L$)	SM-2340 C	201.1	-	**127.0 – 381.0**
Fats, Oil & Grease (mg/L)	SM-5520 B	<1	a	-
Calcium (µg Ca/L)	EPA 200.7	70800	a	**40,000 - 101,000**
Magnesium (µg Mg/ L)	EPA 200.7	2320	a	**3,600-27,000**
Silica (µg SiO_4/L)	EPA 200.7	5050	a	**5,000-39,000**
Zinc (µg Zn/ L)	EPA 200.7	<11.0	BDL, a	-
Copper (µg Cu/ L)	EPA 200.7	<2.6	BDL, a	-
Arsenic (µg As/ L)	EPA 200.7	<3.4	BDL, a	-
Mercury (µg Hg/ L)	EPA 245.1	<0.090	BDL, a	-
Chromium (µg Cr/ L)	EPA 200.7	<1.7	a	-
Manganese (µg Mn/ L)	EPA 200.7	13.1	a	-
Sodium (µg Na/ L)	EPA 200.7	2690	a	**4,500-12,000**
Lead (µg Pb/ L)	EPA 200.7	<4.6	BDL, a	-
Iron (µg Fe/ L)	EPA 200.7	310	a	-
Pesticides Screen (ppb)	EPA Method 8181 B	Absent	a	-
Dissolved Organic Carbon (mg C/ L)	SM-5130 B	1.00	a	-
Total Organic Carbon (mg C/ L)	SM-5130 B	1.10	a	-

***Blue shaded parameters are ISO/IEC 17025 accredited.**

Please note that the data presented in the table above are determined to be compliant or non-compliant based on the value provided without the incorporation of the measurement uncertainty.

Sample ID (Matrix) - Qualifier: BB-WQ7 (Surface Water) **-☐C(B) ☐C(C) ☒C(L)**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Freshwater Standard
pH (pH units)	DR	7.76 @ 25.0ºC	c	7.00- 8.40
Dissolved Oxygen (mg O_2/L)	DR	7.45 @ 25.0ºC	c	
Conductivity (mS/cm)	DR	0.325 @ 25.0ºC	c	0.15- 0.6
Salinity (ppt)	DR	0.15 @ 25.0ºC	c	
Total Dissolved Solids (mg/L)	DR	211.25 @ 25.0ºC	c	120.0- 300.0
Nitrate as Nitrogen (mg NO_3^--N /L)	H-8039	0.3	P(1)	-
Nitrate (mg NO_3^-/L)		1.3		0.1 -7.5
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.11	-	0.01- 0.8
Sulfate (mg SO_4^{2-}/L)	H -8051	2	E(M1)	3.0 -10.0
Faecal Coliform (MPN/100ml)	SM-9221	920	-	-
E. coli (MPN/100ml)	SM-9221	350	-	-
Chemical Oxygen Demand (mg O_2/L)	H-8000	6	P(P)	-
Total Suspended Solids (mg /L)	SM-2540 D	4.8	-	-
Chloride (mg Cl^-/L)	SM-4500 Cl^- B	3.1	-	5.0 -20.0
Total Nitrogen (mg N/ L)	H-10071	<2.2	UMR, P(P), P(1)	-
Total Phosphorous (mg P/ L)	SM-4500 B5 & H-8048	0.04	-	-
Phenol (mg C_6H_5OH/ L)	H-8047	<0.002	UMR	-
Biochemical Oxygen Demand (mg O_2/L)	H-8043	1.0	-	-
Total Alkalinity (mg $CaCO_3$/ L)	SM-2320 B	180.8	-	-

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Freshwater Standard
Total Hardness (mg $CaCO_3$/ L)	SM-2340 C	208.1	-	**127.0 – 381.0**
Fats, Oil & Grease (mg/L)	SM-5520 B	<1	a	**-**
Calcium (µg Ca/L)	EPA 200.7	70800	a	**40,000 - 101,000**
Magnesium (µg Mg/ L)	EPA 200.7	2300	a	**3,600-27,000**
Silica (µg SiO_4/L)	EPA 200.7	4970	a	**5,000-39,000**
Zinc (µg Zn/ L)	EPA 200.7	<11.0	BDL, a	**-**
Copper (µg Cu/ L)	EPA 200.7	<2.6	BDL, a	**-**
Arsenic (µg As/ L)	EPA 200.7	<3.4	BDL, a	**-**
Mercury (µg Hg/ L)	EPA 245.1	<0.090	BDL, a	**-**
Chromium (µg Cr/ L)	EPA 200.7	<1.7	BDL, a	**-**
Manganese (µg Mn/ L)	EPA 200.7	11.2	a	**-**
Sodium (µg Na/ L)	EPA 200.7	2740	a	**4,500-12,000**
Lead (µg Pb/ L)	EPA 200.7	<4.6	BDL, a	**-**
Iron (µg Fe/ L)	EPA 200.7	265	a	**-**
Pesticides Screen (ppb)	EPA Method 8181 B	Absent	a	**-**
Dissolved Organic Carbon (mg C/ L)	SM-5130 B	1.20	a	**-**
Total Organic Carbon (mg C/ L)	SM-5130 B	1.00	a	**-**

***Blue shaded parameters are ISO/IEC 17025 accredited.**

Please note that the data presented in the table above are determined to be compliant or non-compliant based on the value provided without the incorporation of the measurement uncertainty.

Sample ID (Matrix) - Qualifier: BB-WQ6 (Surface Water) -☐C(B) ☐C(C) ☒C(L)

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Freshwater Standard
pH (pH units)	DR	7.94 @ 24.5ºC	c	**7.00- 8.40**
Dissolved Oxygen (mg O_2/L)	DR	7.69 @ 24.5ºC	c	
Conductivity (mS/cm)	DR	0.291 @ 24.5ºC	c	**0.15- 0.6**
Salinity (ppt)	DR	0.14 @ 24.5ºC	c	
Total Dissolved Solids (mg/L)	DR	190.45 @ 24.5ºC	c	**120.0- 300.0**
Nitrate as Nitrogen (mg NO_3^--N /L)	H-8039	0.4	P(1)	**-**
Nitrate (mg NO_3^-/L)	H-8039	1.8	P(1)	**0.1 -7.5**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.14	-	**0.01- 0.8**
Sulfate (mg SO_4^{2-}/L)	H -8051	2	E(M1)	**3.0 -10.0**
Faecal Coliform (MPN/100ml)	SM-9221	>1600	-	**-**
***E. coli* (MPN/100ml)**	SM-9221	>1600	-	**-**
Chemical Oxygen Demand (mg O_2/L)	H-8000	6	P(P)	**-**
Total Suspended Solids (mg /L)	SM-2540 D	2.7	-	**-**
Chloride (mg Cl^-/L)	SM-4500 Cl^- B	4.1	-	**5.0 -20.0**
Total Nitrogen (mg N/ L)	H-10071	<2.2	UMR, P(P), P(1)	**-**
Total Phosphorous (mg P/ L)	SM-4500-B5 & H-8048	0.02	-	**-**
Phenol (mg C_6H_5OH/ L)	H-8047	<0.002	UMR	
Biochemical Oxygen Demand (mg O_2/L)	H-8043	0.8	-	**-**
Total Alkalinity (mg $CaCO_3$/ L)	SM-2320 B	163.7	-	**-**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Freshwater Standard
Total Hardness (mg $CaCO_3$/ L)	SM-2340 C	175.1	-	**127.0 – 381.0**
Fats, Oil & Grease (mg/L)	SM-5520 B	<1	a	**-**
Calcium (µg Ca/L)	EPA 200.7	61200	a	**40,000 - 101,000**
Magnesium (µg Mg/ L)	EPA 200.7	2570	a	**3,600-27,000**
Silica (µg SiO_4/L)	EPA 200.7	5230	a	**5,000-39,000**
Zinc (µg Zn/ L)	EPA 200.7	<11.0	BDL, a	**-**
Copper (µg Cu/ L)	EPA 200.7	<2.6	a	**-**
Arsenic (µg As/ L)	EPA 200.7	<3.4	a	**-**
Mercury (µg Hg/ L)	EPA 245.1	<0.090	a	**-**
Chromium (µg Cr/ L)	EPA 200.7	<1.7	a	**-**
Manganese (µg Mn/ L)	EPA 200.7	5.1	a	**-**
Sodium (µg Na/ L)	EPA 200.7	3470	a	**4,500-12,000**
Lead (µg Pb/ L)	EPA 200.7	<4.6	a	**-**
Iron (µg Fe/ L)	EPA 200.7	192	a	**-**
Pesticides Screen (ppb)	EPA Method 8181 B	Absent	a	**-**
Dissolved Organic Carbon (mg C/ L)	SM-5130 B	0.98	a	**-**
Total Organic Carbon (mg C/ L)	SM-5130 B	0.75	a	**-**

***Blue shaded parameters are ISO/IEC 17025 accredited.**

Please note that the data presented in the table above are determined to be compliant or non-compliant based on the value provided without the incorporation of the measurement uncertainty.

Sample ID (Matrix) - Qualifier: BB-WQ5 (Surface Water) -☐C(B) ☐C(C) ☒C(L)

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	7.80 @ 25.2ºC	c	**7.00- 8.40**
Dissolved Oxygen (mg O_2/L)	DR	6.21 @ 25.2ºC	c	
Conductivity (mS/cm)	DR	0.325 @ 25.2ºC	c	**0.15- 0.6**
Salinity (ppt)	DR	0.15 @ 25.2ºC	c	
Total Dissolved Solids (mg/L)	DR	210.6 @ 25.2ºC	c	**120.0- 300.0**
Nitrate as Nitrogen (mg NO_3^--N /L)	H-8039	0.4	P(1)	**-**
Nitrate (mg NO_3^-/L)		1.8		**0.1 -7.5**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.09	-	**0.01- 0.8**
Sulfate (mg SO_4^{2-}/L)	H -8051	2	E(M1)	**3.0 -10.0**
Faecal Coliform (MPN/100ml)	SM-9221	920	-	**-**
***E. coli* (MPN/100ml)**	SM-9221	170	-	**-**
Chemical Oxygen Demand (mg O_2/L)	H-8000	10	P(P)	**-**
Total Suspended Solids (mg /L)	SM-2540 D	5.5	-	**-**
Chloride (mg Cl^-/L)	SM-4500 Cl^- B	3.2	-	**5.0 -20.0**
Total Nitrogen (mg N/ L)	H-10071	<2.2	UMR, P(P), P(1)	**-**
Total Phosphorous (mg P/ L)	SM-4500-B5 & H-8048	0.04	-	**-**
Phenol (mg C_6H_5OH/ L)	H-8047	<0.002	UMR	
Biochemical Oxygen Demand (mg O_2/L)	H-8043	1.4	-	**-**
Total Alkalinity (mg $CaCO_3$/ L)	SM-2320 B	183.6	-	**-**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
Total Hardness (mg $CaCO_3$/ L)	SM-2340 C	210.5	-	**127.0 – 381.0**
Fats, Oil & Grease (mg/L)	SM-5520 B	<1	a	**-**
Calcium (µg Ca/L)	EPA 200.7	71900	a	**40,000 - 101,000**
Magnesium (µg Mg/ L)	EPA 200.7	2350	a	**3,600-27,000**
Silica (µg SiO_4/L)	EPA 200.7	5150	a	**5,000-39,000**
Zinc (µg Zn/ L)	EPA 200.7	<11.0	a	**-**
Copper (µg Cu/ L)	EPA 200.7	<2.6	a	**-**
Arsenic (µg As/ L)	EPA 200.7	<3.4	a	**-**
Mercury (µg Hg/ L)	EPA 245.1	<0.090	a	**-**
Chromium (µg Cr/ L)	EPA 200.7	<1.7	a	**-**
Manganese (µg Mn/ L)	EPA 200.7	14.1	a	**-**
Sodium (µg Na/ L)	EPA 200.7	2750	a	**4,500-12,000**
Lead (µg Pb/ L)	EPA 200.7	<4.6	a	**-**
Iron (µg Fe/ L)	EPA 200.7	343	a	**-**
Pesticides Screen (ppb)	EPA Method 8181 B	Absent	a	**-**
Dissolved Organic Carbon (mg C/ L)	SM-5130 B	1.2	a	**-**
Total Organic Carbon (mg C/ L)	SM-5130 B	0.86	a	**-**

***Blue shaded parameters are ISO/IEC 17025 accredited.**

Please note that the data presented in the table above are determined to be compliant or non-compliant based on the value provided without the incorporation of the measurement uncertainty.

Sample ID (Matrix) - Qualifier: BB-WQ4 (Surface Water) **-☐C(B) ☐C(C) ☒C(L)**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	7.26 @ 25.6ºC	c	**7.00- 8.40**
Dissolved Oxygen (mg O_2/L)	DR	6.17 @ 25.6ºC	c	
Conductivity (mS/cm)	DR	0.201 @ 25.6ºC	c	**0.15- 0.6**
Salinity (ppt)	DR	0.09 @ 25.6ºC	c	
Total Dissolved Solids (mg/L)	DR	128.70 @ 25.6ºC	c	**120.0- 300.0**
Nitrate as Nitrogen (mg NO_3^--N /L)	H-8039	0.4	P(1)	**-**
Nitrate (mg NO_3^-/L)		2.0		**0.1 -7.5**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.05	-	**0.01- 0.8**
Sulfate (mg SO_4^{2-}/L)	H -8051	2	E(M1)	**3.0 -10.0**
Faecal Coliform (MPN/100ml)	SM-9221	240	-	**-**
***E. coli* (MPN/100ml)**	SM-9221	240	-	**-**
Chemical Oxygen Demand (mg O_2/L)	H-8000	6	P(P)	**-**
Total Suspended Solids (mg /L)	SM-2540 D	1.7	-	**-**
Chloride (mg Cl^-/L)	SM-4500 Cl^- B	3.2	-	**5.0 -20.0**
Total Nitrogen (mg N/ L)	H-10071	<2.2	UMR, P(P), P(1)	**-**
Total Phosphorous (mg P/ L)	SM-4500-B5 & H-8048	0.02	-	**-**
Phenol (mg C_6H_5OH/ L)	H-8047	<0.002	UMR	
Biochemical Oxygen Demand (mg O_2/L)	H-8043	1.0	-	**-**
Total Alkalinity (mg $CaCO_3$/ L)	SM-2320 B	103.7	-	**-**

Total Hardness (mg $CaCO_3$/ L)	SM-2340 C	108.6	-	**127.0 – 381.0**
Fats, Oil & Grease (mg/L)	SM-5520 B	<1	a	**-**
Calcium (µg Ca/L)	EPA 200.7	36300	a	**40,000 - 101,000**
Magnesium (µg Mg/ L)	EPA 200.7	2150	a	**3,600- 27,000**
Silica (µg SiO_4/L)	EPA 200.7	6070	a	**5,000- 39,000**
Zinc (µg Zn/ L)	EPA 200.7	<11.0	BDL, a	**-**
Copper (µg Cu/ L)	EPA 200.7	<2.6	a	**-**
Arsenic (µg As/ L)	EPA 200.7	<3.4	a	**-**
Mercury (µg Hg/ L)	EPA 245.1	<0.090	a	**-**
Chromium (µg Cr/ L)	EPA 200.7	<1.7	a	**-**
Manganese (µg Mn/ L)	EPA 200.7	29.4	a	**-**
Sodium (µg Na/ L)	EPA 200.7	5660	a	**4,500- 12,000**
Lead (µg Pb/ L)	EPA 200.7	<4.6	a	**-**
Iron (µg Fe/ L)	EPA 200.7	529	a	**-**
Pesticides Screen (ppb)	EPA Method 8181 B	Absent	a	**-**
Dissolved Organic Carbon (mg C/ L)	SM-5130 B	1.90	a	**-**
Total Organic Carbon (mg C/ L)	SM-5130 B	2.10	a	**-**

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Sample ID (Matrix) - Qualifier: BB-WQ3 (Surface Water) **-☐C(B) ☐C(C) ☒C(L)**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	7.65 @ 24.8ºC	c	**7.00- 8.40**
Dissolved Oxygen (mg O_2/L)	DR	7.48 @ 24.8ºC	c	
Conductivity (mS/cm)	DR	0.325 @ 24.8ºC	c	**0.15- 0.6**
Salinity (ppt)	DR	0.15 @ 24.8ºC	c	
Total Dissolved Solids (mg/L)	DR	211.90 @ 24.8ºC	c	**120.0- 300.0**
Nitrate as Nitrogen (mg NO_3^--N /L)	H-8039	0.3	P(1)	**-**
Nitrate (mg NO_3^-/L)		1.3		**0.1 -7.5**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.08	-	**0.01- 0.8**
Sulfate (mg SO_4^{2-}/L)	H -8051	2	E(M1)	**3.0 -10.0**
Faecal Coliform (MPN/100ml)	SM-9221	220	-	**-**
***E. coli* (MPN/100ml)**	SM-9221	170	-	**-**
Chemical Oxygen Demand (mg O_2/L)	H-8000	5	P(P)	**-**
Total Suspended Solids (mg /L)	SM-2540 D	3.9	-	**-**
Chloride (mg Cl^-/L)	SM-4500 Cl^- B	3.2	-	**5.0 -20.0**
Total Nitrogen (mg N/ L)	H-10071	<2.2	UMR, P(P), P(1)	**-**
Total Phosphorous (mg P/ L)	SM-4500-B5 & H-8048	0.04	-	**-**
Phenol (mg C_6H_5OH/ L)	H-8047	<0.002	BDL	
Biochemical Oxygen Demand (mg O_2/L)	H-8043	0.9	-	**-**
Total Alkalinity (mg $CaCO_3$/ L)	SM-2320 B	180.4	-	**-**

Total Hardness (mg $CaCO_3$/ L)	SM-2340 C	193.2	-	**127.0 – 381.0**
Fats, Oil & Grease (mg/L)	SM-5520 B	<1	a	**-**
Calcium (µg Ca/L)	EPA 200.7	71800	a	**40,000 - 101,000**
Magnesium (µg Mg/ L)	EPA 200.7	2330	a	**3,600- 27,000**
Silica (µg SiO_4/L)	EPA 200.7	5000	a	**5,000- 39,000**
Zinc (µg Zn/ L)	EPA 200.7	<11.0	BDL, a	**-**
Copper (µg Cu/ L)	EPA 200.7	<2.6	BDL, a	**-**
Arsenic (µg As/ L)	EPA 200.7	<3.4	BDL, a	**-**
Mercury (µg Hg/ L)	EPA 245.1	<0.090	BDL, a	**-**
Chromium (µg Cr/ L)	EPA 200.7	<1.7	BDL, a	**-**
Manganese (µg Mn/ L)	EPA 200.7	10.2	a	**-**
Sodium (µg Na/ L)	EPA 200.7	2690	a	**4,500- 12,000**
Lead (µg Pb/ L)	EPA 200.7	<4.6	a	**-**
Iron (µg Fe/ L)	EPA 200.7	245	a	**-**
Pesticides Screen (ppb)	EPA Method 8181 B	Absent	a	**-**
Dissolved Organic Carbon (mg C/ L)	SM-5130 B	0.80	a	**-**
Total Organic Carbon (mg C/ L)	SM-5130 B	0.86	a	**-**

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Sample ID (Matrix) - Qualifier: BB-WQ1 (Surface Water) **-☐C(B) ☐C(C) ☒C(L)**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	7.47 @ 24.6ºC	c, b(1)	**7.00- 8.40**
Dissolved Oxygen (mg O_2/L)	DR	7.36 @ 24.6ºC	c	
Conductivity (mS/cm)	DR	0.337 @ 24.6ºC	c	**0.15- 0.6**
Salinity (ppt)	DR	0.16 @ 24.6ºC	c	
Total Dissolved Solids (mg/L)	DR	221 @ 24.6ºC	c	**120.0- 300.0**
Nitrate as Nitrogen (mg NO_3^--N /L)	H-8039	<0.3	BDL, P(1)	**-**
Nitrate (mg NO_3^-/L)		<1.3		**0.1 -7.5**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.10	-	**0.01- 0.8**
Sulfate (mg SO_4^{2-}/L)	H -8051	2	E(M1)	**3.0 -10.0**
Faecal Coliform (MPN/100ml)	SM-9221	1600	-	**-**
***E. coli* (MPN/100ml)**	SM-9221	540	-	**-**
Chemical Oxygen Demand (mg O_2/L)	H-8000	3	P(P)	**-**
Total Suspended Solids (mg /L)	SM-2540 D	3.1	-	**-**
Chloride (mg Cl^-/L)	SM-4500 Cl^- B	3.5	-	**5.0 -20.0**
Total Nitrogen (mg N/ L)	H-10071	<2.2	UMR, P(P), P(1)	**-**
Total Phosphorous (mg P/ L)	SM-4500-B5 & H-8048	0.04	-	**-**
Phenol (mg C_6H_5OH/ L)	H-8047	<0.002	UMR	**-**
Biochemical Oxygen Demand (mg O_2/L)	H-8043	0.7	-	**-**
Total Alkalinity (mg $CaCO_3$/ L)	SM-2320 B	185.3	-	**-**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
Total Hardness (mg $CaCO_3$/ L)	SM-2340 C	219.8	-	**127.0 – 381.0**
Fats, Oil & Grease (mg/L)	SM-5520 B	<1	a	**-**
Calcium (µg Ca/L)	EPA 200.7	73900	a	**40,000 - 101,000**
Magnesium (µg Mg/ L)	EPA 200.7	2020	a	**3,600-27,000**
Silica (µg SiO_4/L)	EPA 200.7	4130	a	**5,000-39,000**
Zinc (µg Zn/ L)	EPA 200.7	<11.0	BDL, a	**-**
Copper (µg Cu/ L)	EPA 200.7	<2.6	BDL, a	**-**
Arsenic (µg As/ L)	EPA 200.7	<3.4	BDL, a	**-**
Mercury (µg Hg/ L)	EPA 245.1	<0.090	BDL, a	**-**
Chromium (µg Cr/ L)	EPA 200.7	<1.7	BDL, a	**-**
Manganese (µg Mn/ L)	EPA 200.7	5.8	a	**-**
Sodium (µg Na/ L)	EPA 200.7	2560	a	**4,500-12,000**
Lead (µg Pb/ L)	EPA 200.7	<4.6	BDL, a	**-**
Iron (µg Fe/ L)	EPA 200.7	140	a	**-**
Pesticides Screen (ppb)	EPA Method 8181 B	Absent	a	**-**
Dissolved Organic Carbon (mg C/ L)	SM-5130 B	0.64	a	**-**
Total Organic Carbon (mg C/ L)	SM-5130 B	0.69	a	**-**

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Sample ID (Matrix) - Qualifier: BB-WQ9 (Surface Water) -☐C(B) ☐C(C) ☒C(L)

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	6.78 @ 26.3ºC	c	**7.00- 8.40**
Dissolved Oxygen (mg O2/L)	DR	2.82 @ 26.3ºC	c	
Conductivity (mS/cm)	DR	0.442 @ 26.3ºC	c	**0.15- 0.6**
Salinity (ppt)	DR	0.21 @ 26.3ºC	c	
Total Dissolved Solids (mg/L)	DR	280.8 @ 26.3ºC	c	**120.0- 300.0**
Nitrate as Nitrogen (mg NO_3^--N /L)	H-8039	0.6	P(1)	**-**
Nitrate (mg NO_3^-/L)		2.6		**0.1 -7.5**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.02	-	**0.01- 0.8**
Sulfate (mg SO_4^{2-}/L)	H -8051	2	E(M1)	**3.0 -10.0**
Faecal Coliform (MPN/100ml)	SM-9221	920	-	**-**
E. coli **(MPN/100ml)**	SM-9221	350	-	**-**
Chemical Oxygen Demand (mg O_2/L)	H-8000	8	P(P)	**-**
Total Suspended Solids (mg /L)	SM-2540 D	<1.6	BDL	**-**
Chloride (mg Cl^-/L)	SM-4500 Cl^- B	5.6	P(1)	**5.0 -20.0**
Total Nitrogen (mg N/ L)	H-10071	<2.2	UMR, P(P), P(1)	**-**
Total Phosphorous (mg P/ L)	SM-4500-B5 & H-8048	<0.02	BDL	**-**
Phenol (mg C_6H_5OH/ L)	H-8047	<0.002	UMR	
Biochemical Oxygen Demand (mg O_2/L)	H-8043	1.1	-	**-**
Total Alkalinity (mg $CaCO_3$/ L)	SM-2320 B	250.6	-	**-**

Total Hardness (mg $CaCO_3$/ L)	SM-2340 C	281.4	-	**127.0 – 381.0**
Fats, Oil & Grease (mg/L)	SM-5520 B	<1	a	**-**
Calcium (µg Ca/L)	EPA 200.7	99800	a	**40,000 - 101,000**
Magnesium (µg Mg/ L)	EPA 200.7	1650	a	**3,600-27,000**
Silica (µg SiO_4/L)	EPA 200.7	3090	a	**5,000-39,000**
Zinc (µg Zn/ L)	EPA 200.7	<11.0	BDL, a	**-**
Copper (µg Cu/ L)	EPA 200.7	<2.6	BDL, a	**-**
Arsenic (µg As/ L)	EPA 200.7	<3.4	BDL, a	**-**
Mercury (µg Hg/ L)	EPA 245.1	<0.090	BDL, a	**-**
Chromium (µg Cr/ L)	EPA 200.7	<1.7	BDL, a	**-**
Manganese (µg Mn/ L)	EPA 200.7	10.3	a	**-**
Sodium (µg Na/ L)	EPA 200.7	2230	a	**4,500-12,000**
Lead (µg Pb/ L)	EPA 200.7	<4.6	BDL, a	**-**
Iron (µg Fe/ L)	EPA 200.7	109	a	**-**
Pesticides Screen (ppb)	EPA Method 8181 B	Absent	a	**-**
Dissolved Organic Carbon (mg C/ L)	SM-5130 B	3.1	a	**-**
Total Organic Carbon (mg C/ L)	SM-5130 B	3.2	a	**-**

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Certificate of Quality

Parameter: Chemical Oxygen Demand (H-8000)

QEHL Personnel: J. Webster-Jones, T. Thompson **Date of Analysis: 18/11/2021**

	Standard Concentration (mg O_2/L)	Determined Concentration (mg O_2/L)	RPD (%)
MB		7	
BD		440	4.6
		420	
SRS	128-140	132	

Parameter: Chloride (SM-4500 Cl^- B)

QEHL Personnel: N. McCalla, J. Webster **Date of Analysis: 16/11/2021**

	Standard Concentration (mg Cl^-/L)	Determined Concentration (mg Cl^-/L)	RPD (%)
MB		3.2	
BD		115.0	2.6
		112.0	
SRS	93.8-106.2	100.8	

Parameter: Total Suspended Solids (SM-2540 D)

QEHL Personnel: N. McCalla **Date of Analysis: 09/11/2021**

	Standard Concentration (mg/L)	Determined Concentration (mg/L)	RPD (%)
MB		<1.6	
BD		94.0	0.0
		94.0	
SRS	46.1-57.7	47.0	

Parameter: Total Phosphorus (H-8048 & SM-4500P B5)

QEHL Personnel: T. Cox **Date of Analysis: 08/11/2021**

	Standard Concentration (mg P/L)	Determined Concentration (mg P/L)	RPD (%)
MB		0.04	
BD		2.56	1.6
		2.60	
SRS	2.16 – 2.28	2.18	

Parameter: Sulfate (H-8051)

QEHL Personnel: T. Thompson **Date of Analysis: 06/11/2021**

	Standard Concentration ($mg\ SO_4^{2-}/L$)	Determined Concentration ($mg\ SO_4^{2-}/L$)	RPD (%)
MB		<1	
FD		12	0.0
		12	
BD		2	0.0
		2	
SRS	57-63	61	

Parameter: Total Nitrogen (H-10071)

QEHL Personnel: S. Ellis, T. Cox **Date of Analysis: 05/11/2021**

	Standard Concentration (mg N /L)	Determined Concentration (mg N/L)	RPD (%)
MB		<2.2	
BD		36.4	2.2
		35.6	
SRS	9.0-10.8	9.0	

Parameter: Total Hardness (SM-2340 C)

QEHL Personnel: S. Robinson, T. Cox **Date of Analysis: 05/11/2021**

	Standard Concentration ($mg\ CaCO_3/L$)	Determined Concentration ($mg\ CaCO_3/L$)	RPD (%)
Duplicates		280.8	0.4
		282.0	
SRS	0.91 – 1.09	1.05	

Parameter: HR Nitrate (H-8039)

QEHL Personnel: M. Brown, J. Webster **Date of Analysis: 04/11/2021**

	Standard Concentration ($mg\ NO_3^-$-N/L)	Determined Concentration ($mg\ NO_3^-$-N/L)	RPD (%)
MB		0.4	
RB		0.3	
BD		6.2	0.0
		6.2	
FD		1.4	0.0
		1.4	
SRS	8.5-11.5	9.4	

Parameter: Alkalinity (SM-2320 B)

QEHL Personnel: T. Cox **Date of Analysis: 04/11/2021**

	Standard Concentration (mg $CaCO_3$/L)	Determined Concentration (mg $CaCO_3$/L)	RPD (%)
Duplicates		184.7	0.4
		184.0	
SRS	87.4-104	96.5	

Parameter: Orthophosphates (H-8048)

QEHL Personnel: T. Cox, S. Robinson **Date of Analysis: 04/11/2021**

	Standard Concentration (mg PO_4^{3-}/L)	Determined Concentration (mg PO_4^{3-}/L)	RPD (%)
MB		0.03	
RB		0.02	
BD		0.10	0.0
		0.10	
SRS	1.74-1.86	1.81	

***Duplicates accepted based on the sensitivity of the analytical method used.**

Parameter: Phenols (H-8047)

QEHL Personnel: R. Dunkley **Date of Analysis: 04/11/2021**

	Standard Concentration (mg C_6H_5OH/L)	Determined Concentration (mg C_6H_5OH/L)	RPD (%)
BD		<0.002	-
		<0.002	
SRS	0.093 – 0.107	0.101	

Parameter: Biochemical Oxygen Demand (H-8043)

QEHL Personnel: T. Thompson, R. Khan-Haqq, S. Crooks **Date of Analysis: 04/11/2021**

Parameter: Faecal Coliform (SM-9221)

QEHL Personnel: K. Simpson **Date of Analysis: 04/11/2021**

Media/Test Item (Batch#)	DS LTB (01/11/2021)	SS LTB (02/11/2021)	EC (05/11/2021)
Sterile (Yes/No)	Yes	Yes	Yes
Media performance (Typical, not typical)	Typical	Typical	Typical

Parameter: *E. Coli* (SM-9221)
QEHL Personnel: K. Simpson **Date of Analysis: 04/11/2021**

Media/Test Item (Batch#)	DS LTB (01/11/2021)	SS LTB (02/11/2021)	EC Mug (05/11/2021)
Sterile (Yes/No)	Yes	Yes	Yes
Media performance (Typical, not typical)	Typical	Typical	Typical

Parameter: Dissolved Oxygen (DR)
QEHL Personnel: J. Webster **Date of Analysis: 03/11/2021**

Action Limit (%)	Dissolved Oxygen (%)	Temperature (°C)
95.0-105.0	99.2	29.6

Parameter: Conductivity (DR)
QEHL Personnel: J. Webster **Date of Analysis: 03/11/2021**

Standard (mS/cm)	Instrument Reading (mS/cm)	Temperature (°C)
1.98-2.00	2.00	29.8

Parameter: pH (DR)
QEHL Personnel: J. Webster **Date of Analysis: 03/11/2021**

Standard (Buffer)	pH After Calibration	Temperature (°C)
6.95-7.05	7.01	29.2

Glossary

%	Percentage
µg/L	microgram per litre
µS/cm	microsiemens per centimetre
a	Parameter subcontracted
ADB	Azide Dextrose Broth
AIM	The Aquaculture, Inland & Marine Products & By-Products Act (Regulations)
AOAC	American Organization of Analytical Chemists
b (1)	Parameter analysed outside of hold-time; samples submitted outside of the analysis hold-time
b (2)	Parameter analysed outside of hold-time; analysis authorised by Client
BAM	Bacteriological Analytical Manual
BD	Batch Duplicate
BDL	Analyte concentration below laboratory determined limit of detection
BDLS	Analyte detected below method detection limit (MDL). MDL greater than standard value.
BEA	Bile Esculin Azide Agar
BG	Brilliant Green Bile Broth
BGSA	Brilliant Green Sulfa Agar
BHI	Brain Heart Infusion Broth
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
BSA	Bismuth Sulfite Agar
c	parameter analysed in the field
C(B)	Samples collected by the client and picked up by an ESL bearer
C(C)	Samples collected by the client and delivered to ESL
C(H)	Analytical sample submitted in incorrect container. This may affect data quality.
C(L)	Samples collected by ESL
C(S)	Sample collected by the client then sub-sampled and delivered by ESL.
cfu	Colony Forming Units
CMMEF	Compendium of Methods for the Microbiological Examination of Foods
Col	Colourimetry
CVAAS	Cold Vapour Atomic Absorption Spectroscopy
D(I)	Sample was diluted due to the presence of high levels of non-target analytes or other matrix interference
D(C)	Sample diluted due to high concentration of target analyte
DR	Direct Reading
DS ADB	Double Strength azide dextrose broth
DS LTB	Double Strength Lauryl Tryptose Broth
DS PAB	Double Strength Pseudomonas Asparagine Broth
EB	Equipment Blank
E(E1)	Estimated Value. Data acquisition affected by equipment malfunction.
E(L1)	Estimated Value. Analyte recovery in the laboratory control sample (LCS) was outside of QC limits. Results for this may be affected by same bias.
E(L2)	Estimated Value due to the nature of the sample matrix.
E(M1)	Estimated Value. Result calculated using calibration curve.
E(M2)	Estimated Value. Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.
E(M3)	Estimated Value. Sample performance indicate presence of interference
E(R)	Estimated Value. RPD value was outside control limits.
EC	*E. coli* Media
E(V)	Estimated Value. Count(s) obtained is/are outside of the method counting range.
EC-MUG	*E. coli* Media with 4-**m**ethyl**u**mbelliferyl-β-D-**g**lucuronide
EHU	Environmental Health Unit
EPA	(US) Environmental Protection Agency
FAAS	Flame Atomic Absorption Spectroscopy
FAES	Flame Atomic Emission Spectroscopy
FB	Field Blank
FD	Field Duplicate
FL-PRO	Florida Petroleum Range Organic Method
GC-MS	Gas Chromatography Mass Spectrometry
H	Hach Water Analysis Workbook

H(A)	Off-scale high data obtained. Actual value may be greater than value given.
ICP	Inductively Coupled Plasma
ISE	Ion Selective Electrode
LCA	Listeria Chromogenic Agar
LE	Data not available due to laboratory error
LIA	Lysine Iron Agar
MAC	MacConkey Agar
MB	Method Blank
mEndo	mEndo Agar/Broth
MFHPB	Microbiology Food Health Protection Branch, Government of Canada
mmhos/cm	Millimhos per centimetre
mg/kg	milligram per kilogram
mg/L	milligrams per litre
MPN	Most Probable Number
mS/cm	millisiemens per centimetre
N/A (1)	Data not yet Available. Analysis not complete.
N/A (2)	Data not Available. Sample matrix interferences prevented data acquisition.
N/A (3)	Data not Available. Insufficient sample submitted.
N/A (4)	Data not Available. Equipment malfunction prevented data acquisition.
N/A (5)	Data not Available. Analysis not complete due to force majeure.
NA	Nutrient Agar
NB	Nutrient Broth
NEPA	National Environment and Planning Agency
NRCA	Natural Resources Conservation Authority
NTU	Nephelometric Turbidity Units
NWC	Nation Water Commission (Jamaica)
NST	No Time given for collection of samples
P(P)	Sample preserved prior to analysis
P(1)	Non-routine sample pre-treatment required
PAB	Pseudomonas Asparagine Broth
PCA	Plate Count Agar
PDA + C	Potato Dextrose Agar with Chloramphenicol
Pep Water	Peptone Water
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
RED	Parameter Non-compliant
RPD	Relative Percentage Difference
SM	Standard Methods for the Examination of Water and Wastewater 23rd Edition
SRS	Standard Reference Solution
SS	Sample Submerged on receival at laboratory
SS ADB	Single Strength Azide dextrose broth
SS LTB	Single Strength Lauryl Tryptose Broth
SS PAB	Single Strength Pseudomonas Asparagine Broth
T(H)	Samples arrived at ESL-QEHL outside holding temperature (≤4.0°C).
TIT	Titrimetry
TPH	Total Petroleum Hydrocarbon
TSA	Tryptic Soy Agar
TSB	Tryptic Soy Broth
TSYE	Tryptone Soy Yeast Extract
TTC	Triphenyl Tetrazolium Chloride
UMR	Analyte detection was below the measuring range of instrument. This is indicative of possible matrix interference within the sample.
WHO	World Health Organization
XLD	Xylose Lysine Deoxycholate

End of Report

ESL QUALITY & ENVIRONMENTAL HEALTH LABORATORY

A division of

7 Hillview Avenue,
Kingston 10, Jamaica
Tel: (876) 978-9519, 978-6297, 978-5902
Fax: (876) 946-3745
E-mail: envirsol@cwjamaica.com

Certificate of Sample Analysis

CSA#: ESL 22033001-12

Attention:

Mrs. Jaidene Webster-Jones
Environmental Solutions Limited
7 Hillview Avenue
Kingston 10

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ESL QUALITY & ENVIRONMENTAL HEALTH LABORATORY

A division of

Sample(s) Information

Job Number:	**22033001-12**
SPN:	-
Date of Report:	24/06/2022
Revision Date:	**Not Applicable**
Sample(s) Collected:	29/03/2022
Sample(s) Submitted:	30/03/2022
Temperature on Arrival:	3.6ºC
Number of Samples:	12
Analysis Started:	30/03/2022
Analysis Completed:	23/06/2022
Prepared By:	**Tara-Lee Hylton, Technical Assistant**

Verified By ……K. Williams……………
Kivonna Williams,
Analyst, Microbiology

Approved By……S. Ellis……………..
Shadain Ellis,
Senior Analyst

Results of Sample Analysis

Sample ID (Matrix) - Qualifier: WQ 1 (Surface Water) -☐C(B) ☐C(C) ☒C(L)

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	8.19 @ 26.2ºC	c	**7.00 - 8.40**
Dissolved Oxygen (mg O_2/L)	DR	7.19 @ 26.2ºC	c	**-**
Conductivity (mS/cm)	DR	0.352 @ 26.2ºC	c	**0.15 - 0.6**
Salinity (ppt)	DR	0.16 @ 26.2ºC	c	**-**
Total Dissolved Solids (mg/L)	DR	224.25@ 26.2ºC	c	**120.0 - 300.0**
Nitrate (mg NO_3^-/L)	H-8039	1.3	-	**0.1 - 7.5**
Nitrate as Nitrogen (mg NO_3^--N/L)		0.3		**-**
Total Nitrogen (mg/L)	H-10071	2.2	P(P), P(1)	**-**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.09	-	**0.01 - 0.8**
Total Phosphorous (mg P/L)	SM-4500-P B5 & H-8048	0.08	P(P), P(1)	**-**
Sulfate (mg SO_4^{2-}/L)	H -8051	2	E(M1)	**3.0 - 10.0**
Faecal Coliform (MPN/100ml)	SM-9221	920	-	**-**
***E. coli* (MPN/100ml)**	SM-9221	540	-	**-**
Total Suspended Solids (mg/L)	SM-2540 D	<1.6	BDL	**-**
Chloride (mg Cl^-/L)	H-8206	6.0	P(1)	**5.0 - 20.0**
Phenol (mg C_6H_5OH/L)	H-8047	<0.002	UMR	**-**
Total Alkalinity (mg $CaCO_3$/L)	SM-2320 B	179.5	-	**-**
Total Hardness (mg $CaCO_3$/L)	SM-2340 C	209.6	-	**127.0 – 381.0**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
Chemical Oxygen Demand ($mg\ O_2/L$)	H-8000	19	P(P)	-
Dissolved Organic Carbon (mg/L)	SM-5310 B	0.56	a	-
Total Organic Carbon (mg/L)	SM-5310 B	0.57	a	-
Pesticide Screen (ppb)	EPA-8081 B	Not Detected	a	-
Biochemical Oxygen Demand ($mg\ O_2/L$)	H-8043	0.7	-	**0.8 – 1.7**
Fats, Oil & Grease (mg/L)	SM-5520 B	1	a, b(2)	-
Calcium (µg Ca/L)	EPA 6010 & EPA 3010	72300	a	**40000 – 101000**
Magnesium (µg Mg/L)	EPA 6010 & EPA 3010	3300	a	**3600 – 27000**
Silica (µg SiO_4/L)	EPA 6010 & EPA 3010	9390	a	**5000 - 39000**
Zinc (µg Zn/L)	EPA 6010 & EPA 3010	<11.0	BDL, a	-
Potassium (µg K/L)	EPA 6010 & EPA 3010	<270	BDL, a	**740 - 5000**
Copper (µg Cu/L)	EPA 6010 & EPA 3010	<2.6	BDL, a	-
Arsenic (µg As/L)	EPA 6010 & EPA 3010	<3.4	BDL, a	-
Mercury (µg Hg/L)	EPA 7470	<0.090	BDL, a	-
Chromium (µg Cr/L)	EPA 6010 & EPA 3010	<1.7	BDL, a	-
Manganese (µg Mn/L)	EPA 6010 & EPA 3010	2.1	a	-
Sodium (µg Na/L)	EPA 6010 & EPA 3010	2810	a	**4500 – 12000**
Lead (µg Pb/L)	EPA 6010 & EPA 3010	<4.6	BDL, a	-
Iron (µg Fe/L)	EPA 6010 & EPA 3010	<25.0	BDL, a	-

***Blue shaded parameters are ISO/IEC 17025:2017 accredited.**

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Sample ID (Matrix) - Qualifier: WQ 2 (Surface Water) -☐C(B) ☐C(C) ☒C(L)

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	7.96 @ 24.8ºC	c	**7.00 - 8.40**
Dissolved Oxygen (mg O_2/L)	DR	7.77 @ 24.8ºC	c	**-**
Conductivity (mS/cm)	DR	0.361 @ 24.8ºC	c	**0.15 - 0.6**
Salinity (ppt)	DR	0.17 @ 24.8ºC	c	**-**
Total Dissolved Solids (mg/L)	DR	235.95 @ 24.8ºC	c	**120.0 - 300.0**
Nitrate (mg NO_3^-/L)	H-8039	2.6	-	**0.1 - 7.5**
Nitrate as Nitrogen (mg NO_3^--N/L)		0.6		**-**
Total Nitrogen (mg/L)	H-10071	<2.2	BDL, P(P), P(1)	**-**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.14	-	**0.01 - 0.8**
Total Phosphorous (mg P/L)	SM-4500-P B5 & H-8048	0.10	P(P), P(1)	**-**
Sulfate (mg SO_4^{2-}/L)	H -8051	1	E(M1)	**3.0 - 10.0**
Faecal Coliform (MPN/100ml)	SM-9221	350	-	**-**
***E. coli* (MPN/100ml)**	SM-9221	170	-	**-**
Total Suspended Solids (mg/L)	SM-2540 D	2.1	-	**-**
Chloride (mg Cl^-/L)	H-8206	3.6	P(1)	**5.0 - 20.0**
Phenol (mg C_6H_5OH/L)	H-8047	<0.002	UMR	**-**
Total Alkalinity (mg $CaCO_3$/L)	SM-2320 B	189.1	-	**-**
Total Hardness (mg $CaCO_3$/L)	SM-2340 C	202.2	-	**127.0 – 381.0**
Chemical Oxygen Demand (mg O_2/L)	H-8000	12	P(P)	**-**
Dissolved Organic Carbon (mg/L)	SM-5310 B	0.56	a	**-**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
Total Organic Carbon (mg/L)	SM-5310 B	<0.50	BDL, a	**-**
Pesticide Screen (ppb)	EPA-8081 B	Not Detected	a	**-**
Biochemical Oxygen Demand (mg O_2/L)	H-8043	0.8	-	**0.8 – 1.7**
Fats, Oil & Grease (mg/L)	SM-5520 B	3	a, b(2)	**-**
Calcium (µg Ca/L)	EPA 6010 & EPA 3010	76400	a	**40000 – 101000**
Magnesium (µg Mg/L)	EPA 6010 & EPA 3010	3630	a	**3600 – 27000**
Silica (µg SiO_4/L)	EPA 6010 & EPA 3010	10600	a	**5000 - 39000**
Zinc (µg Zn/L)	EPA 6010 & EPA 3010	<11.0	BDL, a	**-**
Potassium (µg K/L)	EPA 6010 & EPA 3010	291	a	**740 - 5000**
Copper (µg Cu/L)	EPA 6010 & EPA 3010	<2.6	BDL, a	**-**
Arsenic (µg As/L)	EPA 6010 & EPA 3010	<3.4	BDL, a	**-**
Mercury (µg Hg/L)	EPA 7470	<0.090	BDL, a	**-**
Chromium (µg Cr/L)	EPA 6010 & EPA 3010	<1.7	BDL, a	**-**
Manganese (µg Mn/L)	EPA 6010 & EPA 3010	3.5	a	**-**
Sodium (µg Na/L)	EPA 6010 & EPA 3010	2020	a	**4500 - 12000**
Lead (µg Pb/L)	EPA 6010 & EPA 3010	<4.6	BDL, a	**-**
Iron (µg Fe/L)	EPA 6010 & EPA 3010	<25.0	BDL, a	**-**

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Sample ID (Matrix) - Qualifier: WQ 3 (Surface Water) **-☐C(B) ☐C(C) ☒C(L)**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	8.23 @ 25.9ºC	c	**7.00 - 8.40**
Dissolved Oxygen (mg O_2/L)	DR	8.15 @ 25.9ºC	c	**-**
Conductivity (mS/cm)	DR	0.335 @ 25.9ºC	c	**0.15 - 0.6**
Salinity (ppt)	DR	0.16 @ 25.9ºC	c	**-**
Total Dissolved Solids (mg/L)	DR	214.50 @ 25.9ºC	c	**120.0 - 300.0**
Nitrate (mg NO_3^-/L)	H-8039	1.3	P(1)	**0.1 - 7.5**
Nitrate as Nitrogen (mg NO_3^--N/L)		0.3		**-**
Total Nitrogen (mg/L)	H-10071	<2.2	BDL, P(P), P(1)	**-**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.10	-	**0.01 - 0.8**
Total Phosphorous (mg P/ L)	SM-4500-P B5 & H-8048	0.06	P(P), P(1)	**-**
Sulfate (mg SO_4^{2-}/L)	H -8051	2	P(1), E(M1)	**3.0 - 10.0**
Faecal Coliform (MPN/100ml)	SM-9221	540	-	**-**
***E. coli* (MPN/100ml)**	SM-9221	280	-	**-**
Total Suspended Solids (mg/L)	SM-2540 D	<1.6	BDL	**-**
Chloride (mg Cl^-/L)	H-8206	6.4	P(1)	**5.0 - 20.0**
Phenol (mg C_6H_5OH/L)	H-8047	<0.002	UMR	**-**
Total Alkalinity (mg $CaCO_3$/L)	SM-2320 B	176.1	-	**-**
Total Hardness (mg $CaCO_3$/L)	SM-2340 C	201.2	-	**127.0 – 381.0**
Chemical Oxygen Demand (mg O_2/L)	H-8000	15	P(P)	**-**
Dissolved Organic Carbon (mg/L)	SM-5310 B	0.59	a	**-**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
Total Organic Carbon (mg/L)	SM-5310 B	<0.50	BDL, a	**-**
Pesticide Screen (ppb)	EPA-8081 B	Not Detected	a	**-**
Biochemical Oxygen Demand (mg O_2/L)	H-8043	0.8	-	**0.8 – 1.7**
Fats, Oil & Grease (mg/L)	SM-5520 B	7	a, b(2)	**-**
Calcium (µg Ca/L)	EPA 6010 & EPA 3010	74300	E(M2), a	**40000 - 101000**
Magnesium (µg Mg/L)	EPA 6010 & EPA 3010	4370	a	**3600 – 27000**
Silica (µg SiO_4/L)	EPA 6010 & EPA 3010	11900	a	**5000 - 39000**
Zinc (µg Zn/L)	EPA 6010 & EPA 3010	<11.0	BDL, a	**-**
Potassium (µg K/L)	EPA 6010 & EPA 3010	702	a	**740 - 5000**
Copper (µg Cu/L)	EPA 6010 & EPA 3010	<2.6	BDL, a	**-**
Arsenic (µg As/L)	EPA 6010 & EPA 3010	<3.4	BDL, a	**-**
Mercury (µg Hg/L)	EPA 7470	<0.090	BDL, a	**-**
Chromium (µg Cr/L)	EPA 6010 & EPA 3010	<1.7	BDL, a	**-**
Manganese (µg Mn/L)	EPA 6010 & EPA 3010	6.5	a	**-**
Sodium (µg Na/L)	EPA 6010 & EPA 3010	8440	E(M2), a	**4500 - 12000**
Lead (µg Pb/L)	EPA 6010 & EPA 3010	<4.6	BDL, a	**-**
Iron (µg Fe/L)	EPA 6010 & EPA 3010	76.2	a	**-**

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Sample ID (Matrix) - Qualifier: WQ 4 (Surface Water) **-☐C(B) ☐C(C) ☒C(L)**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	8.06 @ 26.6ºC	c	**7.00 - 8.40**
Dissolved Oxygen (mg O_2/L)	DR	8.02 @ 26.6ºC	c	**-**
Conductivity (mS/cm)	DR	0.330 @ 26.6ºC	c	**0.15 - 0.6**
Salinity (ppt)	DR	0.15 @ 26.6ºC	c	**-**
Total Dissolved Solids (mg/L)	DR	208.00 @ 26.6ºC	c	**120.0 - 300.0**
Nitrate as Nitrogen (mg NO_3^--N/L)	H-8039	<0.3	BDL, P(1)	**-**
Nitrate (mg NO_3^-/L)		<1.3		**0.1 - 7.5**
Total Nitrogen (mg/L)	H-10071	<2.2	BDL, P(P), P(1)	**-**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.05	-	**0.01 - 0.8**
Total Phosphorous (mg P/ L)	SM-4500-P B5 & H-8048	0.06	P(P), P(1)	**-**
Sulfate (mg SO_4^{2-}/L)	H -8051	3	P(1), E(M1)	**3.0 - 10.0**
Faecal Coliform (MPN/100ml)	SM-9221	350	-	**-**
***E. coli* (MPN/100ml)**	SM-9221	350	-	**-**
Total Suspended Solids (mg/L)	SM-2540 D	<1.6	BDL	**-**
Chloride (mg Cl^-/L)	H-8206	6.4	P(1)	**5.0 - 20.0**
Phenol (mg C_6H_5OH/L)	H-8047	<0.002	UMR	**-**
Total Alkalinity (mg $CaCO_3$/L)	SM-2320 B	159.0	-	**-**
Total Hardness (mg $CaCO_3$/L)	SM-2340 C	177.9	-	**127.0 – 381.0**
Chemical Oxygen Demand (mg O_2/L)	H-8000	16	P(P)	**-**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
Dissolved Organic Carbon (mg/L)	SM-5310 B	1.3	a	-
Total Organic Carbon (mg/L)	SM-5310 B	1.2	a	-
Pesticide Screen (ppb)	EPA-8081 B	Not Detected	a	-
Biochemical Oxygen Demand (mg O_2/L)	H-8043	0.9	-	**0.8 – 1.7**
Fats, Oil & Grease (mg/L)	SM-5520 B	5	a, b(2)	-
Calcium (µg Ca/L)	EPA 6010 & EPA 3010	68100	a	**40000 – 101000**
Magnesium (µg Mg/L)	EPA 6010 & EPA 3010	2810	a	**3600 – 27000**
Silica (µg SiO_4/L)	EPA 6010 & EPA 3010	11900	a	**5000 - 39000**
Zinc (µg Zn/L)	EPA 6010 & EPA 3010	<11.0	BDL, a	-
Potassium (µg K/L)	EPA 6010 & EPA 3010	760	a	**740 - 5000**
Copper (µg Cu/L)	EPA 6010 & EPA 3010	<2.6	BDL, a	-
Arsenic (µg As/L)	EPA 6010 & EPA 3010	<3.4	BDL, a	-
Mercury (µg Hg/L)	EPA 7470	<0.090	BDL, a	-
Chromium (µg Cr/L)	EPA 6010 & EPA 3010	<1.7	BDL, a	-
Manganese (µg Mn/L)	EPA 6010 & EPA 3010	35.3	a	-
Sodium (µg Na/L)	EPA 6010 & EPA 3010	6770	a	**4500 – 12000**
Lead (µg Pb/L)	EPA 6010 & EPA 3010	<4.6	BDL, a	-
Iron (µg Fe/L)	EPA 6010 & EPA 3010	238	a	-

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Sample ID (Matrix) - Qualifier: WQ 5 (Surface Water) **-☐C(B) ☐C(C) ☒C(L)**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	8.14 @ 24.4ºC	c	**7.00 - 8.40**
Dissolved Oxygen (mg O_2/L)	DR	8.80 @ 24.4ºC	c	**-**
Conductivity (mS/cm)	DR	0.325 @ 24.4ºC	c	**0.15 - 0.6**
Salinity (ppt)	DR	0.16 @ 24.4ºC	c	**-**
Total Dissolved Solids (mg/L)	DR	213.85 @ 24.4ºC	c	**120.0 - 300.0**
Nitrate as Nitrogen (mg NO_3^--N/L)	H-8039	0.3	-	**-**
Nitrate (mg NO_3^-/L)		1.3		**0.1 - 7.5**
Total Nitrogen (mg/L)	H-10071	<2.2	BDL, P(P), P(1)	**-**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.07	-	**0.01 - 0.8**
Total Phosphorous (mg P/ L)	SM-4500-P B5 & H-8048	0.04	P(P), P(1)	**-**
Sulfate (mg SO_4^{2-}/L)	H -8051	1	E(M1)	**3.0 - 10.0**
Faecal Coliform (MPN/100ml)	SM-9221	350	-	**-**
E. coli **(MPN/100ml)**	SM-9221	350	-	**-**
Total Suspended Solids (mg/L)	SM-2540 D	<1.6	BDL	**-**
Chloride (mg Cl^-/L)	H-8206	4.4	P(1)	**5.0 - 20.0**
Phenol (mg C_6H_5OH/ L)	H-8047	<0.002	UMR	**-**
Total Alkalinity (mg $CaCO_3$/L)	SM-2320 B	172.0	-	**-**
Total Hardness (mg $CaCO_3$/L)	SM-2340 C	202.8	-	**127.0 – 381.0**
Chemical Oxygen Demand (mg O_2/L)	H-8000	19	P(P)	**-**
Dissolved Organic Carbon (mg/L)	SM-5310 B	0.68	a	**-**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
Total Organic Carbon (mg/L)	SM-5310 B	0.51	a	**-**
Pesticide Screen (ppb)	EPA-8081 B	Not Detected	a	**-**
Biochemical Oxygen Demand (mg O_2/L)	H-8043	1.3	-	**-**
Fats, Oil & Grease (mg/L)	SM-5520 B	6	b(2), a	**-**
Calcium (µg Ca/L)	EPA 6010 & EPA 3010	72100	a	**40000 – 101000**
Magnesium (µg Mg/L)	EPA 6010 & EPA 3010	3770	a	**3600 – 27000**
Silica (µg SiO_4/L)	EPA 6010 & EPA 3010	11400	a	**5000 - 39000**
Zinc (µg Zn/L)	EPA 6010 & EPA 3010	<11.0	BDL, a	**-**
Potassium (µg K/L)	EPA 6010 & EPA 3010	404	a	**740 - 5000**
Copper (µg Cu/L)	EPA 6010 & EPA 3010	<2.6	BDL, a	**-**
Arsenic (µg As/L)	EPA 6010 & EPA 3010	<3.4	BDL, a	**-**
Mercury (µg Hg/L)	EPA 7470	<0.090	BDL, a	**-**
Chromium (µg Cr/L)	EPA 6010 & EPA 3010	<1.7	BDL, a	**-**
Manganese (µg Mn/L)	EPA 6010 & EPA 3010	6.7	a	**-**
Sodium (µg Na/L)	EPA 6010 & EPA 3010	3200	a	**4500 – 12000**
Lead (µg Pb/L)	EPA 6010 & EPA 3010	<4.6	BDL, a	**-**
Iron (µg Fe/L)	EPA 6010 & EPA 3010	43.3	a	**-**

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Sample ID (Matrix) - Qualifier: WQ 6 (Surface Water) -☐C(B) ☐C(C) ☒C(L)

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	8.36 @ 25.4ºC	c	**7.00 - 8.40**
Dissolved Oxygen (mg O_2/L)	DR	8.18 @ 25.4ºC	c	**-**
Conductivity (mS/cm)	DR	0.282 @ 25.4ºC	c	**0.15 - 0.6**
Salinity (ppt)	DR	0.13 @ 25.4ºC	c	**-**
Total Dissolved Solids (mg/L)	DR	182.00 @ 25.4ºC	c	**120.0 - 300.0**
Nitrate as Nitrogen (mg NO_3^--N/L)	H-8039	<0.3	BDL	**-**
Nitrate (mg NO_3^-/L)		<1.3		**0.1 - 7.5**
Total Nitrogen (mg/L)	H-10071	<2.2	BDL, P(P), P(1)	**-**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.06	-	**0.01 - 0.8**
Total Phosphorous (mg P/ L)	SM-4500-P B5 & H-8048	0.04	P(P), P(1)	**-**
Sulfate (mg SO_4^{2-}/L)	H -8051	1	E(M1)	**3.0 - 10.0**
Faecal Coliform (MPN/100ml)	SM-9221	350	-	**-**
***E. coli* (MPN/100ml)**	SM-9221	48	-	**-**
Total Suspended Solids (mg/L)	SM-2540 D	<1.6	BDL	**-**
Chloride (mg Cl^-/L)	H-8206	4.8	P(1)	**5.0 - 20.0**
Phenol (mg C_6H_5OH/L)	H-8047	<0.002	UMR	**-**
Total Alkalinity (mg $CaCO_3$/L)	SM-2320 B	143.7	-	**-**
Total Hardness (mg $CaCO_3$/L)	SM-2340 C	163.2	-	**127.0 – 381.0**
Chemical Oxygen Demand (mg O_2/L)	H-8000	17	P(P)	**-**
Dissolved Organic Carbon (mg/L)	SM-5310 B	0.82	a	**-**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
Total Organic Carbon (mg/L)	SM-5310 B	0.56	a	**-**
Pesticide Screen (ppb)	EPA-8081 B	Not Detected	a	**-**
Biochemical Oxygen Demand ($mg\ O_2/L$)	H-8043	1.1	-	**0.8 – 1.7**
Fats, Oil & Grease (mg/L)	SM-5520 B	8	a, b(2)	**-**
Calcium (µg Ca/L)	EPA 6010 & EPA 3010	58900	a	**40000 – 101000**
Magnesium (µg Mg/L)	EPA 6010 & EPA 3010	3730	a	**3600 – 27000**
Silica (µg SiO_4/L)	EPA 6010 & EPA 3010	12500	a	**5000 - 39000**
Zinc (µg Zn/L)	EPA 6010 & EPA 3010	<11.0	BDL, a	**-**
Potassium (µg K/L)	EPA 6010 & EPA 3010	444	a	**740 - 5000**
Copper (µg Cu/L)	EPA 6010 & EPA 3010	<2.6	BDL, a	**-**
Arsenic (µg As/L)	EPA 6010 & EPA 3010	<3.4	BDL, a	**-**
Mercury (µg Hg/L)	EPA 7470	<0.090	BDL, a	**-**
Chromium (µg Cr/L)	EPA 6010 & EPA 3010	<1.7	BDL, a	**-**
Manganese (µg Mn/L)	EPA 6010 & EPA 3010	3.1	a	**-**
Sodium (µg Na/L)	EPA 6010 & EPA 3010	3760	a	**4500 – 12000**
Lead (µg Pb/L)	EPA 6010 & EPA 3010	<4.6	BDL, a	**-**
Iron (µg Fe/L)	EPA 6010 & EPA 3010	42.6	a	**-**

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Sample ID (Matrix) - Qualifier: WQ 7 (Surface Water) -☐C(B) ☐C(C) ☒C(L)

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	8.22 @ 24.7 ºC	c	**7.00 - 8.40**
Dissolved Oxygen (mg O_2/L)	DR	7.34 @ 24.7 ºC	c	**-**
Conductivity (mS/cm)	DR	0.330 @ 24.7 ºC	c	**0.15 - 0.6**
Salinity (ppt)	DR	0.16 @ 24.7 ºC	c	**-**
Total Dissolved Solids (mg/L)	DR	215.80 @ 24.7 ºC	c	**120.0 - 300.0**
Nitrate as Nitrogen (mg NO_3^--N/L)	H-8039	0.4	-	**-**
Nitrate (mg NO_3^-/L)		1.8		**0.1 - 7.5**
Total Nitrogen (mg/L)	H-10071	<2.2	BDL, P(P), P(1)	**-**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.09	-	**0.01 - 0.8**
Total Phosphorous (mg P/L)	SM-4500-P B5 & H-8048	0.06	P(P), P(1)	**-**
Sulfate (mg SO_4^{2-}/L)	H -8051	2	E(M1)	**3.0 - 10.0**
Faecal Coliform (MPN/100ml)	SM-9221	280	-	**-**
***E. coli* (MPN/100ml)**	SM-9221	24	-	**-**
Total Suspended Solids (mg/L)	SM-2540 D	<1.6	BDL	**-**
Chloride (mg Cl^-/L)	H-8206	5.6	P(1)	**5.0 - 20.0**
Phenol (mg C_6H_5OH/L)	H-8047	<0.002	UMR	**-**
Total Alkalinity (mg $CaCO_3$/L)	SM-2320 B	175.1	-	**-**
Total Hardness (mg $CaCO_3$/L)	SM-2340 C	199.7	P(P), P(1)	**127.0 – 381.0**
Chemical Oxygen Demand (mg O_2/L)	H-8000	28	P(P)	**-**
Dissolved Organic Carbon (mg/L)	SM-5310 B	1.6	a	**-**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
Total Organic Carbon (mg/L)	SM-5310 B	0.66	a	-
Pesticide Screen (ppb)	EPA-8081 B	Not Detected	a	-
Biochemical Oxygen Demand (mg O_2/L)	H-8043	0.4	-	**0.8 - 1.7**
Fats, Oil & Grease (mg/L)	SM-5520 B	6	b(2), a	-
Calcium (µg Ca/L)	EPA 6010 & EPA 3010	73600	a	**40000 – 101000**
Magnesium (µg Mg/L)	EPA 6010 & EPA 3010	3780	a	**3600 – 27000**
Silica (µg SiO_4/L)	EPA 6010 & EPA 3010	11600	a	**5000 - 39000**
Zinc (µg Zn/L)	EPA 6010 & EPA 3010	<11.0	BDL, a	-
Potassium (µg K/L)	EPA 6010 & EPA 3010	350	a	**740 - 5000**
Copper (µg Cu/L)	EPA 6010 & EPA 3010	<2.6	BDL, a	-
Arsenic (µg As/L)	EPA 6010 & EPA 3010	<3.4	BDL, a	-
Mercury (µg Hg/L)	EPA 7470	<0.090	BDL, a	-
Chromium (µg Cr/L)	EPA 6010 & EPA 3010	<1.7	BDL, a	-
Manganese (µg Mn/L)	EPA 6010 & EPA 3010	7.2	a	-
Sodium (µg Na/L)	EPA 6010 & EPA 3010	2860	a	**4500 – 12000**
Lead (µg Pb/L)	EPA 6010 & EPA 3010	<4.6	BDL, a	-
Iron (µg Fe/L)	EPA 6010 & EPA 3010	60.4	a	-

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Sample ID (Matrix) - Qualifier: WQ 8 (Surface Water) -☐C(B) ☐C(C) ☒C(L)

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	8.15 @ 25.1ºC	c	**7.00 - 8.40**
Dissolved Oxygen (mg O_2/L)	DR	6.87 @ 25.1ºC	c	**-**
Conductivity (mS/cm)	DR	0.336 @ 25.1ºC	c	**0.15 - 0.6**
Salinity (ppt)	DR	0.16 @ 25.1ºC	c	**-**
Total Dissolved Solids (mg/L)	DR	217.75 @ 25.1ºC	c	**120.0 - 300.0**
Nitrate as Nitrogen (mg NO_3^--N/L)	H-8039	0.3	-	**-**
Nitrate (mg NO_3^-/L)		1.3		**0.1 - 7.5**
Total Nitrogen (mg/L)	H-10071	<2.2	BDL, P(P), P(1)	**-**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.12	-	**0.01 - 0.8**
Total Phosphorous (mg P/L)	SM-4500-P B5 & H-8048	0.04	P(P), P(1)	**-**
Sulfate (mg SO_4^{2-}/L)	H -8051	2	E(M1)	**3.0 - 10.0**
Faecal Coliform (MPN/100ml)	SM-9221	350	-	**-**
***E. coli* (MPN/100ml)**	SM-9221	240	-	**-**
Total Suspended Solids (mg/L)	SM-2540 D	1.7	-	**-**
Chloride (mg Cl^-/L)	H-8206	3.2	P(1)	**5.0 - 20.0**
Phenol (mg C_6H_5OH/L)	H-8047	<0.002	UMR	**-**
Total Alkalinity (mg $CaCO_3$/L)	SM-2320 B	175.1	-	**-**
Total Hardness (mg $CaCO_3$/L)	SM-2340 C	195.1	P(P), P(1)	**127.0 – 381.0**
Chemical Oxygen Demand (mg O_2/L)	H-8000	12	P(P)	**-**
Dissolved Organic Carbon (mg/L)	SM-5310 B	0.51	a	**-**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
Total Organic Carbon (mg/L)	SM-5310 B	0.61	a	-
Pesticide Screen (ppb)	EPA-8081 B	Not Detected	a	-
Biochemical Oxygen Demand ($mg\ O_2/L$)	H-8043	0.9	-	**0.8 – 1.7**
Fats, Oil & Grease (mg/L)	SM-5520 B	5	b(2), a	-
Calcium (µg Ca/L)	EPA 6010 & EPA 3010	73300	a	**40000 – 101000**
Magnesium (µg Mg/L)	EPA 6010 & EPA 3010	3760	a	**3600 – 27000**
Silica (µg SiO_4/L)	EPA 6010 & EPA 3010	11700	a	**5000 - 39000**
Zinc (µg Zn/L)	EPA 6010 & EPA 3010	<11.0	BDL, a	-
Potassium (µg K/L)	EPA 6010 & EPA 3010	382	a	**740 - 5000**
Copper (µg Cu/L)	EPA 6010 & EPA 3010	<2.6	BDL, a	-
Arsenic (µg As/L)	EPA 6010 & EPA 3010	<3.4	BDL, a	-
Mercury (µg Hg/L)	EPA 7470	<0.090	BDL, a	-
Chromium (µg Cr/L)	EPA 6010 & EPA 3010	<1.7	BDL, a	-
Manganese (µg Mn/L)	EPA 6010 & EPA 3010	9.5	a	-
Sodium (µg Na/L)	EPA 6010 & EPA 3010	2840	a	**4500 – 12000**
Lead (µg Pb/L)	EPA 6010 & EPA 3010	<4.6	BDL, a	-
Iron (µg Fe/L)	EPA 6010 & EPA 3010	119	a	-

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Sample ID (Matrix) - Qualifier: WQ 9 (Surface Water) -☐C(B) ☐C(C) ☒C(L)

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	6.98 @ 25.1ºC	c	**7.00 - 8.40**
Dissolved Oxygen (mg O_2/L)	DR	2.30 @ 25.1ºC	c	**-**
Conductivity (mS/cm)	DR	0.498 @ 25.1ºC	c	**0.15 - 0.6**
Salinity (ppt)	DR	0.24 @ 25.1ºC	c	**-**
Total Dissolved Solids (mg/L)	DR	323.05 @ 25.1ºC	c	**120.0 - 300.0**
Nitrate as Nitrogen (mg NO_3^--N/L)	H-8039	<0.3	BDL, P(1)	**-**
Nitrate (mg NO_3^-/L)		<1.3		**0.1 - 7.5**
Total Nitrogen (mg/L)	H-10071	<2.2	BDL, P(P), P(1)	**-**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.04	-	**0.01 - 0.8**
Total Phosphorous (mg P/L)	SM-4500-P B5 & H-8048	0.07	P(P), P(1)	**-**
Sulfate (mg SO_4^{2-}/L)	H -8051	5	P(1), E(M1)	**3.0 - 10.0**
Faecal Coliform (MPN/100ml)	SM-9221	540	-	**-**
***E. coli* (MPN/100ml)**	SM-9221	540	-	**-**
Total Suspended Solids (mg/L)	SM-2540 D	4.0	-	**-**
Chloride (mg Cl^-/L)	H-8206	5.2	-	**5.0 - 20.0**
Phenol (mg C_6H_5OH/L)	H-8047	<0.002	UMR	**-**
Total Alkalinity (mg $CaCO_3$/L)	SM-2320 B	267.2	-	**-**
Total Hardness (mg $CaCO_3$/L)	SM-2340 C	311.8	P(P), P(1)	**127.0 – 381.0**
Chemical Oxygen Demand (mg O_2/L)	H-8000	46	P(P)	**-**
Dissolved Organic Carbon (mg/L)	SM-5310 B	3.3	a	**-**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
Total Organic Carbon (mg/L)	SM-5310 B	3.5	a	**-**
Pesticide Screen (ppb)	EPA-8081 B	Not Detected	a	**-**
Biochemical Oxygen Demand (mg O_2/L)	H-8043	3.3	-	**-**
Fats, Oil & Grease (mg/L)	SM-5520 B	6	b(2), a	**-**
Calcium (µg Ca/L)	EPA 6010 & EPA 3010	117000	a	**40000 – 101000**
Magnesium (µg Mg/L)	EPA 6010 & EPA 3010	1900	a	**3600 – 27000**
Silica (µg SiO_4/L)	EPA 6010 & EPA 3010	6420	a	**5000 - 39000**
Zinc (µg Zn/L)	EPA 6010 & EPA 3010	<11.0	BDL, a	**-**
Potassium (µg K/L)	EPA 6010 & EPA 3010	424	a	**740 - 5000**
Copper (µg Cu/L)	EPA 6010 & EPA 3010	<2.6	BDL, a	**-**
Arsenic (µg As/L)	EPA 6010 & EPA 3010	<3.4	BDL, a	**-**
Mercury (µg Hg/L)	EPA 7470	<0.090	BDL, a	**-**
Chromium (µg Cr/L)	EPA 6010 & EPA 3010	<1.7	BDL, a	**-**
Manganese (µg Mn/L)	EPA 6010 & EPA 3010	36.6	a	**-**
Sodium (µg Na/L)	EPA 6010 & EPA 3010	2760	a	**4500 – 12000**
Lead (µg Pb/L)	EPA 6010 & EPA 3010	<4.6	BDL, a	**-**
Iron (µg Fe/L)	EPA 6010 & EPA 3010	1600	a	**-**

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Sample ID (Matrix) - Qualifier: WQ 10 (Surface Water) **-☐C(B) ☐C(C) ☒C(L)**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	8.13 @ 24.5ºC	c	**7.00 - 8.40**
Dissolved Oxygen (mg O_2/L)	DR	8.54 @ 24.5ºC	c	**-**
Conductivity (mS/cm)	DR	0.327 @ 24.5ºC	c	**0.15 - 0.6**
Salinity (ppt)	DR	0.16 @ 24.5ºC	c	**-**
Total Dissolved Solids (mg/L)	DR	215.15 @ 24.5ºC	c	**120.0 - 300.0**
Nitrate as Nitrogen (mg NO_3^--N/L)	H-8039	<0.3	BDL	**-**
Nitrate (mg NO_3^-/L)		<1.3		**0.1 - 7.5**
Total Nitrogen (mg/L)	H-10071	2.3	P(P), P(1)	**-**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.07	-	**0.01- 0.8**
Total Phosphorous (mg P/L)	SM-4500-P B5 & H-8048	0.06	P(P), P(1)	**-**
Sulfate (mg SO_4^{2-}/L)	H -8051	2	E(M1)	**3.0 - 10.0**
Faecal Coliform (MPN/100ml)	SM-9221	540	-	**-**
***E. coli* (MPN/100ml)**	SM-9221	540	-	**-**
Total Suspended Solids (mg/L)	SM-2540 D	<1.6	BDL	**-**
Chloride (mg Cl^-/L)	H-8206	4.0	P(1)	**5.0 - 20.0**
Phenol (mg C_6H_5OH/L)	H-8047	<0.002	UMR	**-**
Total Alkalinity (mg $CaCO_3$/L)	SM-2320 B	177.5	-	**-**
Total Hardness (mg $CaCO_3$/L)	SM-2340 C	195.5	P(P), P(1)	**127.0 – 381.0**
Chemical Oxygen Demand (mg O_2/L)	H-8000	10	P(P)	**-**
Dissolved Organic Carbon (mg/L)	SM-5310 B	0.65	a	**-**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
Total Organic Carbon (mg/L)	SM-5310 B	0.53	a	**-**
Pesticide Screen (ppb)	EPA-8081 B	Not Detected	a	**-**
Biochemical Oxygen Demand ($mg\ O_2/L$)	H-8043	0.9	-	**0.8 – 1.7**
Fats, Oil & Grease (mg/L)	SM-5520 B	6	b(2), a	**-**
Calcium (µg Ca/L)	EPA 6010 & EPA 3010	72700	a	**40000 – 101000**
Magnesium (µg Mg/L)	EPA 6010 & EPA 3010	3780	a	**3600 – 27000**
Silica (µg SiO_4/L)	EPA 6010 & EPA 3010	11500	a	**5000 - 39000**
Zinc (µg Zn/L)	EPA 6010 & EPA 3010	<11.0	BDL, a	**-**
Potassium (µg K/L)	EPA 6010 & EPA 3010	344	a	**740 - 5000**
Copper (µg Cu/L)	EPA 6010 & EPA 3010	<2.6	BDL, a	**-**
Arsenic (µg As/L)	EPA 6010 & EPA 3010	<3.4	BDL, a	**-**
Mercury (µg Hg/L)	EPA 7470	<0.090	BDL, a	**-**
Chromium (µg Cr/L)	EPA 6010 & EPA 3010	<1.7	BDL, a	**-**
Manganese (µg Mn/L)	EPA 6010 & EPA 3010	8.4	a	**-**
Sodium (µg Na/L)	EPA 6010 & EPA 3010	2860	a	**4500 – 12000**
Lead (µg Pb/L)	EPA 6010 & EPA 3010	<4.6	BDL, a	**-**
Iron (µg Fe/L)	EPA 6010 & EPA 3010	86.4	a	**-**

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Sample ID (Matrix) - Qualifier: WQ 11 (Surface Water) -☐C(B) ☐C(C) ☒C(L)

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	8.16 @ 25.4ºC	c	**7.00 - 8.40**
Dissolved Oxygen (mg O_2/L)	DR	7.87 @ 25.4ºC	c	-
Conductivity (mS/cm)	DR	0.325 @ 25.4ºC	c	**0.15 - 0.6**
Salinity (ppt)	DR	0.15 @ 25.4ºC	c	-
Total Dissolved Solids (mg/L)	DR	209.95 @ 25.4ºC	c	**120.0 - 300.0**
Nitrate as Nitrogen (mg NO_3^--N/L)	H-8039	0.4	-	-
Nitrate (mg NO_3^-/L)		1.6		**0.1 - 7.5**
Total Nitrogen (mg/L)	H-10071	<2.2	BDL, P(P), P(1)	-
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.07	-	**0.01- 0.8**
Total Phosphorous (mg P/ L)	SM-4500-P B5 & H-8048	0.04	P(P), P(1)	-
Sulfate (mg SO_4^{2-}/L)	H -8051	1	E(M1)	**3.0 - 10.0**
Faecal Coliform (MPN/100ml)	SM-9221	49	-	-
***E. coli* (MPN/100ml)**	SM-9221	49	-	-
Total Suspended Solids (mg/L)	SM-2540 D	2.0	-	-
Chloride (mg Cl^-/L)	H-8206	4.0	P(1)	**5.0 - 20.0**
Phenol (mg C_6H_5OH/L)	H-8047	<0.002	UMR	-
Total Alkalinity (mg $CaCO_3$/L)	SM-2320 B	171.3	-	-
Total Hardness (mg $CaCO_3$/L)	SM-2340 C	190.5	P(P), P(1)	**127.0 – 381.0**
Chemical Oxygen Demand (mg O_2/L)	H-8000	14	P(P)	-
Dissolved Organic Carbon (mg/L)	SM-5310 B	0.78	a	-

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
Total Organic Carbon (mg/L)	SM-5310 B	0.55	a	**-**
Pesticide Screen (ppb)	EPA-8081 B	Not Detected	a	**-**
Biochemical Oxygen Demand (mg O_2/L)	H-8043	0.8	-	**0.8 – 1.7**
Fats, Oil & Grease (mg/L)	SM-5520 B	<1	b(2), a	**-**
Calcium (µg Ca/L)	EPA 6010 & EPA 3010	70400	a	**40000 – 101000**
Magnesium (µg Mg/L)	EPA 6010 & EPA 3010	3710	a	**3600 – 27000**
Silica (µg SiO_4/L)	EPA 6010 & EPA 3010	11500	a	**5000 - 39000**
Zinc (µg Zn/L)	EPA 6010 & EPA 3010	<11.0	BDL, a	**-**
Potassium (µg K/L)	EPA 6010 & EPA 3010	364	a	**740 - 5000**
Copper (µg Cu/L)	EPA 6010 & EPA 3010	<2.6	BDL, a	**-**
Arsenic (µg As/L)	EPA 6010 & EPA 3010	<3.4	BDL, a	**-**
Mercury (µg Hg/L)	EPA 7470	0.11	a	**-**
Chromium (µg Cr/L)	EPA 6010 & EPA 3010	<1.7	BDL, a	**-**
Manganese (µg Mn/L)	EPA 6010 & EPA 3010	8.4	a	**-**
Sodium (µg Na/L)	EPA 6010 & EPA 3010	2890	a	**4500 – 12000**
Lead (µg Pb/L)	EPA 6010 & EPA 3010	<4.6	BDL, a	**-**
Iron (µg Fe/L)	EPA 6010 & EPA 3010	85.2	a	**-**

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Sample ID (Matrix) - Qualifier: WQ 12 (Surface Water) -☐C(B) ☐C(C) ☒C(L)

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
pH (pH units)	DR	7.65 @ 25.5ºC	c	**7.00 - 8.40**
Dissolved Oxygen (mg O_2/L)	DR	6.42 @ 25.5ºC	c	**-**
Conductivity (mS/cm)	DR	0.60 @ 25.5ºC	c	**0.15 - 0.6**
Salinity (ppt)	DR	0.29 @ 25.5ºC	c	**-**
Total Dissolved Solids (mg/L)	DR	390.00 @ 25.5ºC	c	**120.0 - 300.0**
Nitrate as Nitrogen (mg NO_3^--N/L)	H-8039	<0.3	BDL	**-**
Nitrate (mg NO_3^-/L)		<1.3		**0.1 - 7.5**
Total Nitrogen (mg/L)	H-10071	<2.2	BDL, P(P), P(1)	**-**
Orthophosphate (mg PO_4^{3-}/L)	H-8048	0.07	-	**0.01 - 0.8**
Total Phosphorous (mg P/L)	SM-4500-P B5 & H-8048	0.04	P(P), P(1)	**-**
Sulfate (mg SO_4^{2-}/L)	H -8051	13	E(M1)	**3.0 - 10.0**
Faecal Coliform (MPN/100ml)	SM-9221	240	-	**-**
***E. coli* (MPN/100ml)**	SM-9221	79	-	**-**
Total Suspended Solids (mg/L)	SM-2540 D	2.7	-	**-**
Chloride (mg Cl^-/L)	H-8206	10.4	P(1)	**5.0 - 20.0**
Phenol (mg C_6H_5OH/L)	H-8047	<0.002	UMR	**-**
Total Alkalinity (mg $CaCO_3$/L)	SM-2320 B	175.9	-	**-**
Total Hardness (mg $CaCO_3$/L)	SM-2340 C	229.0	P(P), P(1)	**127.0 – 381.0**
Chemical Oxygen Demand (mg O_2/L)	H-8000	19	P(P)	**-**
Dissolved Organic Carbon (mg/L)	SM-5310 B	0.61	a	**-**

Parameters (units)	Test Method	Results	Qualifier	NRCA Ambient Water Standard
Total Organic Carbon (mg/L)	SM-5310 B	0.60	a	**-**
Pesticide Screen (ppb)	EPA-8081 B	Not Detected	a	**-**
Biochemical Oxygen Demand (mg O_2/L)	H-8043	1.0	-	**0.8 – 1.7**
Fats, Oil & Grease (mg/L)	SM-5520 B	<1	a, b(2)	**-**
Calcium (µg Ca/L)	EPA 6010 & EPA 3010	77400	a	**40000 – 101000**
Magnesium (µg Mg/L)	EPA 6010 & EPA 3010	7620	a	**3600 – 27000**
Silica (µg SiO_4/L)	EPA 6010 & EPA 3010	9520	a	**5000 - 39000**
Zinc (µg Zn/L)	EPA 6010 & EPA 3010	<11.0	BDL, a	**-**
Potassium (µg K/L)	EPA 6010 & EPA 3010	1800	a	**740 - 5000**
Copper (µg Cu/L)	EPA 6010 & EPA 3010	<2.6	BDL, a	**-**
Arsenic (µg As/L)	EPA 6010 & EPA 3010	<3.4	BDL, a	**-**
Mercury (µg Hg/L)	EPA 7470	0.16	a	**-**
Chromium (µg Cr/L)	EPA 6010 & EPA 3010	<1.7	a	**-**
Manganese (µg Mn/L)	EPA 6010 & EPA 3010	13.0	a	**-**
Sodium (µg Na/L)	EPA 6010 & EPA 3010	43800	a	**4500 – 12000**
Lead (µg Pb/L)	EPA 6010 & EPA 3010	<4.6	BDL, a	**-**
Iron (µg Fe/L)	EPA 6010 & EPA 3010	176	a	**-**

***Blue shaded parameters are ISO/IEC 17025:2017 accredited.**

Please note that the data presented in the table above are determined to be compliant or non-compliant based on the value provided without the incorporation of the measurement uncertainty.

Certificate of Quality

Parameter: Biochemical Oxygen Demand (H-8043)

QEHL Personnel: T. Thompson, J. Webster-Jones, C. Giscombe Date of Analysis: 30/03/2022

Parameter: pH (DR)

QEHL Personnel: J. Webster-Jones **Date of Analysis: 29/03/2022**

Standard (Buffer)	pH After Calibration	Temperature (°C)
6.95-7.05	6.99	30.3

Parameter: Dissolved Oxygen (DR)

QEHL Personnel: J. Webster-Jones **Date of Analysis: 29/03/2022**

Action Limit (DO%)	Saturation (DO%)	Temperature (°C)
95.0-105.0	99.7	29.4

Parameter: Conductivity (DR)

QEHL Personnel: J. Webster-Jones **Date of Analysis: 29/03/2022**

Standard (mS/cm)	Instrument Reading (mS/cm)	Temperature (°C)
1.98-2.00	1.99	31.0

Parameter: Salinity (DR)

QEHL Personnel: J. Webster-Jones **Date of Analysis: 29/03/2022**

Standard (mS/cm)	Instrument Reading (mS/cm)	Temperature (°C)
1.98-2.00	1.99	31.0

Parameter: Total Dissolved Solids (DR)

QEHL Personnel: J. Webster-Jones **Date of Analysis: 29/03/2022**

Standard (mS/cm)	Instrument Reading (mS/cm)	Temperature (°C)
1.98-2.00	1.99	31.0

Parameter: Alkalinity (SM-2320 B)

QEHL Personnel: N. McCalla **Date of Analysis: 04/04/2022**

	Standard Concentration (mg $CaCO_3$/L)	Determined Concentration (mg $CaCO_3$/L)	RPD (%)
Duplicates		176.1	0.0
		176.1	
SRS	87.4-104	88.6	

Parameter: Total Hardness (SM-2340 C)
QEHL Personnel: T. Cox, M. Brown **Date of Analysis: 01/04/2022**

	Standard Concentration (mg $CaCO_3$/L)	Determined Concentration (mg $CaCO_3$/L)	RPD (%)
FB		<18.3	
FD		131.0	4.6
		125.1	
Duplicates		198.7	1.0
		200.7	
SRS	0.91 – 1.09	1.01	

Parameter: Total Hardness (SM-2340 C)
QEHL Personnel: T. Cox, M. Brown **Date of Analysis: 31/03/2022**

	Standard Concentration (mg $CaCO_3$/L)	Determined Concentration (mg $CaCO_3$/L)	RPD (%)
FB		<18.3	
FD		131.0	4.6
		125.1	
Duplicates		211.2	1.5
		208.0	
SRS	0.91 – 1.09	1.01	

Parameter: Phenols (H-8047)
QEHL Personnel: R. Dunkley **Date of Analysis: 30/03/2022**

	Standard Concentration (mg C_6H_5OH/L)	Determined Concentration (mg C_6H_5OH/L)	RPD (%)
BD		<0.002	-
		<0.002	
SRS	0.093 – 0.107	0.100	

Parameter: Chloride (H-8206)
QEHL Personnel: N. M^C^Calla, S. Robinson **Date of Analysis: 30/03/2022**

	Standard Concentration (mg Cl^-/L)	Determined Concentration (mg Cl^-/L)	RPD (%)
MB		<3.0	
RB		<3.0	
BD		96.0	0.0
		96.0	
SRS	96.9 – 103.3	97.2	

Parameter: Total Suspended Solids (SM-2540 D)

QEHL Personnel: N. McCalla, S. Robinson **Date of Analysis: 31/03/2022**

	Standard Concentration (mg/L)	Determined Concentration (mg/L)	RPD (%)
MB		<1.6	
BD		57.1	0.0
		57.1	
SRS	46.1-57.7	51.0	

Parameter: Chemical Oxygen Demand (H-8000)

QEHL Personnel: T. Thompson **Date of Analysis: 01/04/2022**

	Standard Concentration (mg O_2/L)	Determined Concentration (mg O_2/L)	RPD (%)
MB		<3	
BD		124	0.0
		124	
SRS	118-132	129	

Parameter: Sulfate (H-8051)

QEHL Personnel: T. Cox, N. McCalla **Date of Analysis: 01/04/2022**

	Standard Concentration (mg SO_4^{2-}/L)	Determined Concentration (mg SO_4^{2-}/L)	RPD (%)
MB		<1	
FB		1	
FD		11	0.0
		11	
BD		11	0.0
		11	
SRS	59-65	60	

Parameter: Total Phosphorus (SM-4500-P B5 & H-8048)

QEHL Personnel: S. Robinson, M. Brown **Date of Analysis: 04/04/2022**

	Standard Concentration (mg P/L)	Determined Concentration (mg P/L)	RPD (%)
MB		<0.04	
BD		0.06	28.6*
		0.08	
SRS	1.94-2.02	1.95	

***Duplicates accepted based on the sensitivity of the analytical method used.**

Parameter: Orthophosphates (H-8048)

QEHL Personnel: S. Robinson **Date of Analysis: 30/03/2022**

	Standard Concentration ($mg\ PO_4^{3-}/L$)	Determined Concentration ($mg\ PO_4^{3-}/L$)	RPD (%)
MB		<0.02	
RB		<0.02	
BD		0.10	0.0
		0.10	
SRS	1.94-2.02	1.96	

Parameter: HR Nitrate (H-8039)

QEHL Personnel: T. Cox **Date of Analysis: 30/03/2022**

	Standard Concentration ($mg\ NO_3^{-}$-N/L)	Determined Concentration ($mg\ NO_3^{-}$-N/L)	RPD (%)
MB		0.3	
RB		0.3	
FB		<0.3	
FD		<0.3	-
		<0.3	
BD		<0.3	-
		<0.3	
SRS	9.2 – 10.8	9.7	

Parameter: Total Nitrogen (H-10071)

QEHL Personnel: T. Cox **Date of Analysis: 04/04/2022**

	Standard Concentration (mg N /L)	Determined Concentration (mg N/L)	RPD (%)
MB		<2.2	
BD		27.6	4.4
		26.4	
SRS	8.8 – 10.8	9.1	

Parameter: Faecal Coliform (SM-9221)

QEHL Personnel: K. Williams **Date of Analysis: 30/03/2022**

Media/Test Item (Batch#)	DS LTB (29/03/2022)	SS LTB (29/03/2022)	EC Broth (25/03/2022) & (30/03/2022)
Sterile (Yes/No)	Yes	Yes	Yes
Media performance (Typical, not typical)	Typical	Typical	Typical

Parameter: *E. Coli* (SM-9221)

QEHL Personnel: K. Williams **Date of Analysis: 30/03/2022**

Media/Test Item (Batch#)	DS LTB (29/03/2022)	SS LTB (29/03/2022)	EC Mug (25/02/2022) & (05/04/2022)
Sterile (Yes/No)	Yes	Yes	Yes
Media performance (Typical, not typical)	Typical	Typical	Typical

Glossary

%	Percentage
µg/L	microgram per litre
µS/cm	microsiemens per centimetre
a	Parameter subcontracted
ADB	Azide Dextrose Broth
AIM	The Aquaculture, Inland & Marine Products & By-Products Act (Regulations)
AOAC	American Organization of Analytical Chemists
b (1)	Parameter analysed outside of hold-time; samples submitted outside of the analysis hold-time
b (2)	Parameter analysed outside of hold-time; analysis authorised by Client
BAM	Bacteriological Analytical Manual
BD	Batch Duplicate
BDL	Analyte concentration below laboratory determined limit of detection
BDLS	Analyte detected below method detection limit (MDL). MDL greater than standard value.
BEA	Bile Esculin Azide Agar
BG	Brilliant Green Bile Broth
BGSA	Brilliant Green Sulfa Agar
BHI	Brain Heart Infusion Broth
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
BSA	Bismuth Sulfite Agar
c	parameter analysed in the field
C(B)	Samples collected by the client and picked up by an ESL bearer
C(C)	Samples collected by the client and delivered to ESL
C(H)	Analytical sample submitted in incorrect container. This may affect data quality.
C(L)	Samples collected by ESL
C(S)	Sample collected by the client then sub-sampled and delivered by ESL.
cfu	Colony Forming Units
CMMEF	Compendium of Methods for the Microbiological Examination of Foods
Col	Colourimetry
CVAAS	Cold Vapour Atomic Absorption Spectroscopy
D(I)	Sample was diluted due to the presence of high levels of non-target analytes or other matrix interference
D(C)	Sample diluted due to high concentration of target analyte
DR	Direct Reading
DS ADB	Double Strength azide dextrose broth
DS LTB	Double Strength Lauryl Tryptose Broth
DS PAB	Double Strength Pseudomonas Asparagine Broth
EB	Equipment Blank
E(E1)	Estimated Value. Data acquisition affected by equipment malfunction.
E(L1)	Estimated Value. Analyte recovery in the laboratory control sample (LCS) was outside of QC limits. Results for this may be affected by same bias.
E(L2)	Estimated Value due to the nature of the sample matrix.
E(M1)	Estimated Value. Result calculated using calibration curve.
E(M2)	Estimated Value. Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.
E(M3)	Estimated Value. Sample performance indicate presence of interference
E(R)	Estimated Value. RPD value was outside control limits.
EC	*E. coli* Media
E(V)	Estimated Value. Count(s) obtained is/are outside of the method counting range.
EC-MUG	*E. coli* Media with 4-**m**ethyl**u**mbelliferyl-β-D-**g**lucuronide
EHU	Environmental Health Unit
EPA	(US) Environmental Protection Agency
FAAS	Flame Atomic Absorption Spectroscopy
FAES	Flame Atomic Emission Spectroscopy
FB	Field Blank
FD	Field Duplicate
FL-PRO	Florida Petroleum Range Organic Method
GC-MS	Gas Chromatography Mass Spectrometry
H	Hach Water Analysis Workbook
H(A)	Off-scale high data obtained. Actual value may be greater than value given.

ICP	Inductively Coupled Plasma
ISE	Ion Selective Electrode
LCA	Listeria Chromogenic Agar
LE	Data not available due to laboratory error
LIA	Lysine Iron Agar
MAC	MacConkey Agar
MB	Method Blank
mEndo	mEndo Agar/Broth
MFHPB	Microbiology Food Health Protection Branch, Government of Canada
mmhos/cm	Millimhos per centimetre
mg/kg	milligram per kilogram
mg/L	milligrams per litre
MPN	Most Probable Number
mS/cm	millisiemens per centimetre
N/A (1)	Data not yet Available. Analysis not complete.
N/A (2)	Data not Available. Sample matrix interferences prevented data acquisition.
N/A (3)	Data not Available. Insufficient sample submitted.
N/A (4)	Data not Available. Equipment malfunction prevented data acquisition.
N/A (5)	Data not Available. Analysis not complete due to force majeure.
NA	Nutrient Agar
NB	Nutrient Broth
NEPA	National Environment and Planning Agency
NRCA	Natural Resources Conservation Authority
NTU	Nephelometric Turbidity Units
NWC	Nation Water Commission (Jamaica)
NST	No Time given for collection of samples
P(P)	Sample preserved prior to analysis
P(1)	Non-routine sample pre-treatment required
PAB	Pseudomonas Asparagine Broth
PCA	Plate Count Agar
PDA + C	Potato Dextrose Agar with Chloramphenicol
Pep Water	Peptone Water
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
RED	Parameter Non-compliant
RPD	Relative Percentage Difference
SM	Standard Methods for the Examination of Water and Wastewater 23rd Edition
SRS	Standard Reference Solution
SS	Sample Submerged on receival at laboratory
SS ADB	Single Strength Azide dextrose broth
SS LTB	Single Strength Lauryl Tryptose Broth
SS PAB	Single Strength Pseudomonas Asparagine Broth
T(H)	Samples arrived at ESL-QEHL outside holding temperature (≤4.0°C).
TIT	Titrimetry
TPH	Total Petroleum Hydrocarbon
TSA	Tryptic Soy Agar
TSB	Tryptic Soy Broth
TSA+YE	Tryptic Soy Agar + Yeast Extract
TTC	Triphenyl Tetrazolium Chloride
UMR	Analyte detection was below the measuring range of instrument. This is indicative of possible matrix interference within the sample.
WHO	World Health Organization
XLD	Xylose Lysine Deoxycholate

End of Report

ESL QUALITY & ENVIRONMENTAL HEALTH LABORATORY

A division of

7 Hillview Avenue,
Kingston 10, Jamaica
Tel: (876) 978-9519, 978-6297, 978-5902
Fax: (876) 946-3745
E-mail: envirsol@cwjamaica.com

Certificate of Sample Analysis

CSA#: ESL 21110409-15

Attention:

Jaidene Webster
Environmental Solutions Ltd.
7 Hillview Avenue
Kingston 10

Proprietary Restrictions Notice

This report only pertains to samples mentioned herein. ESL-QEHL bears no responsibility for any decisions taken by the client as a result of the data reported.

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Where samples are collected by ESL, these are identified, and collection follows the lab's internal procedure for sampling, ESL-P 5.7.3 and the sampling plan created for the client and identified by the Sampling Plan Number (SPN) given in this report.

The ISO/IEC 17025 accreditation only applies to the tests identified in the Results of Sample Analysis.

The data presented in this report does not imply certification, approval, or endorsement of the client's services by ESL-QEHL or the accreditation body.

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In all our undertakings, ESL maintains confidentiality and impartiality relating the client's business and operations. Any information relating to this exercise is subject to our confidentiality and impartiality policy and is held inviolate for a minimum of 5 years.

Sample(s) Information

Job Number:	**21110409-15**
SPN:	**-**
Date of Report:	20/12/2021
Revision Date:	**Not Applicable**
Sample(s) Collected:	02-03/11/2021
Sample(s) Submitted:	04/11/2021
Temperature on Arrival:	Ambient
Number of Samples:	7
Analysis Started:	02/11/2021
Analysis Completed:	15/11/2021
Prepared By:	**Tara-Lee Hylton, Technical Assistant**

Verified By ……K. Williams……… Approved By……S. Ellis…………
Kivonna Williams, **Shadain Ellis,**
Analyst **Senior Analyst**

Results of Sample Analysis

Qualifier: ☐C(B) ☐C(C) ☒C(L)

Sample ID (Matrix)	Test Method	PM_{10} Concentration (μgm^{-3})	Qualifier	USEPA/NEPA Standard μgm^{-3}/24 hr.
AQ6 ESL FP 16 (Filter)	Gravimetry	19.8	a	Once exceedance standard 150
AQ7 ESL FP 03 (Filter)		29.6	a	
AQ3 ESL FP 12 (Filter)		<0.1	a	
AQ4 ESL FP 17 (Filter)		4.9	a	
AQ5 ESL FP 07 (Filter)		2.1	a	
AQ1 ESL FP 13 (Filter)		5.1	a	
AQ2 ESL FP 20 (Filter)		39.9	a	

***Blue shaded parameters are ISO/IEC 17025:2017 accredited.**

Please note that the data presented in the table above are determined to be compliant or non-compliant based on the value provided without the incorporation of the measurement uncertainty.

Qualifier: ☐C(B) ☐C(C) ☒C(L)

Sampling Station	Test Method	Noise (dBA)	NEPA Ambient Noise Standard (dBA)
AQ1	DR	57.1	55
AQ2		74.1	
AQ3		65.5	
AQ4		57.1	
AQ5		61.5	
AQ6		66.6	
AQ7		66.7	

***Blue shaded parameters are ISO/IEC 17025:2017 accredited.**
****Readings taken on November 2, 2021**

Please note that the data presented in the table above are determined to be compliant or non-compliant based on the value provided without the incorporation of the measurement uncertainty.

Qualifier: ☐C(B) ☐C(C) ☒C(L)

Sampling Station	Test Method	Noise (dBA)	NEPA Ambient Noise Standard (dBA)
AQ1	DR	60.3	55
AQ2		58.7	
AQ3		54.2	
AQ4		72.0	
AQ5		63.9	
AQ6		70.6	
AQ7		59.0	

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****Readings taken on November 3, 2021.**

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Glossary

%	Percentage
µg/L	microgram per litre
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MB	Method Blank
mEndo	mEndo Agar/Broth
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mg/L	milligrams per litre
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ppt	parts per thousand
RED	Parameter Non-compliant
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TSB	Tryptic Soy Broth
TSYE	Tryptone Soy Yeast Extract
TTC	Triphenyl Tetrazolium Chloride
UMR	Analyte detection was below the measuring range of instrument. This is indicative of possible matrix interference within the sample.
WHO	World Health Organization
XLD	Xylose Lysine Deoxycholate

End of Report

CL ENVIRONMENTAL
Taking Care of You and Your Environment.

20 Windsor Avenue, Kgn. 5
Telephone: (876) 756-0338. Fax: (876) 756-0338
E-mail: ccampbell@clenvironmental.com

May 11, 2022

Mrs. Rashidah Khan-Haqq
Environmental Solutions Limited
7 Hillview Avenue
Kingston, Jamaica

Dear Mrs. Khan-Haqq,

Re: Report for PM10 Particulate Survey at seven (7) locations at Friendship, Westmoreland

INTRODUCTION
This document contains the results of the PM10 particulate assessment conducted at Friendship, Westmoreland on March 31 – April 1, 2022.

METHODOLOGY

PM10 particulate sampling exercises were conducted at the seven (7) locations (See Figure 1) for 24 hours each on one (1) sampling occasion using Airmetrics Minivol Tactical Air Samplers (Plate 1) (Calibration Certificate in Appendix 1). The PM10 sampling exercise was conducted from 2:00pm March 31st, 2022 to 2:00pm April 1st, 2022.

The filter papers used in the samplers were desiccated, stabilized, and weighed (pre- and post-assessment). A Time Weighted Average (TWA) value was calculated to determine the particulate concentrations (Appendix 2).

Coarse particles (PM10) are airborne pollutants that fall between 2.5 and 10 micrometres in diameter. Fine particle (PM2.5) are airborne pollutants that fall below 2.5 micrometres in diameter. Sources of coarse particles include crushing or grinding operations and dust stirred up by vehicles traveling on roads. Sources of fine particles include all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and some industrial processes. **A fine particle (PM2.5) assessment was not conducted for this report.**

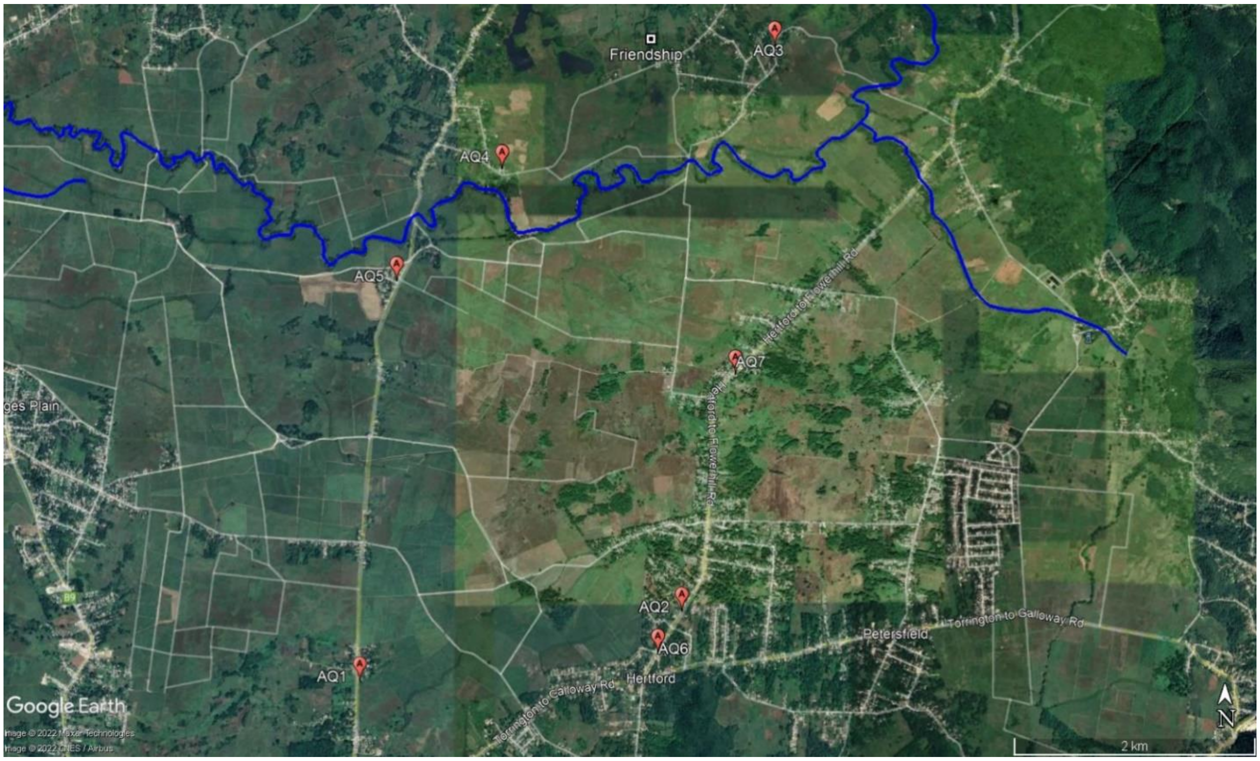


Figure 1 Map showing particulate sampling locations

Plate 1 Airmetrics Tactical Air Sampler

RESULTS

The results of the PM10 sampling exercise are shown in Table 1. All locations had PM10 concentrations compliant with the 24-hour Natural Resources Conservation Authority (NRCA) standard of 150 $\mu g/m^3$. PM10 concentrations ranged from a low of 20.42 $\mu g/m^3$ at Station AQ3, to a high of 41.03 $\mu g/m^3$ at Station AQ7.

Table 1 PM10 Results

STATION	PM10 RESULT ($\mu g/m^3$)	24-HR NRCA PM10 STD. ($\mu g/m^3$)
AQ 1	**32.22**	150
AQ2	**29.58**	150
AQ3	**20.42**	150
AQ4	**25.14**	150
AQ5	**32.64**	150
AQ6	**30.97**	150
AQ7	**41.03**	150

Yours sincerely
C. L. ENVIRONMENTAL COMPANY LIMITED

....

MATTHEW LEE
ENVIRONMENTAL SCIENTIST

Appendix 1 - Airmetrics Minivol Tactical Air Sampler Calibration Certificate

NIST Traceable Transfer Standard Calibration

Calibration Date: 07/21/2021 Orifice # MNF1829- By:
Ambient Temp, °K: 297.9 Pri Std # LFE774300
Amb Press, mmHg: 758.0 Manometer # DIG1829 Chk: __________

Std ΔH (inH_2O)	Manometer ΔH (inH_2O)	Actual Flow (alpm)	Calc Flow (alpm)	Difference* (%diff)
4.82	4.75	7.867	7.852	0.20
4.00	3.92	7.108	7.123	-0.21
3.20	3.13	6.343	6.354	-0.17
2.47	2.41	5.571	5.563	0.15
1.84	1.79	4.792	4.780	0.26
1.49	1.44	4.269	4.276	-0.17
1.16	1.12	3.743	3.759	-0.43
0.86	0.82	3.215	3.201	0.42

Manometer ΔH vs Act Flow Linear Regression Results:

m_{flo} =	**5.8231**
b_{flo} =	**-0.1039**
r^2 =	**0.9999**

* all points must be within ± 2%

The MiniFlo calibration is performed with an NIST-traceable standard. Each unit has a unique pair of calibration constants derived from the calibration which are used to calculate the actual air flow rate at all ambient conditions. The unit's calibration should be recertified annually.

The actual flow rate is a function of the pressure drop across the device, the ambient temperature, and the ambient pressure. The relationship of these variables and the unique calibration constants ("m" and "b") for each device is presented in the following equation (Eq.A):

$$Q_{act} = m_{flo} \times \sqrt{\frac{\Delta H \times T_{act}}{P_{act}}} + b_{flo}$$

Q_{act} = actual flowrate, liters per min
ΔH = manometer reading, inches of water
T_{act} = ambient temperature, °K
P_{act} = ambient pressure, millimeters of mercury

CAUTION: The weather service, most airports, etc, reduce the atmospheric pressure to a common reference (sea level). The equation above requires the atmospheric pressure at the location where the MiniFlo is being used.

The equation below may be used to estimate the ambient atmospheric pressure at any elevation if the sea level pressure is known.

$$P_{act} = P_{sea} \times \left(1 - \frac{E}{145300}\right)^{5.25}$$

P_{act} = Ambient Atmospheric Pressure
P_{sea} = Sea Level Atmospheric Pressure
E = Site elevation, feet

Airmetrics
1940 Don St., Suite 300
Springfield, OR 97477
(541) 683-5420

Appendix 2 – Time Weighted Average PM10 Calculation Sheet

Sampling Date	STATION	Weights of filter (mg)			Sampling Time/ hr	Volume of air sampled/ m^3	$[PM_{10}]/ugm^{-3}$
		Before	After	Change			
March 31 - April 1, 2022	AQ1	145.407	145.639	0.232	24	7.2	**32.22**
	AQ2	143.894	144.107	0.213	24	7.2	**29.58**
	AQ3	144.633	144.78	0.147	24	7.2	**20.42**
	AQ4	145.684	145.865	0.181	24	7.2	**25.14**
	AQ5	143.077	143.264	0.187	19.1	5.73	**32.64**
	AQ6	143.726	143.949	0.223	24	7.2	**30.97**
	AQ7	145.099	145.147	0.048	3.9	1.17	**41.03**

Due to battery failure, the sampler at Station AQ5 ran for 19.1 hours, and sampler at Station AQ7 ran for 3.9 hours.

ESL QUALITY & ENVIRONMENTAL HEALTH LABORATORY

A division of

7 Hillview Avenue,
Kingston 10, Jamaica
Tel: (876) 978-9519, 978-6297, 978-5902
Fax: (876) 946-3745
E-mail: envirsol@cwjamaica.com

Certificate of Sample Analysis

CSA#: ESL 22052651-57

Attention:

Jaidene Webster-Jones
Environmental Solutions Ltd.
7 Hillview Avenue
Kingston 10

Proprietary Restrictions Notice

This report only pertains to samples mentioned herein. ESL-QEHL bears no responsibility for any decisions taken by the client as a result of the data reported.

This report may not be reproduced except in full, without the written permission of ESL-QEHL.

Where samples are collected by ESL, these are identified, and collection follows the lab's internal procedure for sampling, ESL-P 5.7.3 and the sampling plan created for the client and identified by the Sampling Plan Number (SPN) given in this report.

The ISO/IEC 17025 accreditation only applies to the tests identified in the Results of Sample Analysis.

The data presented in this report does not imply certification, approval, or endorsement of the client's services by ESL-QEHL or the accreditation body.

Unsigned electronic copies of our Reports serve only to provide information to our clients. The signed copy is the only version that is considered legally binding.

In all our undertakings, ESL maintains confidentiality and impartiality relating the client's business and operations. Any information relating to this exercise is subject to our confidentiality and impartiality policy and is held inviolate for a minimum of 5 years.

Sample(s) Information

Job Number:	**22052651-57**
SPN:	**-**
Date of Report:	01/06/2022
Revision Date:	**Not Applicable**
Sample(s) Collected:	26/05/2022
Sample(s) Submitted:	27/05/2022
Temperature on Arrival:	Not Applicable
Number of Samples:	7
Analysis Started:	26/05/2022
Analysis Completed:	26/05/2022
Prepared By:	**Tara-Lee Hylton, Technical Assistant**

Verified By ………K. Williams………
Kivonna Williams,
Analyst

Approved By………S. Ellis…………
Shadain Ellis,
Senior Analyst

Results of Sample Analysis

Qualifier: ☐C(B) ☐C(C) ☒C(L)

Sampling Station	Test Method	Noise (dBA)	NEPA Ambient Noise Standard (dBA)
AQ1	DR	67.0	55
AQ2		71.4	
AQ3		60.2	
AQ4		59.7	
AQ5		64.0	
AQ6		62.4	
AQ7		61.5	

***Blue shaded parameters are ISO/IEC 17025:2017 accredited.**
****Readings taken on May 26, 2022.**

Please note that the data presented in the table above are determined to be compliant or non-compliant based on the value provided without the incorporation of the measurement uncertainty.

Glossary

%	Percentage
µg/L	microgram per litre
µS/cm	microsiemens per centimetre
a	Parameter subcontracted
ADB	Azide Dextrose Broth
AIM	The Aquaculture, Inland & Marine Products & By-Products Act (Regulations)
AOAC	American Organization of Analytical Chemists
b (1)	Parameter analysed outside of hold-time; samples submitted outside of the analysis hold-time
b (2)	Parameter analysed outside of hold-time; analysis authorised by Client
BAM	Bacteriological Analytical Manual
BD	Batch Duplicate
BDL	Analyte concentration below laboratory determined limit of detection
BDLS	Analyte detected below method detection limit (MDL). MDL greater than standard value.
BEA	Bile Esculin Azide Agar
BG	Brilliant Green Bile Broth
BGSA	Brilliant Green Sulfa Agar
BHI	Brain Heart Infusion Broth
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
BSA	Bismuth Sulfite Agar
c	parameter analysed in the field
C(B)	Samples collected by the client and picked up by an ESL bearer
C(C)	Samples collected by the client and delivered to ESL
C(H)	Analytical sample submitted in incorrect container. This may affect data quality.
C(L)	Samples collected by ESL
C(S)	Sample collected by the client then sub-sampled and delivered by ESL.
cfu	Colony Forming Units
CMMEF	Compendium of Methods for the Microbiological Examination of Foods
Col	Colourimetry
CVAAS	Cold Vapour Atomic Absorption Spectroscopy
D(I)	Sample was diluted due to the presence of high levels of non-target analytes or other matrix interference
D(C)	Sample diluted due to high concentration of target analyte
DR	Direct Reading
DS ADB	Double Strength azide dextrose broth
DS LTB	Double Strength Lauryl Tryptose Broth
DS PAB	Double Strength Pseudomonas Asparagine Broth
EB	Equipment Blank
E(E1)	Estimated Value. Data acquisition affected by equipment malfunction.
E(L1)	Estimated Value. Analyte recovery in the laboratory control sample (LCS) was outside of QC limits. Results for this may be affected by same bias.
E(L2)	Estimated Value due to the nature of the sample matrix.
E(M1)	Estimated Value. Result calculated using calibration curve.
E(M2)	Estimated Value. Matrix spike recovery exceeded QC limits. Batch accepted based on laboratory control sample (LCS) recovery.
E(M3)	Estimated Value. Sample performance indicate presence of interference
E(R)	Estimated Value. RPD value was outside control limits.
EC	*E. coli* Media
E(V)	Estimated Value. Count(s) obtained is/are outside of the method counting range.
EC-MUG	*E. coli* Media with 4-**m**ethyl**u**mbelliferyl-β-D-**g**lucuronide
EHU	Environmental Health Unit
EPA	(US) Environmental Protection Agency
FAAS	Flame Atomic Absorption Spectroscopy
FAES	Flame Atomic Emission Spectroscopy
FB	Field Blank
FD	Field Duplicate
FL-PRO	Florida Petroleum Range Organic Method
GC-MS	Gas Chromatography Mass Spectrometry
H	Hach Water Analysis Workbook

H(A)	Off-scale high data obtained. Actual value may be greater than value given.
ICP	Inductively Coupled Plasma
ISE	Ion Selective Electrode
LCA	Listeria Chromogenic Agar
LE	Data not available due to laboratory error
LIA	Lysine Iron Agar
MAC	MacConkey Agar
MB	Method Blank
mEndo	mEndo Agar/Broth
MFHPB	Microbiology Food Health Protection Branch, Government of Canada
mmhos/cm	Millimhos per centimetre
mg/kg	milligram per kilogram
mg/L	milligrams per litre
MPN	Most Probable Number
mS/cm	millisiemens per centimetre
N/A (1)	Data not yet Available. Analysis not complete.
N/A (2)	Data not Available. Sample matrix interferences prevented data acquisition.
N/A (3)	Data not Available. Insufficient sample submitted.
N/A (4)	Data not Available. Equipment malfunction prevented data acquisition.
N/A (5)	Data not Available. Analysis not complete due to force majeure.
NA	Nutrient Agar
NB	Nutrient Broth
NEPA	National Environment and Planning Agency
NRCA	Natural Resources Conservation Authority
NTU	Nephelometric Turbidity Units
NWC	Nation Water Commission (Jamaica)
NST	No Time given for collection of samples
P(P)	Sample preserved prior to analysis
P(1)	Non-routine sample pre-treatment required
PAB	Pseudomonas Asparagine Broth
PCA	Plate Count Agar
PDA + C	Potato Dextrose Agar with Chloramphenicol
Pep Water	Peptone Water
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
RED	Parameter Non-compliant
RPD	Relative Percentage Difference
SM	Standard Methods for the Examination of Water and Wastewater 23rd Edition
SRS	Standard Reference Solution
SS	Sample Submerged on receival at laboratory
SS ADB	Single Strength Azide dextrose broth
SS LTB	Single Strength Lauryl Tryptose Broth
SS PAB	Single Strength Pseudomonas Asparagine Broth
T(H)	Samples arrived at ESL-QEHL outside holding temperature (≤4.0°C).
TIT	Titrimetry
TPH	Total Petroleum Hydrocarbon
TSA	Tryptic Soy Agar
TSB	Tryptic Soy Broth
TSYE	Tryptone Soy Yeast Extract
TTC	Triphenyl Tetrazolium Chloride
UMR	Analyte detection was below the measuring range of instrument. This is indicative of possible matrix interference within the sample.
WHO	World Health Organization
XLD	Xylose Lysine Deoxycholate

End of Report

15-Nov-2021

Jaidene Webster-Jones
Environmental Solutions Ltd.
7 Hillview
Kingston, Jamaica,

Re: **Not Provided** Work Order: **21110329**

Dear Jaidene,

ALS Environmental received 6 samples on 09-Nov-2021 08:52 AM for the analyses presented in the following report.

The analytical data provided relates directly to the samples received by ALS Environmental and for only the analyses requested.

QC sample results for this data met laboratory specifications. Any exceptions are noted in the Case Narrative, or noted with qualifiers in the report or QC batch information. Should this laboratory report need to be reproduced, it should be reproduced in full unless written approval has been obtained from ALS Laboratory Group. Samples will be disposed in 30 days unless storage arrangements are made.

The total number of pages in this report is 9.

If you have any questions regarding this report, please feel free to contact me.

Sincerely,

Rob Nieman

Electronically approved by: Rob Nieman

Rob Nieman
Project Manager

Report of Laboratory Analysis

Client: Environmental Solutions Ltd.
Project: Not Provided
Work Order: **21110329**

Work Order Sample Summary

Lab Samp ID	Client Sample ID	Matrix	Tag Number	Collection Date	Date Received	Hold
21110329-01	DL-286	Air		11/3/2021	11/9/2021 08:52	☐
21110329-02	DL 287	Air		11/3/2021	11/9/2021 08:52	☐
21110329-03	DL 288	Air		11/3/2021	11/9/2021 08:52	☐
21110329-04	DL 289	Air		11/3/2021	11/9/2021 08:52	☐
21110329-05	DL 290	Air		11/3/2021	11/9/2021 08:52	☐
21110329-06	DL 291	Air		11/3/2021	11/9/2021 08:52	☐

Client: Environmental Solutions Ltd.
Project: Not Provided
Work Order: 21110329

Case Narrative

The sample condition upon receipt was acceptable except where noted.

Results relate only to the items tested and are not blank corrected unless indicated.

Compound identification is based upon retention time matching only. Any compound with a similar retention time will interfere.

Samples were prepared and analyzed by the analytical method and the laboratory's applicable standard operating procedure listed below:
- IH-001- "Determination of Analytes Using NIOSH and OSHA Methods Using Gas Chromatography."
- IH-002- "Determination of Suspended Particulates in the Atmosphere Using Various Media"
- IH-003- "Determination of Suspended Particulates Not Otherwise Regulated (Total and Respirable)."
- IH-004- "Determination of Analytes by NIOSH and OSHA Methods Using Liquid Chromatography."
- IH-005- "Benzene-Soluble Fraction and Total Particulate (Asphalt Fume)."
- IH-006- "Methods IO-3.1 and IO-3.4 Modified for Metals Preparation and Analysis for Suspended Particulates."
- IH-196- "Carbon Black by OSHA 196."
- IH-6009- "Determination of Mercury in Industrial Hygiene Samples by Manual Cold Vapor Atomic Absorption Spectroscopy."
- ENV-6010B- "Determination of Trace Metals in Solution by Inductively Coupled Plasma-Atomic Emission Spectroscopy by EPA Method 6010B Non-VAP."
- IH-7300 modified- "Elements by ICP."

ALS is an EPA recognized NLLAP laboratory for lead paint, soil, and dust wipe analyses under its AIHA-LAP accreditation.

All sampling information was provided by the client.

ALS Environmental

Date: *15-Nov-21*

Client: Environmental Solutions Ltd.
Project: Not Provided

Work Order: 21110329

Analytical Results

Lab ID: 21110329-01A
Client Sample ID: DL-286
Collection Date: 11/3/2021
Matrix: AIR

Analyses

HYDROGEN SULFIDE USING RADIELLO Method: **RADIELL** Time (Min): **1567** Analyst: **JAP**

Date Analyzed: 11/11/2021

		Reporting Limit	
	ppb	ppb	ppm
Hydrogen sulfide	ND	0.57	<0.00057

Lab ID: 21110329-02A
Client Sample ID: DL 287
Collection Date: 11/3/2021
Matrix: AIR

Analyses

HYDROGEN SULFIDE USING RADIELLO Method: **RADIELL** Time (Min): **1281** Analyst: **JAP**

Date Analyzed: 11/11/2021

		Reporting Limit	
	ppb	ppb	ppm
Hydrogen sulfide	ND	0.57	<0.00057

Lab ID: 21110329-03A
Client Sample ID: DL 288
Collection Date: 11/3/2021
Matrix: AIR

Analyses

HYDROGEN SULFIDE USING RADIELLO Method: **RADIELL** Time (Min): **1326** Analyst: **JAP**

Date Analyzed: 11/11/2021

		Reporting Limit	
	ppb	ppb	ppm
Hydrogen sulfide	ND	0.57	<0.00057

Lab ID: 21110329-04A
Client Sample ID: DL 289
Collection Date: 11/3/2021
Matrix: AIR

Analyses

HYDROGEN SULFIDE USING RADIELLO Method: **RADIELL** Time (Min): **1404** Analyst: **JAP**

Date Analyzed: 11/11/2021

		Reporting Limit	
	ppb	ppb	ppm
Hydrogen sulfide	ND	0.57	<0.00057

Note:

ALS Environmental

Date: *15-Nov-21*

Client: Environmental Solutions Ltd.
Project: Not Provided

Work Order: 21110329

Analytical Results

Lab ID: 21110329-05A
Client Sample ID: DL 290
Collection Date: 11/3/2021
Matrix: AIR

Analyses

HYDROGEN SULFIDE USING RADIELLO Method: **RADIELL** Time (Min): **1403** Analyst: **JAP**

Date Analyzed: 11/11/2021

	ppb	Reporting Limit ppb	ppm
Hydrogen sulfide	ND	0.57	<0.00057

Lab ID: 21110329-06A
Client Sample ID: DL 291
Collection Date: 11/3/2021
Matrix: AIR

Analyses

HYDROGEN SULFIDE USING RADIELLO Method: **RADIELL** Time (Min): **0** Analyst: **JAP**

Date Analyzed: 11/11/2021

	ppb	Reporting Limit ppb	ppm
Hydrogen sulfide	ND	0.57	<0.00057

Note:

ALS Environmental

Date: 15-Nov-21

Client: Environmental Solutions Ltd.

Work Order: 21110329

Project: Not Provided

QC BATCH REPORT

Batch ID: **R197581** Instrument ID: **UVVIS1** Method: **RADIELLO**

MBLK Sample ID: **MB-R197581-R197581** Units: **ppb** Analysis Date: **11/11/2021**

Client ID: Run ID: **UVVIS1_211111B** SeqNo: **2606014** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Hydrogen sulfide	ND	0.57								

LCS Sample ID: **LCS-R197581-R197581** Units: **ppb** Analysis Date: **11/11/2021**

Client ID: Run ID: **UVVIS1_211111B** SeqNo: **2606015** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Hydrogen sulfide	53.4	0.57	57.77	0	92.4	80-120	0			

LCSD Sample ID: **LCSD-R197581** Units: **ppb** Analysis Date: **11/11/2021**

Client ID: Run ID: **UVVIS1_211111B** SeqNo: **2606024** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Hydrogen sulfide	53.24	0.57	57.77	0	92.2	80-120	53.4	0.3	20	

The following samples were analyzed in this batch:

21110329-01A	21110329-02A	21110329-03A
21110329-04A	21110329-05A	21110329-06A

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

ALS Environmental

Date: 15-Nov-21

Client: Environmental Solutions Ltd.
Project: Not Provided
WorkOrder: **21110329**

QUALIFIERS, ACRONYMS, UNITS

Qualifier	Description
*	Value exceeds Regulatory Limit
a	Not accredited
B	Analyte detected in the associated Method Blank above the Reporting Limit
E	Value above quantitation range
H	Analyzed outside of Holding Time
J	Analyte detected below quantitation limit
n	Not offered for accreditation
ND	Not Detected at the Reporting Limit
O	Sample amount is > 4 times amount spiked
P	Dual Column results percent difference > 40%
R	RPD above laboratory control limit
S	Spike Recovery outside laboratory control limits
U	Analyzed but not detected above the MDL

Acronym	Description
DUP	Method Duplicate
E	EPA Method
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
MBLK	Method Blank
MDL	Method Detection Limit
MQL	Method Quantitation Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
PDS	Post Digestion Spike
PQL	Practical Quantitaion Limit
SDL	Sample Detection Limit
SW	SW-846 Method

Units Reported	Description
ppb	

ALS Environmental

Sample Receipt Checklist

Client Name: **ENVIRONMENTALSOLUTIONS-** Date/Time Received: **09-Nov-21 08:52**

Work Order: **21110329** Received by: **AB**

Checklist completed by: Alec Bolender (eSignature) Date: 09-Nov-21 Reviewed by: Rob Nieman (eSignature) Date: 11-Nov-21

Matrices: air

Carrier name: FedEx

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on shipping container/cooler?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time?	Yes ☑	No ☐	
Container/Temp Blank temperature in compliance?	Yes ☑	No ☐	
Sample(s) received on ice?	Yes ☐	No ☑	
Temperature(s)/Thermometer(s):			
Cooler(s)/Kit(s):			
Date/Time sample(s) sent to storage:			
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☐	N/A ☑
pH adjusted?	Yes ☐	No ☐	N/A ☑
pH adjusted by:	-		

Login Notes:

Client Contacted: Date Contacted: Person Contacted:

Contacted By: Regarding:

Comments:

CorrectiveAction:

ALS | Environmental
4388 Glendale Milford Rd.
Cincinnati, Ohio 45242
Phone: (800) 458-1493 or (513) 733-5336
Fax: (513) 733-5347

Page 1 of 1

ANALYTICAL REQUEST FORM

35970

☐ REGULAR Status 21110829

☑ RUSH Status Required - ADDITIONAL CHARGE

RESULTS REQUIRED BY November 15, 2021 (DATE)

CONTACT ALS LABORATORY GROUP PRIOR TO SENDING SAMPLES

Date 1/11/21 Purchase Order No.

Company Name Environmental Solutions Limited

Address 7 Hillview Avenue

Kingston 10

City State Zip

Send Report To Jaidene Webster - Jones

Email Address jwebster@eslcaribbean.com

Telephone (876) 978 - 9519

Alt. Contact Name Rashidah Khan - Hagg

Alt. Contact Info rKhan@eslcaribbean.com

Quote No. 9730

Sampling Site

Date/Time of Collection 2-3/11/2021

Project No.

Billing Address (if different)

Lab Use Only	Client Sample Number	Media Type	Sample Volume (L)	Sample Time (min.)	ANALYSES REQUESTED - Use Method Number if Known
1	DL 286	Radiello		1567	Hydrogen Sulfide using Radiello
2	DL 287			1281	
3	DL 288			1326	
4	DL 289			1404	
5	DL 290			1403	
6	DL 291 (Blank)			—	

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Date / Time
M. Anderson	08/11/21	[signature]	11/9 0852
M. Anderson	08/11/21		
M. Anderson	08/11/21		

ALS LAB USE ONLY

COOLER TEMP: °C Taken with IR#:

COOLING METHOD: NONE COOLER WET ICE DRY ICE ICE PACK

DELIVERY METHOD: CLIENT DROP BOX FEDEX UPS STD MAIL PRTY MAIL ALS COURIER OTHER:

CUSTODY SEALS: COOLER PACKAGE SAMPLES NOT REQUIRED

EQUIP. RETURNED:

13-Dec-2021

Shadain Ellis
Environmental Solutions Ltd.
7 Hillview
Kingston, Jamaica,

Re: **Jamaica** Work Order: **21120160**

Dear Shadain,

ALS Environmental received 6 samples on 06-Dec-2021 01:03 PM for the analyses presented in the following report.

The analytical data provided relates directly to the samples received by ALS Environmental and for only the analyses requested.

QC sample results for this data met laboratory specifications. Any exceptions are noted in the Case Narrative, or noted with qualifiers in the report or QC batch information. Should this laboratory report need to be reproduced, it should be reproduced in full unless written approval has been obtained from ALS Laboratory Group. Samples will be disposed in 30 days unless storage arrangements are made.

The total number of pages in this report is 10.

If you have any questions regarding this report, please feel free to contact me.

Sincerely,

Rob Nieman

Electronically approved by: Rob Nieman

Rob Nieman
Project Manager

Report of Laboratory Analysis

ALS Environmental Date: 13-Dec-21

Client: Environmental Solutions Ltd.
Project: Jamaica
Work Order: **21120160**

Work Order Sample Summary

Lab Samp ID	Client Sample ID	Matrix	Tag Number	Collection Date	Date Received	Hold
21120160-01	106391 (Blank)	Air		11/25/2021 13:30	12/6/2021 13:03	☐
21120160-02	106381	Air		11/25/2021 13:30	12/6/2021 13:03	☐
21120160-03	106425	Air		11/25/2021 13:30	12/6/2021 13:03	☐
21120160-04	106372	Air		11/25/2021 13:30	12/6/2021 13:03	☐
21120160-05	106416	Air		11/25/2021 13:30	12/6/2021 13:03	☐
21120160-06	106385	Air		11/25/2021 13:30	12/6/2021 13:03	☐

ALS Environmental

Date: 13-Dec-21

Client: Environmental Solutions Ltd.
Project: Jamaica
Work Order: 21120160

Case Narrative

The sample condition upon receipt was acceptable except where noted.

Results relate only to the items tested and are not blank corrected unless indicated.

Compound identification is based upon retention time matching only. Any compound with a similar retention time will interfere.

Samples were prepared and analyzed by the analytical method and the laboratory's applicable standard operating procedure listed below:
- IH-001- "Determination of Analytes Using NIOSH and OSHA Methods Using Gas Chromatography."
- IH-002- "Determination of Suspended Particulates in the Atmosphere Using Various Media"
- IH-003- "Determination of Suspended Particulates Not Otherwise Regulated (Total and Respirable)."
- IH-004- "Determination of Analytes by NIOSH and OSHA Methods Using Liquid Chromatography."
- IH-005- "Benzene-Soluble Fraction and Total Particulate (Asphalt Fume)."
- IH-006- "Methods IO-3.1 and IO-3.4 Modified for Metals Preparation and Analysis for Suspended Particulates."
- IH-196- "Carbon Black by OSHA 196."
- IH-6009- "Determination of Mercury in Industrial Hygiene Samples by Manual Cold Vapor Atomic Absorption Spectroscopy."
- ENV-6010B- "Determination of Trace Metals in Solution by Inductively Coupled Plasma-Atomic Emission Spectroscopy by EPA Method 6010B Non-VAP."
- IH-7300 modified- "Elements by ICP."

ALS is an EPA recognized NLLAP laboratory for lead paint, soil, and dust wipe analyses under its AIHA-LAP accreditation.

All sampling information was provided by the client.

ALS Environmental

Date: *13-Dec-21*

Client: Environmental Solutions Ltd.
Project: Jamaica

Work Order: 21120160

Analytical Results

Lab ID: 21120160-01A
Client Sample ID: 106391 (Blank)
Collection Date: 11/25/2021 1:30:00 PM
Matrix: AIR

Analyses

NITROGEN DIOXIDE — Method: **O182** — Time (Min): **0** — Analyst: **TH**
Date Analyzed: 12/7/2021 15:03

	µg/sample	Reporting Limit µg/sample	ppm
Nitrogen dioxide	ND	2.0	NA

SULFUR DIOXIDE — Method: **IH-004** — Time (Min): **0** — Analyst: **TH**
Date Analyzed: 12/7/2021 17:28

	µg/sample	Reporting Limit µg/sample	ppm
Sulfur Dioxide	ND	2.0	NA

Lab ID: 21120160-02A
Client Sample ID: 106381
Collection Date: 11/25/2021 1:30:00 PM
Matrix: AIR

Analyses

NITROGEN DIOXIDE — Method: **O182** — Time (Min): **62** — Analyst: **TH**
Date Analyzed: 12/7/2021 15:17

	µg/sample	Reporting Limit µg/sample	ppm
Nitrogen dioxide	ND	2.0	<0.99

SULFUR DIOXIDE — Method: **IH-004** — Time (Min): **62** — Analyst: **TH**
Date Analyzed: 12/7/2021 17:42

	µg/sample	Reporting Limit µg/sample	ppm
Sulfur Dioxide	ND	2.0	<0.81

Lab ID: 21120160-03A
Client Sample ID: 106425
Collection Date: 11/25/2021 1:30:00 PM
Matrix: AIR

Analyses

NITROGEN DIOXIDE — Method: **O182** — Time (Min): **62** — Analyst: **TH**
Date Analyzed: 12/7/2021 15:31

	µg/sample	Reporting Limit µg/sample	ppm
Nitrogen dioxide	ND	2.0	<0.99

SULFUR DIOXIDE — Method: **IH-004** — Time (Min): **62** — Analyst: **TH**
Date Analyzed: 12/7/2021 17:56

	µg/sample	Reporting Limit µg/sample	ppm
Sulfur Dioxide	ND	2.0	<0.81

Note:

ALS Environmental

Date: *13-Dec-21*

Client: Environmental Solutions Ltd.
Project: Jamaica

Work Order: 21120160

Analytical Results

Lab ID: 21120160-04A
Client Sample ID: 106372
Collection Date: 11/25/2021 1:30:00 PM
Matrix: AIR

Analyses

NITROGEN DIOXIDE		Method: **O182**	Time (Min): **62**	Analyst: **TH**
Date Analyzed: 12/7/2021 15:59		Reporting Limit		
	µg/sample	µg/sample	ppm	
Nitrogen dioxide	ND	2.0	<0.99	

SULFUR DIOXIDE		Method: **IH-004**	Time (Min): **62**	Analyst: **TH**
Date Analyzed: 12/7/2021 18:23		Reporting Limit		
	µg/sample	µg/sample	ppm	
Sulfur Dioxide	ND	2.0	<0.81	

Lab ID: 21120160-05A
Client Sample ID: 106416
Collection Date: 11/25/2021 1:30:00 PM
Matrix: AIR

Analyses

NITROGEN DIOXIDE		Method: **O182**	Time (Min): **62**	Analyst: **TH**
Date Analyzed: 12/7/2021 16:12		Reporting Limit		
	µg/sample	µg/sample	ppm	
Nitrogen dioxide	ND	2.0	<0.99	

SULFUR DIOXIDE		Method: **IH-004**	Time (Min): **62**	Analyst: **TH**
Date Analyzed: 12/7/2021 18:37		Reporting Limit		
	µg/sample	µg/sample	ppm	
Sulfur Dioxide	ND	2.0	<0.81	

Lab ID: 21120160-06A
Client Sample ID: 106385
Collection Date: 11/25/2021 1:30:00 PM
Matrix: AIR

Analyses

NITROGEN DIOXIDE		Method: **O182**	Time (Min): **62**	Analyst: **TH**
Date Analyzed: 12/7/2021 16:26		Reporting Limit		
	µg/sample	µg/sample	ppm	
Nitrogen dioxide	ND	2.0	<0.99	

SULFUR DIOXIDE		Method: **IH-004**	Time (Min): **62**	Analyst: **TH**
Date Analyzed: 12/7/2021 18:51		Reporting Limit		
	µg/sample	µg/sample	ppm	
Sulfur Dioxide	ND	2.0	<0.81	

Note:

Client: Environmental Solutions Ltd.
Work Order: 21120160
Project: Jamaica

QC BATCH REPORT

Batch ID: **78900** Instrument ID: **IC2** Method: **IH-004**

MBLK Sample ID: **MBLK-78900-78900** Units: **µg/sample** Analysis Date: **12/7/2021 05:01 PM**
Client ID: Run ID: **IC2_211207A** SeqNo: **2625943** Prep Date: **12/7/2021** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Sulfur Dioxide	0.4925	2.0								J

LCS Sample ID: **LCS-78900-78900** Units: **µg/sample** Analysis Date: **12/7/2021 05:08 PM**
Client ID: Run ID: **IC2_211207A** SeqNo: **2625944** Prep Date: **12/7/2021** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Sulfur Dioxide	7.452	2.0	6.67	0	112	70-130	0			

LCSD Sample ID: **LCSD-78900-78900** Units: **µg/sample** Analysis Date: **12/7/2021 05:14 PM**
Client ID: Run ID: **IC2_211207A** SeqNo: **2625945** Prep Date: **12/7/2021** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Sulfur Dioxide	8.329	2.0	6.67	0	125	70-130	7.452	11.1	20	

The following samples were analyzed in this batch:

21120160-01A	21120160-02A	21120160-03A
21120160-04A	21120160-05A	21120160-06A

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client: Environmental Solutions Ltd.
Work Order: 21120160
Project: Jamaica

QC BATCH REPORT

Batch ID: **78901** Instrument ID: **IC2** Method: **O182**

MBLK	Sample ID: **MBLK-78901-78901**				Units: **µg/sample**		Analysis Date: **12/7/2021 02:35 PM**			
Client ID:		Run ID: **IC2_211207A**			SeqNo: **2625830**		Prep Date: **12/7/2021**		DF: **1**	
Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen dioxide	ND	2.0								

LCS	Sample ID: **LCS-78901-78901**				Units: **µg/sample**		Analysis Date: **12/8/2021 12:58 PM**			
Client ID:		Run ID: **IC2_211207A**			SeqNo: **2626090**		Prep Date: **12/7/2021**		DF: **1**	
Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen dioxide	5.809	2.0	6.3	0	92.2	70-130	0			

LCSD	Sample ID: **LCSD-78901-78901**				Units: **µg/sample**		Analysis Date: **12/7/2021 02:49 PM**			
Client ID:		Run ID: **IC2_211207A**			SeqNo: **2625832**		Prep Date: **12/7/2021**		DF: **1**	
Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen dioxide	5.676	2.0	6.3	0	90.1	70-130	5.809	2.3	20	

The following samples were analyzed in this batch:

21120160-01A	21120160-02A	21120160-03A
21120160-04A	21120160-05A	21120160-06A

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client: Environmental Solutions Ltd.
Project: Jamaica
WorkOrder: **21120160**

QUALIFIERS, ACRONYMS, UNITS

Qualifier	Description
*	Value exceeds Regulatory Limit
a	Not accredited
B	Analyte detected in the associated Method Blank above the Reporting Limit
E	Value above quantitation range
H	Analyzed outside of Holding Time
J	Analyte detected below quantitation limit
n	Not offered for accreditation
ND	Not Detected at the Reporting Limit
O	Sample amount is > 4 times amount spiked
P	Dual Column results percent difference > 40%
R	RPD above laboratory control limit
S	Spike Recovery outside laboratory control limits
U	Analyzed but not detected above the MDL

Acronym	Description
DUP	Method Duplicate
E	EPA Method
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
MBLK	Method Blank
MDL	Method Detection Limit
MQL	Method Quantitation Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
PDS	Post Digestion Spike
PQL	Practical Quantitaion Limit
SDL	Sample Detection Limit
SW	SW-846 Method

Units Reported	Description
µg/sample	

ALS Environmental

Sample Receipt Checklist

Client Name: **ENVIRONMENTALSOLUTIONS-**

Date/Time Received: **06-Dec-21 13:03**

Work Order: **21120160**

Received by: **HXP**

Checklist completed by: Hannah Ponder (eSignature) 06-Dec-21 (Date)

Reviewed by: Rob Nieman (eSignature) 08-Dec-21 (Date)

Matrices: air

Carrier name: DHL

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on shipping container/cooler?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time?	Yes ☑	No ☐	
Container/Temp Blank temperature in compliance?	Yes ☑	No ☐	
Sample(s) received on ice?	Yes ☐	No ☑	
Temperature(s)/Thermometer(s):			
Cooler(s)/Kit(s):			
Date/Time sample(s) sent to storage:	12/6/21 14.01		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☐	N/A ☑
pH adjusted?	Yes ☐	No ☐	N/A ☑
pH adjusted by:	-		

Login Notes:

Client Contacted:

Date Contacted:

Person Contacted:

Contacted By:

Regarding:

Comments:

CorrectiveAction:

ANALYTICAL REQUEST FORM

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

21120160

(ALS)

1. ☐ REGULAR Status

☐ RUSH Status Requested - ADDITIONAL CHARGE
RESULTS REQUIRED BY ____________ DATE
CONTACT ALS DATACHEM PRIOR TO SENDING SAMPLES

2. Date Nov 29, 2021 Purchase Order No.

3. Company Name Environmental Solutions Limited

Address 7 Hillview Avenue, Kingston 10

Person to Contact Shadain Ellis

Telephone 876 978 9519

Fax Telephone (876) 946-3745

E-mail Address sellis@eslcaribbean.com

Billing Address 7 Hillview Avenue, Kingston 10

4. Quote No.

ALS Project Manager Shawn Smythe

5. **Sample Collection**

Sampling Site Jamaica

Industrial Process N/A

Date of Collection November 25, 2021

Time Collected 12:28pm -1:30pm

Date of Shipment November 29, 2021

Chain of Custody No

6. **REQUEST FOR ANALYSES**

Laboratory Use Only	Client Sample Number	Matrix*	Sample Volume	ANALYSES REQUESTED - Use method number if known	Units**
01	106391 (Blank)	Filter type		IH-004 and O182	mg/m3
02	106381	Filter type		IH-004 and O182	mg/m3
03	106425	Filter type		IH-004 and O182 NOx and SOx	mg/m3
04	106372	Filter type		IH-004 and O182	mg/m3
05	106416	Filter type		IH-004 and O182	mg/m3
06	106385	Filter type		IH-004 and O182	mg/m3

* Specify: Solid sorbent tube, e.g. Charcoal; Filter type; Impinger solution; Bulk sample; Blood; Urine; Tissue; Soil; Water; Other

** 1. mg/sample 2. mg/m^3 3. ppm 4. % 5. _____ (other) Please indicate one or more units in the column entitled Units**

Comments

Possible Contamination and/or Chemical Hazards N/A

Relinquished by M Anderson Date/Time 29/11/2021 10:36 am

Received by Harold Parker Date/Time 12-6-21 13:03

Relinquished by Date/Time

Received by Date/Time

Relinquished by Date/Time

Received by Date/Time

DHL

02-May-2022

Rashidah Khan-Haqq
Environmental Solutions Ltd.
7 Hillview
Kingston, Jamaica,

Re: **Westmoreland** Work Order: **22040241**

Dear Rashidah,

ALS Environmental received 14 samples on 07-Apr-2022 10:19 AM for the analyses presented in the following report.

The analytical data provided relates directly to the samples received by ALS Environmental and for only the analyses requested.

QC sample results for this data met laboratory specifications. Any exceptions are noted in the Case Narrative, or noted with qualifiers in the report or QC batch information. Should this laboratory report need to be reproduced, it should be reproduced in full unless written approval has been obtained from ALS Laboratory Group. Samples will be disposed in 30 days unless storage arrangements are made.

The total number of pages in this report is 14.

If you have any questions regarding this report, please feel free to contact me.

Sincerely,

Rob Nieman

Electronically approved by: Rob Nieman

Rob Nieman
Project Manager

Report of Laboratory Analysis

Client: Environmental Solutions Ltd.
Project: Westmoreland
Work Order: **22040241**

Work Order Sample Summary

Lab Samp ID	Client Sample ID	Matrix	Tag Number	Collection Date	Date Received	Hold
22040241-01	AQ1	Air		4/1/2022	4/7/2022 10:19	☐
22040241-02	AQ2	Air		4/1/2022	4/7/2022 10:19	☐
22040241-03	AQ2 DUP	Air		4/1/2022	4/7/2022 10:19	☐
22040241-04	AQ3	Air		4/1/2022	4/7/2022 10:19	☐
22040241-05	AQ4	Air		4/1/2022	4/7/2022 10:19	☐
22040241-06	AQ7	Air		4/1/2022	4/7/2022 10:19	☐
22040241-07	Blank	Air		4/1/2022	4/7/2022 10:19	☐
22040241-08	AQ1 - NO2SO2	Air		4/1/2022	4/7/2022 10:19	☐
22040241-09	AQ2 - NO2SO2	Air		4/1/2022	4/7/2022 10:19	☐
22040241-10	AQ2 DUP - NO2SO2	Air		4/1/2022	4/7/2022 10:19	☐
22040241-11	AQ3 - NO2SO2	Air		4/1/2022	4/7/2022 10:19	☐
22040241-12	AQ4 - NO2SO2	Air		4/1/2022	4/7/2022 10:19	☐
22040241-13	AQ7 - NO2SO2	Air		4/1/2022	4/7/2022 10:19	☐
22040241-14	Blank - NO2SO2	Air		4/1/2022	4/7/2022 10:19	☐

Client: Environmental Solutions Ltd.
Project: Westmoreland
Work Order: 22040241

Case Narrative

The sample condition upon receipt was acceptable except where noted.

Results relate only to the items tested and are not blank corrected unless indicated.

Compound identification is based upon retention time matching only. Any compound with a similar retention time will interfere.

Samples were prepared and analyzed by the analytical method and the laboratory's applicable standard operating procedure listed below:
- IH-001- "Determination of Analytes Using NIOSH and OSHA Methods Using Gas Chromatography."
- IH-002- "Determination of Suspended Particulates in the Atmosphere Using Various Media"
- IH-003- "Determination of Suspended Particulates Not Otherwise Regulated (Total and Respirable)."
- IH-004- "Determination of Analytes by NIOSH and OSHA Methods Using Liquid Chromatography."
- IH-005- "Benzene-Soluble Fraction and Total Particulate (Asphalt Fume)."
- IH-006- "Methods IO-3.1 and IO-3.4 Modified for Metals Preparation and Analysis for Suspended Particulates."
- IH-196- "Carbon Black by OSHA 196."
- IH-6009- "Determination of Mercury in Industrial Hygiene Samples by Manual Cold Vapor Atomic Absorption Spectroscopy."
- ENV-6010B- "Determination of Trace Metals in Solution by Inductively Coupled Plasma-Atomic Emission Spectroscopy by EPA Method 6010B Non-VAP."
- IH-7300 modified- "Elements by ICP."

ALS is an EPA recognized NLLAP laboratory for lead paint, soil, and dust wipe analyses under its AIHA-LAP accreditation.

All sampling information was provided by the client.

ALS Environmental

Date: *02-May-22*

Client: Environmental Solutions Ltd. **Work Order:** 22040241
Project: Westmoreland

Analytical Results

Lab ID: 22040241-01A **Collection Date:** 4/1/2022
Client Sample ID: AQ1 **Matrix:** AIR

Analyses

HYDROGEN SULFIDE USING RADIELLO Method: **RADIELL** Time (Min): **1547** Analyst: **JAP**

Date Analyzed: 4/14/2022

	ppb	Reporting Limit ppb	ppm
Hydrogen sulfide	ND	0.57	<0.00057

Lab ID: 22040241-02A **Collection Date:** 4/1/2022
Client Sample ID: AQ2 **Matrix:** AIR

Analyses

HYDROGEN SULFIDE USING RADIELLO Method: **RADIELL** Time (Min): **1664** Analyst: **JAP**

Date Analyzed: 4/14/2022

	ppb	Reporting Limit ppb	ppm
Hydrogen sulfide	ND	0.57	<0.00057

Lab ID: 22040241-03A **Collection Date:** 4/1/2022
Client Sample ID: AQ2 DUP **Matrix:** AIR

Analyses

HYDROGEN SULFIDE USING RADIELLO Method: **RADIELL** Time (Min): **1664** Analyst: **JAP**

Date Analyzed: 4/14/2022

	ppb	Reporting Limit ppb	ppm
Hydrogen sulfide	ND	0.57	<0.00057

Lab ID: 22040241-04A **Collection Date:** 4/1/2022
Client Sample ID: AQ3 **Matrix:** AIR

Analyses

HYDROGEN SULFIDE USING RADIELLO Method: **RADIELL** Time (Min): **1628** Analyst: **JAP**

Date Analyzed: 4/14/2022

	ppb	Reporting Limit ppb	ppm
Hydrogen sulfide	ND	0.57	<0.00057

Note:

Client: Environmental Solutions Ltd. **Work Order:** 22040241
Project: Westmoreland

Analytical Results

Lab ID: 22040241-05A **Collection Date:** 4/1/2022
Client Sample ID: AQ4 **Matrix:** AIR

Analyses

HYDROGEN SULFIDE USING RADIELLO Method: **RADIELL** Time (Min): **1611** Analyst: **JAP**

Date Analyzed: 4/14/2022

	ppb	Reporting Limit ppb	ppm
Hydrogen sulfide	ND	0.57	<0.00057

Lab ID: 22040241-06A **Collection Date:** 4/1/2022
Client Sample ID: AQ7 **Matrix:** AIR

Analyses

HYDROGEN SULFIDE USING RADIELLO Method: **RADIELL** Time (Min): **1654** Analyst: **JAP**

Date Analyzed: 4/14/2022

	ppb	Reporting Limit ppb	ppm
Hydrogen sulfide	ND	0.57	<0.00057

Lab ID: 22040241-07A **Collection Date:** 4/1/2022
Client Sample ID: Blank **Matrix:** AIR

Analyses

HYDROGEN SULFIDE USING RADIELLO Method: **RADIELL** Time (Min): **0** Analyst: **JAP**

Date Analyzed: 4/14/2022

	ppb	Reporting Limit ppb	ppm
Hydrogen sulfide	ND	0.57	<0.00057

Note:

ALS Environmental

Date: *02-May-22*

Client: Environmental Solutions Ltd.
Project: Westmoreland

Work Order: 22040241

Analytical Results

Lab ID: 22040241-08A **Collection Date:** 4/1/2022
Client Sample ID: AQ1 - NO2SO2 **Matrix:** AIR

Analyses

NITROGEN DIOXIDE		Method: O182	Time (Min): 1547	Analyst: TH
Date Analyzed: 4/8/2022 16:09		Reporting Limit		
	µg/sample	µg/sample	ppm	
Nitrogen dioxide	ND	2.0	<0.040	

SULFUR DIOXIDE		Method: IH-004	Time (Min): 1547	Analyst: TH
Date Analyzed: 4/11/2022 19:15		Reporting Limit		
	µg/sample	µg/sample	ppm	
Sulfur Dioxide	ND	2.0	<0.032	

Lab ID: 22040241-09A **Collection Date:** 4/1/2022
Client Sample ID: AQ2 - NO2SO2 **Matrix:** AIR

Analyses

NITROGEN DIOXIDE		Method: O182	Time (Min): 1664	Analyst: TH
Date Analyzed: 4/8/2022 16:23		Reporting Limit		
	µg/sample	µg/sample	ppm	
Nitrogen dioxide	ND	2.0	<0.037	

SULFUR DIOXIDE		Method: IH-004	Time (Min): 1664	Analyst: TH
Date Analyzed: 4/11/2022 19:29		Reporting Limit		
	µg/sample	µg/sample	ppm	
Sulfur Dioxide	ND	2.0	<0.030	

Lab ID: 22040241-10A **Collection Date:** 4/1/2022
Client Sample ID: AQ2 DUP - NO2SO2 **Matrix:** AIR

Analyses

NITROGEN DIOXIDE		Method: O182	Time (Min): 1664	Analyst: TH
Date Analyzed: 4/8/2022 16:37		Reporting Limit		
	µg/sample	µg/sample	ppm	
Nitrogen dioxide	ND	2.0	<0.037	

SULFUR DIOXIDE		Method: IH-004	Time (Min): 1664	Analyst: TH
Date Analyzed: 4/11/2022 19:44		Reporting Limit		
	µg/sample	µg/sample	ppm	
Sulfur Dioxide	ND	2.0	<0.030	

Note:

ALS Environmental

Date: *02-May-22*

Client: Environmental Solutions Ltd. **Work Order:** 22040241
Project: Westmoreland

Analytical Results

Lab ID: 22040241-11A **Collection Date:** 4/1/2022
Client Sample ID: AQ3 - NO2SO2 **Matrix:** AIR

Analyses

NITROGEN DIOXIDE		Method: **O182**	Time (Min): **1628**	Analyst: **TH**
Date Analyzed: 4/11/2022 17:23		Reporting Limit		
	µg/sample	µg/sample	ppm	
Nitrogen dioxide	ND	2.0	<0.038	

SULFUR DIOXIDE		Method: **IH-004**	Time (Min): **1628**	Analyst: **TH**
Date Analyzed: 4/11/2022 20:14		Reporting Limit		
	µg/sample	µg/sample	ppm	
Sulfur Dioxide	ND	2.0	<0.031	

Lab ID: 22040241-12A **Collection Date:** 4/1/2022
Client Sample ID: AQ4 - NO2SO2 **Matrix:** AIR

Analyses

NITROGEN DIOXIDE		Method: **O182**	Time (Min): **1611**	Analyst: **TH**
Date Analyzed: 4/11/2022 17:38		Reporting Limit		
	µg/sample	µg/sample	ppm	
Nitrogen dioxide	ND	2.0	<0.038	

SULFUR DIOXIDE		Method: **IH-004**	Time (Min): **1611**	Analyst: **TH**
Date Analyzed: 4/11/2022 20:29		Reporting Limit		
	µg/sample	µg/sample	ppm	
Sulfur Dioxide	ND	2.0	<0.031	

Lab ID: 22040241-13A **Collection Date:** 4/1/2022
Client Sample ID: AQ7 - NO2SO2 **Matrix:** AIR

Analyses

NITROGEN DIOXIDE		Method: **O182**	Time (Min): **1654**	Analyst: **TH**
Date Analyzed: 4/11/2022 17:53		Reporting Limit		
	µg/sample	µg/sample	ppm	
Nitrogen dioxide	ND	2.0	<0.037	

SULFUR DIOXIDE		Method: **IH-004**	Time (Min): **1654**	Analyst: **TH**
Date Analyzed: 4/11/2022 20:44		Reporting Limit		
	µg/sample	µg/sample	ppm	
Sulfur Dioxide	ND	2.0	<0.030	

Note:

ALS Environmental

Date: *02-May-22*

Client: Environmental Solutions Ltd.
Project: Westmoreland

Work Order: 22040241

Analytical Results

Lab ID: 22040241-14A
Client Sample ID: Blank - NO2SO2
Collection Date: 4/1/2022
Matrix: AIR

Analyses

NITROGEN DIOXIDE		Method: **O182**	Time (Min): **0**	Analyst: **TH**
Date Analyzed: 4/11/2022 18:08		Reporting Limit		
	µg/sample	µg/sample	ppm	
Nitrogen dioxide	ND	2.0	NA	

SULFUR DIOXIDE		Method: **IH-004**	Time (Min): **0**	Analyst: **TH**
Date Analyzed: 4/11/2022 20:58		Reporting Limit		
	µg/sample	µg/sample	ppm	
Sulfur Dioxide	ND	2.0	NA	

Note:

Client: Environmental Solutions Ltd.
Work Order: 22040241
Project: Westmoreland

QC BATCH REPORT

Batch ID: **82114** Instrument ID: **IC2** Method: **O182**

MBLK	Sample ID: **MBLK-82114-82114**	Units: **µg/sample**	Analysis Date: **4/8/2022 03:41 PM**
Client ID:	Run ID: **IC2_220408A**	SeqNo: **2708155**	Prep Date: **4/8/2022** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen dioxide	ND	2.0								

LCS	Sample ID: **LCS-82114-82114**	Units: **µg/sample**	Analysis Date: **4/8/2022 03:48 PM**
Client ID:	Run ID: **IC2_220408A**	SeqNo: **2708156**	Prep Date: **4/8/2022** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen dioxide	8.188	2.0	8.43	0	97.1	70-130	0			

LCSD	Sample ID: **LCSD-82114-82114**	Units: **µg/sample**	Analysis Date: **4/8/2022 03:55 PM**
Client ID:	Run ID: **IC2_220408A**	SeqNo: **2708157**	Prep Date: **4/8/2022** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Nitrogen dioxide	8.266	2.0	8.43	0	98.1	70-130	8.188	0.943	20	

The following samples were analyzed in this batch:

22040241-08A	22040241-09A	22040241-10A
22040241-11A	22040241-12A	22040241-13A
22040241-14A		

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client: Environmental Solutions Ltd.
Work Order: 22040241
Project: Westmoreland

QC BATCH REPORT

Batch ID: **82206** Instrument ID: **IC2** Method: **IH-004**

MBLK Sample ID: **MBLK-82206-82206** Units: **µg/sample** Analysis Date: **4/11/2022 06:45 PM**
Client ID: Run ID: **IC2_220408A** SeqNo: **2708556** Prep Date: **4/8/2022** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Sulfur Dioxide	ND	2.0								

LCS Sample ID: **LCS-82206-82206** Units: **µg/sample** Analysis Date: **4/11/2022 06:52 PM**
Client ID: Run ID: **IC2_220408A** SeqNo: **2708557** Prep Date: **4/8/2022** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Sulfur Dioxide	6.018	2.0	6.67	0	90.2	70-130	0			

LCSD Sample ID: **LCSD-82206-82206** Units: **µg/sample** Analysis Date: **4/11/2022 07:00 PM**
Client ID: Run ID: **IC2_220408A** SeqNo: **2708558** Prep Date: **4/8/2022** DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Sulfur Dioxide	6.243	2.0	6.67	0	93.6	70-130	6.018	3.68	20	

The following samples were analyzed in this batch:

22040241-08A	22040241-09A	22040241-10A
22040241-11A	22040241-12A	22040241-13A
22040241-14A		

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

Client: Environmental Solutions Ltd.
Work Order: 22040241
Project: Westmoreland

QC BATCH REPORT

Batch ID: **R203251** Instrument ID: **UVVIS1** Method: **RADIELLO**

MBLK Sample ID: **MB-R203251-R203251** Units: **ppb** Analysis Date: **4/14/2022**
Client ID: Run ID: **UVVIS1_220414A** SeqNo: **2709492** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Hydrogen sulfide	ND	0.57								

LCS Sample ID: **LCS-R203251-R203251** Units: **ppb** Analysis Date: **4/14/2022**
Client ID: Run ID: **UVVIS1_220414A** SeqNo: **2709493** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Hydrogen sulfide	41.12	0.57	42.82	0	96	80-120	0			

LCS Sample ID: **LCSD-R203251** Units: **ppb** Analysis Date: **4/14/2022**
Client ID: Run ID: **UVVIS1_220414A** SeqNo: **2709501** Prep Date: DF: **1**

Analyte	Result	PQL	SPK Val	SPK Ref Value	%REC	Control Limit	RPD Ref Value	%RPD	RPD Limit	Qual
Hydrogen sulfide	40.91	0.57	42.82	0	95.5	80-120	0			

The following samples were analyzed in this batch:

22040241-01A	22040241-02A	22040241-03A
22040241-04A	22040241-05A	22040241-06A
22040241-07A		

Note: See Qualifiers Page for a list of Qualifiers and their explanation.

ALS Environmental

Date: 02-May-22

Client:	Environmental Solutions Ltd.
Project:	Westmoreland
WorkOrder:	**22040241**

QUALIFIERS, ACRONYMS, UNITS

Qualifier	Description
*	Value exceeds Regulatory Limit
a	Not accredited
B	Analyte detected in the associated Method Blank above the Reporting Limit
E	Value above quantitation range
H	Analyzed outside of Holding Time
J	Analyte detected below quantitation limit
n	Not offered for accreditation
ND	Not Detected at the Reporting Limit
O	Sample amount is > 4 times amount spiked
P	Dual Column results percent difference > 40%
R	RPD above laboratory control limit
S	Spike Recovery outside laboratory control limits
U	Analyzed but not detected above the MDL

Acronym	Description
DUP	Method Duplicate
E	EPA Method
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
MBLK	Method Blank
MDL	Method Detection Limit
MQL	Method Quantitation Limit
MS	Matrix Spike
MSD	Matrix Spike Duplicate
PDS	Post Digestion Spike
PQL	Practical Quantitaion Limit
SDL	Sample Detection Limit
SW	SW-846 Method

Units Reported	Description
µg/sample	
ppb	

ALS Environmental

Sample Receipt Checklist

Client Name: **ENVIRONMENTALSOLUTIONS-**

Date/Time Received: **07-Apr-22 10:19**

Work Order: **22040241**

Received by: **HXP**

Checklist completed by: Hannah Ponder (eSignature) 07-Apr-22 (Date)

Reviewed by: Rob Nieman (eSignature) 12-Apr-22 (Date)

Matrices: air

Carrier name: DHL

Shipping container/cooler in good condition?	Yes ☑	No ☐	Not Present ☐
Custody seals intact on shipping container/cooler?	Yes ☐	No ☐	Not Present ☑
Custody seals intact on sample bottles?	Yes ☐	No ☐	Not Present ☑
Chain of custody present?	Yes ☑	No ☐	
Chain of custody signed when relinquished and received?	Yes ☑	No ☐	
Chain of custody agrees with sample labels?	Yes ☑	No ☐	
Samples in proper container/bottle?	Yes ☑	No ☐	
Sample containers intact?	Yes ☑	No ☐	
Sufficient sample volume for indicated test?	Yes ☑	No ☐	
All samples received within holding time?	Yes ☑	No ☐	
Container/Temp Blank temperature in compliance?	Yes ☑	No ☐	
Sample(s) received on ice?	Yes ☐	No ☑	
Temperature(s)/Thermometer(s):			
Cooler(s)/Kit(s):			
Date/Time sample(s) sent to storage:	4/7/22 11.14		
Water - VOA vials have zero headspace?	Yes ☐	No ☐	No VOA vials submitted ☑
Water - pH acceptable upon receipt?	Yes ☐	No ☐	N/A ☑
pH adjusted?	Yes ☐	No ☐	N/A ☑
pH adjusted by:	-		

Login Notes:

Client Contacted:

Date Contacted:

Person Contacted:

Contacted By:

Regarding:

Comments:

CorrectiveAction:

ALS | Environmental
4388 Glendale Milford Rd.
Cincinnati, Ohio 45242
Phone: (800) 458-1493 or (513) 733-5336
Fax: (513) 733-5347

Page 1 of 1

ANALYTICAL REQUEST FORM

48194

☑ REGULAR Status 2204024I

☐ RUSH Status Required - ADDITIONAL CHARGE

RESULTS REQUIRED BY ________ DATE

CONTACT ALS LABORATORY GROUP PRIOR TO SENDING SAMPLES

Date 5/4/22 Purchase Order No. ________

Company Name Environmental Solutions Limited

Address 7 Hillview Avenue, Kgn 10, Jamaica

St. Andrew (City) N/A (State) N/A (Zip)

Send Report To Radhidan Khan-Hagg

Email Address rkhan@eslcaribbean.com

Telephone (876) 564-0104

Alt. Contact Name Andrene Webster-Jones

Alt. Contact Info 876-559-9849

Quote No. 9886

Sampling Site Westmoreland

Date/Time of Collection ~~April 21, 2022~~ March 31, 2022 - April 1, 2022 (AW 5/4/22)

Project No. ________

Billing Address (if different) ________

Lab Use Only	Client Sample Number	Media Type	Sample Volume (L)	Sample Time (min.)	ANALYSES REQUESTED - Use Method Number if Known
01	AQ1	–	–	1547	
02	AQ2	–	–	1664	
03	AQ2 Dup	–	–	1664	H_2S using Radiello
04	AQ3	–	–	1628	
05	AQ4	–	–	1611	
06	AQ7	–	–	1654	
07	Blank	–	–	–	
08	AQ1	–	–	1547	
09	AQ2	–	–	1664	
10	AQ2 Dup	–	–	1664	NO_x & SO_x using UMEX-200
11	AQ3	–	–	1628	
12	AQ4	–	–	1611	
13	AQ7	–	–	1654	
14	Blank	–	–	–	

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Date / Time
[signature]	5.4.22 8:45a	Hannah Ponder	4-7-22 10:19
[signature]	5.4.22 8:45a		
[signature]	5.4.22 8:45a		

ALS LAB USE ONLY

COOLER TEMP: °C Taken with IR#:

COOLING METHOD: NONE COOLER WET ICE DRY ICE ICE PACK

DELIVERY METHOD: CLIENT DROP BOX FEDEX UPS STD MAIL PRTY MAIL ALS COURIER OTHER: DHL

CUSTODY SEALS: COOLER PACKAGE SAMPLES NOT REQUIRED

EQUIP. RETURNED:

DEPLOYABLE PARTICULATE SAMPLER (DPS)

A NEW COST-EFFECTIVE, SIMPLE-TO-OPERATE PORTABLE PM SAMPLING SYSTEM

Saulius Trakumas, Donald L. Smith, Charles W. Nachreiner, Peter M. Hall, SKC Inc., 863 Valley View Road, Eighty Four, PA 15330, Joseph B. Sutphin, J. Christopher Weir, CDR, USACHPPM, 5158 Blackhawk Road, APG, MD 21010-5403.

Category: Informational
Discipline: Environmental Programs
Sub-Discipline: Air sampling/Instrumentation; Deployment support

This submission is pertinent to the Conference theme: "Emerging Global Health Issues: Meeting the Challenge through Preventive Medicine" because it presents a newly developed deployable particulate sampling system that is highly suitable for monitoring PM exposure of military personnel deployed in various regions.

Background: Particulate matter (PM) monitoring is an important component in assessing potential exposure that may affect the health of deployed personnel.

Objective: The objective was to develop a PM measuring system that improved upon existing non-Federal Reference Method (non-FRM) systems and met requirements such as accuracy, portability, simple operation, and quick deployability.

Methodology: The Deployable Particulate Sampler (DPS) System was developed and tested. A compact inertial impactor (Fig. 1, U.S. patent pending), comprised of a PM2.5 or PM10 inlet, outlet, and 47-mm filter cassette, was designed to accurately collect PM2.5, PM10, or PM coarse. Its removable filter cassette can be preloaded and incorporates replaceable impaction substrate for simple operation. The system's battery-operated pump provides a constant 10.0 L/min flow rate to ensure accuracy during monitoring up to 24 hours. All components fit in a 47 x 35.7 x 17.6 cm case weighing 6.1 kg and take only a few minutes to deploy (Fig. 2).

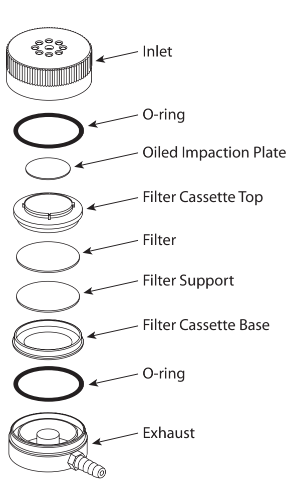


Figure 1. Schematic of DPS Impactor

Figure 2. Deployable Particulate Sampler

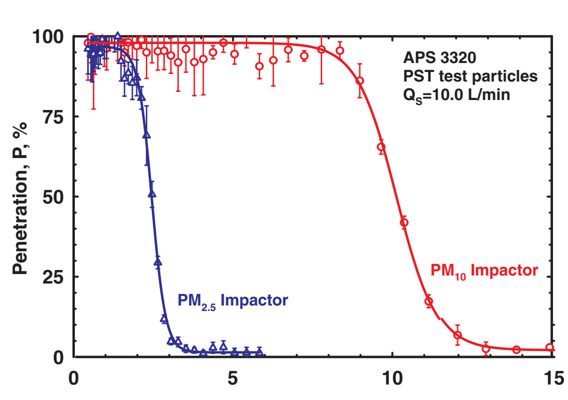


Figure 3. Calibration of PM2.5 and PM10 Impactors

Results: The DPS PM2.5 and PM10 impactors were calibrated in the laboratory (Fig. 3) using an APS 3320 (TSI Inc.). The field test included comparison of the 24-hour ambient PM10 concentration from collocated DPS (SKC Inc.), MiniVol (Airmetrics, Inc.), and FH 62 C14 continuous ambient PM monitor (Thermo Andersen). Field data, including monitoring PM exposure of military personnel in Kuwait, revealed good agreement between the DPS System and other collocated non-FRM samplers (Fig. 4 and 5).

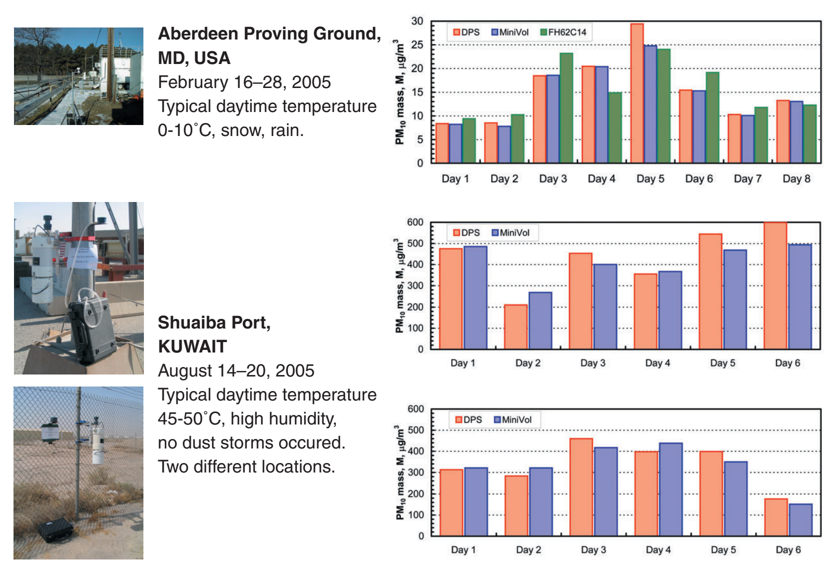


Figure 4. Comparison of 24-hour PM10 mass concentrations from collocated samplers

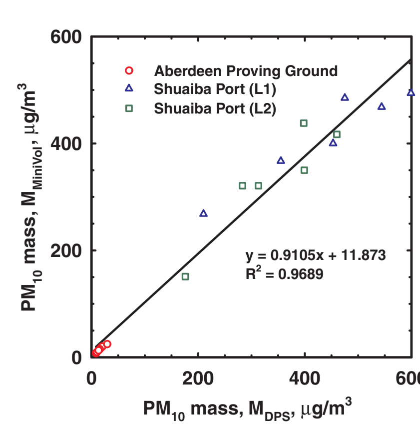


Figure 5. Comparison of PM10 mass from DPS and MiniVol

Discussion/Conclusion: Results of this study show DPS System performance is comparable to existing non-FRM systems for monitoring PM exposure of military personnel deployed in various regions.

Recommendation: Because of the DPS System's demonstrated effectiveness in monitoring PM exposure, it is recommended that the DPS System be considered an accurate system that improves upon the portability, deployability, and operation of existing non-FRM systems.

Publication 1620 Rev 1910

Leland Legacy Sample Pump

High Flows, Long Runs Enhance Measurement Sensitivity!

Flows: 5 to 15 L/min

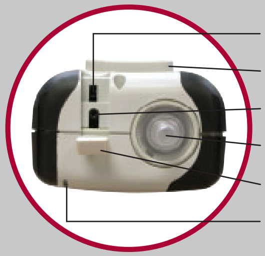
Certifications

CE

ETV performance verified

8 inches

3.9 inches



Top view

Leland Legacy® is the perfect partner for the Sioutas Impactor

⦿ High flows — 5 to 15 L/min
- Provides the high flows and long run times of a vacuum-style pump in a compact, portable, battery-operated sampler within specified back pressure range

⦿ Designed for use with impactors, spore traps, 37-mm filters, low-volume PUF tubes, and other low-pressure applications†

⦿ Long 24-hour runs on one charge with Li-Ion battery
- Suitable for unattended ambient air sampling

⦿ Low noise, size, and weight
- Ideal for indoor air studies or unattended ambient air sampling

⦿ Longer runs + Higher flows = Enhanced sensitivity for measuring low concentrations

⦿ Highly accurate isothermal flow control system

⦿ Flexible programming options
- Manual three-button programmability using the large built-in keypad
- PC programmability with DataTrac Software for Leland Legacy
  - Create complete running sequences, download sampling history, and generate exposure reports for ISO 9000 or quality programs

⦿ Large easy-to-read LCD
- Displays battery status indicator, flow fault, run time data, and sampling parameters

⦿ CalChek automatic calibration feature
- Provides hands-free direct communication to a Defender calibrator

⦿ Adjustable datalogging interval from 3 seconds to 8 hours with DataTrac Software

⦿ Rugged and convenient case design
- Tough rubber overmolding protects the pump and provides a sure grip
- Anti-static thermoplastic material
- Inlet port with removable protective cover
- Easy-access computer interface and battery charging jack under protective cover

⦿ Performance with Sioutas Impactor verified by EPA-ETV

⦿ Featured in deployable sampler systems

⦿ CE marked

† *Leland Legacy is not recommended for high back pressure applications such as asbestos clearance sampling.*

SKC Inc. 724-941-9701 **SKC-West** 714-992-2780 **SKC Gulf Coast** 281-859-8050 **SKC South** 434-352-7149

www.skcinc.com

Quick View

Flow Rate (ml/min)	
5 to 15 (L/min)	
Weight in Ounces (grams)	
36 (1000)	
Compensation Range (inches water)	
Up to 12 at 10 L	
Built-in Timer/Clock	
Clock	
Constant Flow	
Yes	
Programmable	
Yes	
PC-compatible	
Yes	
Multi-tube Sampling	
N/A	
Flow Fault Feature	
Yes	
RFI/EMI Shielded	
Yes	
Intrinsic Safety	
N/A	
MSHA-approved Models Available	
N/A	
ATEX Models Available	
N/A	
CE Marked	
Yes	
Corrects for Changes in Atmospheric Pressure	
Yes	
Corrects for Changes in Temperature	
Yes	
Battery Type	
Li-Ion (7.4 V, 12 Ah, 89 Wh)	
Battery Check	
Yes	
Tubing	
Requires 3/8-inch ID tubing	

Recommended Accessories
Chargers
Battery Charging Adapter Cat. No. 223-248
CalChek Communication Cable Cat. No. 210-502
Noise-reducing Case
TSI 4146 Calibration Kit Cat. No. 740-4146
DataTrac Software for Leland Legacy Cat. No. 877-92
Low-volume PUF Tube Holder Cat. No. 224-29P
Tubing Adapter Cat. No. P31211
Filter Holders
Tubing

Leland Legacy Sample Pump

Performance Profile	
Flow Rate Accuracy	± 5% of set-point after calibration
Timing Accuracy	1 min/mo at 25 C
Atmospheric Pressure Accuracy	± 3% in Hg
Typical Run Time	***Battery:*** 24 hrs at 9 L/min with Sioutas Impactor (approx. 13 in water back pressure) 24 hrs at 5 L/min with low-volume PUF tube 24 hrs at 10 L/min with IMPACT Sampler in DPS System 24 hrs at 8 L/min with 8 L/min Respirable PPI ***Using charger with AC power:*** Extended run times
Charge Time *(varies with battery capacity and level of discharge)*	15 hrs with approved charger
Temperature Range	***Operating:*** 32 to 104 F (0 to 40 C) ***Storage:*** -4 to 95 F (-20 to 35 C) ***Charging:*** 32 to 113 F (0 to 45 C)
Altitude	The pump can apply correction to volumetric flow during sampling for weather-related or altitude variations from the atmospheric pressure established at calibration up to at least 7500 feet (2286 meters) above and 5000 feet (1524 meters) below sea level.
Timer Display Range	1 to 99999 min (69 days); if run time exceeds 69 days, timer display rolls over
Time Display	Time of day in hours and minutes (12 or 24-hr clock) with AM and PM indicators
Volume Display	Continually updated based on corrected flow rate multiplied by sampling time When volume exceeds 99,999 liters, the pump will continue to run normally but an O_FlO Error will appear on the LCD.
Noise Level	62.5 dBA‡ - pump without case 52 dBA‡ - pump housed in noise-reducing case (optional accessory)
Flow Fault	After 15 sec, pump goes into Hold, retains accumulated run time and historical data, and displays fault icon. Auto-restart is attempted every 20 sec up to 10 times (adjustable with DataTrac Software)
Flow Control	An internal isothermal flow sensor measures flow directly and continuously. Sensor readings are used in a flow monitoring algorithm to maintain calibrated volumetric flow. In addition, built-in atmospheric temperature and pressure sensors provide readings to correct volumetric flow for these parameters when they vary from point of calibration.
Weight	36 oz (1 kg)

‡ *Measured 3 feet (1 meter) from pump operating at 10 L/min and 12 inches water back pressure*

Ordering Information

Leland Legacy requires 3/8-inch ID tubing.

Pump and Kits		**Cat. No.**
Leland Legacy Pump** with Li-Ion battery pack and screwdriver set, *requires charger*		**100-3002**
Starter Kit includes pump, single charger, Tygon tubing (3 feet, 3/8-inch ID), and collar clip with cable tie	**100-240 V**	**100-3002-S**
Single Pump Kit*‡** includes Leland Legacy pump and single charger, in a Pelican carry case	**100-240 V**	**100-3002K**
5-pack Pump Kit*‡** includes 5 Leland Legacy pumps, Take Charge 5 Multi-charger, and DataTrac Software, in a deluxe Pelican case	**100-240 V**	**100-3002K5**
Accessories		
TSI 4146 Calibration Kit, flow measurement from 0.01 to 20 L/min, includes calibrator, soft-side case, mounting lugs, 1/4-inch ID tubing, battery pack, 6 AA batteries, inlet filter, dampening module, NIST certificate, and manual		**740-4146**
Chargers		
Single	**100-240 V**	**223-241**
Take Charge 5 Multi-charger	**100-240 V**	**223-441**
CalChek Communication Cable, *required for CalChek calibration*		**210-502**
Tubing Adapter, adapts 3/8-inch ID tubing to 1/4-inch ID tubing		**P31211**
Replacement Parts		
Replacement Battery Pack,** Li-Ion *Replacing batteries with non-approved battery packs voids any warranty.*		**P75692**
Replacement Filter/O-ring Set, 5 filters and 1 O-ring		**P40021B**
Replacement Inlet Filters, pk/50		**P40021A**

** *Leland Legacy pumps contain Li-Ion batteries and are subject to special shipping regulations.*

SKC Limited Warranty and Return Policy
SKC products are subject to the SKC Limited Warranty and Return Policy, which provides SKC's sole liability and the buyer's exclusive remedy. To view the complete SKC Limited Warranty and Return Policy, go to http://www.skcinc.com/warranty.

Modular Impactors — Accurate, Simple-to-operate, and Cost-effective Environmental PM Samplers

Saulius Trakumas and Donald L. Smith, SKC Inc., 863 Valley View Road, Eighty Four, PA 15330

Abstract

The EPA has defined PM2.5, PM10, and PM Coarse to monitor environmental exposure to particulate matter. Despite the PM2.5 and PM10 definition being somewhat different from the respirable, thoracic, and inhalable fractions defined by ACGIH, monitoring environmental PM provides important information leading to better assessment of overall worker exposure to particulate matter.

This study presents a series of new inertial impactors developed to monitor exposure to PM2.5, PM10, and PM Coarse. The impactors feature modular construction that includes an inlet, outlet, and filter cassette with incorporated support for an impaction substrate. To achieve optimal impactor performance, an oiled porous plastic support disk is recommended for use as the disposable impaction substrate.

The impactors were calibrated in the laboratory using an Aerodynamic Particle Sizer APS 3320. Data indicate good agreement with PM2.5 and PM10 as defined by EPA for both personal and area impactors. Field data obtained in different environmental conditions reveal good agreement between the newly developed modular IMPACT PM10 Impactor, and a collocated MiniVol Sampler (Airmetrics, Inc.) and FH 62 C14 Continuous Ambient PM Monitor (Thermo Andersen).

www.skcinc.com

Inertial Impactor Design Theory

Particle-laden air enters the impactor through the inlet nozzles. Larger particles with enough inertia deviate from the airstream lines and impact on the impaction plate while smaller particles follow the airstream lines around the impaction plate and collect on the filter (Figure 1). Impactor cut-off size can be adjusted by changing air velocity (particle velocity) inside the acceleration nozzle. An increase of particle velocity inside the nozzle will lead to collection of smaller particles due to an increase of their inertia. In contrast, the size of particles able to follow the airstream lines will increase with decreased velocity.

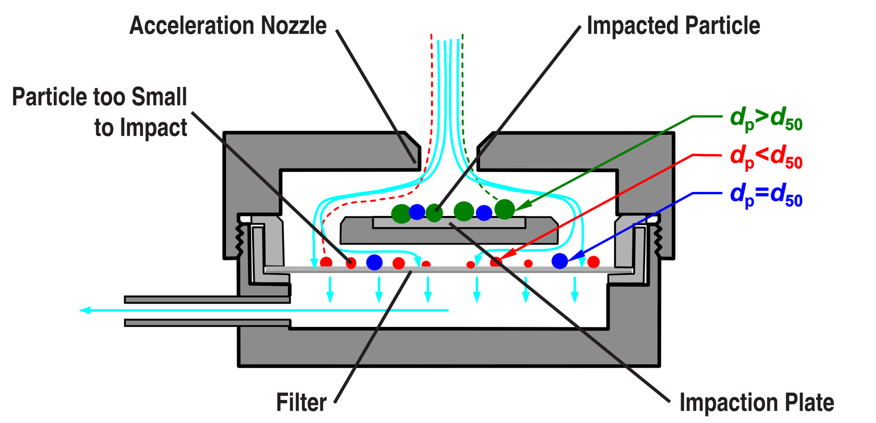


Figure 1. Schematic of inertial impactor

Performance of an inertial impactor is defined in terms of 50% cut-off size, d_{50}; 50% of particles with d_{50} penetrate through the impactor and another 50% are collected. d_{50} can be calculated using the following formula (Rader and Marple 1985):

$$d_{50} = \sqrt{\frac{9\mu W Stk_{50}}{\rho_p V_o C}}$$

Formula 1

where μ is air viscosity, W is the width or diameter of the impactor nozzle, Stk_{50} is the Stokes number corresponding to a 50% particle cut-off, ρ_p is the particle density, V_o is average air velocity in the nozzle, and C is the size-dependent Cunningham slip correction factor. Stk_{50} depends on the Reynolds number of the flow through the nozzle, Re, jet-to-plate distance, S, and impactor nozzle throat length, T.

Modular Impactor Design

The new modular impactors (U.S. Patent No. 7,334,453) are comprised of two modules: a housing and a particle collecting assembly. The inlet attaches to the outlet by screwing the two parts together and the particle collecting assembly is housed inside (Figure 2A). Particle-laden air enters the impactor through the inlet nozzles. Larger particles collect on the impaction substrate while smaller ones follow the airstream lines through the annular opening around the impaction substrate and collect on the filter. An oiled porous plastic support disk is recommended for use as the disposable impaction substrate to achieve optimal impactor performance. After sampling, the impactor inlet is unscrewed from the outlet and the particle collecting assembly (filter cassette with incorporated collection substrate) is readily available for quick replacement of the filter and impaction substrate. In addition to a single-stage impactor, a multiple-stage sampler can be assembled using similar modules (Figure 2B). The two-stage impactor featuring a PM10 inlet as Stage 1 and a PM2.5 impactor as Stage 2 will collect PM Coarse and PM2.5 simultaneously. The modular impactor design was applied to build samplers for personal and area sampling. Formula 1 was employed to determine the size and number of nozzles for each particular impactor. Personal Modular Impactors (PMI) operate at a 3.0 L/min flow rate and use a 37-mm filter and 25-mm impaction substrate (Figure 3). PMI 2.5 has four nozzles with a 1.5-mm diameter each. There are eight 2.8-mm diameter nozzles in the PMI 10. The IMPACT Samplers (Figure 4) operate at a flow rate of 10.0 L/min, are designed for area sampling, and employ a 47-mm filter and 37-mm impaction substrate. IMPACT 2.5 has eight 1.8-mm diameter nozzles and IMPACT 10 features eight nozzles with a diameter of 4.3-mm each. The IMPACT Sampler together with a battery operated pump form a compact, portable, and simple-to-operate particle sampling system known as the Deployable Particulate Sampler or DPS (Figure 5).

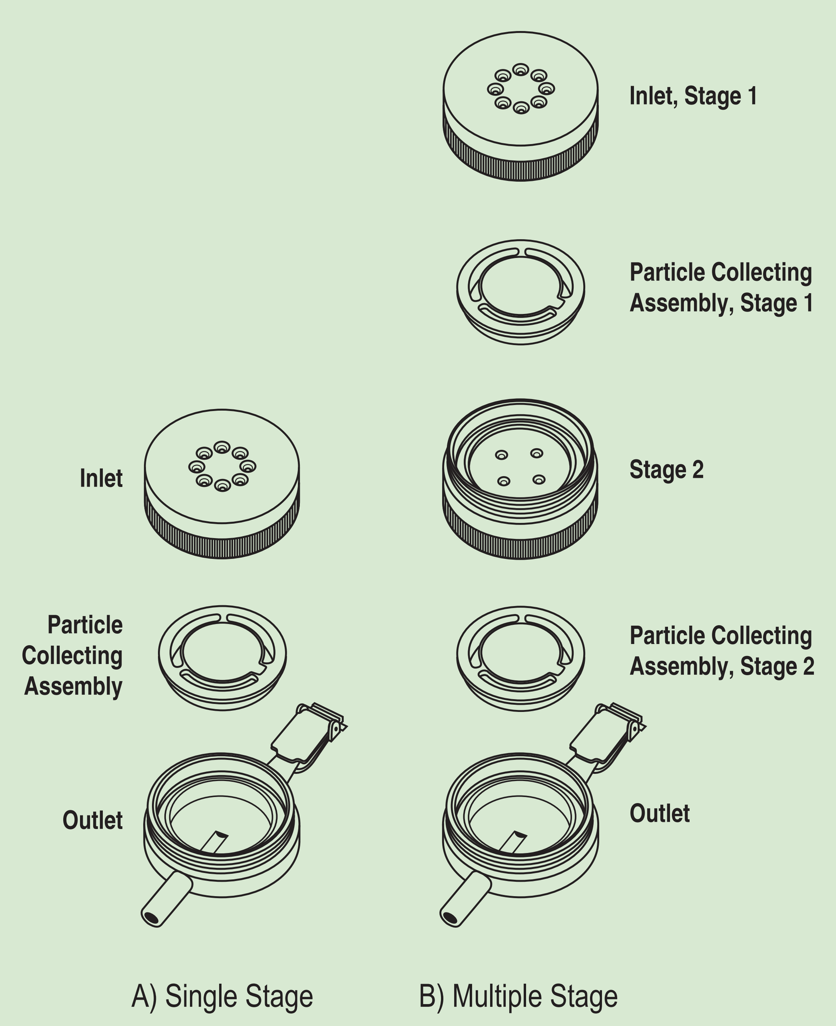


Figure 2. Modular impactor design

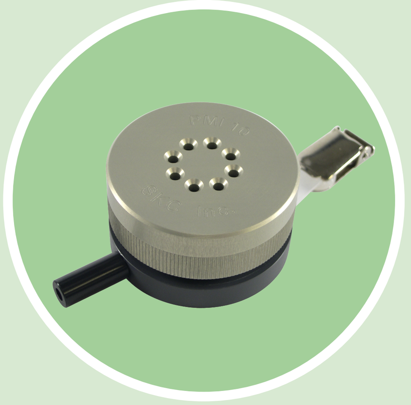


Figure 3. Personal Modular Impactor (PMI)

Figure 4. IMPACT Sampler

Figure 5. Deployable Particulate Sampler (DPS)

Test Methods

The newly developed impactors were calibrated in an aerosol test chamber (Figure 6) using an APS 3320 (TSI Inc.). Field tests included comparison of the 2-hour ambient PM10 concentration from a collocated DPS System (SKC Inc.), MiniVol Sampler (Airmetrics, Inc.), and FH 62 C14 Continuous Ambient PM Monitor (Thermo Andersen). Three series of field tests were performed in different geographical locations and ambient conditions.

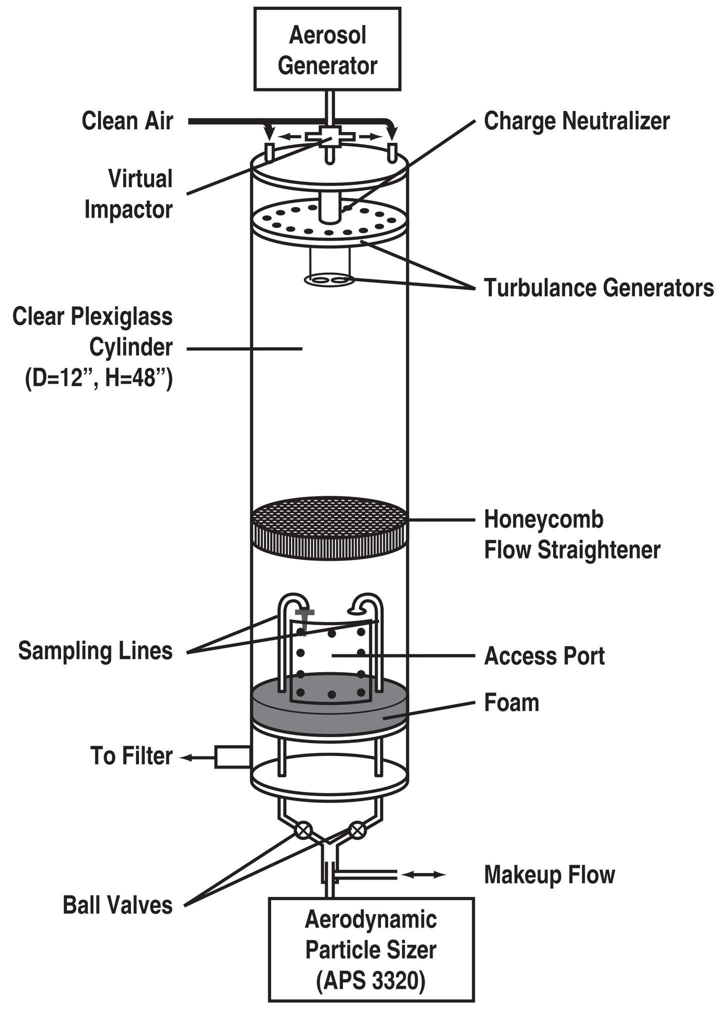


Figure 6. Schematic of aerosol test chamber

Performance of Newly Developed Modular Impactors

Figure 7 shows the sampling efficiency of the newly developed modular impactors measured in the test chamber. As shown, both PM2.5 samplers, 3.0 L/min and 10.0 L/min versions, follow closely EPA's PM2.5 curve. The sampling efficiency curves of the PM10 impactors are somewhat sharper than the PM10 curve defined by EPA. Nevertheless, side-by-side comparison of the IMPACT PM10 Sampler with the performance of a collocated MiniVol Sampler and FH 62 C14 Continuous Ambient PM Monitor show good agreement between data obtained with all of these samplers (Figure 8).

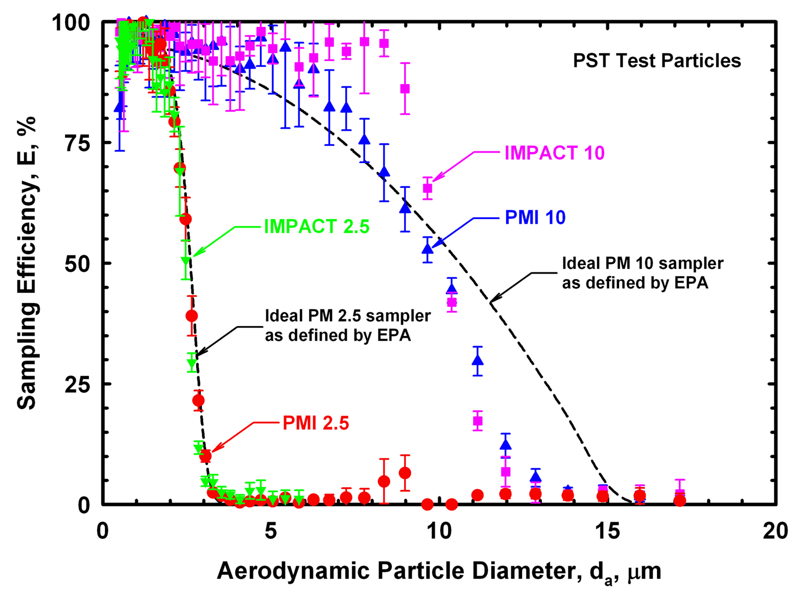


Figure 7. Sampling efficiency of new modular impactors

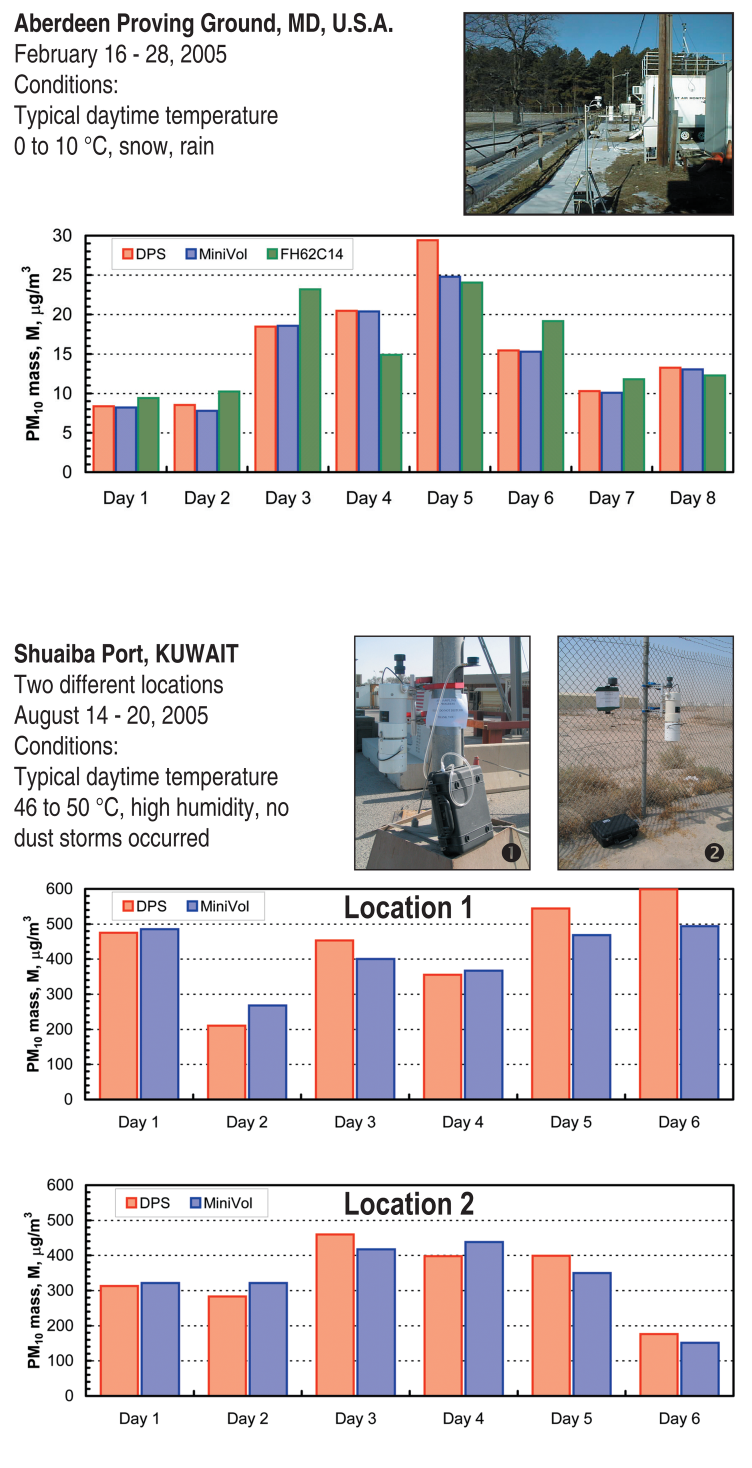


Figure 8. Comparison of IMPACT PM10 (in DPS System) with MiniVol Sampler and FH 62 C14 Monitor

Conclusion

A series of new inertial impactors were developed, manufactured, and tested. The modular design of the new impactors has been proven to provide an accurate, simple-to-operate, and economical solution for monitoring exposure to PM2.5, PM10, and PM Coarse.

Reference — Rader, D.J. and Marple, V.A. (1985). Effects of Ultra-Stokesian Drag and Particle Interception on Impaction Characteristics. *Aerosol Sci. Techno.* 4:141-156.

UME^x 200 Passive Sampler

Sulfur Dioxide and Nitrogen Dioxide Sampling

The SKC UME^x 200 Passive Sampler effectively collects sulfur dioxide (SO_2) using a sampling rate of 15.2 ml/min and/or nitrogen dioxide (NO_2) at 17.3 ml/min. The sample medium (tape treated with triethanolamine [TEA]) and a "blank" section of tape are contained in one sampler, saving time and money. The lightweight UME^x 200 clips easily in the breathing zone for occupational sampling or in an area for environmental monitoring. The single-use samplers are provided in individual aluminized pouches that can be used to transport the sampler to a laboratory. The label on the outside of each pouch contains the shelf-life date for easy inventory management.

Using the UME^x 200 Passive Sampler

Sampling with the UME^x 200 Passive Sampler for sulfur dioxide and/or nitrogen dioxide is easy and requires no pump or training. Simply remove the sampler from the pouch, record sampling information, and slide the cover to the "on" or sampling position. Clip the sampler on a worker for occupational sampling up to 8 hours or in an area for environmental monitoring up to 24 hours. When sampling is complete, slide the cover to the "off" position, place the sampler back in the pouch immediately, and seal. Send the sampler to an accredited laboratory for analysis by ion chromatography (IC) with conductivity detection (CD). The UME^x 200 sampler is designed for single use only. Do not reuse UME^x samplers.

UME^x *Sampler with sliding cover in "on" position*

- **Validation range extended below new TLV-TWA for NO_2**
- **Same chemistry as active OSHA Method ID-182**
  - Accurate, reliable personal sampling
- **Ready to use**
- **Lightweight sampler clips easily in the breathing zone**
- **Economical**
  - No pump or training required
  - Low-cost sampler
  - Sample medium and blank in one unit
- **Safe — no glass or chemical liquids in the sampler**
- **Validated sampling of sulfur dioxide and/or nitrogen dioxide from 15 minutes to 24 hours**
- **Validated for 24-hour ambient air sampling of NO_2/SO_2 to complement federal EPA reference methods** *(see Performance Profile on reverse side)*
- **Free media blank included**

Publication 1779 Rev 1809

UME^{x}200 Passive Sampler

Sulfur Dioxide and Nitrogen Dioxide Sampling

Performance Profile

Sampling Rate:	**SO_2:** 15.2 ml/min with a relative standard deviation of 16.5% **NO_2:** 17.3 ml/min with a relative standard deviation of 11.4%
Validated Concentration Range:	**SO_2:** 0.4 to 8 ppm, 15 min to 24 hrs **NO_2:** 0.05 to 8.5 ppm, 15 min to 24 hrs
Analysis Method for SO_2 and/or NO_2:	Solvent extraction and ion chromatography with conductivity detection
Lower Detection Limits:	**SO_2:** 15 min: 1.8 ppm 8 hrs: 52 ppb 24 hrs: 17.4 ppb **NO_2:** 15 min: 200 ppb 8 hrs: 6.3 ppb 24 hrs: 2 ppb
Shelf-life:	18 mos from date of manufacture at ambient temperature
Storage:	*Before use:* Ambient temperature *After use:* Ambient temperature or at ≤ 39.2 F (4 C) and analyze within 3 weeks
Accuracy:	**SO_2:** ± 30% **NO_2:** ± 26%
Temperature Effects:	No effect on sampling rate from: **SO_2:** 20 to 25 C **NO_2:** 22 to 40 C
Humidity Effects:	No effect from 20 to 80% relative humidity (RH)
Wind Velocity Effects:	No effect from 5 to 100 cm/sec
Interferences:	None identified
Dimensions:	3.4 x 1.1 x 0.35 in (8.6 x 2.8 x 0.89 cm)
Weight:	0.38 oz (10.9 gm)
Slide Cover:	Yellow

Other UME^x Passive Samplers Available

The same convenient and economical UME^x design is also available for sampling formaldehyde/other aldehydes (**UME^{x}100**) and ammonia (**UME^{x}300**). Contact SKC for more information or visit www.skcinc.com.

Potential Sources of Occupational and Environmental Exposure to SO_2 and NO_2

Sulfur dioxide is used in industry as a(n):

- Intermediate in the manufacture of sulfuric acid
- Bleaching agent
- Disinfectant
- Fumigant
- Solvent
- Refrigerant
- Food preservative
- Reagent in the manufacture of magnesium, sodium sulfite, and other chemicals

Other sources are:

- Copper smelting
- Processing or burning coal or fuel oils
- Manufacture of paper and fertilizers

Nitrogen dioxide is used in:

- Agricultural silos
- Arc or gas welding, especially in confined space
- Electroplating plants
- Food and textile bleaching
- Jewelry manufacturing
- Nitric acid production
- Nitrogen fertilizer production
- Nitro-explosive production
- Pickling plants

Ordering Information

Description	Cat. No.
UME^{x}200 Passive Sampler for Sulfur Dioxide and/or Nitrogen Dioxide,*† individually packaged in aluminized pouch, pk/10	**500-200**
Stand for Area Sampling	**690-302**
Shelter for Outdoor Sampling	**690-303**

* *Limited shelf-life*

† *Designed for single use only. Do not reuse UME^x samplers.*

USER MANUAL 2019

radiello®

Centro di Ricerche Ambientali

Istituti Clinici Scientifici Maugeri

ENGLISH 01-2019

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ISTITUTI CLINICI SCIENTIFICI MAUGERI S.p.A. - SB
Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

Subject index

Istituti Clinici Scientifici Maugeri

ISTITUTI CLINICI SCIENTIFICI MAUGERI S.p.A. - SB
Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

how does *the diffusive sampler work?*

The diffusive sampler is a closed box, usually cylindrical. Of its two opposite sides, one is "transparent" to gaseous molecules which cross it, and are adsorbed onto the second side. The former side is named diffusive surface, the latter is the adsorbing surface (marked with ***S*** and ***A*** in the figure).

Driven by the concentration gradient ***dC***/***dl***, the gaseous molecules cross ***S*** and diffuse towards ***A*** along the path ***l***, parallel to the axis of the cylindrical box. The molecules, which can be trapped by the adsorbing material, are eventually adsorbed onto ***A*** according to the equation:

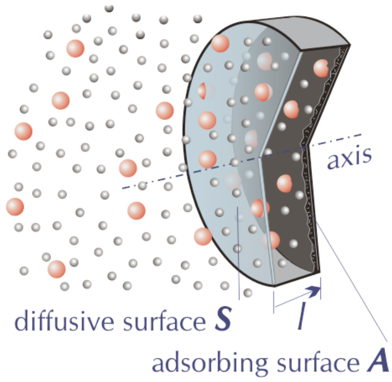
$$\frac{dm}{dt} = D\,S\,\frac{dC}{dl} \qquad [1]$$

where ***dm*** is the adsorbed mass during time ***dt*** and ***D*** is the diffusion coefficient. Let ***C*** be the concentration at the diffusive surface and C_0 the concentration at the adsorbing surface, the integral of [1] becomes

$$\frac{m}{t} = D\frac{S}{l}\,(C-C_0) \qquad [2]$$

If the concentration at the adsorbing surface is negligible, the equation can be approximated to

$$\frac{m}{t\,C} = D\frac{S}{l} = Q \quad \text{and then} \quad C = \frac{m}{t\,Q} \qquad [3]$$



In the diffusive sampler, the adsorbing and the diffusive surfaces are two opposing plane of a closed box. Driven by the concentration gradient, the gaseus molecules (coloured in the figure) pass through the diffusive surface and are trapped from the adsorbing surface.

Q is the ***sampling rate*** and has the dimensions of a gaseous flow (if ***m*** is expressed in μg, ***t*** in minutes and ***C*** in $\mu g \cdot l^{-1}$, ***Q*** is expressed in $l \cdot min^{-1}$).

Therefore, if ***Q*** is constant and measured, to calculate the ambient air concentration you need only to quantify the mass of analyte trapped by the adsorbing material and to keep note of the time of exposure of the diffusive sampler.

To improve the analytical sensitivity the collected mass ***m*** should be increased by enlarging ***Q***. As ***D*** is a constant term, one can only try to improve the ***S***/***l*** ratio, namely the ***geometrical constant*** of the sampler. Unfortunately, in the common axial simmetry sampler, if ***S*** is enlarged, the adsorbing surface ***A*** must be enlarged too, in order to keep the two parallel surfaces at a fixed distance. Since the analytes can be recovered from the axial sampler only by solvent extraction, any increase of ***A*** lead to a proportional increase of the extraction solvent volume, thus the improvement of ***Q*** is canceled out by the effect of dilution.

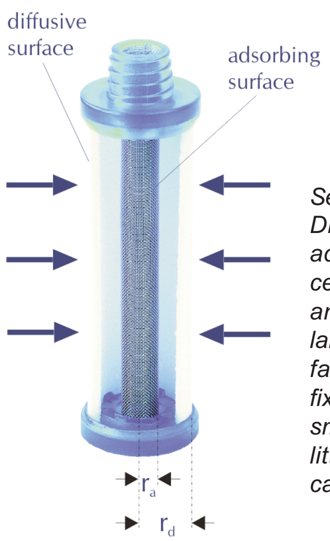
The value of distance ***l*** could also be reduced, but under the critical value of about 8 mm the diffusion law is no longer valid in the case of low air velocity values, since adsorption rate becomes higher than supplying rate of analyte molecules at the diffusive surface.

Cannot we improve ***Q*** then?

The answer is to improve the sampler geometry to a ***radial*** design.

From this idea the **radiello** sampler has been developed, its cylindrical outer surface acting as diffusive membrane: the gaseus molecules move axially parallel towards an adsorbent bed which is cylindrical too and coaxial to the diffusive surface.

When compared to the axial sampler, **radiello** shows a much higher diffusive surface without increase of the adsorbing material amount. Even if the adsorbing surface is quite smaller then the diffusive one, each point of the diffusive layer faces the diffusion barrier at the same distance.



Section of **radiello**. *Diffusive and adsorbing surfaces are cylindrical and coaxial: a large diffusive surface faces, at a fixed distance, the small surface of a little concentric cartridge.*

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

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As $S=2\pi rh$ (where h is the height of the cylinder) and the diffusive path is as long as the radius r, we can then express equation [1] as follows

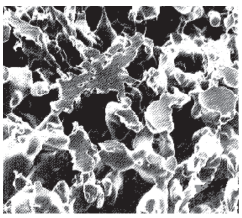
$$\frac{dm}{dt} = D\, 2\pi\, h\, r \frac{dC}{dr} \qquad [4]$$

The integral of equation [4] from r_d (radius of the diffusive cylindrical surface) to r_a (radius of the adsorbing surface) becomes

$$\frac{m}{t\,C} = D \frac{2\pi\, h}{\ln \frac{r_d}{r_a}} = Q \qquad [5]$$

the ratio

$$\frac{2\pi\, h}{\ln \frac{r_d}{r_a}}$$



The microporous sintered polyethylene diffusive barrier of radiello photographed at the electron microscope; the path length is much longer than the membrane thickness due to the tortuosity of the pores.

is the geometrical constant of radiello. The calculated uptake rate [5] is therefore proportional to the height of the diffusive cylinder and inversely proportional to the logarithm of the ratio of diffusive *vs* adsorbing cylinder radii.

While r_a can be easily measured, r_d can only be calculated by exposure experiments. Actually the diffusive membrane has been designed with a thick tubular microporous layer. The actual diffusive path length is therefore much longer than the distance among the diffusive and adsorbing surfaces due to the tortuosity of the path through the pores. A diffusive cylinder of external diameter 8 mm, thickness 1.7 mm and average porosity of 25 µm, coupled to an adsorbing cartridge with radius 2.9 mm creates a diffusive path of 18 mm instead of the straight line path estimation of (8-2.9) = 5.1 mm.

The sampling rate Q is function of diffusive coefficient D, which is a thermodynamic property of each chemical substance. D varies with temperature (T) and pressure (p); therefore also the sampling rate is a function of those variables according to

$$Q = f\,(T, p)$$

Q values that will be quoted in the following have been measured at 25 °C and 1013 hPa. As a consequence, they should be corrected so as to reflect the actual sampling conditions.

The correction of Q for atmospheric pressure is usually negligible since its dependence is linear and very seldom we face variations of more than 30 hPa about the average value of 1013 hPa. In the worst case, if corrections for pressure are ignored you make an error of ±3%, usually it is within ±1.5%.

On the other hand, Q depends exponentially on temperature variations, therefore more relevant errors can be introduced if average temperature is significantly different from 25 °C. Moreover, when chemiadsorbing cartridge are used kinetic effects (variations of reaction velocities between analyte and chemiadsorbing substrate) can be evident, apart from thermodynamic ones (variation of D).

It is therefore very important to know the average temperature in order to ensure accuracy of experimental data. See how you can perform on-field temperature measurements on page B3.

Even if some cartridges adsorb large quantities of water when exposed for a long time in wet atmosphere, generally this does not affect sampling by **radiello**. Some consequences, neverthless, can sometimes be felt on the analysis. As an example, a very wet graphitised charcoal cartridge could generate ice plugs during cryogenic focusing of thermally desorbed compounds or blow out a FID flame.

It is therefore important to protect radiello from bad weather. See page B1 how this can be easily done.

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ISTITUTI CLINICI SCIENTIFICI MAUGERI S.p.A. - SB
Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

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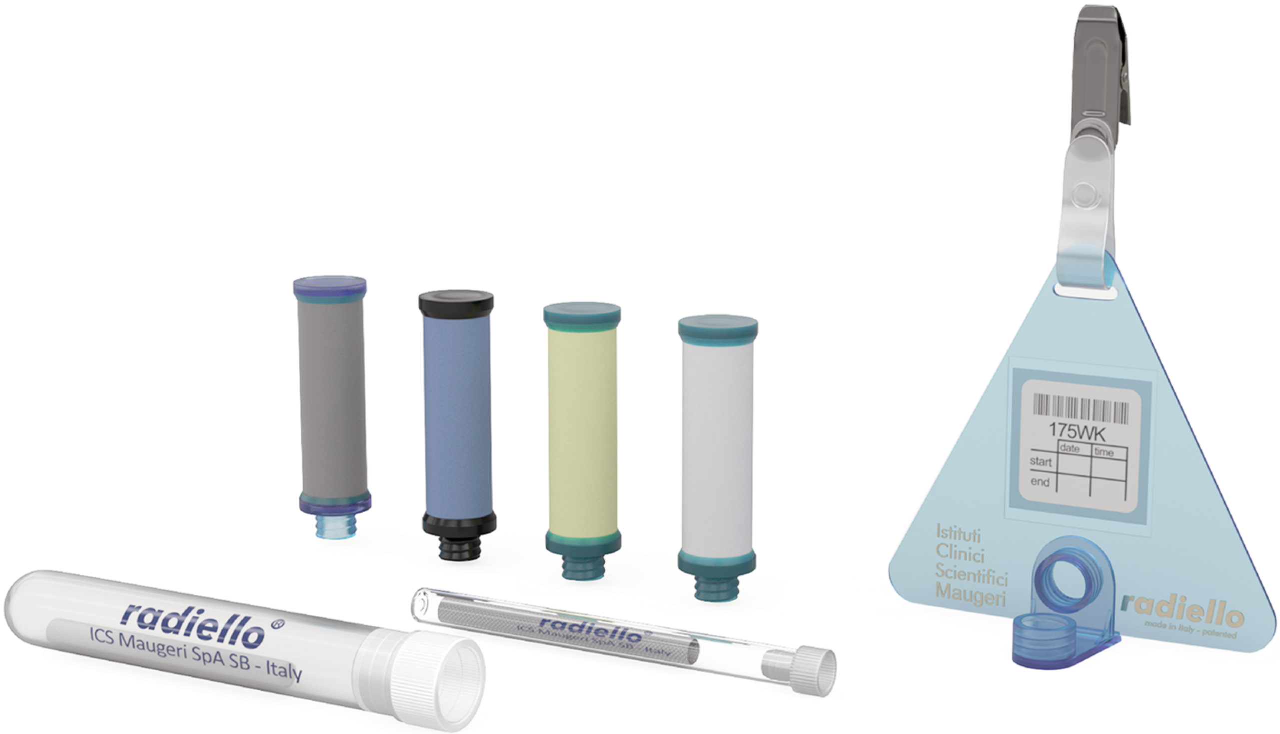


why *radiello* is so special?

The diffusive sampling does not involve the use of heavy and encumbering pumping systems, does not have energy power supply problems, does not require supervision, is noiseless, is not flammable and does not represent an explosion hazard, can be performed by everybody everywhere and with very low costs.

Moreover, it is not subject to the breakthrough problem, which can be serious when active pumping is performed.

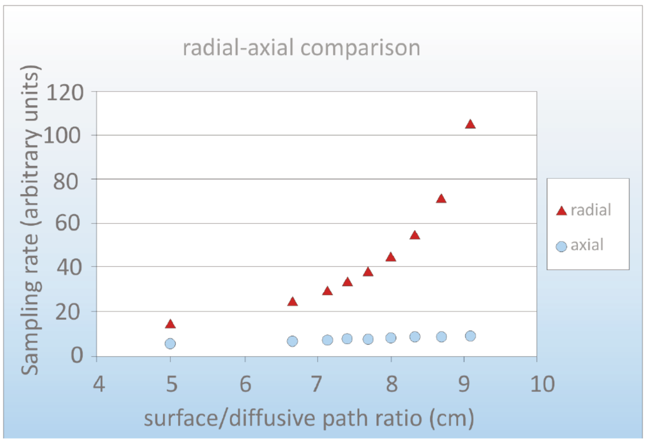
Why diffusive sampling has not been so extensively adopted up to now?

This is due to the fact that the traditional axial symmetry sampler has generally poor sensitivity and reproducibility because of the limits set by its geometry. On one side, uptake rate values are generally low, on the other, they often vary depending on environmental conditions.

These limitations have been overcome by ***radiello***.

By virtue of radial simmetry, uptake rate is:

- ✓ **high**, with the same dimensions, radiello's uptake rate is at least three times higher than that of any axial diffusive sampler;
- ✓ **constant**, due to the great adsorbing capacity of the adsorbing substrates;



For a traditional axial symmetry sampler the uptake rate increases linearly with tha ratio of diffusive surface vs diffusive path length, while for the radial simmetry sampler, the corresponding increase is exponential. This means that, let the diffusive surface vs diffusive path length ratio be 8:1, for the axial sampler the uptake rate value is 8 (regardless of dimensions) while for the radial one it is 45.

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
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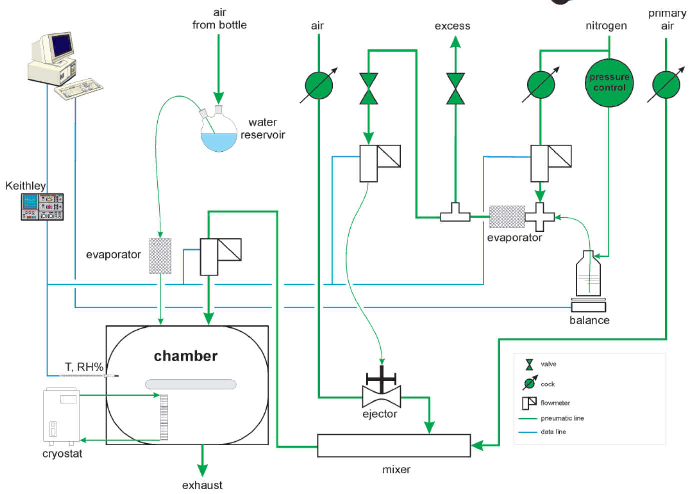
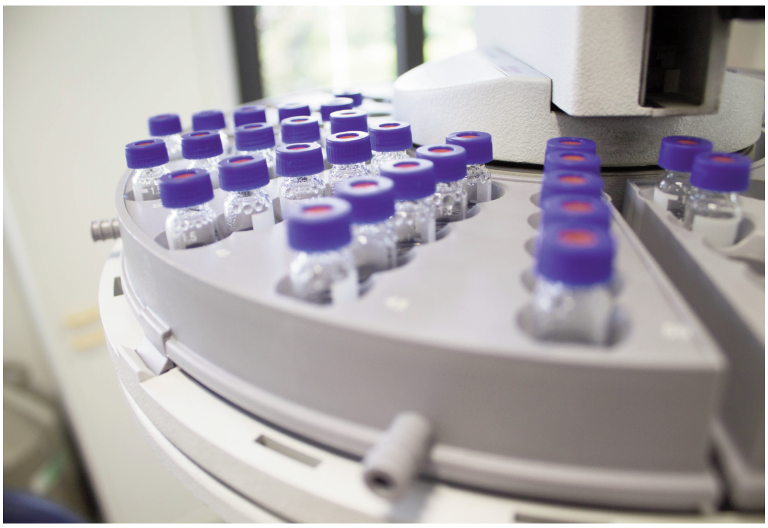
- ✓ **reproducible**, for the continuous control of the homogeneity of the materials used and of all the production lots of radiello;
- ✓ **precisely measured**, because the flow rate is not estimated but calculated experimentally, measured in a dynamic atmosphere controlled chamber in a wide range of conditions of concentration, temperature, humidity, air velocity, presence of interfering...



Moreover, ***radiello***

- is able to work properly also with bad weather conditions due to the water-repellent diffusive body
- has blank values lower than three times the instrumental noise due to the complex conditioning procedures of the bulk adsorbing (or chemiadsorbing) materials and to the repeated quality controls along the whole production
- has low detection limits and high adsorbing capacities that allow exposure time duration from 15 minutes to 30 days and concentration measurements from 1 ppb to over 1000 ppm
- offers high precision and accuracy over a wide range of exposure values
- allows thermal desorption and HRGC-MS analysis without interferents

- is suited to the sampling of a vast range of gaseous pollutants
- is though and chemically inert, being made of polycarbonate, microporous polyethylene and stainless steel
- is indefinitely reusable in all of its components apart from the adsorbing cartridge; the latter can be recovered if thermal desorption is employed
- it comes from the efforts of one of the main European scientific research institutions that produces it directly by high technology equipment and continuously submits it to severe tests and performs research and development in its laboratory in Padova



All the images in the manual concern the Environmental Research Center of the Istituti Clinici Scientifici Maugeri

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the components of *radiello*

The essential parts of *radiello* are the adsorbing cartridge, the diffusive body, the supporting plate and the adhesive label with the bar code indication. Apart from the adsorbing cartridge, if not differently stated, all of the other components can be repeatedly used for several sampling experiments.

The adsorbing cartridge

Depending on the polluting compound to be sampled, many different adsorbing or chemiadsorbing cartridges have been developed. Their dimensions are neverthless the same for all: 60 mm length and 4.8 or 5.8 mm diameter.

They are contained in glass or plastic tubes wrapped up in a transparent polyethylene thermowelded bag.

The code number, printed onto the bag along with the lot number and expiry date indicates the kind of cartridge.

Apart from the thermal desorption cartridges, all of the other kinds are for single use only.

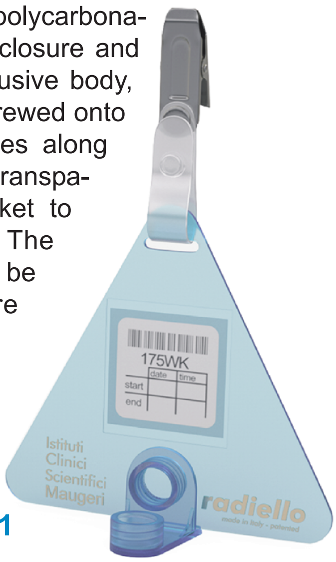
Available in 5 or 20 pieces per package.

The cartridge has to be introduced into the diffusive body.

The supporting plate

It is identified by the **code RAD121**. Made of polycarbonate, it acts both as closure and support for the diffusive body, which has to be screwed onto the thread. It comes along with a clip and a transparent adhesive pocket to hold the label. The three parts are to be assembled before use (see page A6).

Available in 20 pieces per package only.



code RAD121

The diffusive body

Four kinds of diffusive bodies are available, with like outer dimensions: 60 mm height and 16 mm diameter.

The **white** diffusive body, **code RAD120**, of general use, is made of microporous polyethylene 1.7 mm thick and average porosity 25 ± 5 μm. Diffusive path length is 18 mm.

The **blue** diffusive body, **code RAD1201**, has the same properties of the white one but is opaque to light: it is suited to the sampling of light-sensitive compounds.

The **yellow** diffusive body, **code RAD1202**, should be used whenever the sampling rate must be reduced; it is made of microporous polyethylene 5 mm thick and average porosity 10 ± 2 μm. Diffusive path length is 150 mm.

The **permeative** diffusive body, **code RAD1203**, is a 50 μm thick silicone membrane strengthened by a stainless steel net and a microporous polyethylene cylinder. It is employed for anaesthetic gases and vapours sampling.

Available in 20 pieces per package only.

The diffusive body has to be screwed onto the supporting plate.

RAD120 RAD1201 RAD1202 RAD1203

The label

Self-adhesive, with printed barcode number. Since each barcode number has been printed in only one copy, it allows an unmistakable identification of the sampling tube on field and in the laboratory for the subsequent analysis.

Each package of 20 adsorbing cartridges contains also 21 labels.

code RAD190

If the labels are ordered separately, they are shipped in 198 pieces per package only.

ISTITUTI CLINICI SCIENTIFICI MAUGERI S.p.A. - SB
Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
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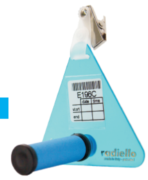

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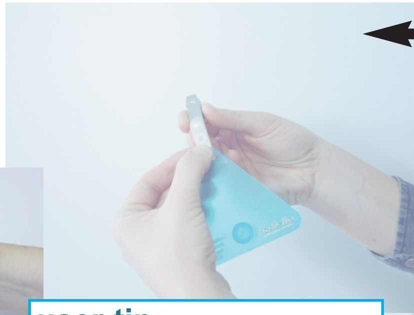
how to use *radiello*

assembling the supporting plate

before sampling

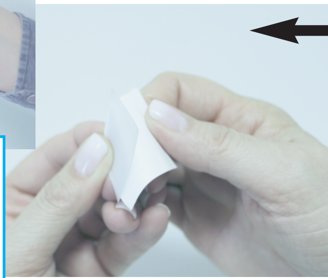
Before using ***radiello***, you have to assemble the supporting plate with the clip, necessary to suspend it, and the adhesive label pocket.

1. insert the clip strip in the slot, with the peg facing upwards



2. ply the strip and insert the peg into the hole

3. peel off the transparent pocket



user tip

assemble the supporting plate in your laboratory before the sampling campaign: on the field they are uselessly time-consuming.

4. and stick it onto the plate in a central position;

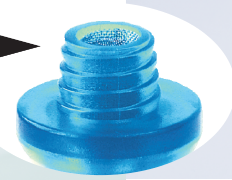
if you prefer, the pocket can be applied to the rear of the plate, but BE CAREFUL, always with the label insertion slot on the side (otherwise, if it starts raining the label can get wet)

on-field

to start the sampling

1. open the plastic bag, draw the cartridge out from the tube and put it in the diffusive body. ***Keep the glass or the plastic tube and stopper in the original plastic bag.***

The lower part of the diffusive body holds a seat for the central positioning of the cartridge. **A correctly centered cartridge should not stick out even by half a millimeter. If it is not so, the cartridge is not correctly positioned and is out of axis.**



As a consequence, when the diffusive body is screwed onto the supporting plate the cartridge is bent, the geometry of the sampler is disturbed and the results obtained become unreliable.

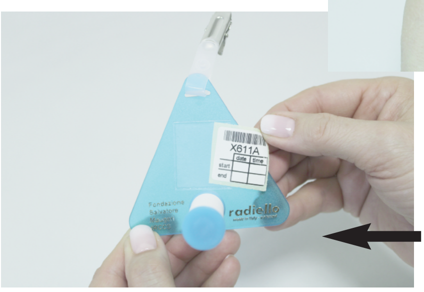
To place the cartridge centrally you need only to tap on the diffusive body.

2. keeping the diffusive body in a vertical position, screw it onto the supporting plate.

BE CAREFUL: do not hold the diffusive body horizontally when you screw it onto the plate, otherwise the cartridge could come out from its seat and stick out.

user tip

Do not touch the cartridge with your fingers if possible, particularly if it is impregnated with reactive



3. Insert a label in the pocket without peeling it off. Keep note of the date and time and expose ***radiello***. Sampling has started.

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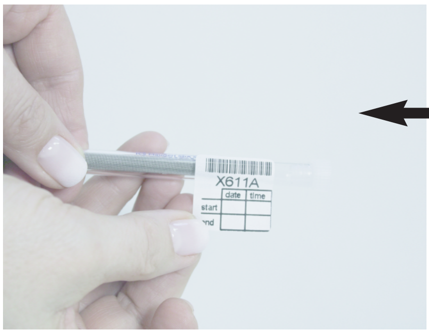
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

user tip

even if you can write date and time of the sampling start and end on the adhesive label, we suggest you to keep note of these parameters also separately: after a week exposure with bad weather conditions, your writings could become illegible!

DO NOT USE MARKING PENS to write on the label: they contain solvents that are sampled by *radiello*!

after the sampling



Keep note of the date and time of the end of exposure.

4 Place the cartridge into the tube, peel off the label and stick it onto the tube <u>such that the barcode is parallel to the axis of the tube</u>.

If you have performed the sampling of different polluting compounds at the same time, ***BE CAREFUL NOT TO MIX UP THE TUBES***: place the exposed cartridge in its original tube, identified by the code printed on the plastic bag.

IMPORTANT:

Always stick the label such that the barcode is <u>parallel to the axis of the tube</u>: any other position will compromise the barcode automated reading by the optic reading device.

maintenance

When exposed outdoors or in a workplace environment, the diffusive body may get dirty from airborne dust. Fine particles (PM_{10}) are especially harmful to yellow diffusive bodies since they can obstruct the pores. When the diffusive bodies are dirty you can wash them as follows.

Immerse the diffusive bodies in a beaker with a soapy solution (e.g. dish detergent) and sonicate them for 20 minutes. As the diffusive bodies float, you may make them sink by putting a smaller beaker on them, with water inside enough to dip it a few centimeters.

Rinse the diffusive bodies with plenty of water and then deionized water; let them finally dry in the air.

IMPORTANT:

<u>Never use solvents to clean the diffusive body</u>

After four or five washings, diffusive bodies need replacing: repeatedly adsorbed dust may have penetrated the pores such deeply to be undisturbed by washing.

The following table shows the advised washing schedule:

PM_{10} concentration ($\mu g \cdot m^{-3}$)	<30	40	>50
Washing after days of exposure	45	30	15

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radiello-ready-to-use

The ready-to-use version may be advantageous when you prefer not to assemble all of the components on field. It can be purchased as it is or in separate parts to be assembled by the customer.

In the ***as-it-is version*** the adsorbing cartridge is already contained in a diffusive body closed with a polycarbonate screw-thread cap. The whole is closed in a polypropylene airtight container. Just before use draw the diffusive body out of the container and fit it to the special snapping vertical adapter fixed to the supporting plate. After the end of exposure, the diffusive body with its content is placed again in the polypropylene airtight container to be shipped to the laboratory for analysis. The ***ready-to-use as-it-is radiello*** (polycarbonate cap, glass or plastic tube, special vertical adapter, barcode label and polypropylene container comprised for each type) is available for the sampling of the following compounds:

code	sampling of	contains
RAD1231	BTEX and VOCs	white diffusive body and cartridge code RAD130
RAD1232	BTEX and VOCs	yellow diffusive body and cartridge code RAD145
RAD1233	NO_2, SO_2 and HF	blue diffusive body and cartridge code RAD166
RAD1233	aldehydes	blue diffusive body and cartridge code RAD165
RAD1235	ozone	blue diffusive body and cartridge code RAD172
RAD1236	hydrogen sulfide	white diffusive body and cartridge code RAD170
RAD1237	ammonia	blue diffusive body and cartridge code RAD168
RAD1238	HCl	white diffusive body and cartridge code RAD169

on top:
to the right, ***radiello-ready-to-use***
to the left, the diffusive body with the polycarbonate cap and the adsorbing cartridge inside
in the center: the special snapping adapter

IMPORTANT: in the ready-to-use version ***the supporting plate is not provided***.

near here: the supporting plate with the vertical snapping adapter

If you prefer ***to assemble it by yourselves***, you should order:

- ✓ diffusive bodies (of the required type, see following chapters)
- ✓ adsorbing cartridges (of the required type, see following chapters)
- ✓ polycarbonate caps, **code RAD1241**
- ✓ special snapping adapters, **code RAD1221**
- ✓ polypropylene containers, **code RAD1242**
- ✓ supporting plates, **code RAD121**

user tip

the ***ready-to-use*** version of radiello is very useful in the workplace sampling campaigns but is not advised if very low concentrations in outdoor or domestic environments are to be measured

Fit the diffusive body to the adapter by pushing it till you hear a clicking sound

Draw the diffusive body by tilting it with decision

accessories

vertical adapter

code RAD122

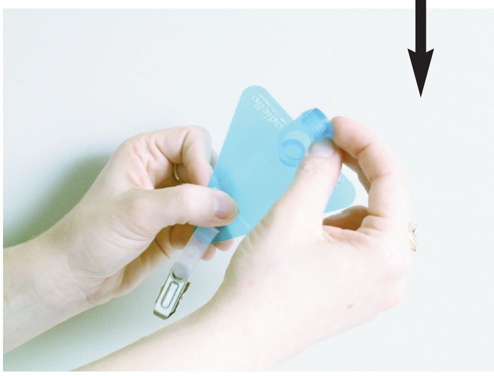
Available in 20 pieces per package only

The diffusive body can be fitted to the supporting plate either in a vertical or horizontal position, the vertical one being more comfortable when *radiello* is used for personal sampling.

To assemble *radiello* in vertical position you have to screw it to the **vertical adapter code RAD122**, fitted to the supporting plate.

code RAD122

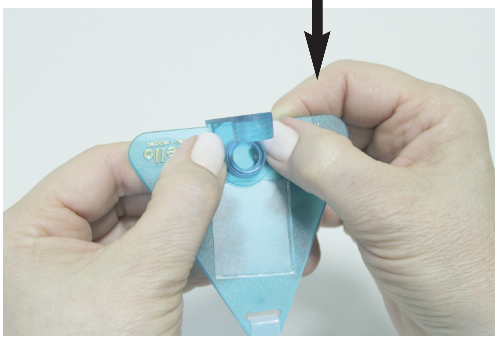
1. place the vertical adapter over the mounting point on the plate



IMPORTANT:
when mounting the diffusive body be careful to keep it vertical with the thread upside (see page A6).

2. press the adapter onto the plate with your thumbs till the ridge fits the edge of the plate.

The adapter can be removed from the plate by lifting the ridge



shelter

code RAD196

For outdoor exposures a mountable polypropylene shelter is available which can be hanged to lamp posts.

Available in 10 pieces per package only

It has been designed to be mounted easily and without any tool on field, so that it is not cumbersome when you transport it from your laboratory. Once assembled, it ensures the best compromise between protection against bad weather and ventilation.

It can house up to four *radiello* and is able to fit a wide range of pole diameters.

Its colour is quite similar to that of the majority of lampposts: being less visible, it is less subject to acts of vandalism.

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

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Il riparo è formato da:

how to assemble the shelter

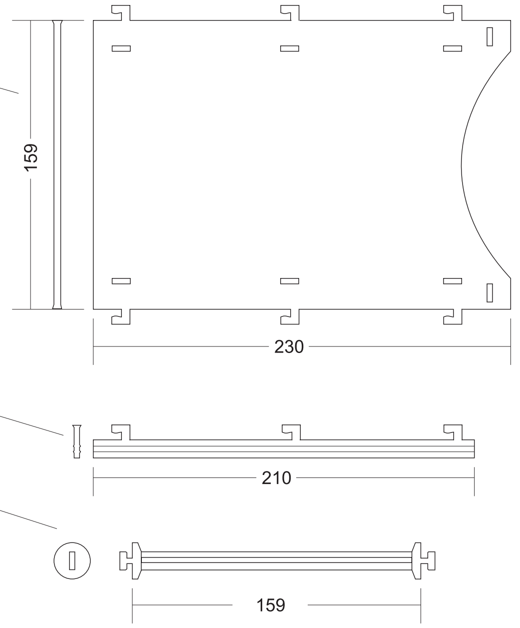
All of the components are snap-on assembled.

One of the three equivalent panels will act as the roof of the shelter (quotes are in mm)

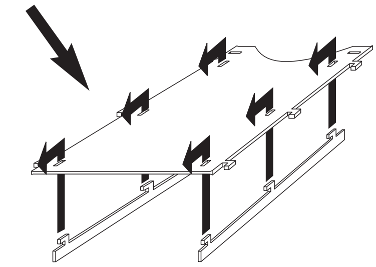
the two supports where to suspend *radiello*

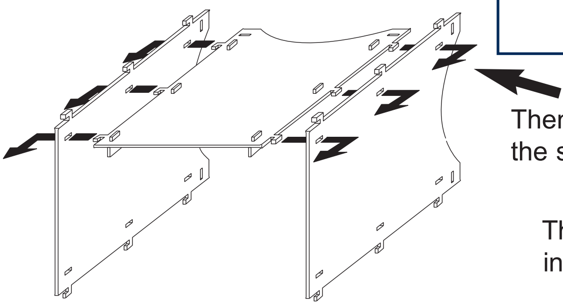
two spacers

two strips



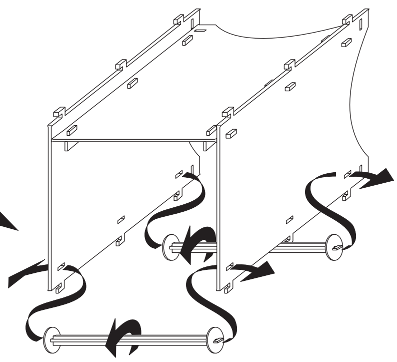
First of all, insert on this panel (the roof) the two supports that will be used to suspend the samplers.

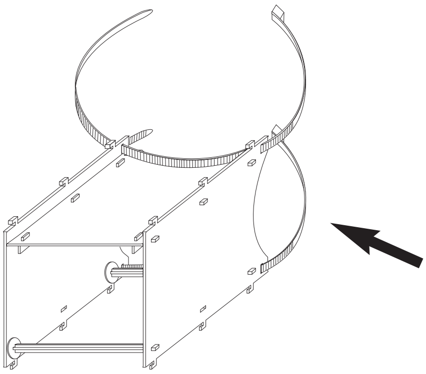




Then fix the two walls on the sides of the roof panel.

The whole becomes rigid by insertion of the two spacers. Fit them to the slots on bottom of the side panels and turn them by 90° (performing this rotation you may feel some resistance, but go on until you hear a clicking sound).





Finally, insert two plastic strips in the rear vertical slots of the side panels. The **strips** are also available as spare parts, in 100 pieces per package, identified by the **code RAD198**.

Suspend the shelter to the pole by closure of the strips, but ***DO NOT DRAW SO MUCH THAT THE SHELTER IS DEFORMED***. If the pole has diameter larger than 20 cm, the shelter leans on the curved edges on the rear of the sidewalls. If the pole has a smaller diameter, it leans against the curved edge of the roof panel and the rear spacer. If the diameter is very small the shelter bows down, the wind may make it go round, or the shelter may even slip down to ground. It is then advisable to choose another pole.

user tip

If the pole diameter is larger than the strip length, you can put two or more strips together to extend the fastening system.

If the sampling site is very windy, do not introduce more than two *radiello* samplers in each shelter, otherwise rain could dampen the outermost samplers.

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On-field temperature measurements

codes RAD126 and RAD127

Since the uptake rate values of *radiello* depend on temperature, the concentration values obtained will be more accurate if precise temperature measurements are performed during the sampling.

To get reliable temperature data you may ask the local weather station, if there is one, and if the measurements are performed nearby your sampling sites. Bear in mind that you should take into the account the urban heat island: did you know that there can be a difference of even 4-5 °C between the center and the suburbs of a big town?

With *radiello* you can create your own temperature measurement station.

thermometer code RAD126
Available in 3 pieces per package only

A **thermometer** with precision ± 0,5 °C between -20 and 80 °C and equipped with a data logger capable of recording 2048 data points has been fixed to a vertical adapter (**code RAD126**).

It is tiny enough (< 1 cm^3) to go perfectly unobserved.

It has no battery to replace, needs no maintenance and works properly even with bad weather conditions.

Its memory allows you to record one temperature value every 15 minutes for 22 days, or every 30 minutes for 43 days, or every 60 minutes for 85 days, or... it lasts ten years or a million readings!

The thermometer is fitted to the supporting plate of *radiello*: use the sampler normally and measure temperature and pollution at the same time.

reader code RAD127

A very simple **reader** (**code RAD127**), connected to your PC by a USB port, allows you to program the temperature sensor for the measurements on field, to download the aquired data and to perform data statistical and graphic processing by a very user-friendly software.

One reader serves an unlimited number of thermometers. The *SmartButton Reader Solution* software needed to program the thermometers and download the data can be purchased from the parent company's website at the link:

http://www.acrsystems.com

user tip

When performing urban monitoring install a thermometer every ten sampling sites. If this may help you, contact us to discuss sampling strategies.

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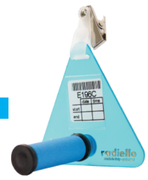
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it



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calibration solution for H_2S

code RAD171

Code RAD171 relieves you from the task of preparing the sodium sulfide standard solution for the calibration curve used for the determination of H_2S by the cartridge code RAD170 (see page H1).

Since sodium sulfide is deliquescent, its weight is not a primary standard and sodium sulfide solution need titration once prepared. Moreover, titration must be repeated often due to the instability of diluted solution (one hour time is sufficient to decrease sulfide content by 10%).

Code RAD171 is a methylene blue concentrated solution that, once diluted 1:50, provides the same absorbance value at 665 nm of a sodium sulfide solution of with concentration 1.145 $\mu g \cdot ml^{-1}$ sulfide ions.

This concentration value has been chosen to obtain the highest absorbance value within the linearity range of the spectrophotometer.

To obtain a complete calibration curve, just dilute the mother solution as shown in the table.

Solution	ml of	ml of water	equivalent to $\mu g \cdot ml^{-1}$ of $S^{=}$
A	2 di codice 171	98	1.145
B	25 di A	25	0.572
C	10 di A	40	0.229
D	5 di A	45	0.115

Code RAD171 allows you to prepare as many as 50 calibration curves.

Kept closed at room temperature, code RAD171 solution is stable for at least one year.

filtration kit

code RAD174

Code RAD174 filtration kit is composed by 20 single use plastic syringes and 20 single use micropore hydrophilic polypropylene filters with diameter 13 mm and 0.45 µm porosity.

Both filter and syringe are suited to filtration of aqueous solutions with pH in the range of 0 to 12 with commonplace eluents for ion chromatography and reverse phase HPLC.

calibration solutions for aldehydes

code RAD302

Calibration curves for aldehydes are obtained with standard solutions of the corresponding 2,4-dinitrophenylhydrazones (see page C1). Although their synthesis is straightforward, their purification is tricky and time-consuming. Code RAD302 offers a certified and convenient choice: a solution of nine 2,4-dinitrophenylhydrazones in a solvent compatible with HPLC eluents and with concentrations suitable for the preparation of calibration curves in the range usually spanned by *radiello* samples.

Code RAD302 is delivered as 10 ml of acetonitrile solutions of the nine 2,4-dinitrophenylhydrazones formed by the aldehydes listed in the table, contained in a pierceable-septum crimped cap vial. The listed concentration values are indicative, actual ones are certified for each lot.

Kept tightly capped in a dark place at 4 °C, the solution is stable for at least four months.

2,4-DNPH of	$\mu g \cdot ml^{-1}$ as aldehyde
formaldehyde	50
acetaldehyde	50
acrolein	10
propanal	50
butanal	50
isopentanal	50
pentanal	50
hexanal	50
benzaldehyde	50

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
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calibration solutions for BTEX

(CS_2 desorption)

code RAD405

Code RAD405 calibration kit has been conceived for the analysis of BTEX sampled in urban environments by the cartridge code RAD130 and chemically desorbed by carbon disulfide (see page D1).

The kit may be used both for routine calibration and for scheduled quality control of the calibration procedure described on page D4.

It is composed of 12 code RAD130 cartridges, three of which are blanks and nine, divided into three groups of three, preloaded with BTEX to simulate 7 days exposures (10,080 minutes) to the concentrations listed in the table. The values shown are indicative, actual ones are certified for each lot.

The mass of each analyte deposited onto the cartridge spans the whole range of concentrations usually found in urban environments, extreme values included.

BTEX loading is performed by injection of precisely known amounts of vaporized standard solutions in CS_2 of the five compounds under nitrogen flow.

Kept at 4 °C, the cartridges are stable for at least four months.

code RAD405	simulated concentrations in $\mu g \cdot m^{-3}$ (7 days exposure equivalent)		
	Group 1	Group 2	Group 3
benzene	1	10	50
toluene	2	20	100
ethylbenzene	1	10	50
m-xylene	1	10	50
p-xylene	1	10	50
o-xylene	1	10	50

calibration solutions for VOCs in workplace environments

code RAD406

The code RAD406 kit has been conceived for scheduled quality control of the calibration procedure for the analysis of volatile organic compounds (VOCs) sampled by code RAD130 cartridges in workplace environments (see page D4).

It is composed of 12 code RAD130 cartridges, three of which are blanks and nine, divided into three groups of three, preloaded with VOCs to simulate 8 hours exposures (480 minutes) to the concentrations listed in the table. The values shown are indicative, actual ones are certified for each lot.

The composition of the mixture is simple but it includes compounds with different polarity. The loaded mass is calculated in order to represent exposures to 0.5, 1 and 2 times the TLV value for the mixture.

code RAD406	simulated concentrations in $mg \cdot m^{-3}$ (8 hours exposure equivalent)		
	Group 1	Group 2	Group 3
benzene	0.1	0.2	0.4
toluene	19	38	76
ethylbenzene	12	24	48
m-xylene	12	24	48
p-xylene	12	24	48
o-xylene	12	24	48
butanol	15	30	60
2-etoxyiethyl acetate	2.5	5	10

VOCs loading is performed by injection of precisely known amounts of calibrated mixtures of the eight compounds under nitrogen flow.

Kept at 4 °C, the cartridges are stable for at least four months.

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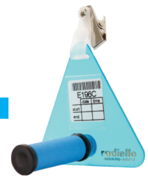

calibration solutions for BTEX
(thermal desorption)

code RAD407	simulated concentrations in µg·m^{-3} (7 days exposure equivalent)		
	Group 1	Group 2	Group 3
benzene	1	5	25
toluene	2	10	50
ethylbenzene	1	5	25
m-xylene	1	5	25
p-xylene	1	5	25
o-xylene	1	5	25

code RAD407

Code RAD407 calibration kit has been conceived for the analysis of BTEX sampled in urban environments by the cartridge code RAD145 and thermally desorbed (see VOCs - thermal desorption).

The kit may be used both for routine calibration and for scheduled quality control of the calibration procedure described on page E5. It is composed of 12 code RAD145 cartridges, three of which are blanks and nine, divided into three groups of three, preloaded with BTEX to simulate 7 days exposures (10,080 minutes) to the concentrations listed in the table.

The values shown are indicative, actual ones are certified for each lot.

BTEX loading is performed by injection of precisely known amounts of vaporized standard solutions in methanol of the five compounds under nitrogen flow. During the analysis the chromatographic peak of methanol will be visible. Kept at 4 °C, the cartridges are stable for at least four months.

the spare parts

Barcode adhesive label
Codice RAD190
Available in 198 pieces per package only

Clips
Code RAD195
Available in 20 pieces per package only.

Strip
Code RAD198
Useful for repositioning of *radiello* shelter.
Lenght 75 cm.
Available in 100 pieces per package only.

Tubes
Available in 20 pieces per package only.

code RAD1991
glass tube, working volume 2.8 ml

code RAD1992
polypropylene tube, working volume 12 ml

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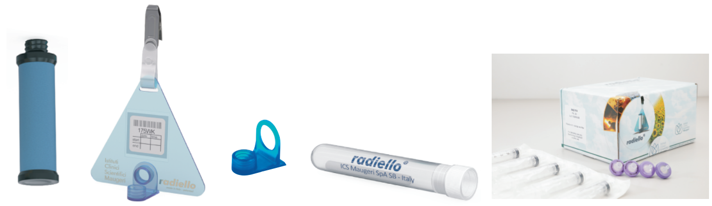
Aldehydes

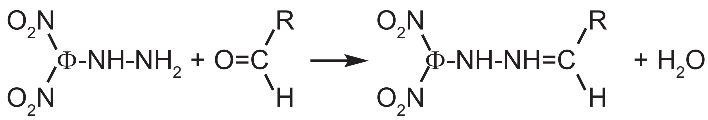
what you need

blue diffusive body code RAD1201
supporting plate code RAD121
vertical adapter code RAD122 (optional)
chemiadsorbing cartridge code RAD165
filtration kit code RAD174 (only for analysis)



Principle

Code RAD165 is a stainless steel net cartridge filled with 2,4-dinitrophenylhydrazine (2,4-DNPH) coated Florisil®. Aldehydes react with 2,4-DNPH to give the corresponding 2,4-dinitrophenylhydrazones



2,4-DNPH aldehyde 2,4-DNPhydrazone

The 2,4-dinitrophenylhydrazones are then extracted with acetronitrile and analyzed by reverse phase HPLC and UV detection.

Sampling rates

Sampling rates values at 298 K (25 °C) and 1013 hPa are listed below:

	sampling rate $ml \cdot min^{-1}$	linearity range $\mu g \cdot m^{-3} \cdot min$	limit of quantitation[1] $\mu g \cdot m^{-3}$	uncertainty at 2σ %
acetaldehyde	84	1,000÷12,000,000	0.1	15.9
acrolein	33	3,000÷3,000,000	0.3	16.5
benzaldehyde	92	1,000÷8,000,000	0.1	17.2
butanal	11	9,000÷10,000,000	0.9	23.5
hexanal	18	5,000÷15,000,000	0.6	20.2
formaldehyde	99	1,000÷4,000,000	0.1	13.8
glutaric aldehyde	90	1,000÷3,000,000	0.1	14.5
isopentanal	61	1,500÷12,000,000	0.2	17.0
pentanal	27	4,000÷12,000,000	0.4	22.9
propanal	39	3,000÷8,000,000	0.3	17.1

[1]after 7 days exposure

Effect of temperature, humidity and wind speed

Sampling rate varies from the value at 298 K on the effect of temperature (in Kelvin) as expressed by the following equation:

$$Q_K = Q_{298}\left(\frac{K}{298}\right)^{0.35}$$

where Q_K is the sampling rate at the temperature K and Q_{298} is the reference value at 298 K. This produces a variation of ± 1% for 10 °C variation (upwards or downwards) from 25 °C.

Sampling rate is invariant with humidity in the range 15-90% and with wind speed between 0.1 and 10 $m \cdot s^{-1}$.

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
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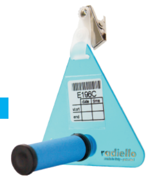


Calculations

The average concentration C over the whole sampling time (in µg·m^{-3}) is calculated according to the expression:

$$C\ [\mu g \cdot m^{-3}] = \frac{m\ [\mu g]}{Q\ [ml \cdot min^{-1}] \cdot t\ [min]}\ 1{,}000{,}000$$

where:
m = mass of aldehyde in µg
t = exposure time in minutes

Exposure

The optimum exposure duration varies with the expected concentration. Taking formaldehyde as an example, concentration values of 5-30 µg·m^{-3} are usually found in outdoor urban measurements while 20-200 µg·m^{-3} are expected in workplace environments. In workplace environments concentrations may be as high as 2,000-3,000 µg·m^{-3} for short time intervals: it can therefore be interesting to evaluate the peak value (usually referred to by *STEL*). The corresponding advised exposure time is shown in the table below:

Advised exposure times

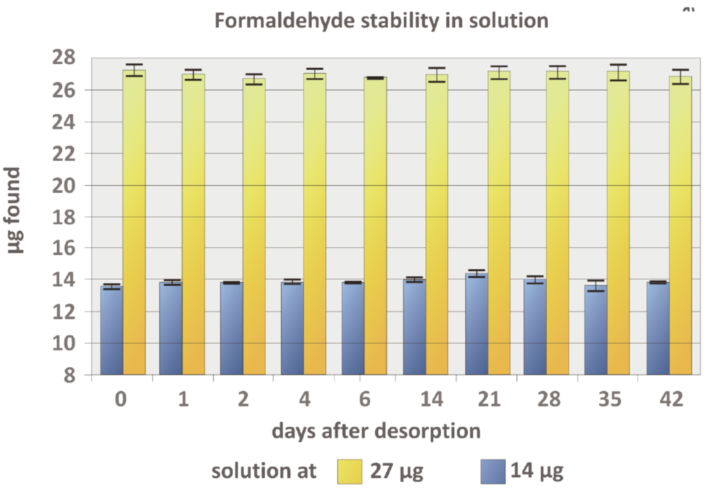
	outdoor environment	indoor environment	workplace environment average conc.	workplace environment peak conc.
minimum	8 h	8 h	2 h	15 minutes
maximum	7 days	7 days	8 h	1 h

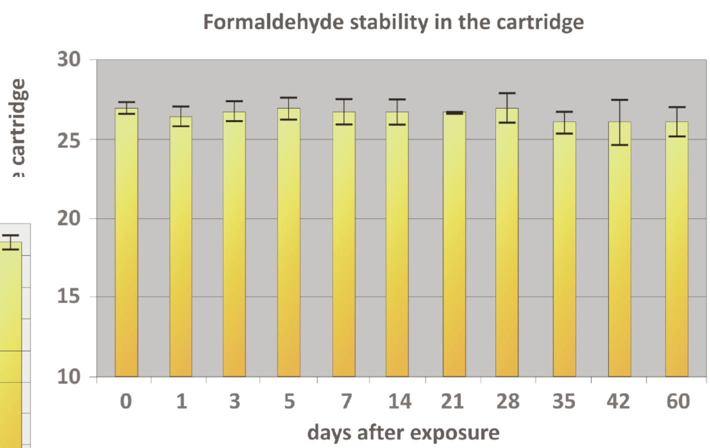
Do not expose all of the cartridges belonging to the same lot: keep at least two cartridges as blanks.

Storage

The cartridges need to be kept, properly sealed, in a dark place at 4 °C for ensuring a shelf life (according to EN 13528-2) of six months. If stored at ≤ -18 °C, the shelf life will be twelve months. Each lot is approved for use when the blank value of formaldehyde and acetaldehyde are less than 0.1 µg and 0.3 µg per cartridge, respectively, corresponding to a concentration in air less than 0.1 and 0.25 µg·m^{-3} over one week of exposure, respectively. The blank value may increase with time.

After exposure keep the cartridges well capped at 4 °C,





Formaldehyde stability in the cartridge after the sampling (on top) and in solution (left). The stability tests were performed upon cartridges exposed for one week in a standard atmosphere chamber at 25 °C and with 50% relative humidity and at two different concentration levels. Each bar in the plot represents the average and error from the analysis of six samples.

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they are stable for 60 days. After solvent desorption (see *Analysis*) discard the cartridge. The resulting solution, well capped and stored at 4 °C, is stable for at least 42 days.

Analysis

Desorption

Materials

- HPLC grade acetonitrile
- class A volumetric pipette, capacity 2 ml
- micropore filter membranes, porosity 0.45 μm, solvent resistant

Procedure

Introduce 2 ml acetonitrile directly in the cartridge tube, recap and stir from time to time for 30 minutes. Discard the cartridge. Filter the resulting solution and keep it well capped until analysis time. If analysis has to be delayed, store the solution at 4 °C.

user tip

For a reliable and rapid filtration employ the filtration kit **code RAD174**.

To obtain an accurate calibration curve we offer you the calibration solution **code RAD302**.

Instrumental analysis

The method suggested below is only indicative; the analyst can choose an alternative method, on the basis of its personal experience.

IMPORTANT: verify the presence and the abundance of the 2,4-DNPH chromatographic peak: otherwise, the cartridge could be saturated.

Materials

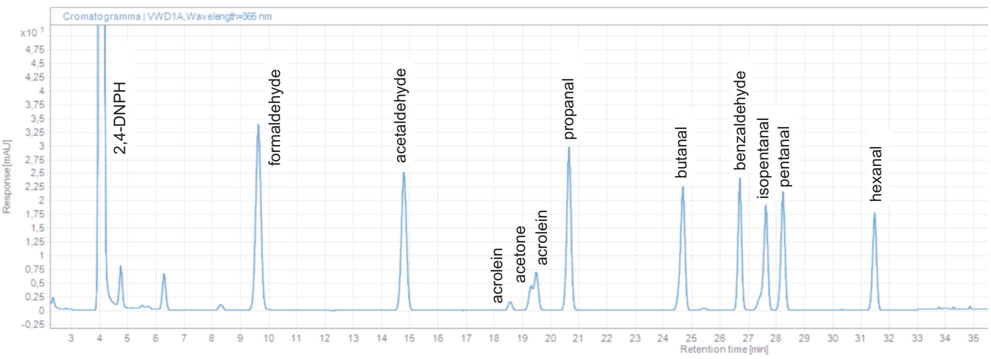
- reverse phase C_{18} HPLC column, length 150 mm, 4.6 mm diameter, 5 μm packing particle size
- HPLC apparatus capable of elution gradient and UV detection

Procedure

Set the detector at the wavelength of 365 nm. Inject between 10 and 50 μl of solution and elute as follow:

- flow: 1.9 ml·min^{-1}
- Isocratic elution with water/acetonitrile 63:37 v/v for 10 minutes, up to water/acetonitrile 31:69 v/v in 20 minutes, isocratic elution with water/acetonitrile 0:100 v/v in 5 minutes, isocratic elution with water/acetonitrile 63:37 v/v in 15 minutes.

On the right: the chromatogram of a real sample analyzed under the described conditions.



HPLC chromatogram of aldehydes sampled by ***radiello***

IMPORTANT:

Acrolein gives place to three chromatographic peaks, two of them are unresolved. Calculate the concentration basing onto this most abundant peak and ignore the others.

Isopentanal appears as two unresolved peaks: its concentration should be obtained by integration of both peaks as a sum.

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user tip

If you perform several analyses, a barcode reader will greatly improve productivity in your laboratory and will also minimize the possibility of errors in the copying of sample labels.

Please contact us to help you in the implementation of the reader.

Interferences

Other carbonyl compounds

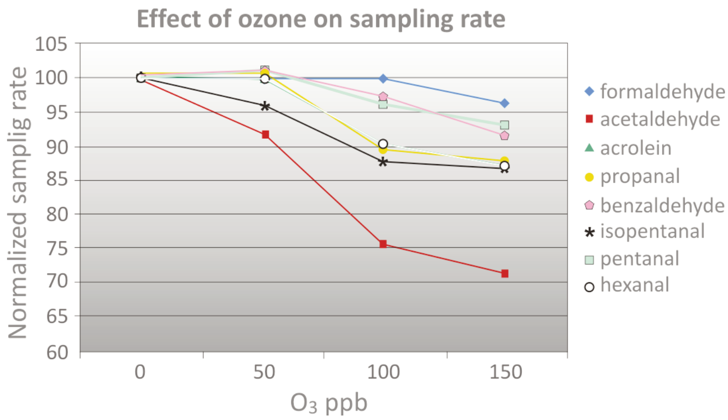
All carbonyl compounds, ketones included, react with 2,4-DNPH but do not interfere in the analysis if proper chromatographic parameters are selected.

In the described chromatographic conditions acetone-2,4-DNPH peak is well resolved from acrolein-2,4-DNPH. Neverthless, if acetone concentration is higher than 50,000 µg·m^{-3}, acrolein-2,4-DNPH peak intensity is depressed by 25%.

Ozone

Examples of ozonolysis of dinitrophenylhydrazones on active supporting materials as silica gel are found in the literature.

On code RAD165 cartridge, packed with coated Florisil®, ozonolysis is much less important than on any other commercial aldehyde sampling device, either diffusive or pumped, and becomes appreciable only if ozone concentration, averaged over the whole exposure time interval, is higher than 100 ppb. Since this is not usually the case, generally no correction is needed to take into account ozone concentration. If there is firm evidence that ozone concentration is equal or higher than 100 ppb over the whole exposure time, make use of the corrected sampling rate values shown in the table below, where $[O_3]$ is ozone concentration in ppb.



Sampling rate as a function of ozone concentration normalized to 100 for $[O_3]$ equal to zero. Apart from acetaldehyde, ozone effect becomes relevant only at concentration levels higher than 100 ppb as an average over the whole exposure time interval.

The listed values are referred to the temperature of 298 K (25 °C), for deviations larger than ± 10 °C substitute the base value (e.g. 99 ml·min^{-1} for formaldehyde) with the corrected value calculated according to equation on page C1.

No experimental data is available for butanal and glutaric aldehyde.

	corrected sampling rate ml·min^{-1}
acetaldehyde	$84-0.018[O_3]$*
acrolein	$33-0.027[O_3]$
benzaldehyde	$92-0.05[O_3]$
hexanal	$18-0.02[O_3]$
formaldehyde	$99-0.02[O_3]$
isopentanal	$61-0.06[O_3]$
pentanal	$27-0.01[O_3]$
propanal	$39-0.03[O_3]$

*apply for ozone concentration higher than 50 ppb

Sampling rate for ozone concentration $[O_3]$ in ppb (apply only if $[O_3]$ >100 ppb)

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Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

Edition 01/2019

Volatile organic compounds (VOCs)

chemically desorbed with CS_2

what you need

white diffusive body code RAD120
supporting plate code RAD121
vertical adapter code RAD122 (optional)
chemiadsorbing cartridge code RAD130

Or: radiello-ready-to-use code RAD1231

Principle

Code RAD130 cartridge is a stainless steel net cylinder, with 100 mesh grid opening and 5.8 mm diameter, packed with 530 ± 30 mg of activated charcoal, particle size is 35-50 mesh. Volatile organic compounds are trapped by adsorption and recovered by carbon disulfide displacementl, analysis is performed by FID gas chromatography.

Sampling rates

The table on pages D2 and D3 lists sampling rate values at 298 K (25 °C) and 1013 hPa, experimentally measured in a standard atmosphere chamber. For other compounds whose diffusion coefficient[1] is known sampling rate can be calculated according to equation [5] on page A2, taking into account that white diffusive body and code RAD130 cartridge give the geometric constant of radiello the value of 14.145 ± 0.110 cm. Several experiments performed in the standard atmosphere chamber demonstrate that the calculated sampling rates seldom deviate by more than ±10% from the experimentally measured values.

Effect of temperature, humidity and wind speed

Sampling rates varies from the value at 298 K on the effect of temperature (in Kelvin) as expressed by the following equation:

$$Q_K = Q_{298}\left(\frac{K}{298}\right)^{1.5}$$

where $\mathbf{Q_K}$ is the sampling rate at the temperature K and $\mathbf{Q_{298}}$ is the reference value at 298 K. This produces a variation of ±5% for 10 °C variation (upwards or downwards) from 25 °C.
Sampling rate is invariant with humidity in the range 15 ÷ 90% and with wind speed between 0.1 and 10 $m\cdot s^{-1}$.

[1]Lugg G.A.: Diffusion Coefficients of Some Organic and Other Vapors in Air. *Anal. Chem.* **40-7**:1072-1077 (1968).

Calculations

The listed sampling rate values already take into account for the desorption efficiency with carbon disulfide. The average concentration over the exposure time interval is therefore calculated from the mass of analyte found onto the cartridge and exposure time without introducing any corrective factor, apart from corrections due to average temperature different from 25 °C.

Average concentration (in $\mu g\cdot m^{-3}$) over the whole exposure time is calculated according to the following expression:

$$C\,[\mu g\cdot m^{-3}] = \frac{m\,[\mu g]}{Q_K\,[ml\cdot min^{-1}]\cdot t\,[min]}\;1{,}000{,}000$$

where:
m = mass of analyte in µg
t = exposure time in minutes

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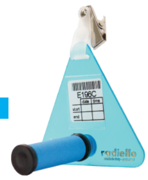

Sampling rate values at 25°C (298 K)

	sampling rate ml·min^{-1}	linearity range µg·m^{-3}·min	uncertainty at 2σ %	notes
acetone	77	10,000-600·10^6	7.0	a
acetonitrile	73	10,000-6·10^6	8.2	b
acrylonitrile	75	1,000-50·10^6	2.2	
benzyl alcohol	37	1,000-800·10^6	6.5	
amyl acetate	52	1,000-800·10^6	3.4	
benzene	80	500-500·10^6	1.8	
bromochloromethane	70	50,000-1,000·10^6	1.4	
butanol	74	1,000-500·10^6	5.0	
sec-butanol	64	1,000-300·10^6	5.2	
tert-butanol	62	1,000-300·10^6	5.5	
butyl acetate	60	1,000-1,000·10^6	3.0	
2-butoxyethanol	56	1,000-100·10^6	5.7	
2-butoxyethyl acetate	41	1,000-100·10^6	5.5	
carbon tetrachloride	67	100,000-60·10^6	9.0	
cyclohexane	54	500-500·10^6	4.5	
cyclohexanone	68	5,000-120·10^6	4.2	
cyclohexanol	54	5,000-120·10^6	4.5	
chlorobenzene	68	1,000-1,000·10^6	3.6	
chloroform	75	100,000-60·10^6	9.7	a
n-decane	43	500-1,000·10^6	1.1	
diaceton alcohol	43	500-1,000·10^6	4.5	
1,4-dichlorobenzene	51	1,000-1,000·10^6	7.7	
1,2-dichloroethane	77	1,000-500·10^6	8.2	
1,2-dichloropropane	66	500-250·10^6	4.5	
dichloromethane	90	500-60·10^6	8.7	
N,N-dimetylformamide	82	1,000-200·10^6	14.5	c
1,4-dioxane	68	1,000-600·10^6	5.5	
n-dodecane	8	1,000-1,000·10^6	4.7	
n-heptane	58	5,000-1,500·10^6	3.0	
n-hexane	66	1,000-1,000·10^6	2.5	
1-hexanol	52	5,000-120·10^6	5.5	
ethanol	102	10,000-500·10^6	7.5	a-b
diethyl ether	78	5,000-500·10^6	12.0	a
ethyl acetate	78	1,000-1,000·10^6	1.5	
ethylbenzene	68	1,000-1,000·10^6	2.4	
2-ethyl-1-hexanol	43	5,000-500·10^6	10.1	
2-ethoxyethanol	55	500-50·10^6	6.7	b
2-ethoxyethyl acetate	54	10,000-100·10^6	2.5	
ethyl-*tert*-butyl ether (ETBE)	61	500-200·10^6	3.0	
isobutanol	77	1,000-300·10^6	2.5	
isobutyl acetate	63	1,000-1,000·10^6	5.2	
isooctane	55	500-1,000·10^6	3.2	
isopropanol	52	10,000-400·10^6	12.0	b
isopropyl acetate	66	1,000-1,000·10^6	9.9	
isopropylbenzene	58	1,000-1,000·10^6	2.7	
limonene	43	1,000-1,000·10^6	10.0	
methanol	125	10,000-250·10^6	9.2	a-b
methyl acetate	80	1,000-1,000·10^6	12.0	
methyl-*ter*-butyl ether (MTBE)	65	500-200·10^6	2.5	

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	sampling rate ml·min^{-1}	linearity range μg·m^{-3}·min	uncertainty at 2σ %	notes
methylcyclohexane	66	1,000-1,000·10^6	6.5	
methylcyclopentane	70	1,000-1,000·10^6	2.5	
methylethylketone	79	1,000-500·10^6	1.6	
methylisobutylketone	67	1,000-250·10^6	8.7	
methyl metacrylate	68	1,000-500·10^6	2.5	
2-methylpentane	70	1,000-1,000·10^6	2.5	
3-methylpentane	70	1,000-1,000·10^6	2.5	
2-methoxyethanol	35	5,000-100·10^6	11.0	**b**
2-methoxyethyl acetate	56	2,000-100·10^6	3.0	
1-methoxy-2-propanol	55	1,000-350·10^6	6.0	
1-methoxy-2-propyl acetate	60	2,000-350·10^6	6.2	
naphtalene	25	1,000-1,000·10^6	7.0	
n-nonane	48	1,000-1,000·10^6	5.4	
n-octane	53	500-1,000·10^6	3.2	
pentane	74	1,000-1,000·10^6	1.9	
α-pinene	53	1,000-1,000·10^6	7.0	
propyl acetate	65	500-1,000·10^6	7.5	
propylbenzene	57	1,000-1,000·10^6	2.9	
styrene	61	1,000-500·10^6	3.0	
tetrachloroethylene	59	10,000-500·10^6	2.5	
tetrahydrofuran	74	2,000-250·10^6	11.0	**b**
toluene	74	500-1,000·10^6	1.5	
1,1,1-trichloroethane	62	5,000-1,000·10^6	5.5	
trichloroethylene	69	5,000-1,000·10^6	2.4	
1,2,4-trimethylbenzene	50	500-1,000·10^6	6.6	
n-undecane	24	1,000-1,000·10^6	10.0	
m-xylene	70	500-1,000·10^6	2.5	
o-xylene	65	500-1,000·10^6	2.5	
p-xylene	70	500-1,000·10^6	2.5	

Notes:

a = weakly adsorbed compound. If its concentration is higher than the TLV for the workplace environments it may be partially displaced by other compounds that are more strongly trapped if their concentration is also high. If this is the case, it is advisable to reduce sampling time under 8 hours.

b = prolonged exposure of charcoal cartridges at relative average humidity higher than 80% causes adsorption of up to 100 mg of water. Water does not interfere with adsorption mechanisms but is displaced by carbon disulfide and gives raise to a separate layer. Some very water soluble polar compounds will distribute between the two solvents, thus provoking an underestimation of the actual air concentration since only the carbon disulfide is injected in the gas chromatograph. When the concentration of polar compounds has to be determined, the calibration curve should be prepared by spiking 50 μl of water in each tube containing the cartridge and the 2 ml of carbon disulfide standard solution (see Analysis).

c = better reproducibility obtained by use of methanol as extraction solvent instead of carbon disulfide.

Limit of quantitation

The limit of quantitation depends on the instrumentation and on the analytical conditions. The minimum revealable environmental concentration can be estimated on the basis of the equation on chapter Calculations, where m is the minimum revealable mass, experimentally measured for each compound. Under the analytical conditions described on the following chapter Analysis, the limit of quantitation for 7 days exposure usually ranges from 0.05 and 1 μg·m^{-3}, depending on the compound.

In any case, the limit of quantitation can never be lower than the inferior limit of the linearity range indicated in the previous table.

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Exposure

Code RAD130 cartridge has a very large loading capacity: about 80 mg, corresponding to an overall VOCs concentration of 3,000 - 3,500 mg·m^{-3} sampled for 8 hours or 70,000 - 80,000 µg·m^{-3} sampled for 14 days. Neverthless, if the quantified overall adsorbed mass should be near 80 mg, sampling rate could have deviated from linearity. If this is the case, it is advisable to repeat the sampling experiment reducing exposure time.

Workplace environment

In workplace environments complex mixtures of airborne solvent vapours are often found at concentrations 2,000-3,000 mg·m^{-3}. The outstanding adsorbing capacity of code RAD130 cartridges allows you to sample them for the whole working shift of 8 hours. On the other hand, the very high values of sampling rates for a variety of compounds allow you to perform accurate concentration measurements even after very short exposures. For example, 15 minutes are enough to measure 0.1 mg·m^{-3} of benzene.

radiello can therefore be employed to evaluate both **TWA** and **STEL** concentrations.

Other indoor sampling experiments and outdoor campaigns

High sampling rates of radiello ensure very low limits of detection also for short exposure time intervals. For example, you may measure benzene concentrations as low as 2 µg·m^{-3} with an error not exceeding 4% after 8 hours of exposure. If radiello is exposed for 7 days, limit of quantitation becomes 0.1 µg·m^{-3}.

Generally speaking, we suggest exposure time duration ranging from 8 hours to 30 days, the ideal value being 7 days.

Storage

The activated charcoal cartridges have undergone a complex conditioning process that ensures an outstanding chromatographic blank level, never exceeding three times the instrumental noise of a FID detector at the lowest attenuation.

Kept in a cool place and away from volatile organic compounds, the cartridges mantain unchanging blank level and adsorbing capacity for at least two years. Expiry day and lot number are printed onto the plastic bag wrapping each cartridge: its integrity stands as warranty seal.

After exposure the cartridges, well capped and kept in a cool and solvent-free place, maintain their content unaltered for at least six months

Analysis

Extraction

Introduce 2 ml of CS_2 and 100 µl of internal standard solution (see next) directly in the radiello glass tube without drawing out the cartridge. <u>Always use class A volumetric pipettes or dispensers</u>. Stir from time to time for 30 minutes. If analysis is not performed soon after, draw out the cartridge and discard it.

IMPORTANT:
always use high purity grade CS_2.

BE CAREFUL

even refrigerated, CS_2 permeates the tube plastic cap: its volume decreases by 4-5% a day. If the internal standard has been added, it is only matter of unpleasant odour...

Calibration

outdoor environment sampling

If benzene, toluene, ethylbenzene and xylenes (BTEX) have to be analyzed, prepare three or four standard solutions in CS_2 having decreasing concentrations of the analytes in the following ranges (in mg·l^{-1}):

benzene	0.04 ÷ 17.6	ethylbenzene	0.04 ÷ 17.7
toluene	0.09 ÷ 34.8	m-xylene	0.04 ÷ 17.2
o-xylene	0.04 ÷ 17.6	p-xylene	0.04 ÷ 17.2

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Analysis of unknown samples

Identify the sample that has been exposed for the longest time or at the highest expected concentration. Introduce 2 ml of CS_2 but do not add the internal standard, stir and let the sample stand for 30 minutes. Without discarding the cartridge, inject the CS_2 solution in the gas chromatograph with FID detector (see below), identify the compounds appearing in the chromatogram and make an estimation of the order of magnitude of their concentrations.

user tip

For a very accurate calibration we offer the preloaded cartridges code RAD405 (outdoor environment) and code RAD406 (workplace environment).

Prepare a CS_2 solution of the identified compounds with doubled concentration with respect to the sample. Dilute this solution in order to obtain standard solutions of concentration respectively about 0.1, 0.5 and 1 times the concentration estimated in the sample. Introduce 2 ml of each standard solution onto a blank code RAD130 cartridge in its glass tube, along with the chosen internal standard solution.

The chosen **internal standard** should have a retention time that does not cause interference with other compounds in the chromatogram. Compatibly with this requirements, we suggest to employ a solution of 2-fluorotoluene in CS_2 with concentration of 100 $\mu l \cdot l^{-1}$ for outdoor samples and 2 $ml \cdot l^{-1}$ for workplace samples.

Add 2 ml of CS_2 and the internal standard to all of the samples, stir, let the samples stand for 30 minutes and discard the cartridges prior to the analysis.

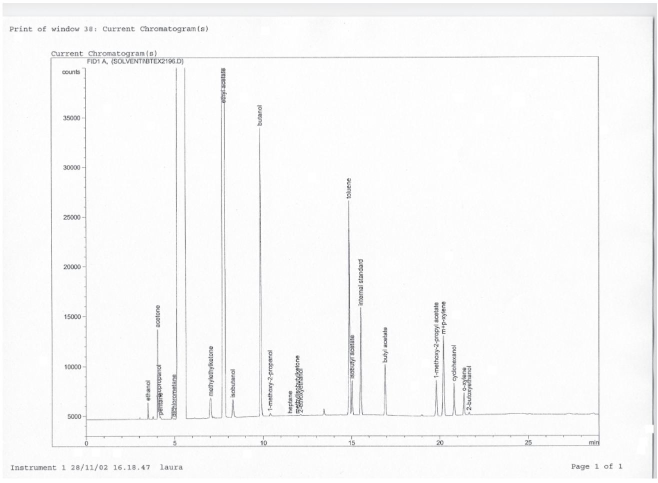
Instrumental analysis (advised)

Capillary gas chromatography with FID detection

outdoor environment samples: 100% dimethylpolysiloxane column 0.2 mm·50 m, film thickness 0.5 µm; split injection of 2 µl; split ratio 25:1; nitrogen carrier gas at constant pressure of 20 psi; injector temperature 240 °C; oven initial temperature 35 °C for 5 minutes, 5 $°C \cdot min^{-1}$ up to 90 °C, maintain for 3 minutes, 10 $°C \cdot min^{-1}$ up to 220 °C, final isotherm for 5 minutes.

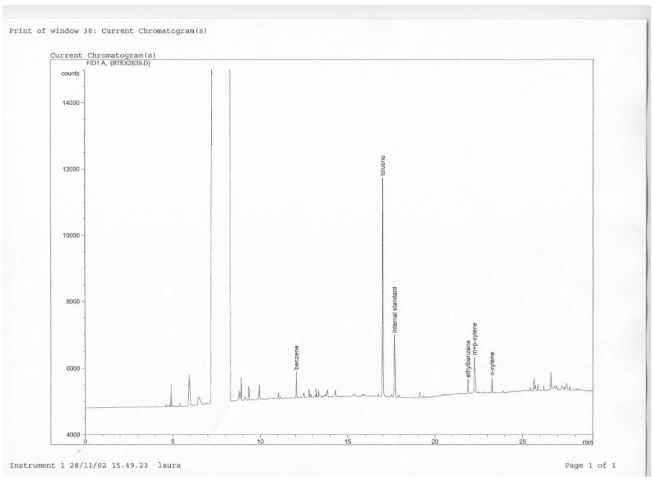
workplace samples: 100% dimethylpolysiloxane column 0.2 mm·50 m, film 0.5 µm; split injection of 3 µl, split ratio 100:1; carrier N_2 at constant pressure of 20 psi; injector temperature 240 °C; oven initial temperature 50 °C for 5 minutes, 5 $°C \cdot min^{-1}$ up to 80 °C, 15 $°C \cdot min^{-1}$ up to 135 °C, 20 $°C \cdot min^{-1}$ up to 220 °C, final isotherm 10 minutes. Total time: 29 minutes.

The retention times for several compounds analyzed under the described conditions are listed in the table on next page.



On top: *FID chromatogram of a real workplace sample*

on the left: *chromatogram of a real urban outdoor sample*



USER TIP

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Please contact us to help you in the implementation of the reader.

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
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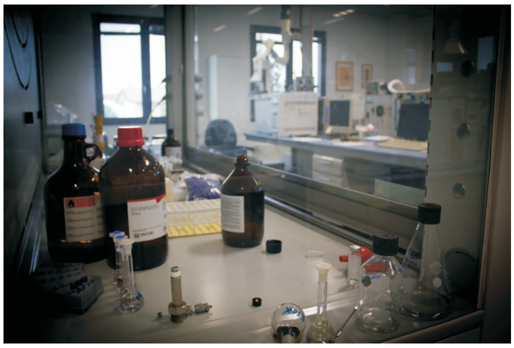
What make the code 130 cartridge incomparable?

	retention time (minutes)
methanol	4.834
ethanol	5.340
acetone	5.712
isopropanol	5.835
pentane	6.121
methyl acetate	6.346
dichloromethane	6.405
2-methylpentane	7.559
methylethylketone	7.719
3-methylpentane	7.941
ethyl acetate	8.331
n-hexane	8.402
isobutanol	8.763
methylcyclopentane	9.350
1,1,1-trichloroethane	9.636
butanol	9.956
isopropyl acetate	9.978
benzene	10.203
1-methoxy-2-propanol	10.424
cyclohexane	10.580
1,2-dichloropropane	11.285
trichloroethylene	11.625
isooctane	11.667
2-ethoxyethanol	11.831
propyl acetate	11.868
n-heptane	12.068
1-ethoxy-2-propanol	12.775
methylcyclohexane	12.912
methylisobutylketone	13.258
isobutyl acetate	14.005
toluene	14.055
butyl acetate	15.279
n-octane	15.435
tetrachloroethylene	15.601
diaceton alcohol	15.915
1-methoxy-2-propyl acetate	16.609
ethylbenzene	16.997
m+p-xylene	17.241
cyclohexanone	17.436
cyclohexanol	17.436
styrene	17.716
o-xylene	17.832
2-buthoxyethanol	17.880
n-nonane	18.186
α-pinene	19.129
n-decane	20.334
n-undecane	22.142

the container

The container is realised by stainless steel cloth AISI 316 with 100 mesh opening. It is electric welded with no supply of foreign materials. It has tolerance of ±0.05 mm diameter and of ±0.1 mm length.

the contents



The cartridge is packed with vegetal activated charcoal with a very large adsorbing surface. Its exceptionally low blank is obtained by conditioning it in a nitrogen stream fluidised bed at 450 °C for 16 hours.

The fluidised bed technique does not only guarantee the thorough purification of adsorbing material but also performs an accurate selection of its granulometry, by ventilation separations of the fraction under 50 mesh and over 35 mesh.

the production

The cartridge is filled up with charcoal by a very complex automated apparatus that was designed and realised in our laboratory. It avoids any contamination of the adsorbing material during the delicate process of cartridge production and ensures a very accurate dosing of the material itself, providing a variability of less than 2% of the weight of the activated charcoal among the cartridges.

the quality controls

Each cartridge batch undergoes statistical quality control of the blank level. If amounts higher than 20 ng of each of the BTEX compounds are found, the entire lot is discarded.

sampling rate measurements

The sampling rate is measured in a standard atmosphere chamber unique in Italy and one of the few found all over Europe.

It allows the dynamic generation of high flows of controlled concentration gas mixtures from 1 $\mu g \cdot m^{-3}$ to 1,000 $mg \cdot m^{-3}$ (dynamic range from 1 to 106) of each investigated compound alone or mixed with others. The chamber allows temperature control from -20 to 60 °C, relative humidity control from 5% to 100% and air speed variation from 0.1 to 10 $m \cdot s^{-1}$.

All of the gas flows are measured as mass flows and have therefore the properties of primary standards. All of the operating parameters (gas flows, temperature, relative humidity, ...) are recorded and the records are available along with the certification documents.

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

Edition 01/2019

Volatile organic compounds (VOCs)

thermally desorbed

what you need

yellow diffusive body code RAD1202
supporting plate code RAD121
vertical adapter code RAD122 (optional)
chemiadsorbing cartridge code RAD145

Principle

Code RAD145 is a stainless steel net cylinder, with 3x8 µm mesh opening and 4.8 mm diameter, packed with 350 ± 10 mg of graphitised charcoal (Carbograph 4), particle size is 35-50 mesh.

Volatile organic compounds are trapped by adsorption and recovered by thermal desorption, analysis is performed by capillary gas chromatography and FID or MS detection.

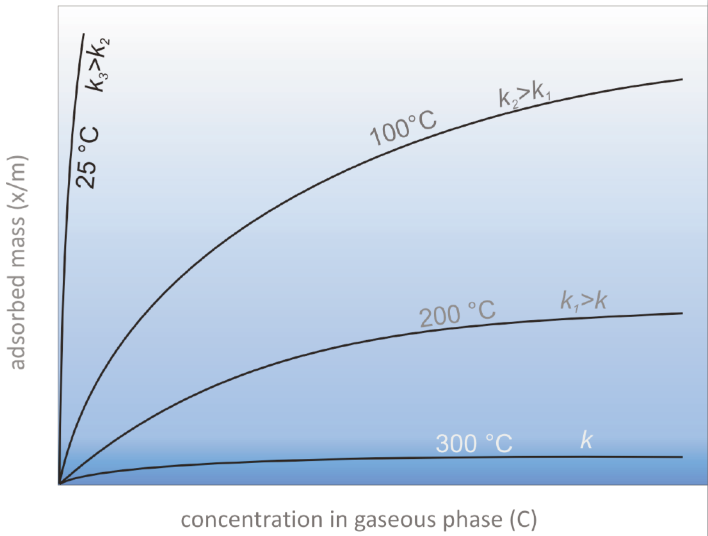
General considerations

Thermal desorption is an easy-to-use technique, but it implies some precautions and is of less general use than chemical desorption.

The recovery of adsorbed compounds is based onto the different shape of adsorption isotherms at different temperatures. Since quantitative desorption of trapped molecules should ideally be accomplished at moderate temperatures, only weak adsorbing media are employed, with active adsorbing surface between 10 and 50 times smaller than that of activated charcoal.

Use of thermal desorption requires therefore an accurate preliminary investigation about the adsorbed compound - adsorbing medium pair. Stronger adsorbents are suitable for very volatile compounds, but will yield only partial desorption of heavier compounds.

Anyway, *backdiffusion* is always lying in wait: due to the adsorbing medium weakness heavier compounds will eventually displace the more volatile ones. Once you have made an accurate choice of the adsorbing material, therefore, you should bear in mind that a real atmosphere is composed by a variety of compounds apart from those you are analyzing at unpredictable concentrations. As a consequence, sampling times can not be as long as those allowed by activated charcoal, otherwise lighter compounds will be lost. With the purpose of allowing reasonable sampling times (up to two weeks) the sampling rate has been dramatically reduced by changing the diffusive body from the white type (code RAD120) to the yellow one (code RAD1202).



When in contact with a solid adsorbing medium, a gaseous compound will be adsorbed following the Freundlich isotherm, *that is to say the adsorbed mass will be* $x/m=kC^{1/n}$, *where x is the mass of gaseous compound adsorbed by the mass m of the solid adsorbent and C is the concentration of the gaseous compound at the equilibrium in the gas phase. K and n depend on temperature and on the adsorbate - adsorbing medium pair. K increases with decreasing temperature and n is the closer to 1 the stronger the adsorbent.*

At low temperatures, x/m *depends almost linearly on the concentration in air (see the curve at 25 °C): this allows diffusive sampling. At high temperatures, the adsorbent mass is very low whatever the concentration in the gas phase: this allows the recovery of adsorbed compounds by heating (see the curve at 300 °C).*

To ensure the best possible recovery yields, k and n have to be small. This, however, will compromise sampling efficiency. In other words, compounds strongly adsorbed at room temperature will be only partially recovered by thermal desorption. On the other hand, compounds that are easily desorbed by heating will be sampled at room temperature with low efficiency.

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Smaller average pore size and thicker diffusive membrane make the diffusive path longer and, as a consequence, sampling rates are reduced to less than one third compared to those obtained with white diffusive bodies.

Some compounds, moreover, are thermally unstable. Thermal degradation of such compounds will cause an underestimation of their concentration or the appearance of ghost peaks.

Thermal desorption is neverthless an outstanding analytical technique because it is easy to perform, it does not require the use of toxic solvents as carbon disulfide, it ensures very low limits of detection, is suited to mass spectrometric detection and allows the recovery of the adsorbing cartridges. Basing on our experience, we have chosen Carbograph 4 as the best compromise between sampling efficiency and recovery yields for a wide range of organic compounds.

Sampling rates

Sampling rate values at 298 K (25 °C) and 1013 hPa are listed in table on page ***E3***. All of the values shown have been experimentally measured. Exposure tests have been performed up to the levels shown (in $\mu g \cdot m^{-3} \cdot min$) and sampling rates are guaranteed to be linear up to the limit values and for overall concentration of volatile organic compounds in air not exceeding 2,000 $\mu g \cdot m^{-3}$.

Effect of temperature, humidity and wind speed

Sampling rates varies from the value at 298 K on the effect of temperature (in Kelvin) as expressed by the following equation

$$Q_K = Q_{298} \left(\frac{K}{298}\right)^{1.5}$$

where Q_K is the sampling rate at the temperature **K** and Q_{298} is the reference value at 298 K. This produces a variation of ± 5% for 10 °C variation (upwards or downwards) from 25 °C.

Sampling rate is invariant with humidity in the range 15-90% and with wind speed between 0.1 and 10 $m \cdot s^{-1}$.
Do not expose directly *radiello* to rain: even if small amounts of water are adsorbed by Carbograph 4, they can neverthless interfere with analysis.

Calculations

The listed sampling rate values take already into account the recovery yields of adsorbed compounds. The average concentration over the sampling period is therefore calculated from sampled mass of analyte and exposure time without introducing any other corrective factor, apart from temperature variations of Q.

Average concentration ***C*** in $\mu g \cdot m^{-3}$ over the whole exposure time is calculated according to the following expression:

$$C\,[\mu g \cdot m^{-3}] = \frac{m\,[\mu g]}{Q_K\,[ml \cdot min^{-1}] \cdot t\,[min]}\;1{,}000{,}000$$

where:
m = mass of analyte in µg
t = exposure time in minutes

Exposure

Workplace environment

The use of ligth adsorbing media is not recommended in the workplace environment.

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

Other indoor sampling experiments and outdoor campaigns

Thermal desorption is exceptionally suited for long exposure times at low concentrations, as in outdoor campaigns and some indoor environments (e.g. homes, schools, etc...), particularly if the subsequent analysis is performed by HRGC-MS.

The recommended exposure times range from 8 hours to the upper limits shown in the table below. It is advisable to reduce sampling time if the estimated overall VOCs concentration is higher than 2,000 $\mu g \cdot m^{-3}$.

Sampling rate values at 25°C (298 K)

	sampling rate $ml \cdot min^{-1}$	exposure time upper limit	linear up to $\mu g \cdot m^{-3} \cdot min$	uncertainty (2σ) %	limit of detection[1] $\mu g \cdot m^{-3}$
benzene	27.8	7	410,000	8.3	0.05
benzene	26.8	14	410,000[2]	7.5	0.05
butyl acetate	24.5	14	580,000	12.4	0.05
2-butoxyethanol	19.4	14	550,000	9.7	0.1
cyclohexane	27.6	7	470,000	14.7	0.1
n-decane	22.3	14	450,000	22.4	0.1
1,4-dichlorobenzene	22.0	14	650,000	9.5	0.1
dimethyl disulfide	23.7	7	500,000	9.1	0.04
n-heptane	25.3	14	420,000	7.6	0.05
n-hexane	25.5	7	420,000	10.9	0.05
ethylbenzene	25.7	14	550,000	9.1	0.01
ethyl-tert-butyl ether (ETBE)	30.0	7	600,000	-	0.1
2-ethyl-1-hexanol	14.3	14	550,000	17.4	0.07
2-ethoxyethanol	26.0	14	570,000	7.7	0.05
2-ethoxyethyl acetate	20.9	14	600,000	8.0	0.05
isopropyl acetate	25.8	7	540,000	9.6	0.1
limonene	12.8	14	550,000	24.8	0.2
methyl-tert-butyl ether (MTBE)	30.0	7	600,000	-	0.2
2-methoxyethanol	4.0	7	1,000,000	--	1.0
2-metoxyethyl acetate	21.0	7	1,000,000	--	0.1
1-methoxy-2-propanol	26.6	7	600,000	11.6	0.2
n-nonane	21.0	14	440,000	11.8	0.07
n-octane	24.1	14	440,000	13.4	0.07
α-pinene	6.4	14	550,000	29.5	0.2
styrene	27.1	14	550,000	24.0	0.01
tetrachloroethylene	25.4	7	1,000,000	8.9	0.02
toluene	30.0	14	550,000	8.3	0.01
1,1,1-trichloroethane	20.0	7	300,000	13.0	0.1
trichloroethylene	27.1	7	800,000	9.5	0.02
1,2,4-trimethylbenzene	21.9	14	550,000	9.6	0.05
n-undecane	12.0	14	520,000	32.7	0.05
m-xylene	26.6	14	550,000	11.3	0.01
o-xylene	24.6	14	550,000	9.1	0.01
p-xylene	26.6	14	550,000	11.3	0.01

[1]after 7 days exposure and with MS detection; analytical conditions as described in the Analysis paragraph
[2]for overall VOCs concentrations not exceeding 500 $\mu g \cdot m^{-3}$

Storage

The cartridges are thermally conditioned in a high temperature stove with an inert atmosphere, with an oxygen content lower than 10 ppm. The duration of the adsorbent capacity of graphitized carbon is virtually unlimited and has been tested six months after production. Cartridges should be stored in a clean and solvent-free environment, in the refrigerator or at room temperature. The expiry date and the lot number are printed on the transparent plastic bag, whose integrity acts as a guarantee seal

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

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Analysis

The methods proposed here have been elaborated with a two-stage thermal desorber coupled to gas chromatograph and mass spectrometer.

A method for BTEX and one for VOC are proposed here. The first refers to samples from urban air monitoring where research is usually limited to benzene, toluene, ethylbenzene and xylene isomers. The second is more suitable for indoor investigations, allowing the quantification of all the compounds listed in the table above and the more general qualitative research, which also includes analytes with medium polarity.

Desorption

The thermal desorber is equipped with 1/4" s.s. sample tubes, they have to be hollow and free: discard the stainless steel gauze disk which is fitted to the groove and discard also the springs if present.

Code RAD145 cartridge has been dimensioned to fit the diameter of thermal desorption tubes. Its length is such that, when the cartridge is introduced into the tube and is stopped by the groove, it is positioned exactly centrally with respect to the tube length.

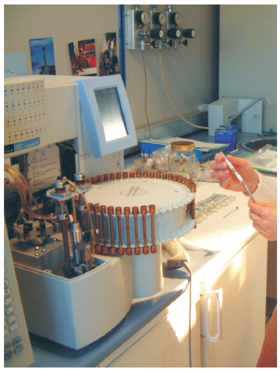
Once capped, the thermal desorber steel tube has to be positioned in the carousel with the grooves on the bottom.

The described conditions have been optimized for seven days exposures to typical concentrations of urban atmospheres and indoor environments. Shorter exposure times or considerably higher concentrations would require different settings of split flows.

BTEX – detector FID

Temperatures and timing

- Desorption: 320 °C for 10 minutes, nitrogen flow through the tube 85 ml·min^{-1}, of which 35 ml·min^{-1} sent to the cryofocalization trap and 50 ml·min^{-1} to the inlet split
- Cryofocusing trap (Tenax TA): adsorption 2 °C, desorption 99 °C·sec^{-1} up to 290 °C, 1 minute at 290 °C, trap desorption in nitrogen flow at 22.8 ml·min^{-1}, of which 22 ml·min^{-1} at the split outlet
- Six port valve: 150 °C
- Transfer line: 200 °C



Usually, the cartridge enters into the Turbomatrix tube by simple pouring. If it does not occur, use a pushing tool to press the cartridge till the nick on the tube.

Flows

- Carrier gas: helium, 24 psi
- Desorption flow: 100 ml·min^{-1}
- Inlet split: 90 ml·min^{-1}
- Outlet split: 30 ml·min^{-1}

Instrumental analysis

Column

capillary column, length 50 m, d.i. 0.2 mm, film thickness 0.5 μm; the column head can be connected directly to the thermal desorber six-way valve.

Temperatures

GC oven: 36 °C for 1 minute, 6 °C·min^{-1} up to 110 °C, mantain for 1 minute, 20 °C·min^{-1} up to 250 °C, final isotherm 5 minutes.

Flows

Carrier gas: nitrogen at 0.8 ml·min^{-1}

COV – detector MSD

Temperatures and timing

- Desorption: 350 °C for 10 minutes, helium flow through the tube 120 ml·min^{-1}, of which 20 ml·min^{-1} sent to the cryofocalization trap and 100 ml·min^{-1} to the inlet split
- Cryofocalization trap (Tenax TA): in adsorption 2 °C, in desorption 99 °C·sec^{-1} up to 290 °C, 1 minute at 290 °C, trap desorption in helium flow at 31 ml·min^{-1}, of which 30 ml·min^{-1} at the split outlet
- Six port valve: 150 °C
- Transfer line: 200 °C

user tip

If you perform several analyses, a barcode reader greatly improve productivity in your lab and will also minimize the possibility of errors in the copying of sample labels.

Please contact us to help you in the implementation of the reader.

Instrumental analysis

Column

capillary column, length 60 m, d.i. 0.25 mm, film thickness 0.25 µm; the column head can be connected directly to the thermal desorber six-way valve.

Temperatures

- GC oven: 45 °C for 10 minute, 5 °C·min^{-1} up to 115 °C, 10 °C·min^{-1} up to 175 °C, 30 °C·min^{-1} up to 295 °C, final isotherm 6 minutes.

Flows

Carrier gas: helium at 1.0 ml·min^{-1}

user tip

For a very accurate BTEX calibration we offer the preloaded cartridges **code RAD407**

On next page we display two total ion current chromatograms from an outdoor urban site and an indoor sampling respectively.

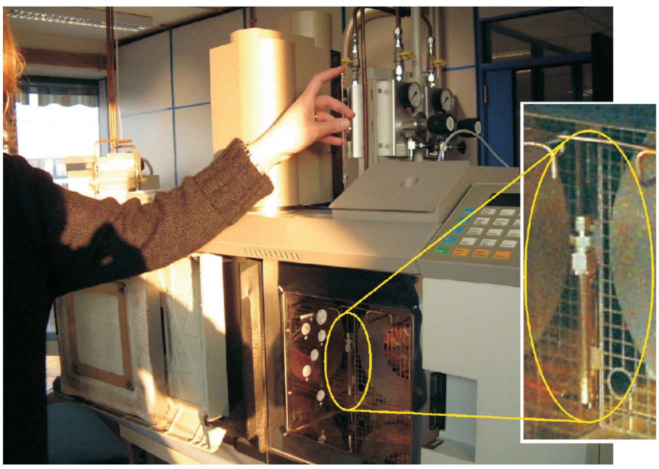
In the first case, the benzene peak corresponds to an average concentration of 2.2 µg·m^{-3} ; in the second the concentration of 1,4-dichlorobenzene was 14 µg·m^{-3}.

Calibration

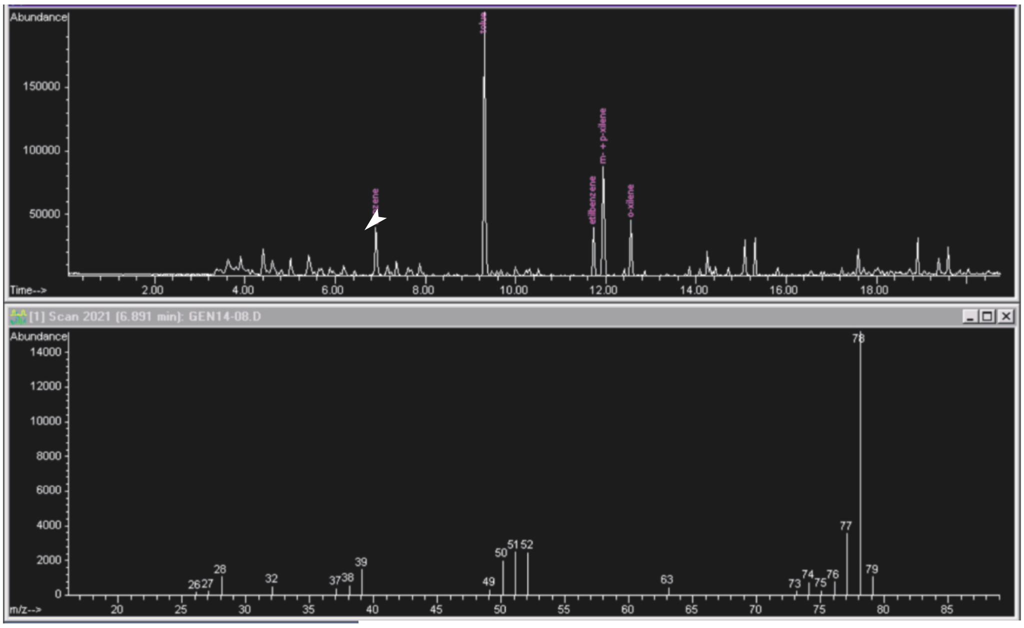
Calibration curves are obtained by gas-phase injection of methanol solutions of the target compounds onto blank cartridges. Injections are performed through a GC injector, where a short piece (10 cm) of wide-bore (0.25 mm i.d.) deactivated uncoated column is installed. The other end bears a Swagelock reducing connection (1/16”-1/4”).

The 1/4” Swagelock nut has to be equipped with a PTFE ferrule instead of the original steel one (use PTFE ferrules that come along with the Turbomatrix caps).

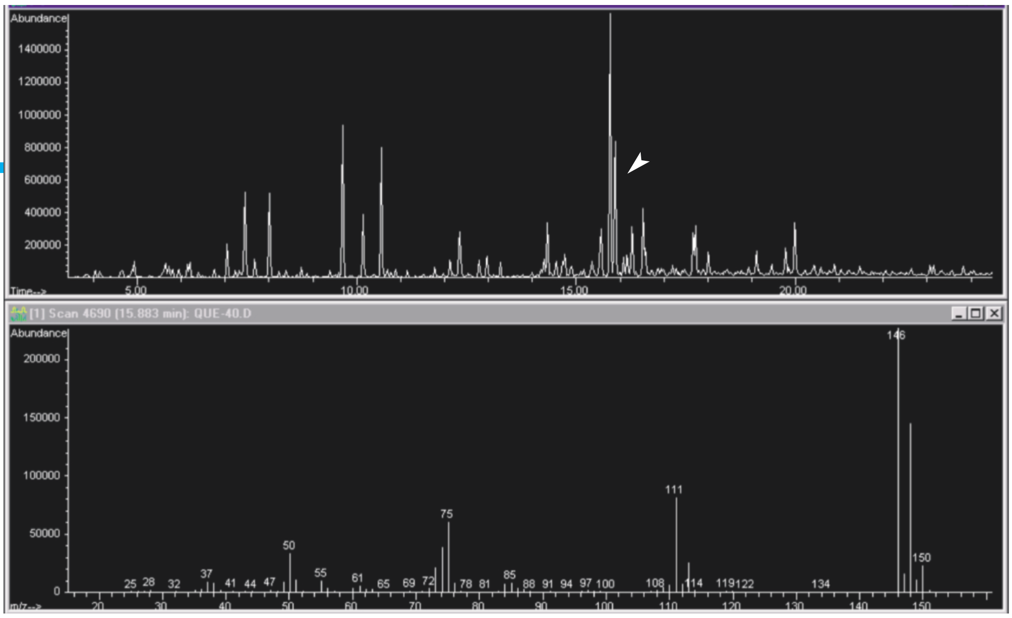
Introduce a blank cartridge in a thermal desorber tube and fit the tube to the Swagelock nut. Mantain the injector at 170 °C but do not heat the oven. Inject slowly 1 µl of each calibration solution under nitrogen flow (40 ml·min^{-1}) and let the system purge for 2 minutes. Analyze the cartridge as you would do with a sample. We suggest you to prepare a complete set of calibration solutions by subsequent dilutions such as they contain, for example, 8, 4, 2, 1, 0.04, 0.02 and 0.01 µg·µl^{-1} of each compound.



To prepare the calibration standards fit a 1/16”-1/4” Swagelock reducing connection to the GC injector by a short piece (10 cm) of wide-bore deactivated uncoated column.



TIC chromatograms of an outdoor urban sampling (left) and of indoor air (bottom). Mass spectra of benzene and of 1,4-dichlorobenzene are shown on bottom of each picture, at concentrations of 2.2 and 14 µg·m^{-3} respectively. Despite the low concentration values, the signal-to-noise ratio is very high in both cases. As a consequence, very reliable mass spectral identification is possible by comparison with mass spectral data libreries with no need of further processing.



Cartridge recovery

The cartridges can be reconditioned using the thermal desorber in "*tube conditioning*" mode, heating them to 350 °C for at least 20 minutes in an inert gas flow (helium or nitrogen at a flow of 50 ÷ 100 ml·min^{-1}).

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

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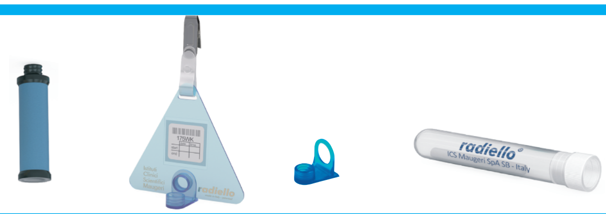
Nitrogen and sulfur dioxides (NO_2 and SO_2)

what you need

blue diffusive body code RAD1201
supporting plate code RAD121
vertical adapter code RAD122 (optional)
chemiadsorbing cartridge code RAD166



Principle

The cartridge code RAD166 is made of mycroporous polyethylene coated with triethanolamine (TEA). Nitrogen (NO_2) and sulfur (SO_2) dioxide is chemiadsorbed onto TEA as nitrite and sulphite or sulphate ions respectively. Nitrite is quantified by visible spectrophotometry while sulphite and sulphate are analysed by ion chromatography (NO_2 and SO_2 can be analysed together by ion chromatography).

Sampling is selective for gaseous molecules: any airborne nitrite, sulphite or suplhate will not cross the diffusive membrane.

Sampling rates

NO_2

The sampling rate value $\mathbf{Q_{298}}$ at 298 K (25°C) and 1013 hPa is **0.141 ± 0.007 ng·ppb^{-1}·min^{-1}**.

SO_2

The sampling rate value $\mathbf{Q_{298}}$ at 298 K (25°C) and 1013 hPa is **0.466 ± 0.022 ng·ppb^{-1}·min^{-1}.**

Effect of temperature, humidity and wind speed

Sampling rate of NO_2 varies from the value at 298 K on the effect of temperature (in Kelvin) following the equation:

$$Q_K = Q_{298} \cdot \left(\frac{K}{298}\right)^{7.0}$$

where $\mathbf{Q_K}$ is the sampling rate at the temperature **K** ranging from 263 to 313 K (from -10 to 40 °C) and $\mathbf{Q_{298}}$ is the reference value at 298 K.
Sampling rate for SO_2 does not vary with temperature between 263 and 313 K (from -10 to 40 °C).
Sampling rate is invariant with humidity in the range 15 - 90% and with wind speed between 0.1 and 10 m·s^{-1} for both gases.

Calculations

NO_2

The concentration $\mathbf{C_{NO_2}}$ is calculated according to the equation:

$$C_{NO2} = \frac{m_{NO2}}{Q_K \cdot t}$$

where $\mathbf{m_{NO_2}}$ is nitrite mass in **ng** found on the cartridge, **t** is exposure time in **minutes** and $\mathbf{Q_K}$ is the sampling rate value at the temperature **K** in Kelvin.

SO_2

Convert the sulphite found onto the cartridge into sulphate by multiplying its mass by 1.2, then sum the obtained value to the sulphate found in the cartridge. The concentration in ppb is calculated according to the equation:

$$C_{SO2} = \frac{m_{SO4}}{0.466 \cdot t}$$

where $\mathbf{m_{SO_4}}$ is the overall sulphate mass in ng found in the cartridge (sulphate itself and sulphite converted into sulphate) and **t** is exposure time in minutes.

user tip
It is advisable to measure the sampling temperature by the thermometer **code RAD126.**

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it
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Exposure

Exposure up to 15 days is feasible but if relative humidity is higher than 70% for the entire sampling duration it is not advisable to sample for more than 7 days. Due to the fact that TEA is very hygroscopic in fact, even if water does not actually interfere with sampling or analysis, the excess water adsorbed by the cartridge could cause some loss of adsorbing medium by percolation.

WARNING: NO_2 results may differ from those produced by automatic chemiluminescent instrumentation due to exponential variation of the sampling rate of radiello with temperature. This phenomenon is characteristic of all NO_2 samplers that use TEA as an absorbent medium. The reason is not yet completely clear, but it is assumed that it depends in part on the balance in the air between the species NO_2 and N_2O_4, whose ratio is strongly linked to temperature: the TEA captures only the species NO_2.

Limit of quantitation and uncertainty

Sampling rate of NO_2 and SO_2 is linear ranging from 10,000 to 5,000,000 ppb·min. Limit of quantitation after 7 days exposure is 1 ppb for both gases. The uncertainty at 2σ is 11.9% for NO_2 and 9.2% for SO_2.

Storage

The cartridges are stable for at least 12 months before and 4 months after the sampling, if kept in the dark at 4 °C. Expiry date is printed on the plastic bag.

Do not expose all of the cartridges belonging to the same lot, keep at least two of them as blanks.

Analysis

Add **5 ml** of water in the plastic tube with the cartridge and stir vigorously by a vortexer for 1 minute. Do the same with two-three unexposed cartridges.

Colorimetric determination of nitrite ion

Nitrogen dioxide is quantitatively converted to nitrite ion. Prepare the following reactives:

- *sulphanilamide*: dissolve 10 g of sulphanilamide in 100 ml concentrated HCl and dilute to 1,000 ml with water
- *NEDA*: dissolve 250 mg of N-(1-naphthyl)ethylendiamine dihydrochloride in 250 ml of water (discard the solution when it turns brown).

Transfer 0.5 ml (or a different volume, see the table below) of the cartridge extraction solution to a plastic or glass 10 ml tube along with 5 ml of *sulphanilamide* reactive. Cap tigthly, stir and wait for 5 minutes. Add 1 ml of *NEDA* reactive, stir and wait for 10 minutes. Do the same with unexposed cartridges.

Measure the absorbance of samples at 537 nm using water to zero the spectrophotometer, then subtract the blank value from unexposed cartridges. Prepare the calibration standards in the same way from sodium nitrite solutions of concentration ranging from 0.1 to 20 mg·l^{-1} expressed as NO_2^-.

When nitrite ion concentration is higher than 20 μg·ml^{-1} (corresponding to 7 days of exposure to 70 ppb) the absorbance value is no longer comprised in the calibration curve. To analyse the samples, draw smaller amounts of the extraction solution as shown in the table. In order to mantain the overall volume unaltered, add the listed volume of water.

average expected concentration for 7 days exposure in ppb	sample volume ml	water volume to be added ml
up to 70	0.5	0
from 70 to 150	0.25	0.25
higher than 150	0.1	0.4

Determination of the sulphite and sulphate ions

Though SO_2 is converted into sulphite and sulphate ions with variable ratios, the sum of the two ion equivalents is linear with exposure to SO_2. To obtain calibration curves, prepare solutions containing both ions at concentrations ranging from 5 to 50 mg·l^{-1}. Perform the ion chromatography analysis of the standard solutions and the extraction solutions from ***radiello*** cartridges in the same way according to your usual laboratory practice.

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

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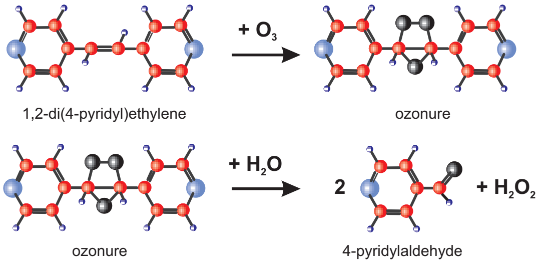
Ozone (O_3)

What you need

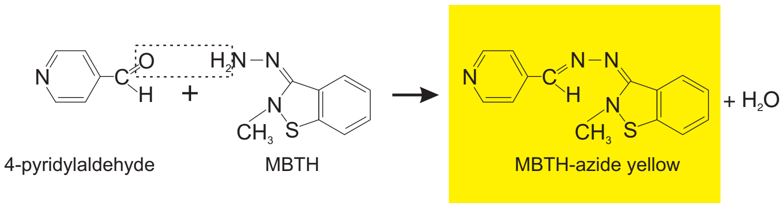
blue diffusive body code RAD1201
supporting plate code RAD121
vertical adapter code RAD122 (optional)
chemiadsorbing cartridge code RAD172

Principle

The adsorbing cartridge is formed by a micropore polyethylene tube filled with silica gel coated with 4,4'-dipyridylethylene and closed, at one end, by a PTFE cap. Upon exposure, acid-catalysed ozonolysis of 4,4'-dipyridylethylene leads to 4-pyridylaldehyde. Silica gel ensures the presence of water, necessary to complete ozonolysis reactions.



In the laboratory, 4-pyridylaldheyde is condensed with 3-methyl-2-benzothiazolinone hydrazone (MTBH) to yield the corresponding azide, yellow coloured.



The absorbance of the solution is measured at 430 nm. Production of 4-pyridylaldehyde is a specific reaction of ozone; neither nitrogen oxides nor organic compounds, if present, do interfere.

Sampling rate

The sampling rate value $\mathbf{Q_{298}}$ at 298 K (25°C) and 1013 hPa is **24.6 ml·min^{-1}**.
Sampling is linear in the exposure range from 10,000 to 4,000,000 µg·m^{-3}·min^{-1}.

Effect of temperature, humidity and wind speed

Sampling rate varies from the value at 298 K on the effect of temperature (in Kelvin) as expressed by the following equation:

$$Q_K = Q_{298}\left(\frac{K}{298}\right)^{1.5}$$

where $\mathbf{Q_K}$ is the sampling rate at the temperature K and $\boldsymbol{Q_{298}}$ is the reference value at 298 K.
Sampling rate is not influenced by humidity or wind speed.

Calculations

The average concentration over the whole exposure time is calculated according to the equation

$$C\,[\mu g\cdot m^{-3}] = \frac{m\,[\mu g]}{24.6\; t\,[min]}\;1{,}000{,}000$$

where ***m*** is ozone mass in µg sampled by *radiello* and **t** is exposure time in minutes.

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

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Exposure

Introduce the cartridge in the diffusive body and make sure that the PTFE cap is positioned at the same end of the screw.

In outdoor environments, where typical ozone concentrations range from 2 to 400 µg·m^{-3}, we suggest exposure time from 24 hours to 14 days. The ideal range is from 3 to 7 days.

In workplace environments it is advisable to sample over the entire 8 hours shift.

Limit of detection and uncertainty

The limit of detection is 2 µg·m^{-3} for 7 days exposures. The cartridge is saturated after 14 days exposure at 400 µg·m^{-3}. The uncertainty at 2σ is 14.5% over the whole sampling rate linearity range.

Storage

The cartridges need only protection from direct sunlight: keep them in a drawer or a cupboard at room temperature. In these conditions, the blank level does not exceed 0.015 absorbance units for up to six months.

Expiry date is printed onto the plastic bag wrapping each cartridge.

Generally, an increase of blank level does not imply that the cartridge must be discarded. The only consequence is a corresponding increase of the analytical limit of quantification.

After exposure the samples have to be stored in the dark as before, along with three unused cartridges to be analysed as blanks. Analyse them within a week.

Analysis

Reactives and materials

- 3-methyl-2-benzothiazolinone hydrazone hydrocloride (MBTH): dissolve 5 g per litre in water and add 5 ml of concentrated sulphuric acid; this solution is to be freshly prepared.
- 4-pyridylaldehyde
- micropore filter membrane 0.45 µm

user tip

For a simple and accurate filtration make use of the filtration kit **code RAD174**.

IMPORTANT:

If the absorbance value is higher than the calibration curve upper limit dilute the sample with the MBTH solution: **never use water to dilute!** Water alters the pH of the solution with unpredictable variations in the linearity of absorbance values vs concentration.

Procedure

Draw the cartridge out from the plastic tube, discard the PTFE cap and pour the silica gel into the tube. Add 5 ml of MBTH solution, recap the tube and stir vigorously. Let the tube stand for at least one hour to react, stirring from time to time. Filter through the micropore filter (if you make use of the code 174, act as follows: fit the filter to the syringe, transfer the solution from the tube to the syringe and filter it into a second tube or directly into the spectrophotometer measure cell).

Measure absorbance at 430 nm using water to zero the spectrophotometer. The yellow colour is stable for several days if the solution is kept well capped in its tube.

Treat in the same manner three unused cartridges of the same lot and subtract the average blank value from the absorbance values of the samples.

Calibration

Dissolve 100 µl (112.2 mg at 20° C) of 4-pyridylaldehyde in 1 litre of water and dilute this solution (e.g. 1:2, 1:5, 1:10) to obtain calibration solutions. Transfer 0.5 ml of each calibration solution in a plastic tube together with 4.5 ml of MTBH solution. Stir and let stand for one hour, then read the absorbance at 430 nm (filtration is not needed). Plot the calibration curve for ozone mass *vs* measured absorbance, taking into account that:

1 µg of 4-pyridylaldehyde = 0.224 µg of ozone.

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ISTITUTI CLINICI SCIENTIFICI MAUGERI S.p.A. - SB
Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

Edition 01/2019

Hydrogen sulfide (H_2S)

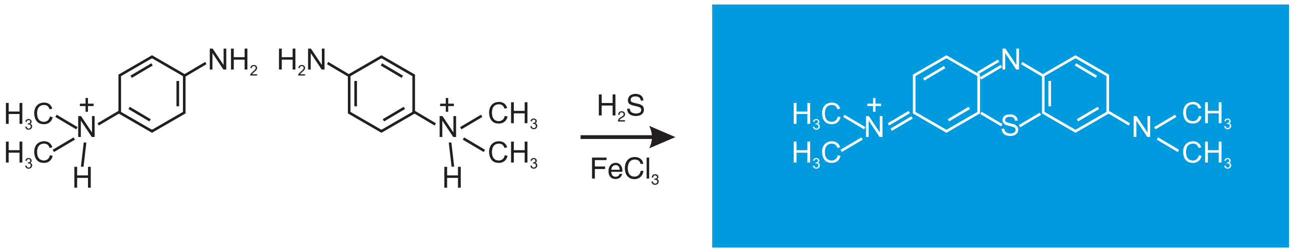
What you need

white diffusive body code RAD120
supporting plate code RAD121
vertical adapter code RAD122 (optional)
chemiadsorbing cartridge code RAD170

Principle

The cartridge code RAD170 is made of microporous polyethylene and impregnated with zinc acetate. Hydrogen sulphide is chemiadsorbed by zinc acetate and transformed into stable zinc sulfide.

The sulfide is recovered by extraction with water. In contact with an oxidizing agent as ferric chloride in a strongly acid solution it reacts with the N,N-dimethyl-p-phenylendiammonium ion to yield methylene blue.



N,N-dimethyl-p-phenylendiammonium Methylene blue

Methylene blue is quantified by visible spectrometry.

Sampling rate

Sampling rate $\mathbf{Q_{298}}$ at 298 K (25°C) and 1013 hPa is **0.096 ± 0.005** ng·ppb^{-1}·min^{-1}.

Effect of temperature, humidity and wind speed

Sampling rate varies from the value at 298 K on the effect of temperature (in Kelvin) as expressed by the following equation:

$$\mathbf{Q_K = 0.096 \left(\frac{K}{298}\right)^{3.8}}$$

where $\mathbf{Q_K}$ is the sampling rate at the temperature K ranging from 268 to 313 K (from -5 to 40 °C).
Sampling rate is invariant with humidity in the range 10 - 90% and with wind speed between 0.1 and 10 m·s^{-1}.

Calculations

Once Q_K at the sampling temperature has been calculated, the concentration **C** is obtained according to the equation:

$$\mathbf{C} = \frac{\mathbf{m}}{\mathbf{Q_K \cdot t}}\,1{,}000$$

where **m** is the mass of sulphide ion in **μg** found onto the cartridge and **t** is exposure time in **minutes**.

Exposure

Exposure duration may vary from 1 hour to 15 days. Sampling is linear from 2,000 to 50,000,000 ppb·min of H_2S.

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it
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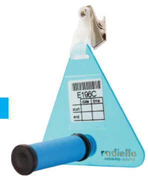

Edition 01/2019

Limit of detection and uncertainty

The limit of detection is 30 ppb for 1 hour exposure or 1 ppb for 24 hour exposure. The uncertainty at 2σ is 8.7% over the whole exposure range.

Storage

The cartridges are stable at least for 12 months before and 6 months after exposure. Do not expose all of the cartridges of the same lot: keep at least two of them as blanks.

Analysis

Reactives and materials

- *sulphuric acid*: slowly add 25 ml of concentrated sulphuric acid to 10 ml water and let the solution cool;
- *amine*: dissolve 6.75 g of N,N-dimethyl-p-phenylendiammonium oxalate in the *sulphuric acid* solution. Dilute this solution to 1 litre with sulphuric acid - water 1:1 v/v. Kept in a dark bottle and well capped, this solution is stable for at least four weeks. **CAUTION**: this solution is very poisonous.
- *ferric chloride*: dissolve 100 g of ferric chloride hexahydrate ($FeCl_3 \cdot 6H_2O$) in 40 ml of water.
- *ferric chloride-amine*: mix 10 ml of *ferric chloride* solution with 50 ml of *amine* solution. This solution has to be freshly prepared;
- *sulphuric acid for dilution*: slowly dissolve 40 ml of concentrated sulphuric acid in 900 ml of water, let the solution cool and make up to 1,000 ml.

Procedure

Add 10 ml of water to the plastic tube containing the cartridge, recap and stir vigorously, preferably by a VORTEX stirrer.

Add 0.5 ml of *ferric chloride - amine* solution, recap **immediately** and stir. The tube must be capped immediately in order to avoid that the developed hydrogen sulfide can escape from the tube before reacting.

Wait for 30 minutes and measure absorbance at 665 nm using water to zero the spectrophotometer. The colour is stable for several weeks.

Do the same with two or three unexposed cartridges of the same lot and obtain the average blank value, then subtract it to the samples.

IMPORTANT:

Absorbance is linear up to 1,200 absorbance units, corresponding to an exposure value of about 80,000 ppb·min. If higher absorbance values are obtained, dilute the samples with the sulphuric acid for dilution.

Be careful to apply the same dilution ratio to the samples and the blanks.

NEVER USE WATER TO DILUTE.

Calibration

Calibration curves may be prepared by sodium sulfide standard solutions, which have to be titrated just before use. As diluted sodium sulfide solutions are very unstable (the sulfide content can diminish as much as the 10% in an hour) it is strongly recommended to make use of the calibration solution code RAD171, following the instructions included.

user tip

Code RAD171 calibration solution relieves you from the task of preparation and titration of the sodium sulfide solutions.

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

Edition 01/2019

Ammonia (NH_3)

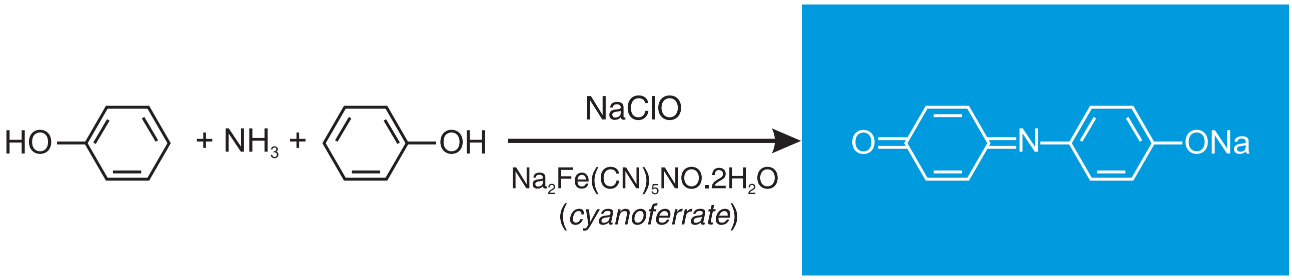
What you need

blue diffusive body code RAD1201
supporting plate code RAD121
vertical adapter code RAD122 (optional)
chemiadsorbing cartridge code RAD168

Principle

The cartridge code RAD168 is made of microporous polyethylene and impregnated with phosphoric acid. Ammonia is adsorbed as ammonium ion. Airborne ammonium salts dispersed as particulate matter do not cross the diffusive membrane of radiello.

Ammonium ion is quantified by visible spectrometry as indophenol: at basic buffered pH ammonium ion reacts with phenol and sodium hypochlorite, with pentacyanonitrosylferrate catalysis (in the following *cyanoferrate*), to form indophenol. The reaction product is intensely coloured in blue, and its absorbance measured at 635 nm.



indophenol

Sampling rate

Sampling rate $\mathbf{Q_{298}}$ at 298 K (25°C) and 1013 hPa is **235** ml·min^{-1}.

Effect of temperature, humidity and wind speed

The effect of temperature on sampling rate is negligible (<0.1%/°C) in the range from 275 ÷ 312 K (2 ÷ 39 °C). Sampling rate is invariant with humidity in the range 10 - 90% and with wind speed between 0.1 and 10 m·s^{-1}.

Calculations

The concentration **C** in µg·m^{-3} is obtained according to the equation:

$$\mathbf{C} = 0.944\,\frac{\mathbf{m}}{\mathbf{235\cdot t}}\,1{,}000{,}000$$

where **m** is the mass of ammonium ion in **µg** found onto the cartridge and **t** is exposure time in **minutes**.
0.944 is the numerical factor necessary to convert ammonium ion into ammonia (see *Analysis*)

Exposure

Introduce the cartridge in the diffusive body and make sure that the PTFE cap is positioned at the same end of the screw.

Ammonia is sampled linearly in the range from 2,000 - 20,000,000 µg·m^{-3}·min.
Exposure time is allowed to range from 1 hour to 14 days.

IMPORTANT:
Do not touch the microporous portion of the cartridge with your fingers: sweat contains ammonium ions.

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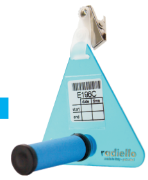
Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it



Edition 01/2019

Limit of detection and uncertainty

The limit of detection is 1 µg·m^{-3} for 24 hour exposure. The uncertainty at 2σ is 6.5% over the whole allowed exposure range.

Storage

The cartridges are stable at least for 12 months before and after exposure if kept at room temperature in an ammonia-free environment. Do not expose all of the cartridges of the same lot: keep at least two of them as blanks.

Analysis

Materials

- plastic or glass tube, volume 12 ml, with cap
- micropipet with variable volume from 0.1 to 1.0 ml
- 5 ml glass pipet

Reactives

- *buffer* solution (pH 10.6): dissolve 1.1 g of NaOH and 3.04 g of $NaHCO_3$ in one litre of water
- *phenol*: dissolve 10 g of phenol in 100 ml of ethanol
- *cyanoferrate*: dissolve 0.5 g of sodium pentacyanonitrosylferrate dihydrate ($Na_2Fe(CN)_5NO \cdot 2H_2O$) in 100 ml of water and add a few drops of 10% NaOH. Keep this solution in a dark bottle and prepare it freshly.
- *oxidising* solution: sodium hypochlorite with 1% of active chlorine in 0.2 M NaOH. Keep cool in a dark bottle.

Ammonium ion quantification

Open ***radiello*** tube and cautiously discard the cartridge PTFE cap (it may have been contaminated with handling). Help yourself with a pair of pliers.

Add 10 ml of deionised water to the cartridge in its tube (make sure that no trace of ammonium ion is found in the water you use). Recap the tube and stir vigorously by a VORTEX stirrer for at least 15 seconds.

Transfer 1 ml of the solution into another tube along with 0.4 ml of *phenol*, 0.4 ml of *cyanoferrate*, 5 ml of *buffer* solution and 1 ml of *oxidising* solution.

Wait for 1 hour and then measure the absorbance of the solution at 635 nm using water to zero the spectrophotometer.

Do the same with two unexposed cartridges and subtract their absorbance value to the samples. Generally, the blank value does not exceed 0.040 absorbance units.

For exposure value higher than 500,000 µg·m^{-3}·min the absorbance value is no longer linear: **diluite a known fraction of the coloured solution with the *buffer*.**

Calibration curves are conveniently prepared with ammonium chloride solutions in the range from 0.5 to 10 mg·l^{-1} as ammonium ion.

IMPORTANT:

If sample is too concentrated (absorbance no longer linear) <u>DO NOT DILUTE WITH WATER:</u> the pH value is critical in the determination of the colour intensity.

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

Edition 01/2019

Hydrochloric acid (HCl)

What you need

white diffusive body code RAD120
supporting plate code RAD121
vertical adapter code RAD122 (optional)
chemiadsorbing cartridge code RAD169

Principle

Code RAD169 cartridge is made of stainless steel net loaded with silica gel (0.1 to 0.4 mm particle size). Gaseous hydrochloric acid is adsorbed by silica gel and subsequently extracted with water to be quantified by ion chromatography as chloride ion.

Sampling is selective for the gaseous molecules: any airborne chloride salt will not cross the diffusive membrane of *radiello*.

Sampling rate

Sampling rate (Q_{298}) at 25 °C (298 K) and 1013 hPa is **103 cm³·min⁻¹**.

Effect of temperature, humidity and wind speed

Sampling rate varies from the value at 298 K (25 °C) on the effect of temperature (in Kelvin) as expressed by the following equation:

$$Q_K = 103 \left(\frac{K}{298}\right)^{1.5}$$

where Q_K is the sampling rate at temperature **K** and Q_{298} is the sampling rate value at the reference temperature of 298 K. This yields a ± 5% variation of Q for a 10 °C variation (upwards or downwards) from 25 °C.

Sampling rate is invariant with humidity in the range 15 - 90% for short exposure time (see *Exposure*) and with wind speed between 0.1 and 10 $m \cdot s^{-1}$.

Calculations

Let m be the mass of chloride ion in µg found onto the cartridge and t the exposure time in minutes, the environmental concentration C of hydrochloric acid in $\mu g \cdot m^{-3}$ is obtained according to the equation:

$$C = \frac{1.028\ m}{Q_K\ t} 1{,}000{,}000$$

where Q_K is the sampling rate at temperature K (in Kelvin) and 1.028 is the ratio between molecular masses of HCl and Cl^- (see *Analysis*).

Exposure

Hydrochloric acid is sampled linearly in the range from 20,000 ÷ 20,000,000 $\mu g \cdot m^{-3} \cdot min$.

Workplace environment

In workplace environment we recommend exposure time from 15 minutes to 8 hours: the *ceiling* values can be measured.

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

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Outdoor environment

We recommend exposure time from 2 hours to 2 days. Exposure time as long as 7 days is allowed if average relative humidity does not exceed 50%, taking into account the water absorbing properties of silica gel.

We also recommend to protect ***radiello*** from rain by the mountable shelter code RAD196.

Limit of detection and uncertainty

The limit of detection is 10 $\mu g \cdot m^{-3}$ for 24 hour exposure. The uncertainty at 2σ is 3.5% over the whole allowed exposure range.

Interferences

Gaseous chlorine is adsorbed by silica gel and is revealed as 0.02 ng of chloride ion for 1 $\mu g \cdot m^{-3} \cdot min$ of chlorine.

Storage

Kept in a clean environment free from gaseous hydrochloric acid, the cartridges code RAD169 are stable for at least 24 months before and after sampling.

If more than six months have passed since you received the cartridges, before environmental sampling campaigns, it is advisable to analyse some cartridges to check for contamination from the background. Discard the cartridges if they contain more than 5 µg of chloride ion.

Analysis

Add 2 ml of deionised water to the cartridge in its tube (make sure that no trace of chloride ion is found in the water you use). Recap the tube and stir vigorously by a VORTEX stirrer for 1-2 minutes. Analyse the solution by ion chromatography. Subtract the blank value obtained from two unexposed cartridges.

Prepare the calibration solutions with sodium or potassium chloride concentrations ranging from 0.5 to 25 mg/litre as Cl^-.

Hydrofluoric acid (HF)

What you need

blue diffusive body code RAD1201
supporting plate code RAD121
vertical adapter code RAD122 (optional)
chemiadsorbing cartridge code RAD166

Principle

The cartridge code RAD166 is made of microporous polyethylene coated with triethanolamine (TEA). Gaseous hydrofluoric acid is adsorbed by TEA and subsequently extracted with water to be quantified by ion chromatography or by ion selective electrode as fluoride ion.

Sampling is selective for the gaseous molecules: any airborne fluoride salt will not cross the diffusive membrane of *radiello*.

Sampling rate

Sampling rate at 25 °C and 1013 hPa is **187** $cm^3 \cdot min^{-1}$.

Effect of temperature, humidity and wind speed

Sampling rate is invariant with humidity in the range 10 - 90% for short exposure time (see *Exposure*) and with wind speed between 0.1 and 10 $m \cdot s^{-1}$. The effect of temperature is under investigation.

Calculations

Let ***m*** be the mass of fluoride ion in µg found onto the cartridge and ***t*** the exposure time in minutes, the environmental concentration ***C*** of HF in $\mu g \cdot m^{-3}$ is obtained according to the equation:

$$\boldsymbol{C} = \frac{1.053\ \boldsymbol{m}}{\mathbf{187}\ \boldsymbol{t}}\ 1{,}000{,}000$$

where 1.053 is the ratio between molecular masses of HF and F^-(see *Analysis*).

Exposure

Hydrofluoric acid is sampled linearly in the range from 10,000 to 50,000,000 $\mu g \cdot m^{-3} \cdot min$.

Workplace environment

In workplace environments we recommend exposure time from 15 minutes to 8 hours: the *ceiling* values can be measured.

Outdoor environment

We recommend exposure time from 2 hours to 14 days.

Protect *radiello* from rain by the mountable shelter code RAD196.

Limit of detection and uncertainty

The limit of detection is 7 $\mu g \cdot m^{-3}$ for 24 hour exposure. The uncertainty at 2σ is 4.5% over the whole exposure range.

ISTITUTI CLINICI SCIENTIFICI MAUGERI S.p.A. - SB
Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

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Storage

Kept in a dark place at 4 °C, the cartridges stay unaltered for at least 12 months before exposure and 4 months after sampling. Expiry date is printed on the plastic bag wrapping each cartridge.

If more than six months have passed since you received the cartridges, before environmental sampling campaigns, it is advisable to analyse some cartridges to measure any contamination from the background. Discard the cartridges if they contain more than 2 μg of fluoride ion.

Keep at least two unexposed cartridges for each lot and analyse them as blanks.

Analysis

Ion chromatography

Add 5 ml of the eluent solution to the *radiello* tube. Stir vigorously by a VORTEX stirrer for 1-2 minutes. Let the tube stand for 10 minutes, then stir manually and inject the solution in the ion chromatographic apparatus without further treatment.

Analyse 1-2 unexposed cartridges and subtract the average blank value to the samples.

Ion Selective Electrode

Prepare an ionic strength buffer as follows. Dissolve 57 ml of acetic acid in 500 ml water and add 50 g of sodium chloride and 0.3 g of sodium citrate. When complete solubilisation has been achieved, adjust the pH value to 5.0-5.5 (ideal value is 5.3) by adding drops of 10 M sodium hydroxide. Make up to 1 litre with water.

Add 5 ml water to *radiello* tube and stir vigorously by a vortexer for 1-2 minutes, then let stand for 10 minutes. Introduce a magnetic stirring bar in a 20 ml beaker, add 10 ml of ionic strength buffer and 1 ml of the extraction solution of the cartridge. Start the magnetic stirrer and make the potentiometric measurement by an ion selective electrode for fluorides. In the described analytical conditions, the electrode response should be linear in the range from 1 to 1,000 $mg \cdot l^{-1}$ of F^- with slope close to 59.0 ± 0.5 (if potential is expressed in mV).

IMPORTANT:

Always use water with fluoride content lower than 0.5 $mg \cdot l^{-1}$.

Analyse 1-2 unexposed cartridges and subtract the average blank value to the samples.

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

Edition 01/2019

Anaesthetic gases and vapours

N_2O, isoflurane, ethrane, halothane, sevorane and desflurane

What you need

Sampling kit code RAD125, containing 20 single packages each composed of:
1 permeative body (code RAD1203)
1 supporting plate (code RAD121)
1 vertical adapter (code RAD122)
1 adsorbing cartridge (code RAD132)

the listed components are contained in a closed aluminum envelope, which is wrapped by a thermowelded paper-polyethylene bag.

The whole is sterilized by γ-rays.

The single components are also available non-sterilized in 20 pieces per package.

Principle

Code RAD132 cartridge is made of stainless steel net loaded with a mixture of molecular sieve and activated charcoal 35-50 mesh.

Nitrous oxide and halogenated anesthetic gases permeate the silicone membrane and are sampled by the molecular sieve and by activated charcoal respectively.

The sampled compounds are displaced by a water-methanol mixture and are quantified by capillary gas chromatography and a headspace sampler.

N_2O, isoflurane, ethrane and halothane are detected by the Electron Capture Detector (ECD) and by Mass Spectrometric Detector (MSD) with good sensitivity; sevorane and desflurane cannot be quantified by ECD detection and have to be analyzed by mass spectrometry.

Sampling rates

Sampling rate values at 25 °C (298 K) and 1013 hPa are listed in the table on the right.

	sampling rate ($ml \cdot min^{-1}$)
N_2O	1.01
isoflurane	2.25
ethrane	3.39
halothane	4.93
sevorane	0.92
desflurane	1.20

Effect of temperature, humidity and wind speed

Sampling rate varies from the values at 298 K on the effect of temperature (in Kelvin) as expressed by the following equation:

$$Q_K = Q_{298}\left(\frac{K}{298}\right)^{1.5}$$

where Q_K is the sampling rate at temperature **K** and Q_{298} is the sampling rate value at reference temperature of 298 K. This yields a ± 5% variation of Q for a 10 °C variation (upwards or downwards) from 25 °C.
Sampling rate is invariant with humidity in the range 10 ÷ 90% for exposure time not exceeding 8 hours and with wind speed between 0.1 and 10 $m \cdot s^{-1}$.

ISTITUTI CLINICI SCIENTIFICI MAUGERI S.p.A. - SB
Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

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Calculations

Concentration in air is obtained by the following equation:

$$C = \frac{m}{Q_K \cdot t} 1{,}000$$

where:
C = concentration in $mg \cdot m^{-3}$
m = mass of analyte found on the cartridge in µg
Q_K = sampling rate in $ml \cdot min^{-1}$
t = exposure time in minutes

Exposure

Sampling rate is constant for exposure time up to 8 hours at relative humidity up to 80% with N_2O concentration up to 500 ppm and overall halogenated anesthetic compounds concentration up to 100 ppm.

Limit of detection and uncertainty

The cartridges are conditioned to ensure a chromatographic blank level lower than one third of the sampled mass of each anesthetic upon exposure to one tenth of its limit value for half an hour time.

If a thoroughly conditioned ECD is employed, 4 hours of exposure ensure the following analytical sensitivities: 0.5 ppm of N_2O, 0.002 ppm of isoflurane, 0.01 ppm of ethrane and 0.002 ppm of halothane. Sevorane and desflurane are not detected by ECD. Acquiring by mass spectrometry in SIM mode (*Single Ion Monitoring*), detection limits close to the ECD performances can be achieved for N_2O, isoflurane, ethrane and halothane. For sevorane and desflurane, 1 hour exposure allows to detect 0.1 and 0.2 ppm respectively.

Storage

The sampling kit code RAD125 is sterilized by gamma rays. Use of the sampler makes it no longer sterile. With the exception of the adsorbing cartridge, the sampler is re-usable. If kept in a dry place free from chemical contamination, the cartridges are stable for at least 12 months.

After the sampling, the samples are stable for 30 days if stored in a dry place, away from chemical contaminations and at temperatures ranging from 4 to 8°C.

IMPORTANT:
DO NOT STERILIZE THE SAMPLER BY AUTOCLAVING. Autoclaving treatment permanently damages the silicone permeative membrane.

Analysis

Materials needed for the analysis

- 20 ml headspace glass vials with open-top aluminum crimp caps and rubber/PTFE septa
- water/methanol mixture 60/40 v/v (gradient grade methanol for HPLC, grade III laboratory water)
- usual laboratory glassware

Materials needed for the calibration curve

- pure N_2O in a gas cylinder
- halogenated anaesthetic compounds
- gastight syringe (volume 500 µl) and other syringes (volume 100 and 10 µl)
- 1 liter glass bottle with threaded neck, equipped with open-top screw cap and rubber/PTFE septum (*the volume of the bottle must be precisely measured and the bottle must be rinsed with dry nitrogen before use*)

- magnetic stirrer with large magnetic stirring bar (about 30-40 mm long)
- usual laboratory glassware

Elution of samples

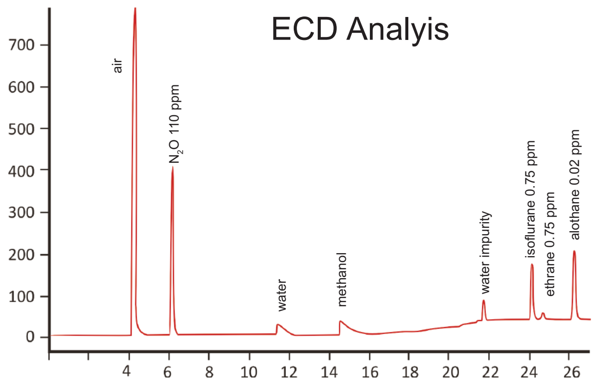
Introduce 10 ml of water/methanol mixture in a headspace vial by a volumetric pipette. Add the radiello cartridge and <u>cap immediately</u>. Stir and let equilibrate, place the vial in the headspace bath and let equilibrate for one hour at 45 °C.

Instrumental analysis

ECD detection (sevorane and desflurane are not detected)

- vial pressurization gas: N_2 at 1.2 atm
- loop volume: 1 ml
- gas chromatographic column: polystyrene-divinylbenzene PLOT, 30 m long, 0.32 mm inner diameter, 20 µm film thickness (allows quantification of nitrous oxide and other anaesthetic gases in one chromatographic run)
- carrier gas: N_2 at 1.0 atm
- split ratio: 10/1
- make-up gas: Ar-CH_4 (CH_4 10% v/v) at 30 ml·min^{-1}
- GC oven: 40° C for 2 min, 10° C·min^{-1} up to 150° C, 6° C·min^{-1} up to 200° C, final isotherm for 5 minutes
- injector temperature: 150° C
- detector temperature: 300° C

In the described analytical conditions chromatograms like to the one in the figure are obtained. In the example shown, exposure time was 4 hours at the concentration values indicated and with relative humidity of 70%.



MS detection

The instrumental conditions are as described above, with the exception of the carrier gas (helium has to be used instead) and the make-up gas, which is not employed. Acquire by SIM (Single Ion Monitoring) focussing the detector on the following signals (the base peak is underlined):

N_2O: <u>44</u>; **desflurane**: <u>51</u>, 149; **isoflurane** and **ethrane**: <u>51</u>, 67, 117; **halothane**: <u>117</u>, 198, 179; **sevorane**: <u>33</u>, 131, 181

If high concentrations of CO_2 interfere (it gives a strong signal at m/z 44), N_2O can be quantified basing on the signal at m/z 30. On page L4 a typical GC-MS chromatogram (as total ion current) is displayed. It can be observed that, as an effect of the vacuum applied on the detector end of the column, retention times are shorter with respect to those obtained with ECD detection.

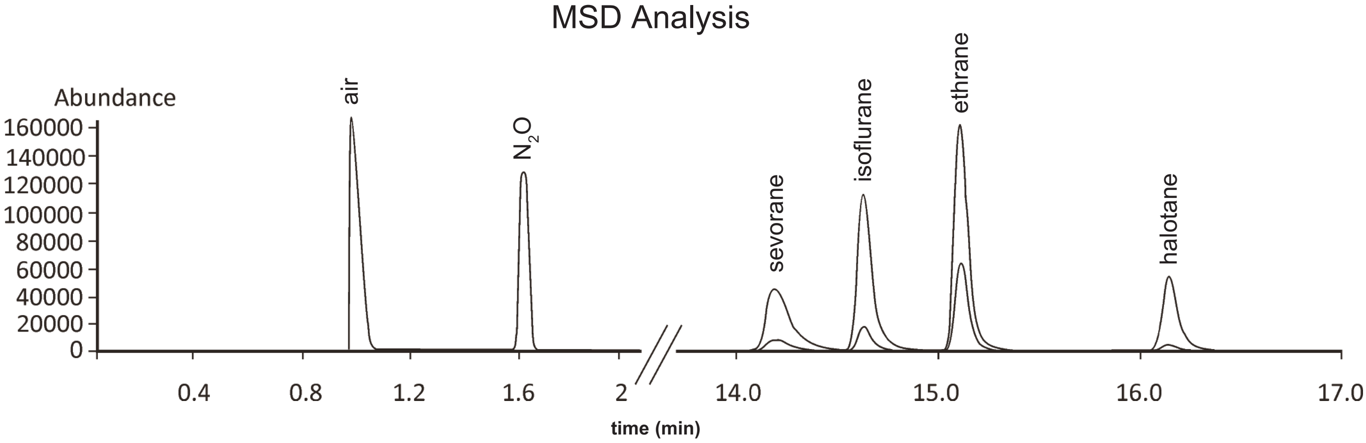
Calibration

Calibration curves for N_2O and halogenated anaesthetics can be prepared simultaneously.

Draw pure N_2O in a gas sampling bulb. Transfer 20 ml of pure N_2O in the 1 litre bottle through the septum by a gastight syringe. Switch on the magnetic stirrer and let the mixture equilibrate for 30 minutes.

Standard solutions of the halogenated compounds must be prepared in water/methanol 60/40 v/v in order to contain from 0.05 to 3.0 mg·l^{-1} of each compound; five calibration levels are recommended.

For each level pipet 10 ml of calibration solution in an empty vial, add a blank code RAD132 cartridge and <u>cap immediately</u>.



Add also a precisely measured volume of diluted N_2O drawn from the bottle by a gastight syringe (usually added volume ranges from 50 to 1,000 µl), stir and let equilibrate at 45 °C for 1 hour.

The values above generally comprise the usual conditions of operating theatres. The analyst may choose different values if needed, but equivalent exposure values should not exceed 400,000 mg·m^{-3}·min for nitrous oxide and 50,000 mg·m^{-3}·min for each of the halogenated compounds.

Pay attention: the ECD and/or MSD response may not be linear. If this should be the case, use a second order calibration curve.

Useful data

name	chemical formula	molecular weight	1 mg·m^{-3} at 25°C = ppm
nitrous oxide	N_2O	44.0	0.556
sevorane	$CH_2F\text{-}O\text{-}CH(CF_3)_2$	200.0	0.123
desflurane	$CF_3\text{-}CHF\text{-}O\text{-}CHF_2$	168.0	0.146
forane	$CHF_2\text{-}O\text{-}CHCl\text{-}CF_3$	184.5	0.133
ethrane	$CHF_2\text{-}O\text{-}CF_2\text{-}CHClF$	184.5	0.133
halothane	$CF_3\text{-}CHBrCl$	197.4	0.124

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
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Edition 01/2019

phenol, methylphenols and dimethylphenols

(thermally desorbed)

What you need

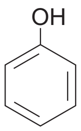
white diffusive body code RAD120
supporting plate code RAD121
vertical adapter code RAD122 (optional)
chemiadsorbing cartridge code RAD147

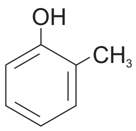


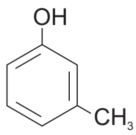

Principle

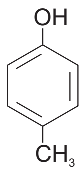
Code RAD147 cartridge is a stainless steel net cylinder with 100 mesh opening and 4.8 mm diameter, packed with 250 ± 10 mg of Tenax-TA, particle size 20-35 mesh. Phenols are trapped by adsorption and recovered by thermal desorption, analysis is performed by capillary gas chromatography and MS detection.

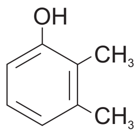
The method has been optimized for the following compounds:

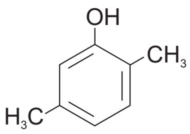

phenol

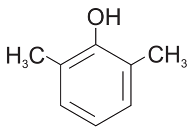

o-cresol

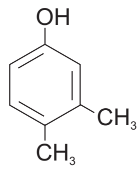

m-cresol

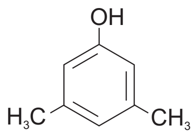

p-cresol


2,3-dimethylphenol


2,5-dimethylphenol


2,6-dimethylphenol


3,4-dimethylphenol


3,5-dimethylphenol

Sampling rates

Sampling rate values (in $ml \cdot min^{-1}$) at 298 K (25 °C) and 1013 hPa are listed in the table on the right. All of the values shown have been experimentally measured.

	sampling rate $ml \cdot min^{-1}$	limit of detection[1] $\mu g \cdot m^{-3}$	uncertainty at 2σ %
phenol	38	0.3	24.1
o-chresol	45	0.4	17.5
m-chresol	48	0.4	8.0
p-chresol	48	0.4	8.0
2,3-dimethylphenol	53	0.4	26.0
2,5-dimethylphenol	51	0.3	25.2
2,6-dimethylphenol	46	0.4	7.6
3,4-dimethylphenol	60	0.4	22.1
3,5-dimethylphenol	61	0.4	22.2

[1]after 24 hours exposure and with MS detection; analytical conditions as described in the *Analysis* paragraph.

Effect of temperature, humidity and wind speed

Sampling rates varies from the value at 298 K on the effect of temperature (in Kelvin) as expressed by the following equation

$$Q_K = Q_{298} \left(\frac{K}{298}\right)^{1.5}$$

where $\mathbf{Q}_K$ is the sampling rate at the temperature K and $\mathbf{Q}_{298}$ is the reference value at 298 K.

This produces a variation of ±5% for 10 °C variation (upwards or downwards) from 25 °C.

Sampling rate is invariant with humidity in the range 15 ÷ 90% and with wind speed between 0.1 and 10 $m \cdot s^{-1}$.

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Calculations

The listed sampling rate values take already into account the recovery yields of adsorbed compounds. The average concentration over the sampling period is therefore calculated from sampled mass of analyte and exposure time without introducing any other corrective factor, apart from temperature variations of Q.

Average concentration ***C*** in µg·m^{-3} over the whole exposure time is calculated according to the following expression:

$$\boldsymbol{C}\,[\mu g \cdot m^{-3}] = \frac{\boldsymbol{m}\,[\mu g]}{\boldsymbol{Q_K}\,[ml \cdot min^{-1}] \cdot \boldsymbol{t}\,[min]}\,1{,}000{,}000$$

where:
m = mass of analyte in µg
t = exposure time in minutes

Exposure

Workplace environment

Exposure time can range from 2 to 8 hours.

Other indoor sampling experiments and outdoor campaigns

The recommended exposure times range from 8 hours to 7 days.

Storage

The duration of Tenax adsorbent capacity is virtually unlimited. If kept in a cool place not contaminated by phenols, white and adsorbent capacity remain unchanged for at least twenty-four months. The expiry date and the lot number are printed on the transparent plastic casing, whose integrity acts as a guarantee seal.

After exposure the cartridges, well capped and kept in a cool and solvent-free place, maintain their content unaltered for at least three months.

Analysis

The analytical method hereafter described have been set up by a two-stage thermal desorber and mass spectrometer detector.

Desorption

The thermal desorber is equipped with 1/4” s.s. sample tubes, they have to be hollow and free: discard the stainless steel gauze disk which is fitted to the groove and discard also the springs if present.

Code RAD147 cartridge has been dimensioned to fit the diameter of thermal desorption tubes. Its length is such that, when the cartridge is introduced into the tube and is stopped by the groove, it is positioned exactly centrally with respect to the tube length.

Once capped, the thermal desorber steel tube has to be positioned in the carousel with the grooves on the bottom.

The desorption conditions described below have been developed to obtain the best results from cartridges exposed for seven days to the usual concentrations of urban and indoor pollution. Shorter exposure times or much higher concentrations than usual may make it necessary to readjust the splits.

Temperatures and timing

- Desorption: 280°C for 10 minutes
- Cryofocusing trap (Tenax TA): during primary desorption maintain at 2 °C, secondary desorption at 99 °C·sec^{-1} up to 290 °C, maintain at 290 °C for 1 minute
- Six port valve: 150 °C
- Transfer line: 200 °C

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Flows

- Carrier gas: helium, 24 psi
- Desorption flow: 100 ml·min^{-1}
- Flow from tube to cryofocusing trap: 20 ml·min^{-1}
- Outlet split: 25 ml·min^{-1}

Instrumental analysis

Column

capillary column, length 60 m, internal diameter 0.25 mm, film thickness 0.25 µm; the column is directly fitted to the six-port valve of thermal desorber apparatus

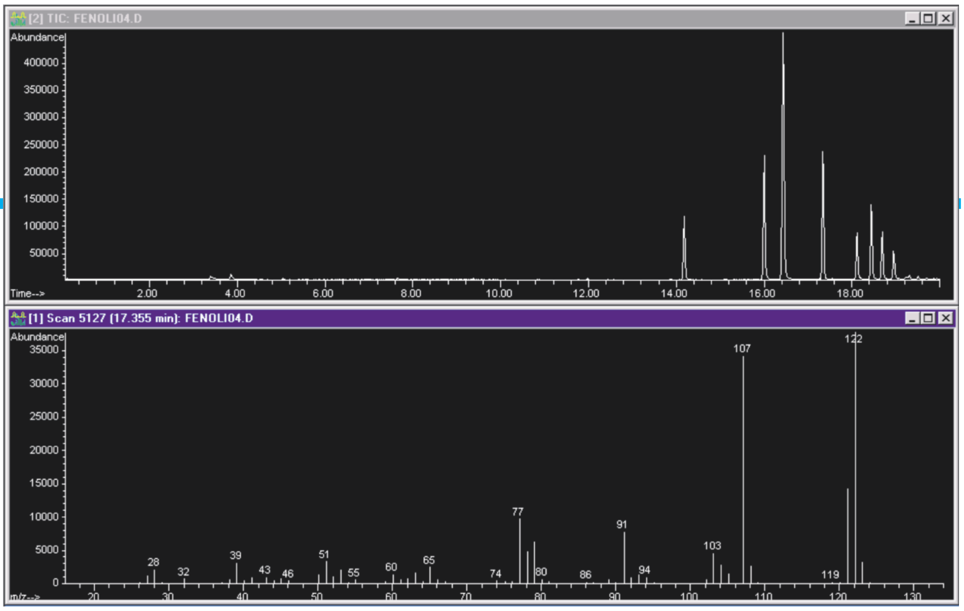
Temperatures

- GC oven: 40 °C for 5 minutes, 5 °C·min^{-1} up to 115°C, 10 °C·min^{-1} up to 165 °C, 30 °C·min^{-1} up to 285 °C, final isotherm 3 minutes
- GC-MS interface: 260 °C
-

Flows

- helium carrier gas: 1.6 ml·min^{-1}

In the figure on the right a typical chromatogram (as total ion current) is shown.



Calibration

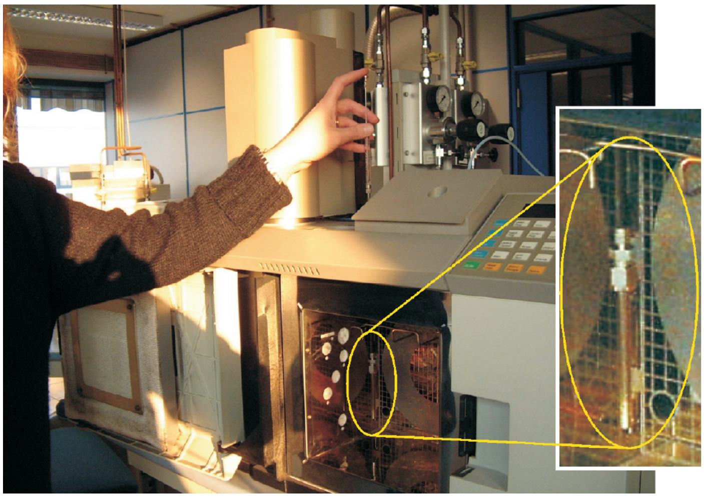
Calibration curves are obtained by gas-phase injection of methanol solutions of the target compounds onto blank cartridges. Injections are performed through a GC injector, where a short piece of wide-bore (0.53 mm i.d.) deactivated uncoated column is installed. The other end bears a Swagelock reducing connection (1/16”-1/4”).

The 1/4” Swagelock nut has to be equipped with a PTFE ferrule instead of the original steel one (use PTFE ferrules that come along with the thermal desorber caps).

Introduce a blank code RAD147 cartridge in a thermal desorber tube and fit the tube to the Swagelock nut. Keep the injector at 170 °C but do not heat the oven. Inject slowly 1 µl of each calibration solution under nitrogen flow (40 ml·min^{-1}) and let the system purge for 2 minutes. Analyze the cartridge as you would do with a sample. We suggest you to prepare a complete set of calibration solutions by subsequent dilutions such as they contain, for example, 4, 2, 1, 0.05, 0.025 and 0.01 µg·µl^{-1} of each compound.

Cartridge recovery

The cartridges can be reconditioned using the thermal desorber in tube conditioning mode, heating them at 280 ° C for at least 20 minutes in an inert gas flow (helium or nitrogen at a flow of 50 ÷ 100 ml·min^{-1}).



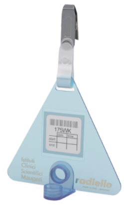
To prepare the calibration standards fit a 1/16”-1/4” Swagelock reducing connection to the GC injector by a short piece of wide-bore deactivated uncoated column.

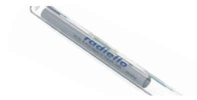
Edition 01/2019

1,3-butadiene and isoprene

What you need

yellow diffusive body code RAD1202
supporting plate code RAD121
vertical adapter code RAD122 (optional)
chemiadsorbing cartridge code RAD141



Principle

Cartridge code RAD141 is a 4.8 mm diameter stainless steel mesh tube with a mesh size of 3x8 µm, filled with approximately 480 mg of graphite carbon (Carbopack X) 40/60 mesh.

1,3-butadiene and isoprene are trapped by adsorption, recovered by thermal desorption and analysed by capillary gas chromatography with MS detector.

Sampling rates

Sampling rate values were measured experimentally at 20°C (273 K) and 1013 hPa in a dynamic controlled atmosphere chamber.

The sampling rate for 1,3-butadiene in the workplace is **30.5 ± 0.3** ml·min^{-1} (nominal value at a concentration between 114 and 226 µg·m^{-3} for 8-hour exposures). For the longer term (7 days) sampling the value is **4.7** ml·min^{-1} [Strandberg et al. (1), (2)].

For isoprene the sampling rate is **41.2 ± 4.9** ml·min^{-1} (in the range 2 ÷ 6,680 µg·m^{-3} for exposures of 30 to 480 min).

Effect of temperature, humidity and wind speed

Both temperature and relative humidity affect the sampling rate of 1,3-butadiene. If the temperature drops to 5 °C, the bias is +12.9% at 20% RH or -2.4% at 80% RH, compared to 20 °C and 50% RH. Avoid sampling at temperatures close to 40 °C, as the sampling rate shows a significant decrease.

The effect of temperature and relative humidity on the isoprene sampling rate is lower: at low temperature and humidity (5°C, 21% RH) the sampling rate is 10% higher, while at high temperature and humidity (41°C, 77% RH) there is a 23% decrease.

Do not expose the sampler directly to rain. Always use the weather box code RAD196 for outdoor sampling to prevent water from entering the membrane and wetting the absorbent.

Calculations

The average concentration C over the exposure time interval is calculated from the mass of the analyte found on the cartridge (corrected for the blank, if measurable) and from the exposure time, using the sampling rate values above, as follows:

$$\boldsymbol{C}\ [\mu g \cdot m^{-3}] = \frac{\boldsymbol{m}\ [\mu g]}{\boldsymbol{Q}\ [ml \cdot min^{-1}] \cdot \boldsymbol{t}\ [min]}\ 1{,}000{,}000$$

where:
m = mass of analyte in µg
t = exposure time in minutes

(1) Strandberg et al. Atmos. Environ., 2006. **39**(22), 4101-4110.

(2) Strandberg et al. Atmos. Environ., 2006. **40**(40), 7686-7695.

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Centro di Ricerche Ambientali - via Atene, 9 - 35010 VIGONZA (PD)
Ph. +39 049 806 45 11 fax +39 049 806 45 55 e.mail cra.padova@icsmaugeri.it

Limit of detection

The blank response, the limit of detection (LOD) and the limit of quantification (LOQ) depend on the instrumentation and the analytical conditions.

Under the analytical conditions specified below, the blank value is not detectable, i.e. it is less than 0.5 ng for both compounds.

The LOQ for 8-hour workplace exposure is 0.1 μg·m^{-3}. For a 7-day exposure to ambient air, the LOQ is 0.03 μg·m^{-3}; see also Strandberg et al. (2).

Measurements uncertainty

The following table shows the values of uncertainty in 1,3-butadiene measurements in the workplace, evaluated with two different approaches. Uncertainties were first determined under laboratory conditions, following the methods of the ISO GUM (*Guide to Expression of Uncertainty in Measurement*, International Organization for Standardization) and ISO 5725 (*Accuracy (trueness and precision)* of measurement methods and results General principles and definitions) standards. In this case, the uncertainty takes into account all the contributions involved in the whole measurement process (time, T, RH on the sampling rate, uncertainty of the measured mass and so on), contributions which were determined according to EN 838. Subsequently, the uncertainty was determined by a field comparison with OSHA 56 (as a reference method), according to ISO 13752.

Uncertainty of measurement for an 8-hour sampling of 1,3-butadiene in working environment

Relative combined expanded uncertainty ($2 \cdot u_c$)	200 μg·m^{-3}	442 μg·m^{-3} (0.1 TLV)	2210 μg·m^{-3} (0.5 TLV)	4420 μg·m^{-3} (TLV-TWA ACGIH)
Laboratory tests at 20 °C, 50% RH (EN 838, calculations by ISO GUM)	48.4%			
Field comparison (ISO 13752)	37.0%	25.0%	11.1%	7.9%

Storage

After exposure, the samples, well capped in their glass tubes, have to be stored in the freezer, because 1,3-butadiene and isoprene are reactive compounds. Laboratory tests according to EN 838 showed for both compounds a loss of analyte of 7-8% after 14-day storage. The samples shall therefore be analysed within 14 days from the end of exposure, in order to ensure the maximum loss of analyte remain within 10%.

Analysis

The method proposed here was developed with a two-stage thermal desorber coupled to a gas chromatograph and mass spectrometer.

Desorption

The 1/4 "stainless steel tubes supplied with the thermal desorber must be empty and free: remove the stainless steel disk placed inside it in correspondence with the circular incision and, if present, also the springs.

The code RAD141 cartridge has been sized so that its outer diameter fits to the inner diameter of the thermal desorber tube. Moreover, its length is such that, when the cartridge is introduced into the tube and is stopped by the groove, it is positioned exactly centrally with respect to the tube length.

Once capped, the thermal desorber steel tube has to be positioned in the carousel with the grooves on the bottom.

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Temperatures and timing

- Desorption: 350 °C for 6 minutes, nitrogen flow through the tube 100 ml·min^{-1}, of which 20 ml·min^{-1} sent to the cryofocalization trap and 80 ml·min^{-1} to the inlet split:
- Cryofocusing trap (Tenax TA): adsorption -20 °C, desorption 99 °C·sec^{-1} up to 290 °C, 1 minute at 290 °C, trap desorption in nitrogen flow at 26.8 ml·min^{-1}, of which 25 ml·min^{-1} at the split outlet;
- Six port valve: 150 °C
- Transfer line: 200 °C

Instrumental analysis

Column

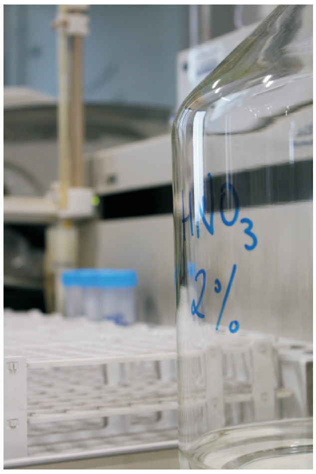
J&W GS-GASPRO, length 60 m, i.d. 0.32 mm; the column is directly fitted to the six-port valve of thermal desorber apparatus.

Temperatures

- GC oven: 80 °C for 1 minute, 25 °C·min^{-1} up to 175 °C, maintain for 8 minutes, 25 °C·min^{-1} up to 250 °C, final isotherm 11.2 minutes
- Interface GC-MS: 290 °C
- Ionic source: 230 °C, quadrupole 150 °C

Flows

- Carrier gas: helium at 1.8 ml·min^{-1}



Calibration

The calibration curve is performed by injecting known aliquots of a certified gaseous mixture of 1,3-butadiene in nitrogen onto virgin cartridges. The operation is carried out the injector of a gas chromatograph whose output is connected with a short piece (10 cm) of a deactivated capillary column (0.25 mm id) connected to a Swagelock reducer 1/16 "-1/4" .

Instead of the 1/4 ”steel ferrule of the reducer use a PTFE ferrule.

Introduce a cartridge in the thermal desorber tube and insert the tube in the Swagelock reducer, keeping the injector at 50 °C and the oven cold. Inject different volumes of the gas mixture under a flow of nitrogen of 30 ml·min^{-1}, leaving the gas flowing for 2 minutes.

It is recommended to use a mixture of 1,000 ppm of 1,3-butadiene in nitrogen and to inject aliquots of 20, 40, 60, 80 and 100 µl of mixture (with a 100 µl gas-tight syringe) or 100 aliquots , 200, 300, 400 and 500 µl of mixture (with a 500 µl gas-tight syringe) according to the desired calibration range.

Cartridges conditioning

The cartridges can be reconditioned using the thermal desorber in "*tube conditioning*" mode, heating them to 350 °C for at least 20 minutes in an inert gas flow (helium or nitrogen at a flow of 50 ÷ 100 ml·min^{-1}).

Index by code

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Appendix N Hydrology Assessment Report

HYDROLOGICAL IMPACT ASSESSMENT
BAMBOO BIOPRODUCTS
FRIENDSHIP, WESTMORELAND
FINAL REPORT

PREPARED FOR ENVIRONMENTAL SOLUTIONS LTD.

HERBERT THOMAS, HYDROLOGIST
hthomasjam@gmail.com
MARCH 28, 2022

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List of Figures

1. BACKGROUND

Bamboo Bioproducts Ltd., UK Headquarters is planning to install in Westmoreland, Jamaica, a new pulp mill for production and marketing of fluff from bamboo. The site which is in the Cabarita River watershed and in the flood plain of the reach of the river between the community of Barham and Fort William (Figure 1) has implication for impacting the flow in the river. As such, Bamboo Bioproducts Ltd. has commissioned a Hydrological Impact Assessment of the proposed mill site.

Figure 1 Proposed Location of the Bamboo Bioproducts Ltd. Mill Site

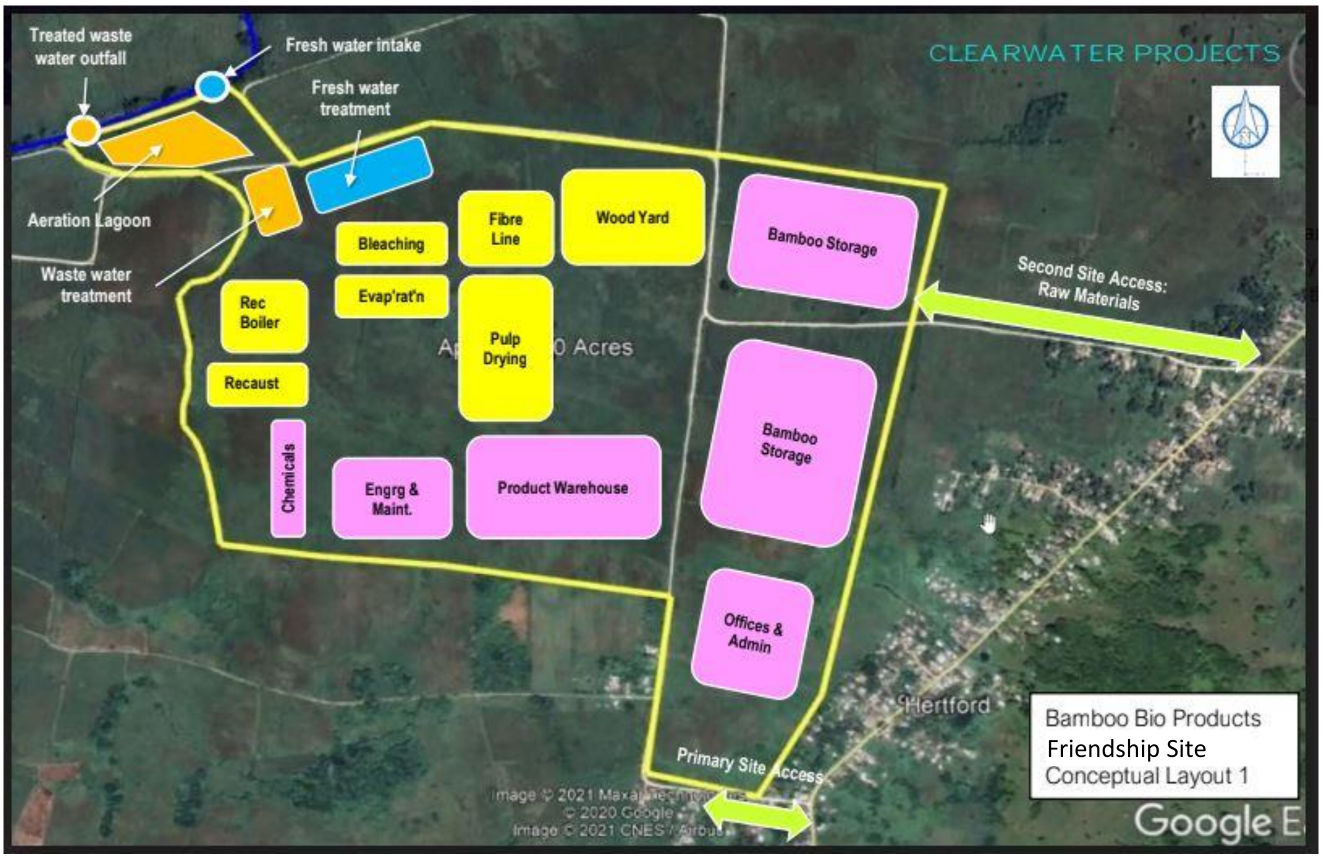
Herbert Thomas
Hydrologist

1.1 Description of the Proposed Bamboo Bioproducts Ltd. (Friendship, Westmoreland) Mill Site Operations

Figure 2 below shows the general layout of storage areas (pink) for the bamboo, the products, energy and the chemicals, for the processing components (yellow) and water treatment. The fresh water is sourced from the Cabarita River at the intake shown and treated waste is discharged back to the river.

The water usage per day is estimated approx. 14,200 m^3 per day (based on 710 tonnes of production per day) and a water requirment of 20 m^3 per tonne. The expected annual pulp production is 250,000 metric tonnes.

Figure 2 Conceptual Layout of the Bamboo Bioproducts Mill Site



The storage, use of chemicals and the discharge of effluents are processes that can have negative implications for surface and groundwater and hence have to be given consideration in the hydrological assessment.

2. PROJECT OBJECTIVE

These are as follows:

a. To conduct a flood risk assessment of the proposed development
b. To assess the possible hydrologic impact of the mill, including water quality
c. To recommend mitigation measures (hard and soft) to prevent any negative impacts from the development on the water resources of the watershed.

2.1 Scope of Work

Based on the Terms of Reference of this assignment, the scope of work are as follows:

i. Map the watershed showing location of the proposed project site in the catchments of the watershed. The watershed definition to be done by terrain processing using ArcGIS along with a suitable DEM
ii. Describe the hydrology and hydrogeology of project site and its watershed environs including the existing surface waterways within and near the site and downstream of the site.
iii. Estimate pre- and post-development downstream run-off for the different return Periods (25, 50 and 100 yr).This will include:
    a. Data collection: streamflow, rainfall and other climatological data and assessment of how this impacts the watershed.
    b. Development of hydrologic and meteorologic models,
    c. Calibration/verification of hydrologic model,
    d. Rainfall-runoff simulations
iv. Use data for nearby wells and from WRA hydrostratigraphy maps to examine sub-surface conditions (soil type, depth to ground water, ground water quality, etc.) and any effects on ground water due to additional pumping water-well post-development, effects on infiltration and percolation and effects on surface and ground water quality.
v. Conduct a natural hazard risk assessment as it relates to flooding and stormwater runoff. (Client to provide a cross-section survey data of main channels identified in the area for the Hydraulic Analysis)
vi. Conduct an Impact assessment of proposed development on the watershed including assessment on water quality.
vii. Assess cumulative impacts.
viii. Report preparation

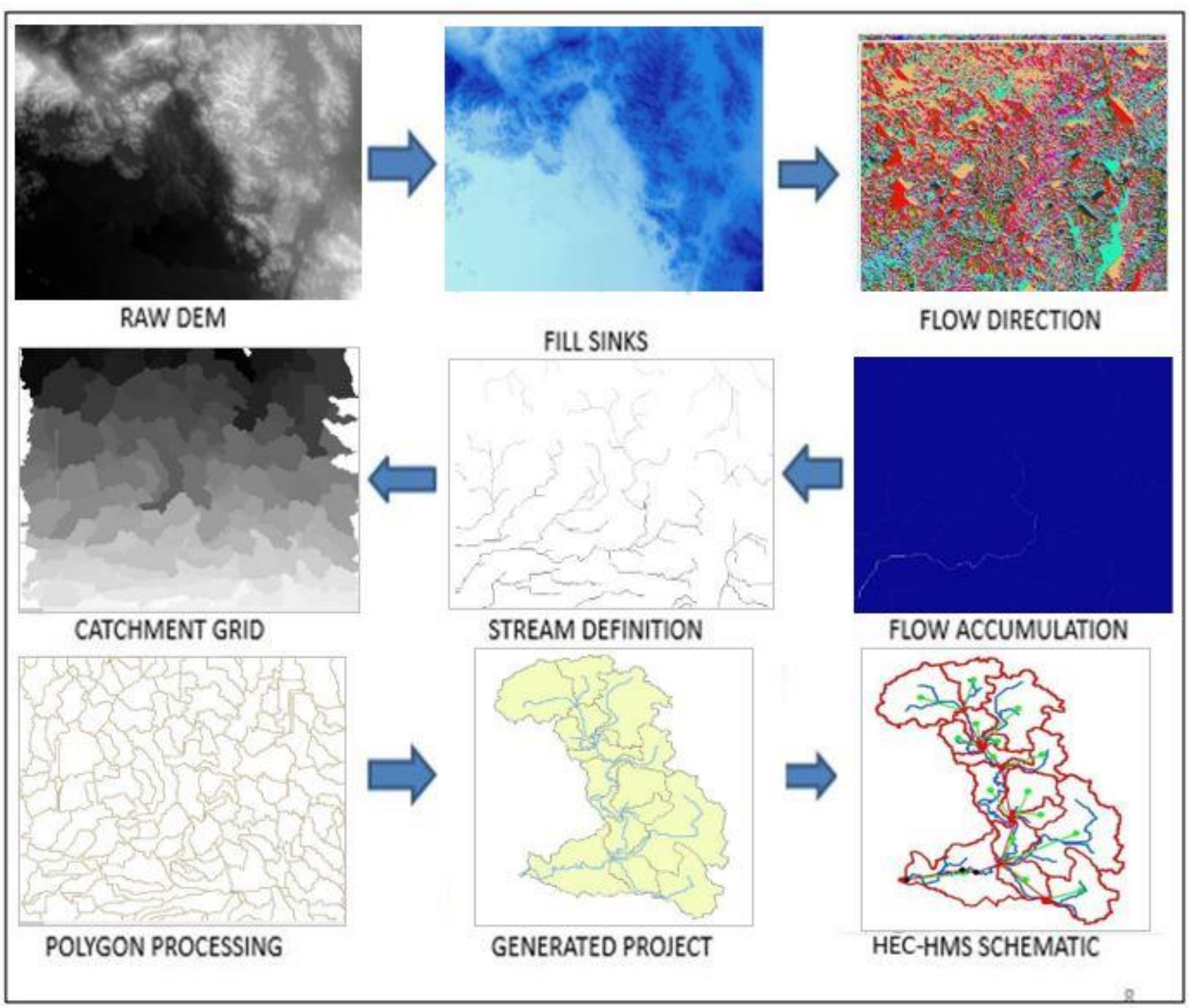
3. METHODOLOGY

3.1 Demarcation of the Bamboo Bioproducts (Friendship, Westmoreland) Mill Site Watershed

The Watershed was demarcated using the HEC-GeoHMS geospatial hydrology toolkit (an ArcView extension) and a 28m x 28m DEM of the area. The terrain pre-processing components are depicted in Figure 3.

As shown, the process involves first the filling of the sinks in the DEM, followed by the estimation of the flow direction and flow accumulation, the definition of the stream flow path and catchment grid. From this grid the Watershed and Sub-basins were demarcated.

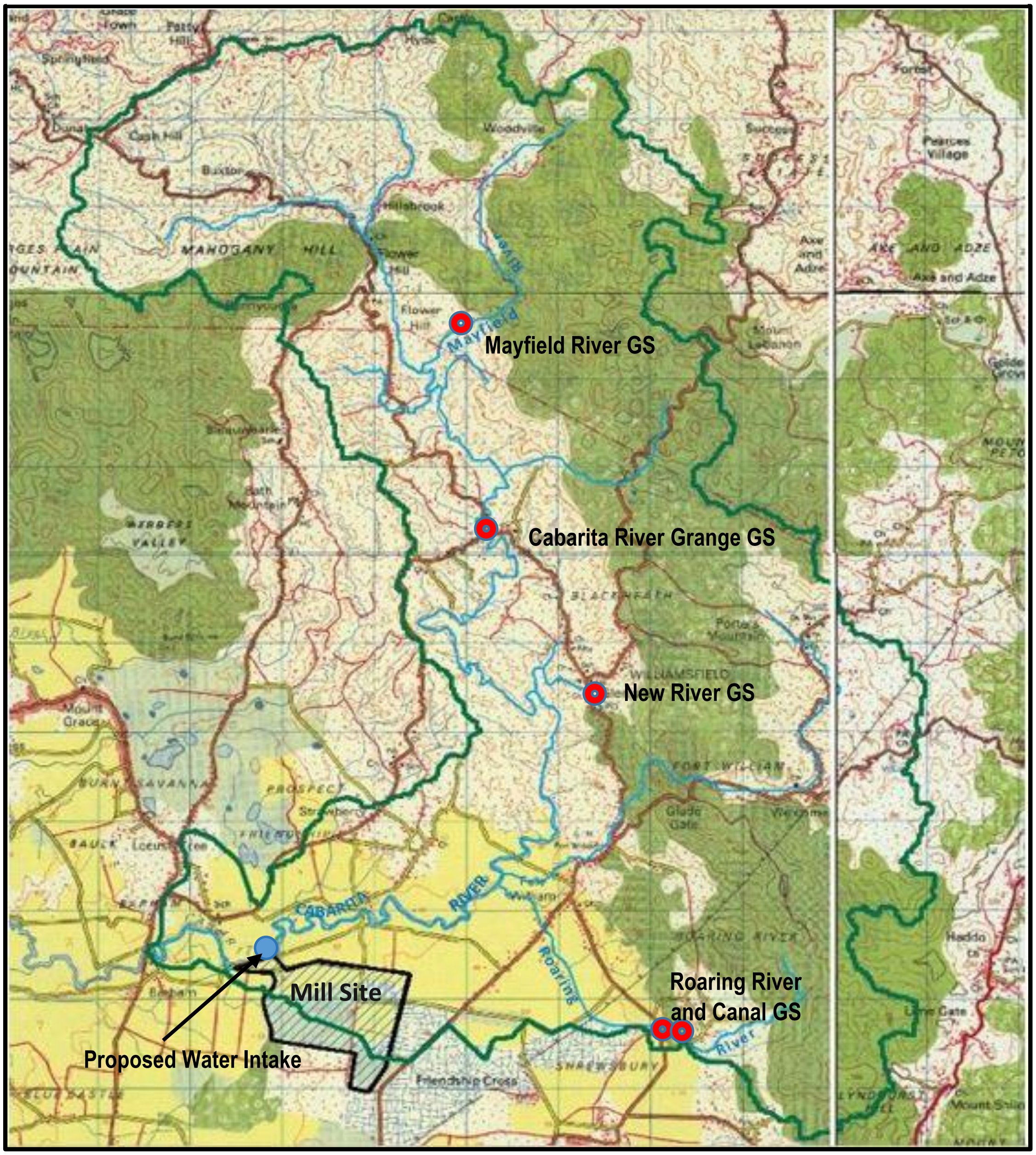
Figure 3 Cabarita River Watershed above Barton Bridge Terrain Pre-processing Components



Herbert Thomas
Hydrologist

The demarcated Cabarita River sub-watershed above the proposed Bamboo Bioproducts Mill Site is overlain on a 1: 50,000 scale topographic map shown in Figure 4 below. The area is referred to hereafter as the "Bamboo (Friendship, Westmoreland) Mill Site Sub-Watershed" and has an area of 63.4 km^2. The mill site area is approximately 1.55 km^2, a relatively small area.

Figure 4 Bamboo (Friendship, Westmoreland) Mill Site Watershed



3.2 Description of the Bamboo (Friendship, Westmoreland) Mill Site Watershed

3.2.1 Hydrology and Drainage

Figure 4 above shows the Cabarita River and the major tributaries (Roaring River, New River, Mayfield River.) upgradient of the Mill Site. The Cabarita River emerges at the foot of the Cash and Patty Hills at near 400 meters elevation and meanders over 22 Kilometers to the outlet of the Sub-watershed at Barham. The Mill site Sub-watershed has river flow gauges operated by the Water Resources Authority at the locations shown in Figures 4 and 5.

Figure 5 Cabarita River Watershed Map showing Flood and landslide Risk Areas

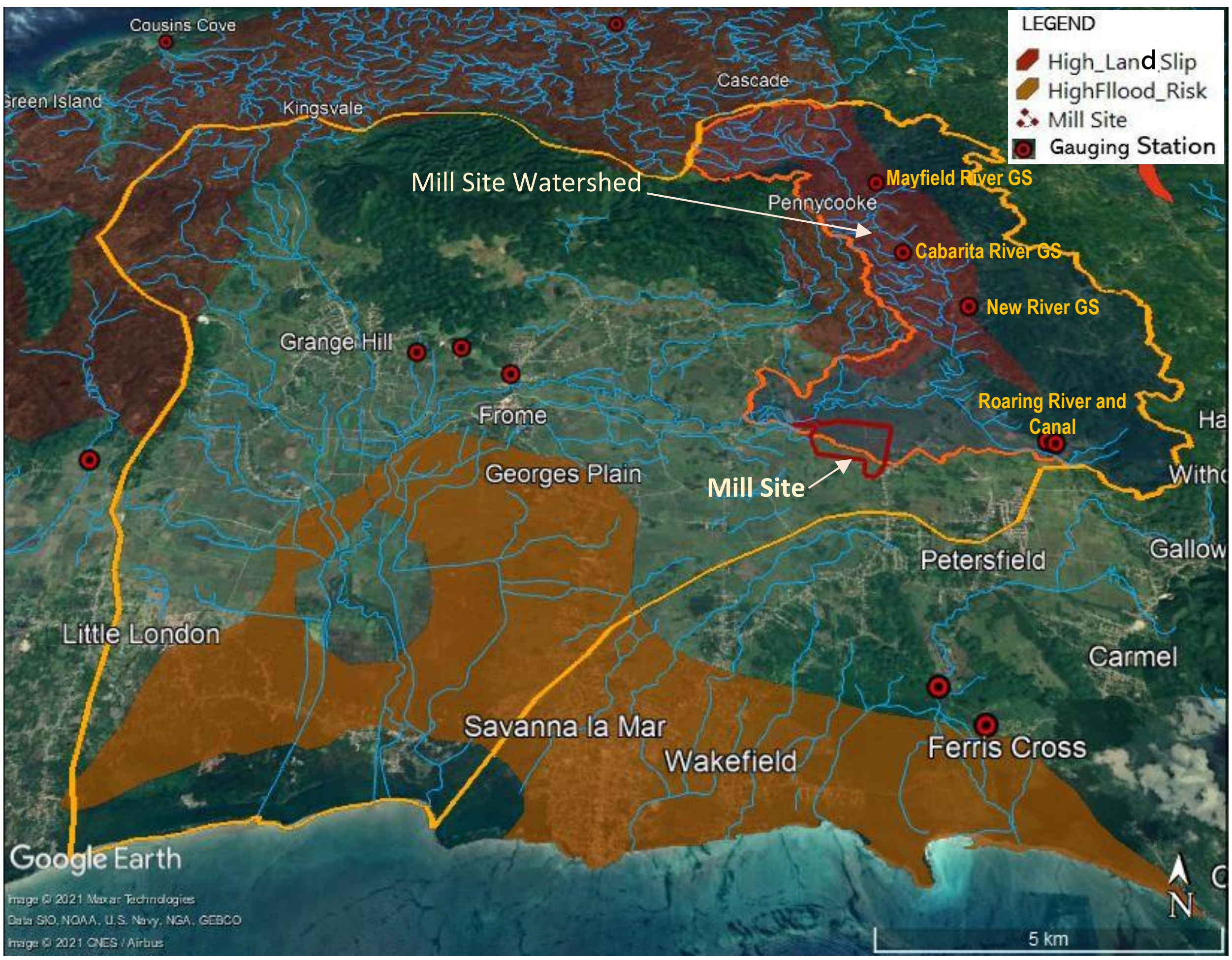


Figure 5 also shows that the Mill Site watershed is upgradient of Georges plain that has a high flooding risk. It also shows that the area of the Mill Site watershed, North of the site is prone to land slippage during heavy rains and is a possible source of sediment deposit in the flood risk area.

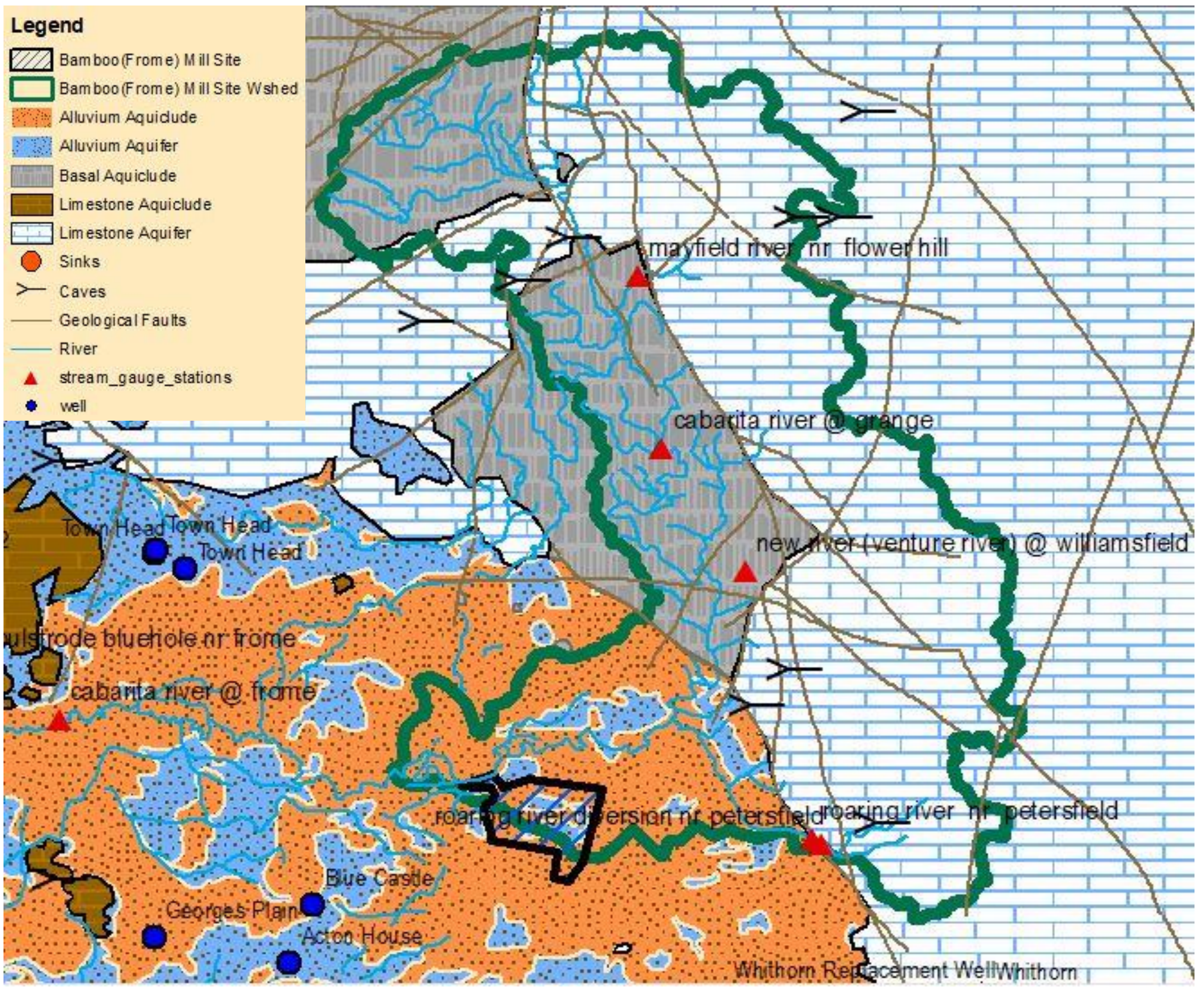
It has been observed in some areas of Jamaica that bamboo on hillside lands tend to uproot and topple during heavy rainfall because of the shallow root structure and heavy canopy. This increases the erodibility of the soil and rate of sedimentation to the drainage network.

To minimise the risk of increased sedimentation rates and aggravation of flooding in the downstream High Flood Risk areas shown in Figure 5, it may be necessary to avoid planting bamboos in the High Land Slip shown in the figure or to apply strategies that will prevent its toppling.

3.2.2 Hydrostratigraphy of the Bamboo Bioproducts-Friendship, Westmoreland Environs

As shown in Figure 6, the mill site is located on the Alluvium Aquiclude with pockets of overlain unconfined Alluvium Aquifers. To the north of the site is the Basal Aquiclude and to the east Limestone Aquifer which is highly fractured with several faults and caves. There are no wells located in the watershed above the Mill Site. Wells are, however, located downstream of the site in the pockets of Alluvium Aquifer.

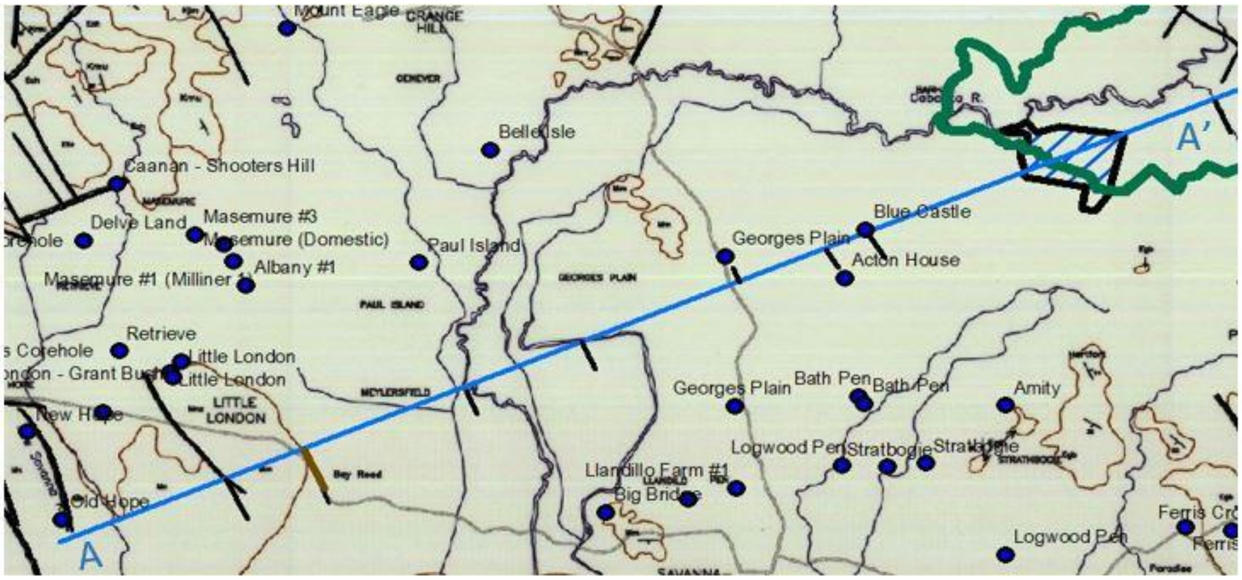
Figure 6 Map showing Hydrostratigrphy and Geologic Features of the Mill Site's Watershed Environs



3.2.3 Examination of the Sub-Surface Conditions

Figure 7 shows an overlay on the Geology map sheet, of the wells from the WRA database that are located down gradient of the Mill Site. These wells could possibly be vulnerable to any spill of contaminants from the site

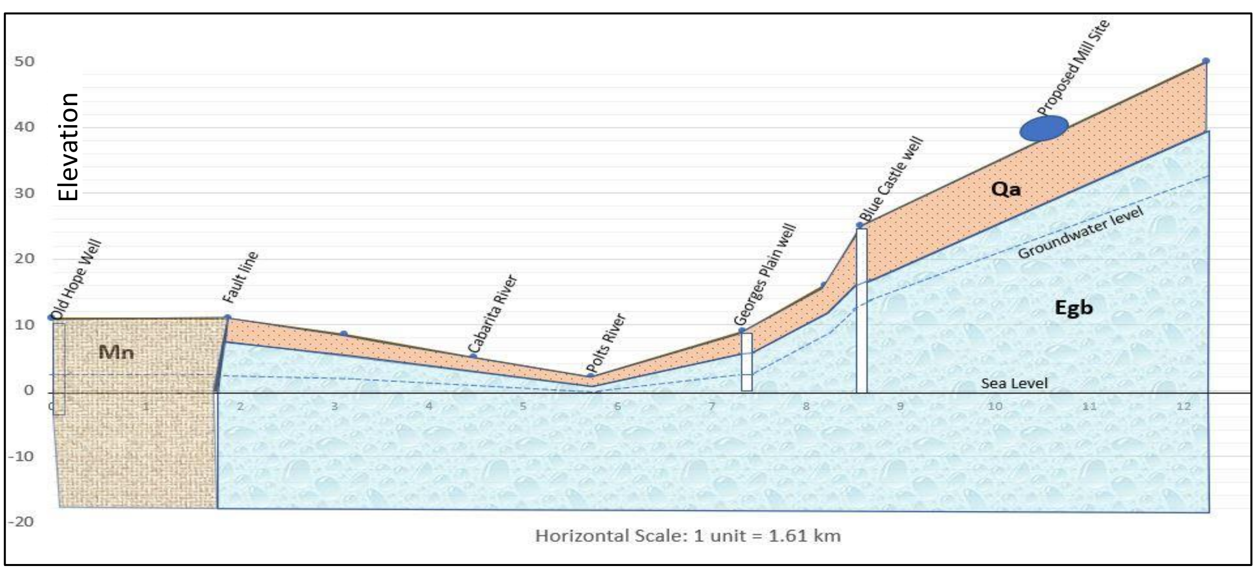
Figure 7 Geology Map of Cabarita River Environs (SW of Mill Site)



(Data source: Water resources Authority. Jamaica)

A geologic cross- section (Figure 8) was constructed from the section A-A' as shown in Figure 7 and with the lithological data for the wells Georges Plain and Blue Castle.

Figure 8 Geological Cross-Section (A-A') Cabarita River Environs



The Figure shows that the Alluvium (Qa) overlays the Gibraltor-Bonnygate Limestone Formation (Egb). The Alluvium over the limestone in this section is a combination of aquiclude and aquifer material.

The closest well to the Mill site is the Blue Castle well, the lithology of which is shown in Table 1 below. The uppermost stratum, the Alluvium, is comprised of clay and gravel of depth 18 ft or 5.5m. In the cross-section (Figure 8), The Alluvium (Qa) was made to also include the soft limestone of depth 8ft (2.5 m). The depth of the alluvium at this well was therefore estimated at 8m. By extrapolation the depth of the alluvium below the Mill Site is estimated at 8m.

Table 1 Blue Castle Well Lithological Data

		Type	Description	
Layer:	Wells	Well Lithology		Display
Object:	Blue Castle			
Parameter:	Well Lithology			
Aggregat.:	None			
Owner:	WRA			

1 of 1

Grid Reference : E 1608 N 5009 Logged By:

STRATA	Depth from /Feet	Depth to /Feet	Thickness /Feet	Remarks
Clay and stone	0	18	18	
Soft limestone	18	26	8	
Hard limestone	26	110	84	

Source: WRA Web-Map

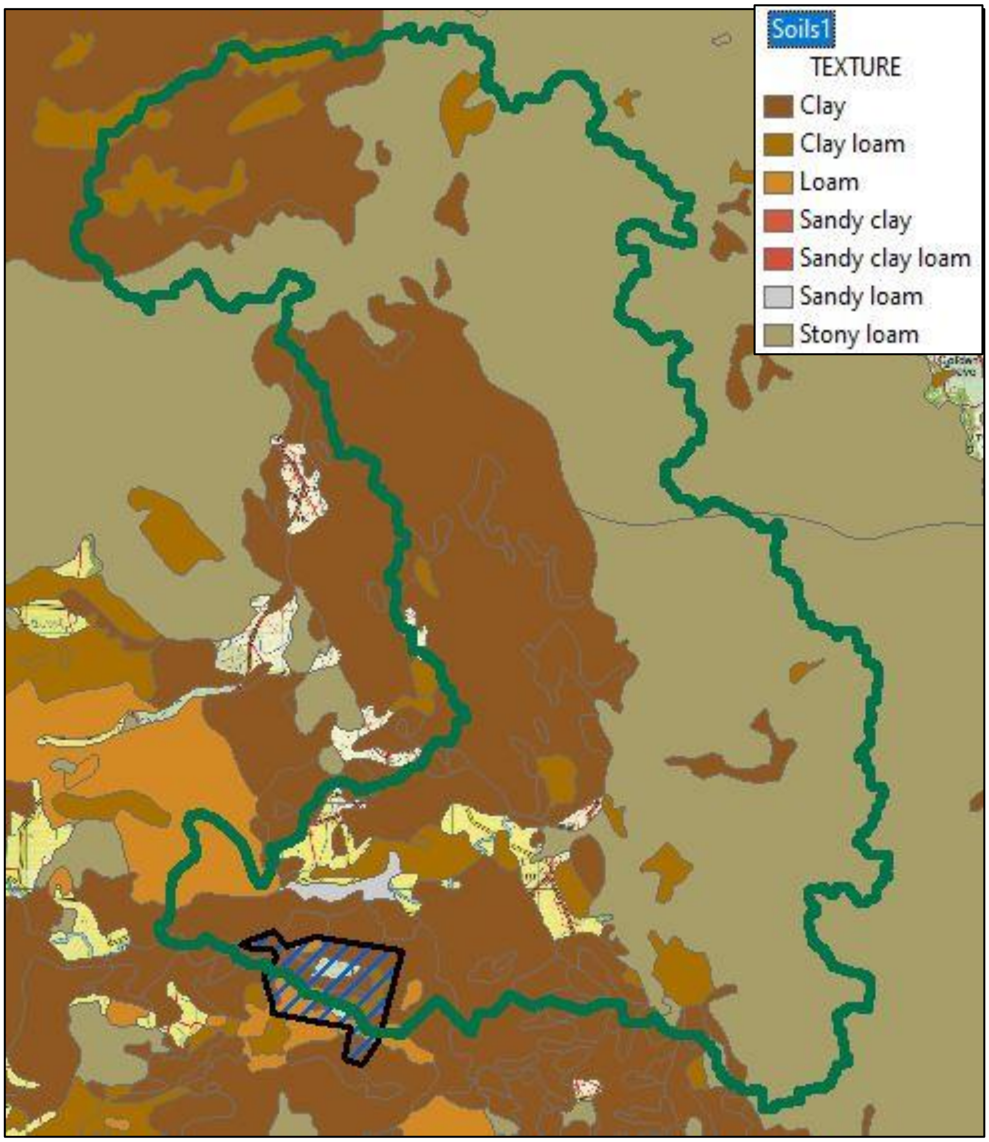
The static groundwater levels in the wells at Georges Plain and Blue Castle were extrapolated to estimate the levels in the limestone Aquifer over the section A – A'. The Alluvium over the limestone in this section being principally aquiclude material may offer some level of protection to the aquifer. The soft underlying limestone could also be of low permeability and offer additional protection to the Egb. However, several pockets of aquifer material are present in the Alluvium (as shown above in Figure 6) and these may facilitate movements of any spilled contaminants to the Limestone.

3.2.4 Soil Characteristics of the Bamboo Bioproducts Watershed

The soil map in Figure 9 is a clipped section from the soil map of Jamaica obtained from the Water Resources Authority (WRA) Jamaica. The soil of the eastern half of the "Bamboo Bioproducts-Friendship, Westmoreland Watershed" is largely of the Stony Loam type. This soil type has very rapid internal drainage properties, which results in very low surface runoff potential.

The other dominant soil type is the clay, the project area (Mill Site) being largely clay and clay loams. These soils have low infiltration rates (slow internal drainage) and favour either ponding where there are depressions or increased runoff rates on steep slopes.

Figure 9 Soil Map of the Cabarita River Watershed

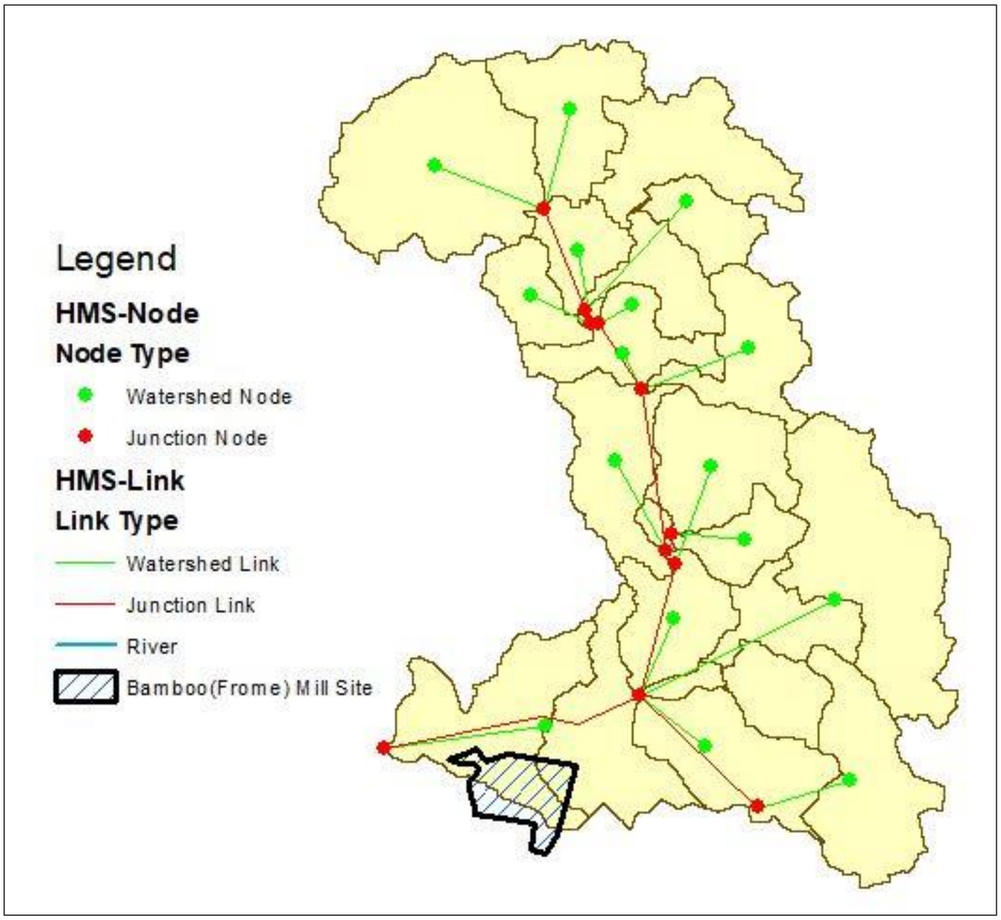


(Data source: Water resources Authority. Jamaica)

3.3 Hydrologic Analysis

The simulation of the 10-, 25-, 50-, 100-year (T-yr) flow hydrographs for the pre- and post-development conditions of the Bamboo Bioproducts Project area and environs was done using the HEC-HMS model (Hydrologic Engineering Centre - Hydrologic Modelling System). The HecHMS schematic for the “Bamboo Bioproducts-Friendship, Westmoreland Watershed” is shown in Figure

Figure 10 HecHMS schematic of the Mill Site Watershed



10.
For a given rainfall intensity, the model estimates the rainfall losses in each sub-watershed and uses the resulting effective rainfall to simulate the runoff hydrograph for each sub-basin/sub-watershed, combine these at the junction nodes shown in Figure 10, and route these via the junction links to the outlet.

The SCS Runoff Curve Number (CN) method was the chosen module for the rainfall-runoff transformation. For each sub-basin of the watershed in Figure 10, the HEC-HMS simulates the runoff depth ***(Q)*** from the effective rainfall ($\boldsymbol{P}$) as shown in equation 1:

$$\boldsymbol{Q} = \frac{(\boldsymbol{P}-\boldsymbol{Ia})^2}{(\boldsymbol{P}-\boldsymbol{Ia})+\boldsymbol{S}} \text{ ……………… (1),}$$

Where: $S = \frac{1000}{CN} - 10$ = potential maximum retention after runoff begins and I_a (Initial abstraction) = $0.2S$. The CN is a coefficient that determines the amount of the effective rainfall depth that becomes runoff depth.

The runoff depth for each sub-basin was then routed through a Unit Hydrograph to generate the runoff hydrograph. Hydrographs were joined at junctions shown in the Schematic (Figure 10) and routed downstream to the next junction. The process of hydrograph combination at junctions and routing through the reaches continues to the outlet of the watershed.

The SCS Unit Hydrograph (UH) method was used for the transformation of the runoff depths of each Sub-basin to discharge hydrographs. The UH lag time (TLag) is the parameter required by the HecHMS model. It is the time difference between the centre of the unit rainfall event and the runoff peak (DHI, 2009, Ref 1). The Soil Conservation Service formula, adopted by DHI in 2009, was used and is given by:

$$\text{TLag} = \frac{(L*3.28*1000)^{0.8}*\left(\frac{1000}{CN}-9\right)^{0.7}}{1900*Y^{0.5}} \quad \text{..............(2)}$$

Where:
T lag – Lag time in hours,
L- Hydraulic length of the catchment in km,
CN–average Curve Number within the catchment area and
Y–average catchment slope in percent.

The routing of flows in the reach between junctions was modelled using the Muskingum methods, characterised by the parameters K and X. Where $\mathrm{K} = \mathrm{L/Vw}$, L is channel Length and Vw is the flood wave estimated as 1.33 – 1.67 times the average velocity. The average velocity was taken from discharge measurement notes for the Cabarita River at Grange. Appendix 1 shows the results of the computation of the K values.

3.3.1 Runoff Curve Number (*CN*) Determination

The *CN* is determined from the *Hydrologic Soil Group* (HSG), the land cover type, treatment, and antecedent runoff condition (ARC). Another factor considered is whether impervious areas are directly connected to the drainage system or whether the flow spreads over pervious areas before entering the drainage system.

3.3.1.1 Soil Reclassification to HSG

The soils in Figure 9 were reclassified into HSGs shown in Figure 11, based on the soil grouping in Table 2. These groups are based on the soil's runoff potential, where HSG A generally have the smallest runoff potential and HSG D the greatest (Ref 2)

Figure 11 HSG- of the Mill Site Watershed

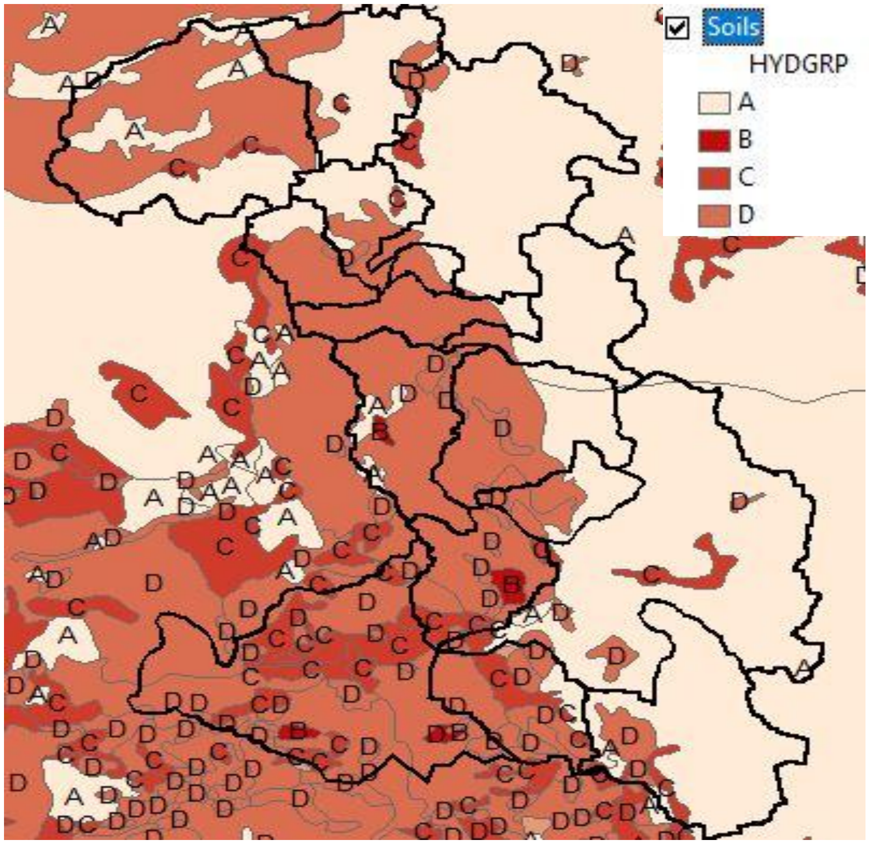
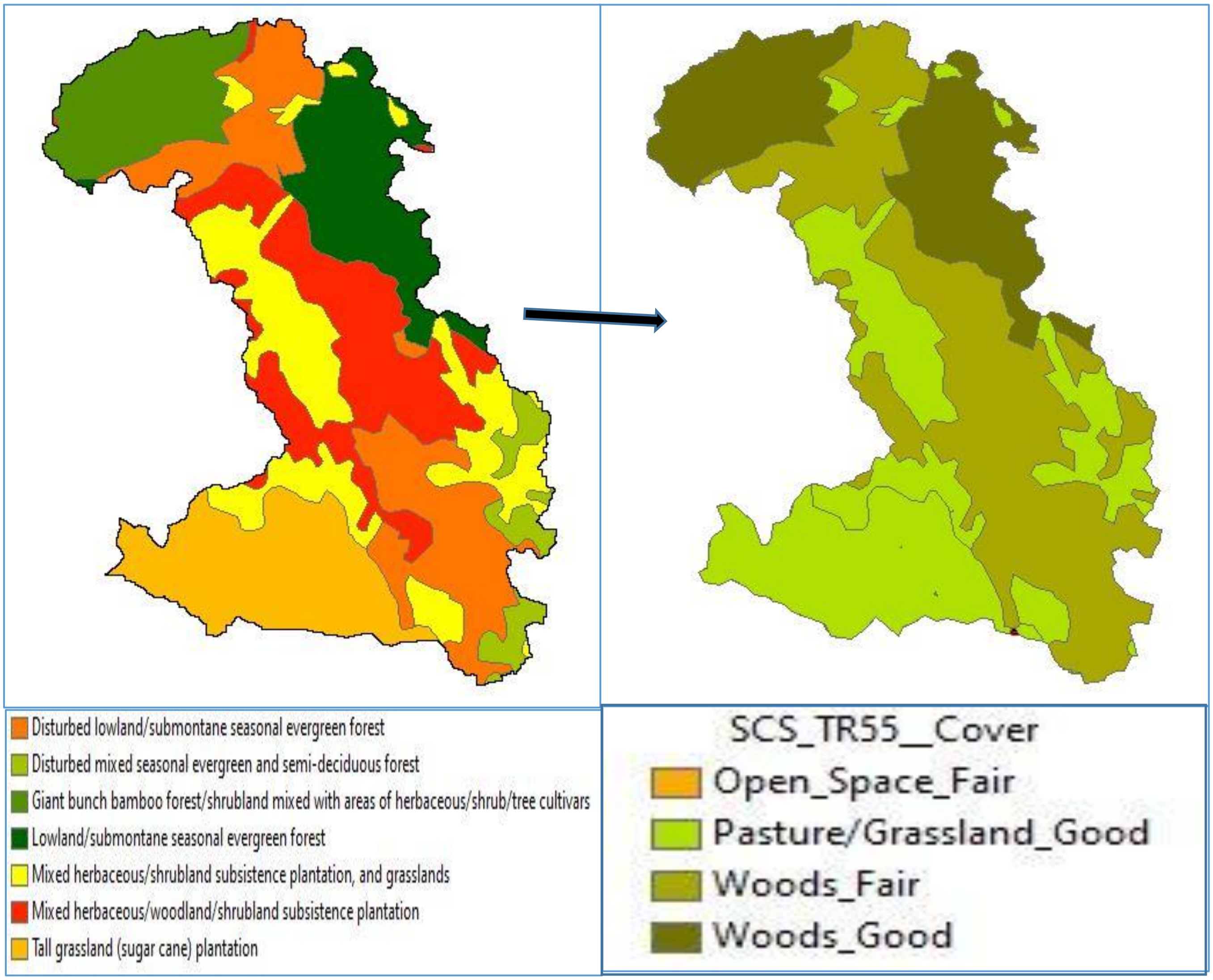


Table 2: Hydrologic Soil Groups	
HSG	**Soil textures**
A	Sand, loamy sand, sandy loam
B	Silt loam, loam
C	Sandy clay loam
D	Clay loam, silty clay loam, sandy clay, silty clay or clay

3.3.1.2 Landuse Reclassification

The HEC-HMS utilises SCS-TR55 land cover type in the CN determination. The land cover map of the watershed was therefore reclassified as the SCS_TR55 Cover type as shown in Figure 12.

Figure 12 Landuse Maps of the Mill Site Watershed



3.3.1.3 Curve Number (CN) Grid Determination

The *CN* grid in Figure 13 was generated using ArcGIS to overlay the HSG map on the reclassified land-use map and applying a CN look-up table (Table 3).

Table 3 CN Look-up Table

OBJECTID *	LuValue	Description	A	B	C	D
1	1	Woods-Good	30	55	70	77
2	2	Woods - Fair	36	60	73	79
3	3	Open Space - Fair	77	85	90	92
4	4	Pasture/Grassland	39	61	74	80

The subbasin *CN Map (Figure 13) was generated from the CN* Grid using ArcGIS and based on the formula for a weighted mean subbasin *CN* = $\frac{\sum A_i\, CN_i}{\sum A_i}$, where A_i is the i^{th} pixel of the sub-basin and CN_i is the corresponding *CN* of the pixel.

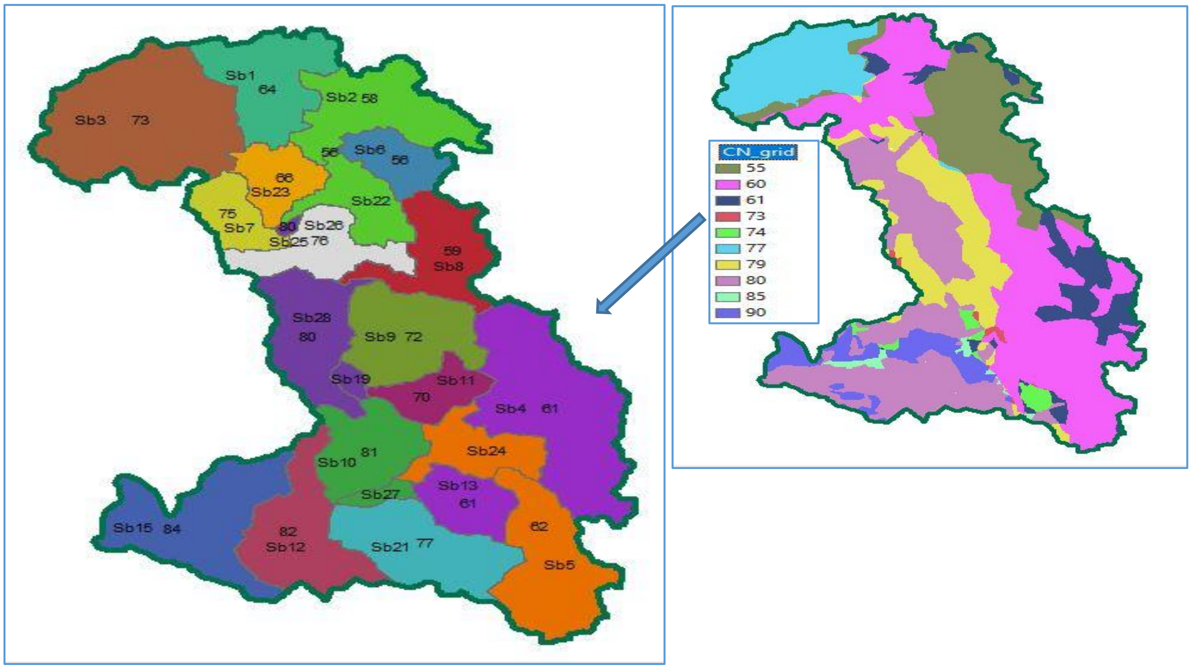


Figure 13 CN Grid and Subbasin CN Map

The CN values in computed in Table 13 are for average antecedent soil moisture conditions (AMC), where AMC refers to the water content present in the soil at a given time. During extreme flood events, the AMC are wet giving rise to saturated soils and increasing the runoff potentials. The SCS (Ref 3) has developed an empirical formula for converting the CN_{II} i.e., CN for AMC-II (average condition) to CN_{III} for AMC-III (wet condition) as follows:

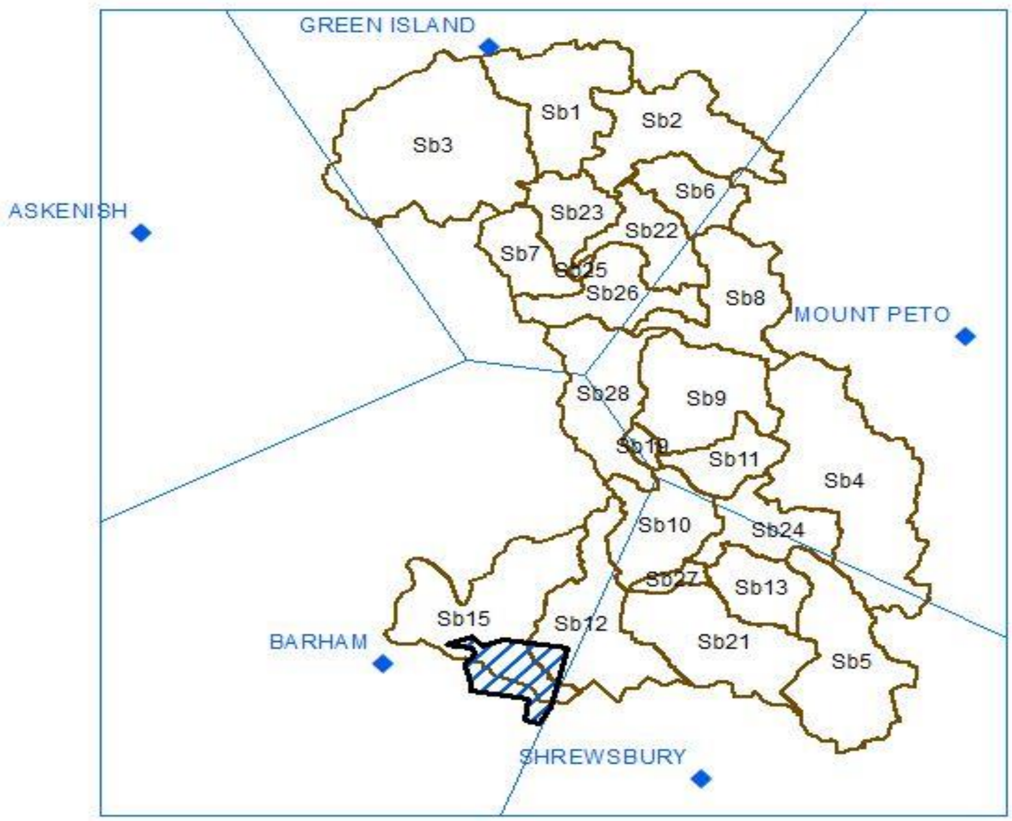
$$CN_{III} = \frac{23 * CN_{II}}{10 + 0.13 * CN_{II}} \quad \text{.............} \ (3)$$

The CN_{III} values from equation (3) were used in the Basin Model for the 50- and 100-year flow simulations

3.3.2 Rainfall Model

Figure 14 shows the location of the rainfall stations that are representative of the watershed and have maximum 24-hour, 10-, 25-, 50-and 100-year rainfall data available. The Thiessen Polygons used for computing the weighted mean rainfall for each sub watershed are also shown in the figure.

Figure 14 Rainfall Station Thiessen Polygons for Mill Site



3.3.2.1 Runoff Model Calibration

The Runoff Model calibration requires that at least one measured discharge hydrograph and the corresponding rainfall hyetograph be available. Rainfall intensity data was not available for the periods of measured flood hydrographs in the WRA database. The calibration of the model was therefore based on the convergence of the simulated 10-year flood (Table 5) and the 10-year flood from the frequency analysis of the annual maximum instantaneous discharge data over 31 years for Cabarita River at Grange.

Discontinuity in the rainfall time series data due to loss of years of data caused by fire has reduced the length of the continuous data series for providing the best estimate of the T-year rainfall.

Consequently, the T-year rainfall in Table 4 were taken from either that derived from the 1930 to 1988 data series by the Meteorological Services of Jamaica or the 1992 to 2008 series by the Water Resources Authority, Jamaica, whichever was the larger for the station, as recommended in research by Burgess[1] etal.

[1] CEAC Solutions Co. Ltd./Christopher Burgess, PE, JP: Extremal Analysis of Jamaica's Rainfall and Estimation of Climate Change Impacts for the period 1992 to 2008

Table 4: Maximum T-year 24Hr Rainfall Depths in mm

Rainfall Stations	Return Periods			
	T10	T25	T50	T100
Askenish (Hanover)	143	167.1	183.3	198.4
Barham (Westmoreland)	194.7	246.1	283.9	320.9
Green Island (Hanover)	174	216	248	278
Mt. Peto Hanover)	227	285	328	370
Shrewbury (Westmoreland)	178	218	247	276

Appendix 2 shows the frequency analysis table and probability plot for Cabarita River at Grange flow data, from which the T-year peak flows were derived. The lower frequency end of the curve in Appendix 2 was extrapolated between the 25-year and 100-year return period based on one measurement that would normally be treated as an outlier because of its inconsistency with the trends shown by the others. Because of the paucity in the high flow measurements for better defining the upper end of the curve the measured Q50 and above from this method could be grossly overestimated. This explains the significant departure of the simulated flows (Q50) for the Grange gauging station shown in Table 5 below.

Table 5: Comparison of Simulated and measured flows

Return Period(T) (yrs)	10	25	50
Measured Q (cumecs)	65	86	157
Simulated Q (cumecs)	75	97	114
%Diff	15%	13%	-30%

Comparative analysis of the T-year rainfall depths over 21 years by C. Burgess Etal[2] have shown increases of 2.6%, 2.2%, 2.1% and 1.5% for the 10-, 25-, 50- and 100 year rainfall depths. These increased rates were used to project the T-year rainfall of Table 4 to that of Table 5, used in the HecHMS runoff simulation model.

Table 5: Maximum T-year 24Hr Rainfall Depths in mm for year 2068

Rainfall Stations	Return Periods			
	T10	T25	T50	T100
Askenish (Hanover)	154	178	195	207
Barham (Westmoreland)	210	262	301	335
Green Island (Hanover)	187	230	263	290
Mt. Peto Hanover)	244	303	348	386
Shrewbury (Westmoreland)	192	232	262	288

[2] Journal of Hydrology: Regional Studies 3 (2015) 424–443

The HEC-HMS model form that was utilised, required rainfall data of duration much shorter than the 24 hour duration. Using the the [3]Modified Chowdhury/IMD empirical reduction model as described in Appendix 3, the T-year rainfall 24-hour rainfall depths for Sangster International Airport (SIA) were reduced to the shorter durations.

The resulting Depth Duration Frequency (DDF) table for SIA was then normalised and used to generate the DDFs for each of the Cabarita River rain gauge station in Table 5.

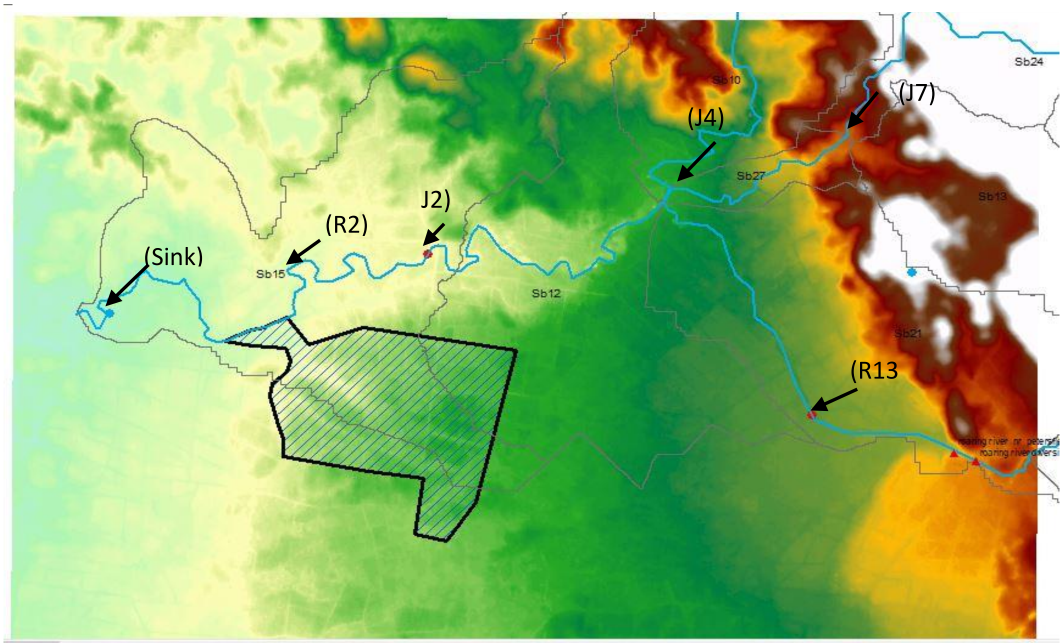
3.3.3 HecHMS Rainfall to Runoff Simulation

Table 6 shows the T-year simulated flows at specified locations also shown on the DTM in Figure 18. These were inputs to the HEC-RAS Model for simulating the T-Year flood level elevations at each cross-section in Figure 15.

Table 6 The HEC-RAS Cabarita Flows (in Cumecs) for Designated Locations

Locations	*Q_10 yr*	*Q_25 yr*	*Q_50 yr*	*Q_100 yr*
J7	*39.8*	*51.3*	*60.2*	*67.8*
J4	*111.7*	*141.8*	*165*	*184.6*
J2	*139.7*	*175.6*	*203.4*	*227*
Rh13	*20.3*	*24.6*	*27.9*	*31*
Rh2	*139.5*	*175.4*	*203*	*227*
Sink	*148.5*	*186.6*	*216*	*241*

Figure 15 Map showing Location of the Simulated Flows for the Designated



[3] C.P. Burgess et al. / Journal of Hydrology: Regional Studies 3 (2015) 424–443

3.3.4 Post Development Model Consideration

The major factor impacting the post development runoff is the permeable areas of the watershed that would become impervious by the changing landuse. The Mill site (1.55km^2) occupies a very small part of the Cabarita River Watershed (63.4km2) above the Mill site, approximately 2.4%. Assuming a worst-case scenario where the entire Mill site would be made impervious, the portions of the subbasin (Sb) it occupies were determine and modelled as impervious areas. Hence, the Subbasins occupied Sb15 and Sb12 shown in Figure 14, had the impervious percent of their areas changed from the predevelopment values of 27% to 42% for Sb15 and 0% to 10% for Sb12. The resulting post development flow increase for the 100-year floods were insignificant as expected and are as follows:

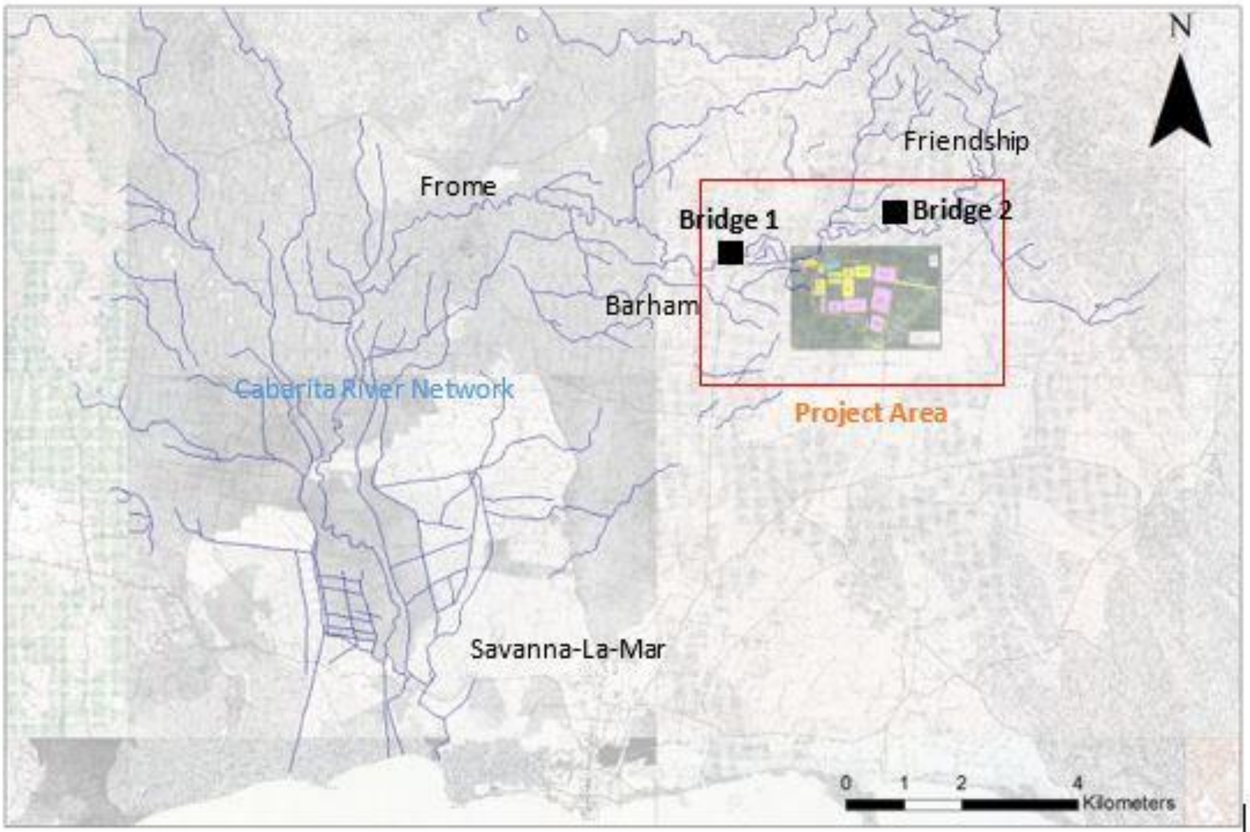
Subbasin	Pre-Dev 100-yr flow	Post-Dev 100-yr flow	Increase
Sb12	33.5 cumecs	33.8 cumecs	0.3 cumecs
Sb15	43.1 cumecs	43.5 cumecs	0.4 cumecs
Outlet	241.1	241.3	0.2 cumecs

3.5 Hydraulic Analysis

3.5.1 Field Reconnaissance

The hydraulic analysis was conducted on a section of the Cabarita River between Barham and Friendship and the land south of that section of the river (Figure 16).

Figure 16 Location of the Flood Assessment Reach



During the site reconnaissance conducted April 8, 2021, two bridge structures were identified within the considered reach of the river shown in Figure 16. Bridge 1 (Plate 1) is located in the Barham area and is a single span bridge. Bridge 2 (Plate 4) is in the upper reach closer to Friendship and is 2-span with a centre pier. The data collected on the bridges during the reconnaissance are presented below.

Bridge 1	**Bridge 2**
Width = 18.3m	2 openings = 6.2m each
depth = 3.2m	Depth to water surface = 2.4m
	Depth of water = ~1m
	Width of pier - 1.2m

Plate 1: Bridge 1

Plate 2: Channel upstream of Bridge 1 and floodplain conditions

Plate 3: Bridge 1 showing road crossing the river and floodplain conditions

The floodplain is mostly used for sugarcane cultivation which can have some impact on flood levels when the crop is fully grown and before harvesting.

Plate 4: Bridge 2

Plate 5: Bridge 2 and downstream channel and floodplain conditions

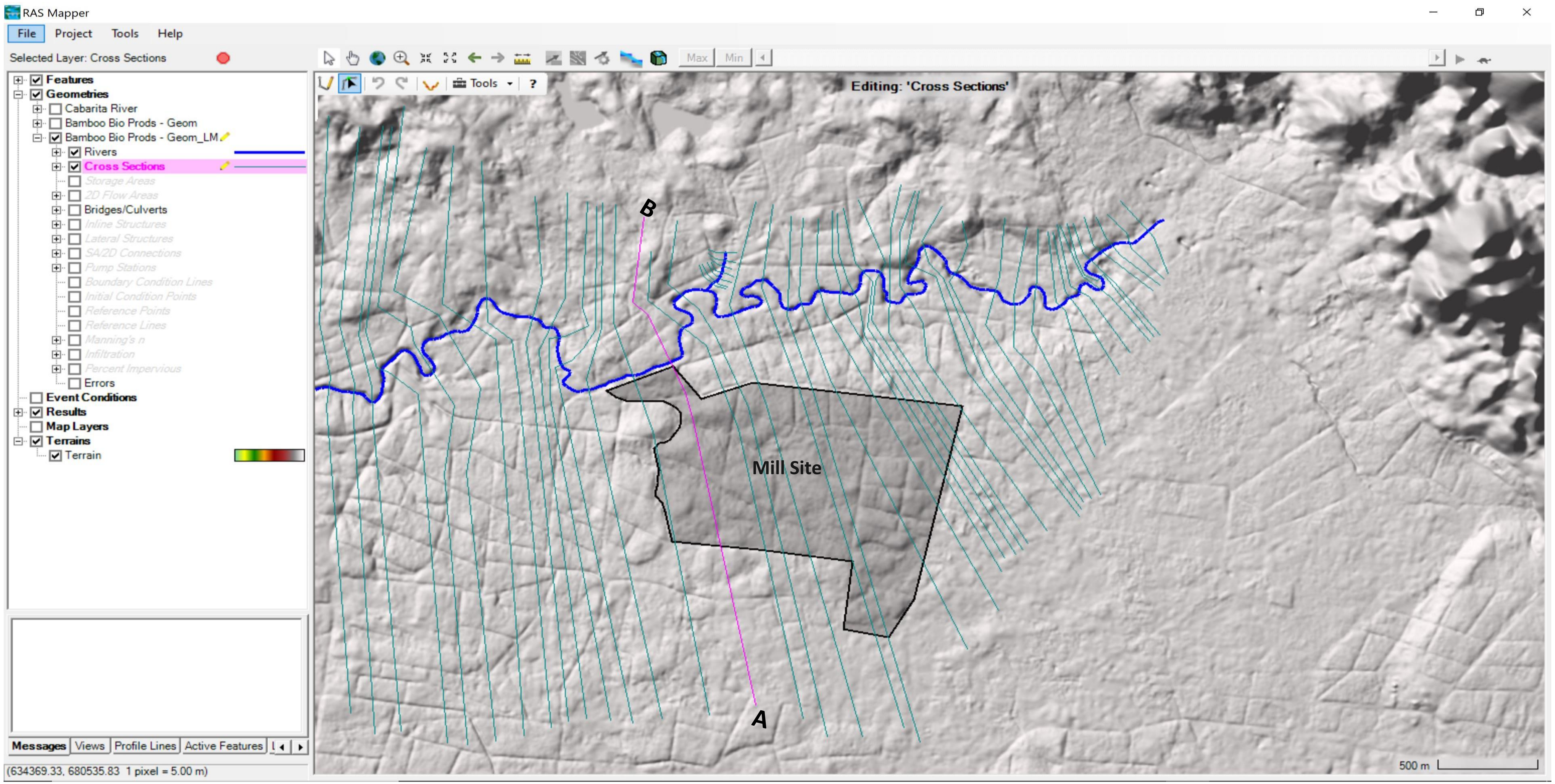
Plate 6 Bridge 2 Upstream Channel and Floodplain Conditions

Plate 6 Bridge 2 showing road crossing the river and floodplain conditions

3.5.2 Elevation Survey and Cross-section Determination

Cross-section elevation data was derived from a digital terrain model (DTM) provided by drone technology from which a surface was prepared. This data has its limitation in that the channel geometry is not clearly defined. The estimate of the channel width and depth was done during the site reconnaissance conducted in April 2021. Figure 17 shows the DTM on which is drawn the location and extent of each cross-section that defines the channel in the designated reach of the Cabarita River between Barham and Friendship.

Figure 17 DTM showing the Cross-Section locations in the Cabarita River Designated Reach



3.5.3 The HEC-RAS model Simulation of Flood Levels

The simulation of T-year flood levels for the designated reaches of the Cabarita River drainage network was performed using the HEC-RAS 6.1 model. The cross-section data input at locations shown in Figure 17 were derived using the RAS the mapper software, and the T-year flood flows simulated from the rainfall to runoff modelling.

4. RESULTS OF ANALYSIS

4.1 HEC-RAS Flood Level Simulation

The profile of cross-section (A-B) passing through the proposed development in Figure 18, indicates that most of the development site is on high ground. The elevations range between 36m and 40m amsl or depths of 5.8m to 9.2m above the left bank of the Cabarita River channel of approximately 30.2m amsl. As shown in the Figure, only a small section of the Mill site will be impacted by flooding. This is the area where the freshwater intake, aerobic lagoon, and water treatment plant are located as depicted in Figure 2.

The water surface elevations in the cross-section (A-B) through the Mill site for the 10-, 25-, 50- and 100-year Return Period (T-year) storm events is presented in Figure 19. Figure 20 shows the longitudinal T-year depth profiled over the designated reach of the river while the inundation extents and flood depths are presented in Figure 21 through to Figure 28.

These inundation maps shows that <u>**the depth of flooding in the affected area reaches up to 1.5 m**</u> for the 100-year event. The rest of the development is on high ground and is not impacted by the floodwaters.

Figure 18 Cross-Section Profile (A-B) Through the Proposed Development

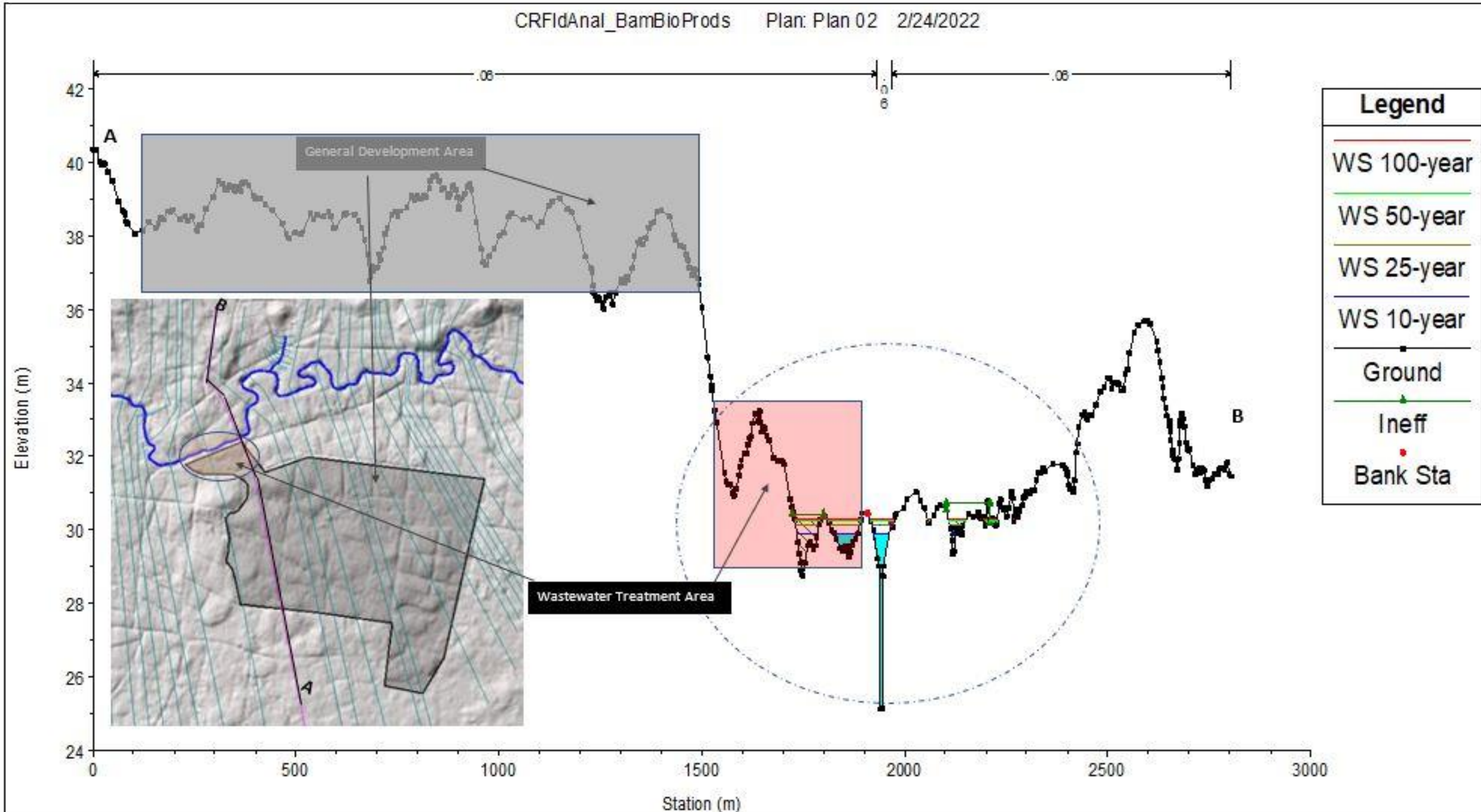


Figure 19 Cross-Section A-B Showing the T-year Water Surface Elevations

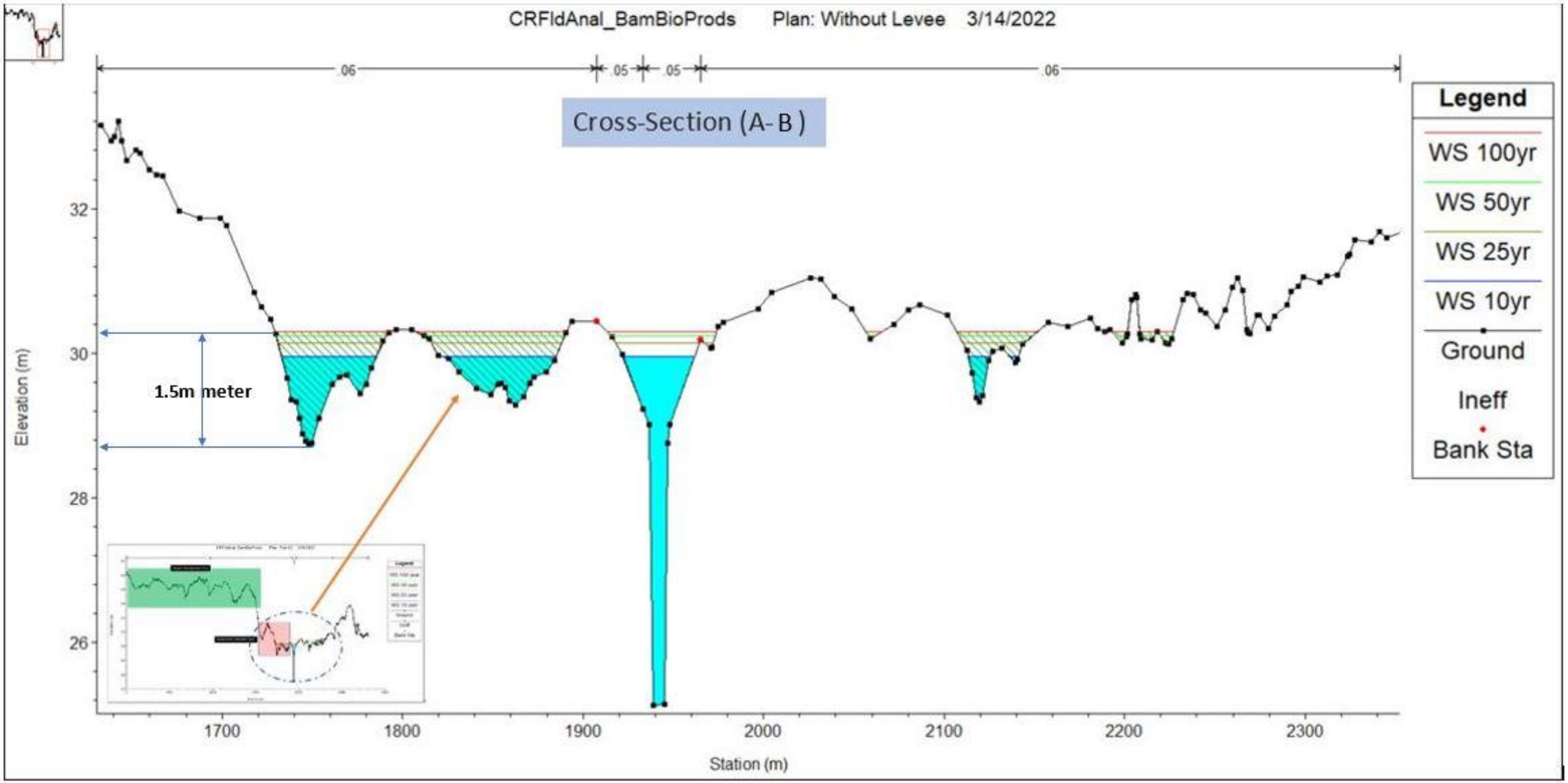


Figure 20 Water Surface Profiles for the 10-, 25-, 50- and 100-Year Return Period Storms

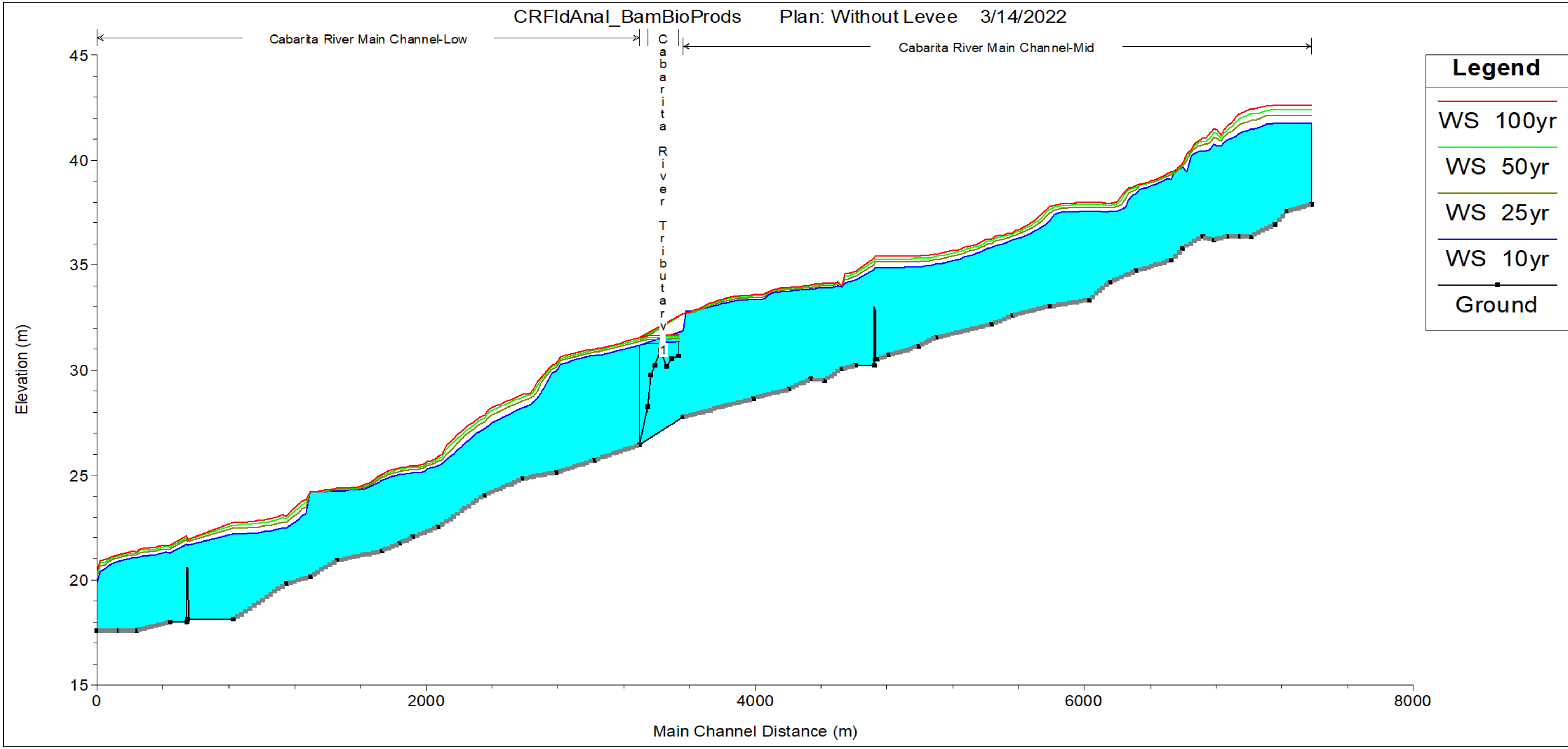


Figure 21 Inundation Extent (100-year storm)

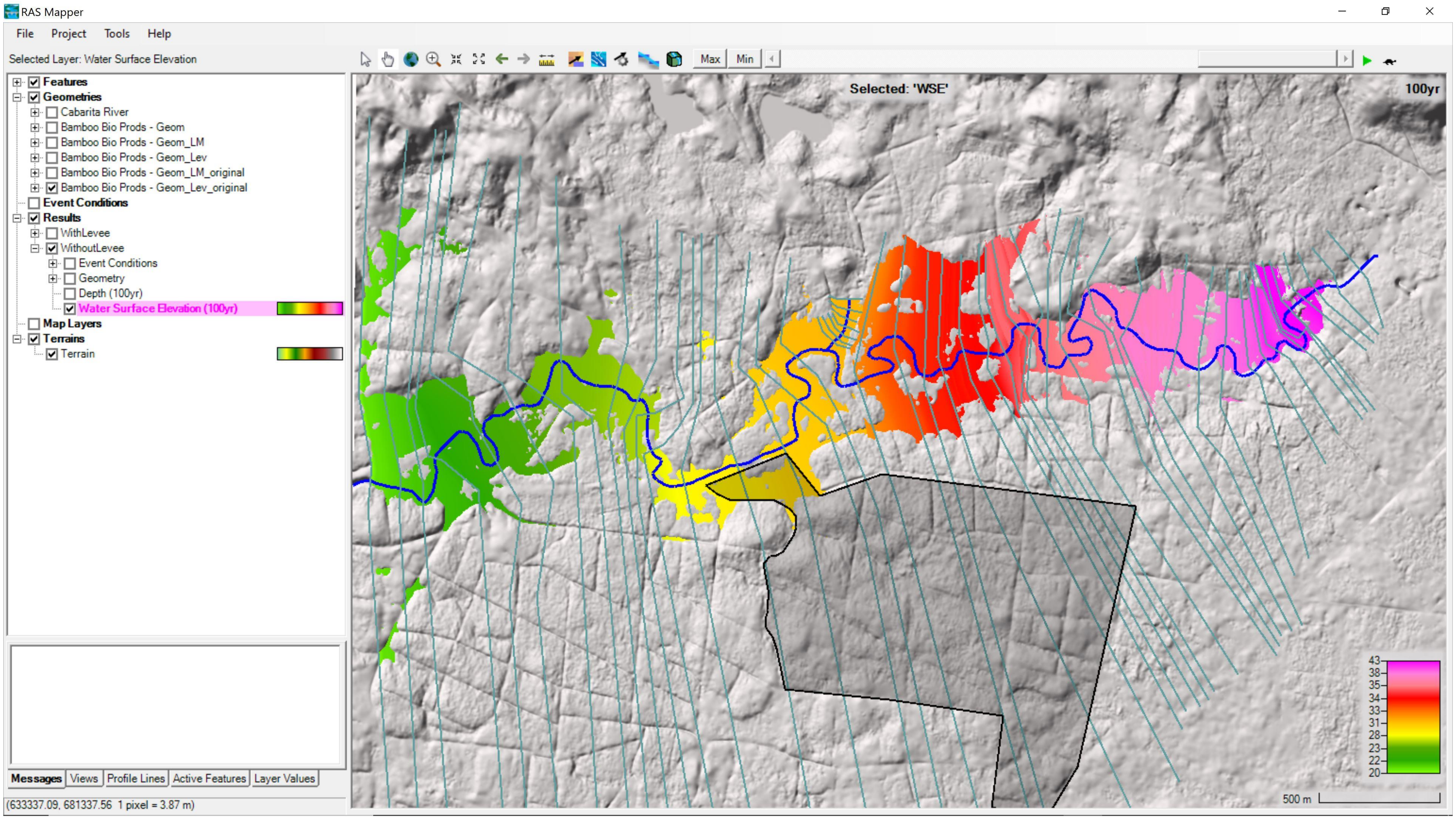


Figure 22 Inundation Depth (100-year storm

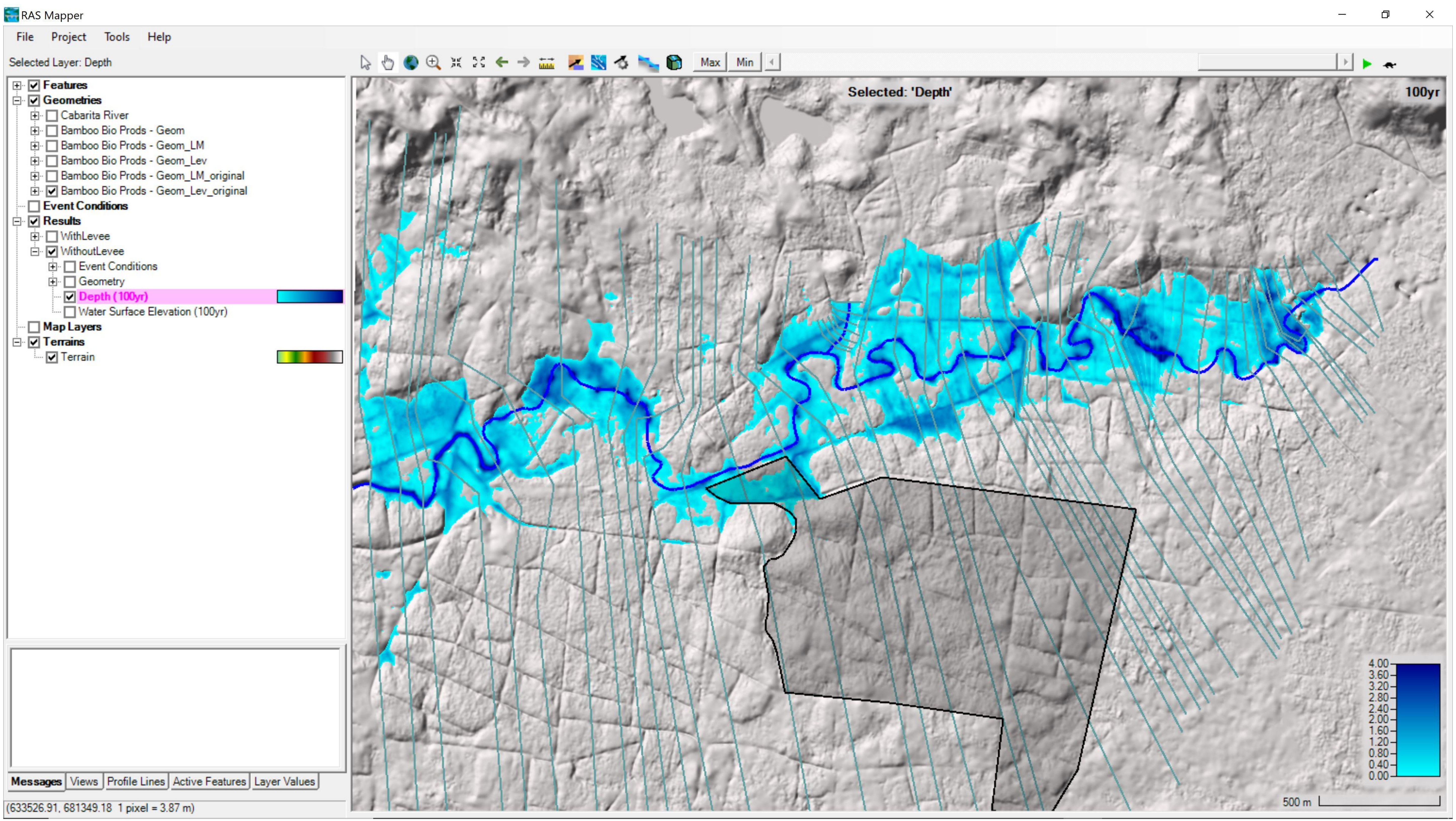


Figure 23 Inundation Extent (50-year storm)

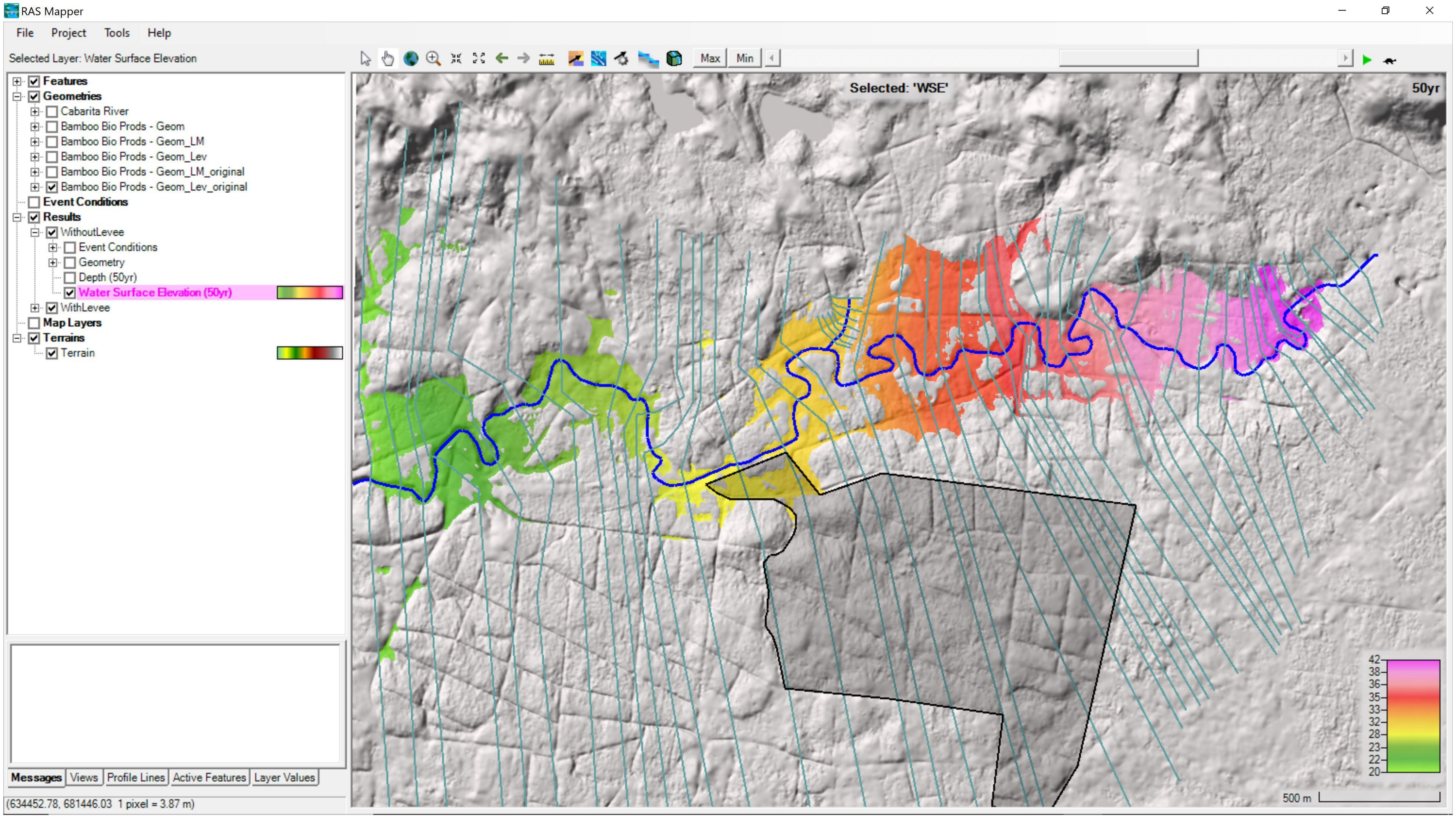


Figure 24 Inundation Depth (50-year storm)

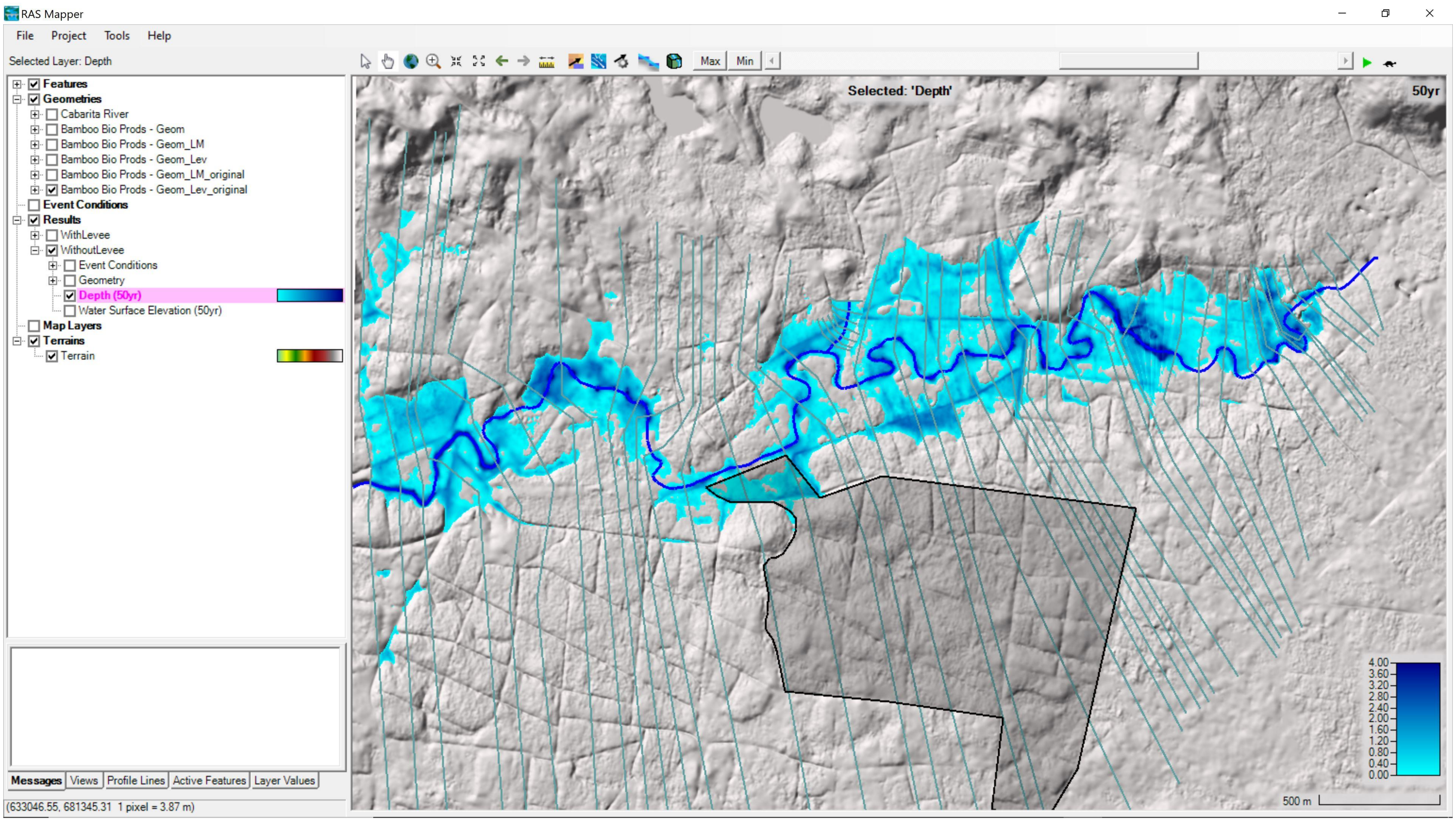


Figure 25 Inundation Extent (25-year storm)

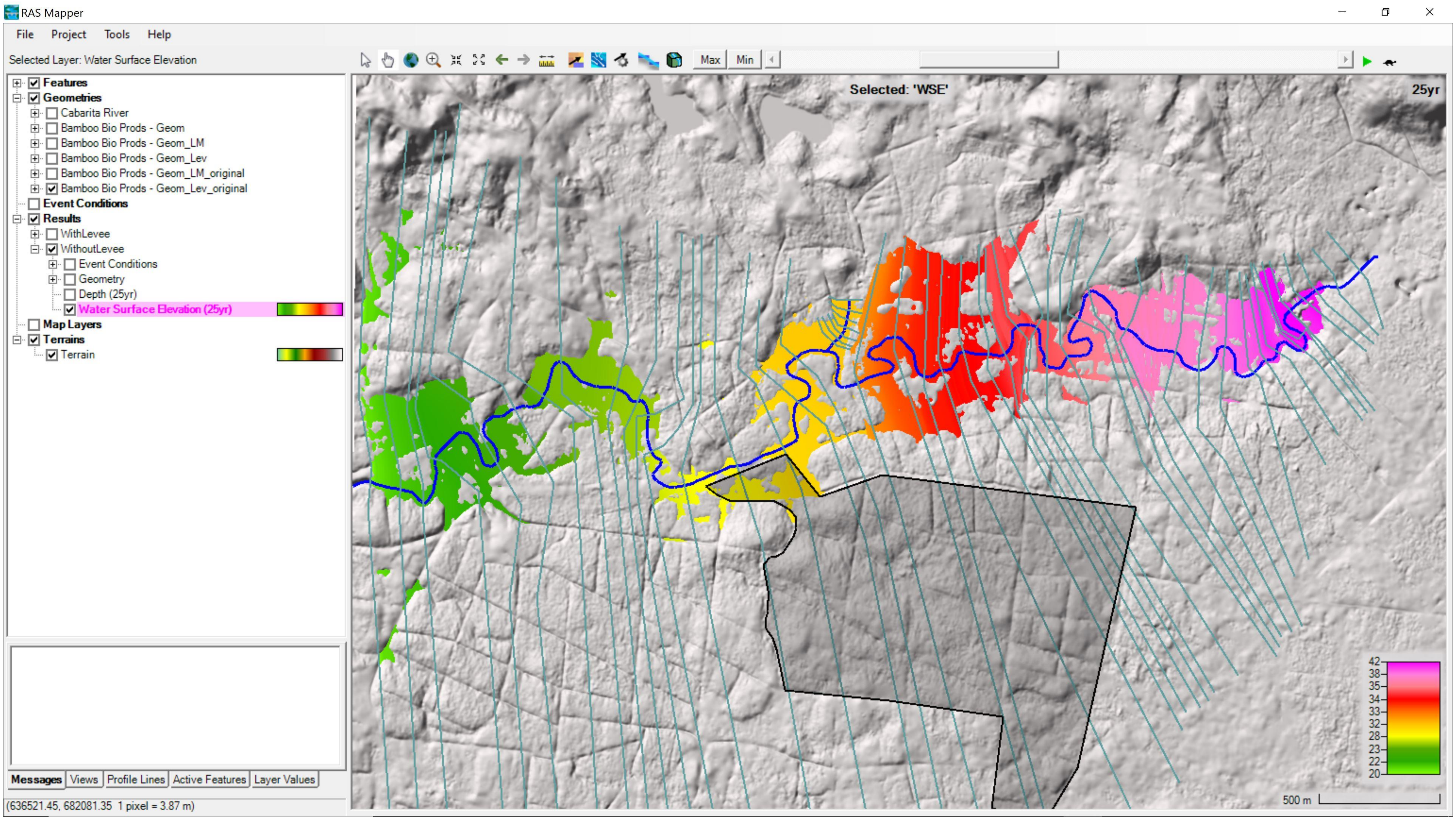


Figure 26 Inundation Depth (25-year storm)

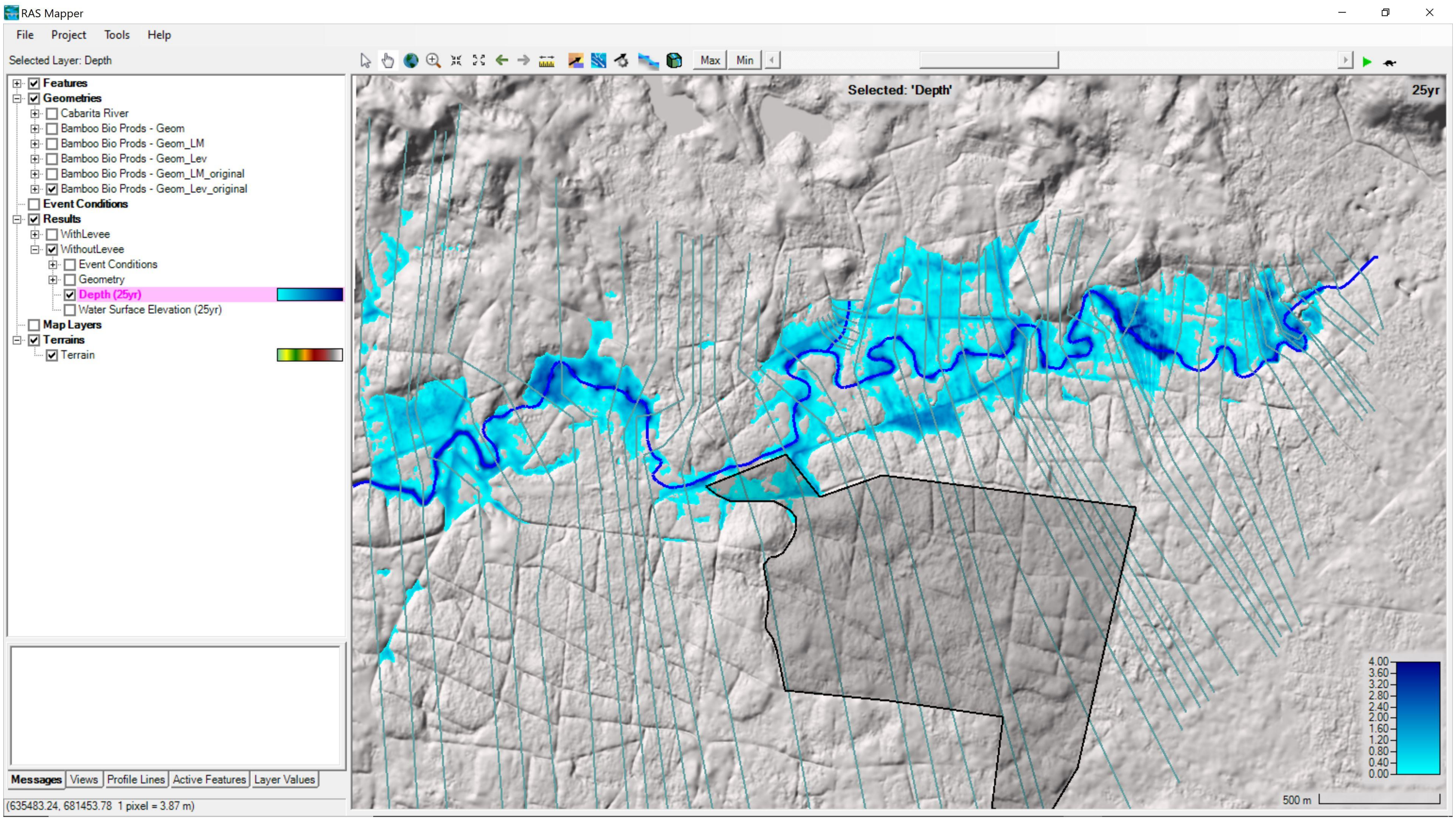


Figure 27 Inundation Extent (10-year storm)

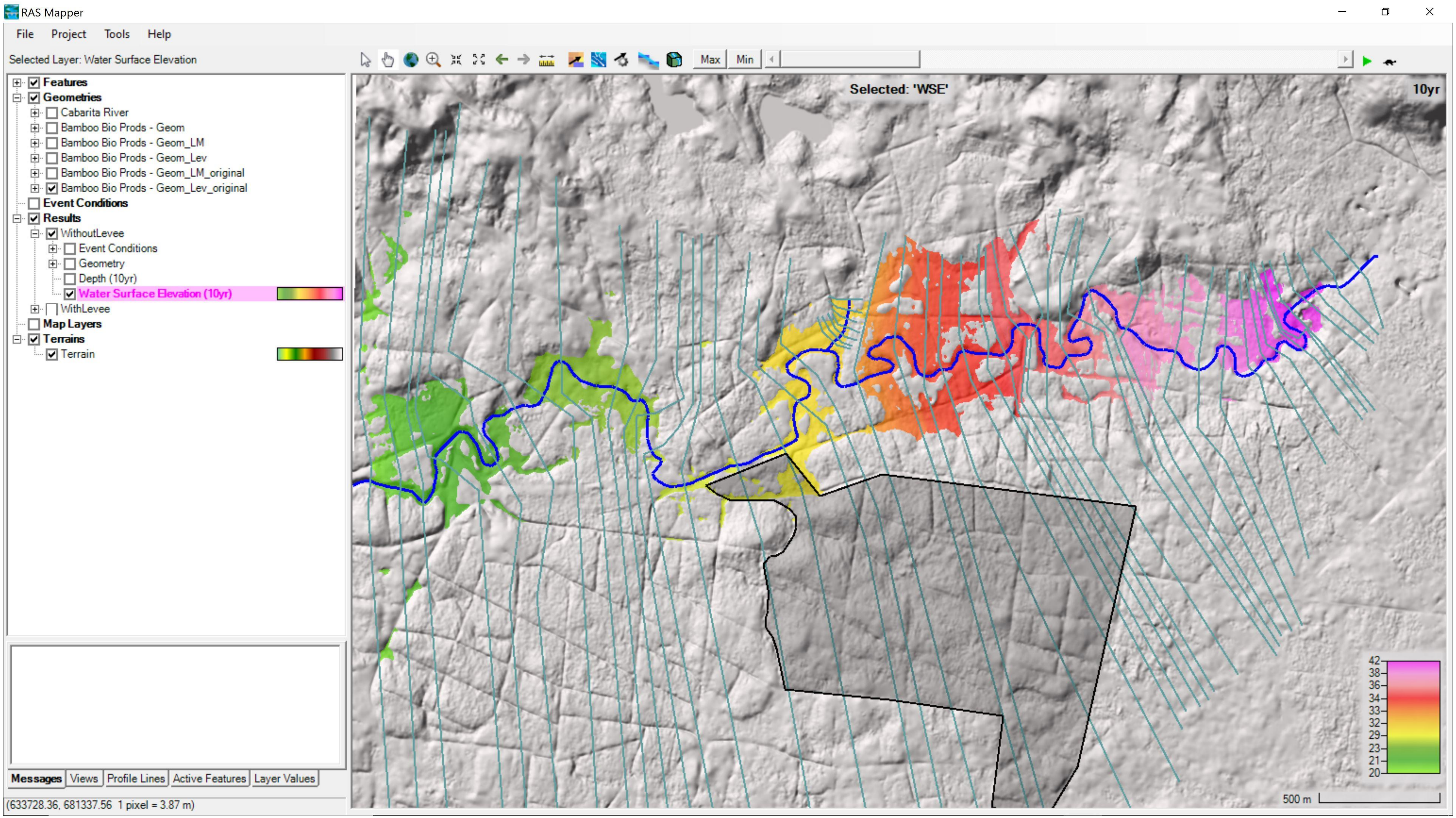
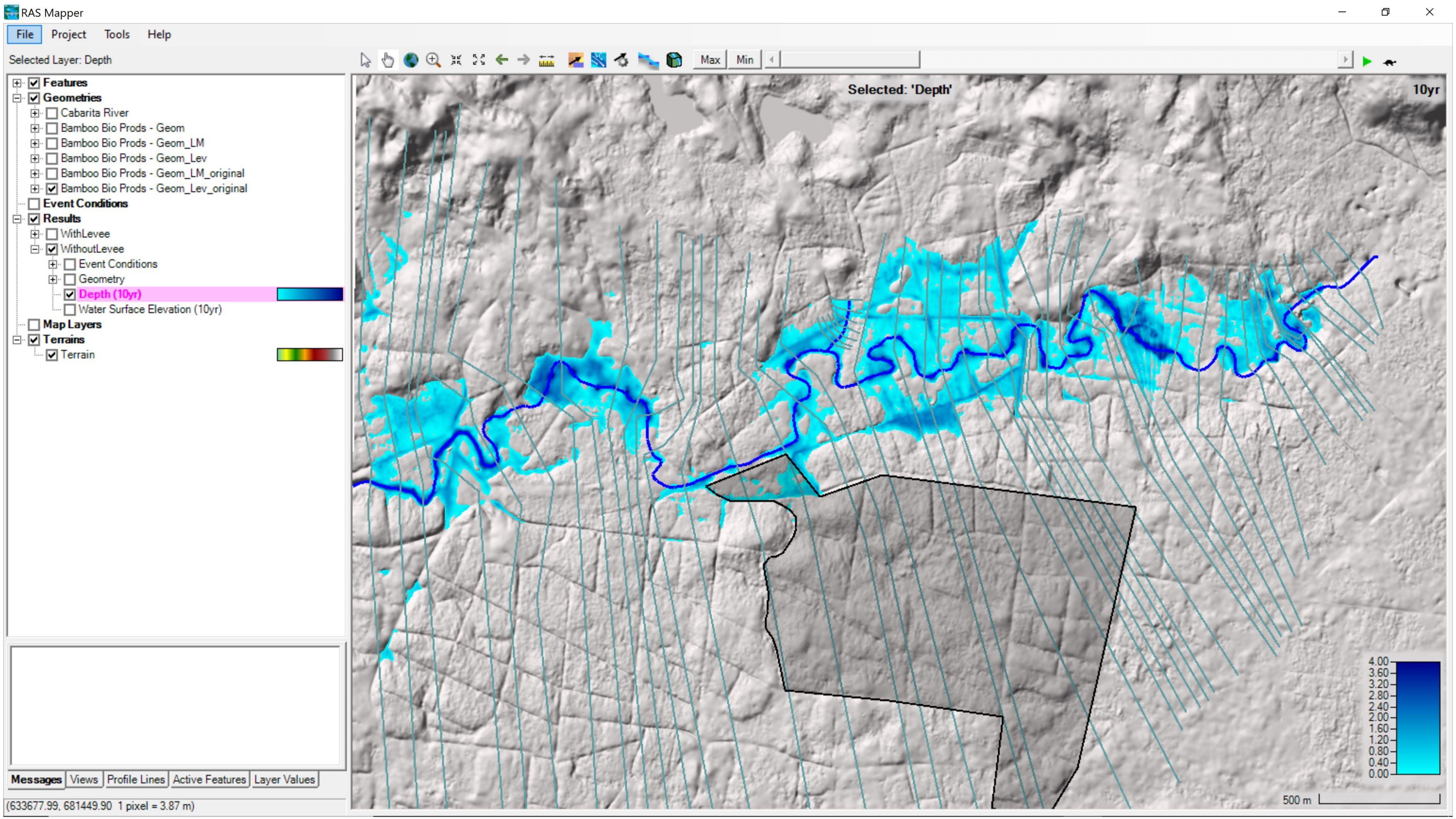


Figure 28 Inundation Depth (10-year storm)



5. IMPACT OF PROPOSED DEVELOPMENT ON WATERSHED

5.1 Flooding Impact

As discussed in Section 3.3.4, the very marginal increase in the post development flows will have no impact on the resultant flood levels at and downstream of the Mill Site.

5.2 Water Demand impact

The daily water requirement for the project from the Cabarita River is estimated at 14,200 m^3/day, based on a daily pulp production rate of 710 tonnes and estimated water requirement of 20 m^3/day per tonne.
As shown in Figure 2, the intake of the water from Cabarita River to the project site is located below its confluence with Roaring River. The Roaring River flows at the Petersfield gauging station is regulated by the National Water Commission (NWC) diversion canal located approximately 100m upstream. The flow at the Petersfield gauging station therefore represents the residual flows after the NWC's abstraction.

5.2.1 Flow reliability assessment

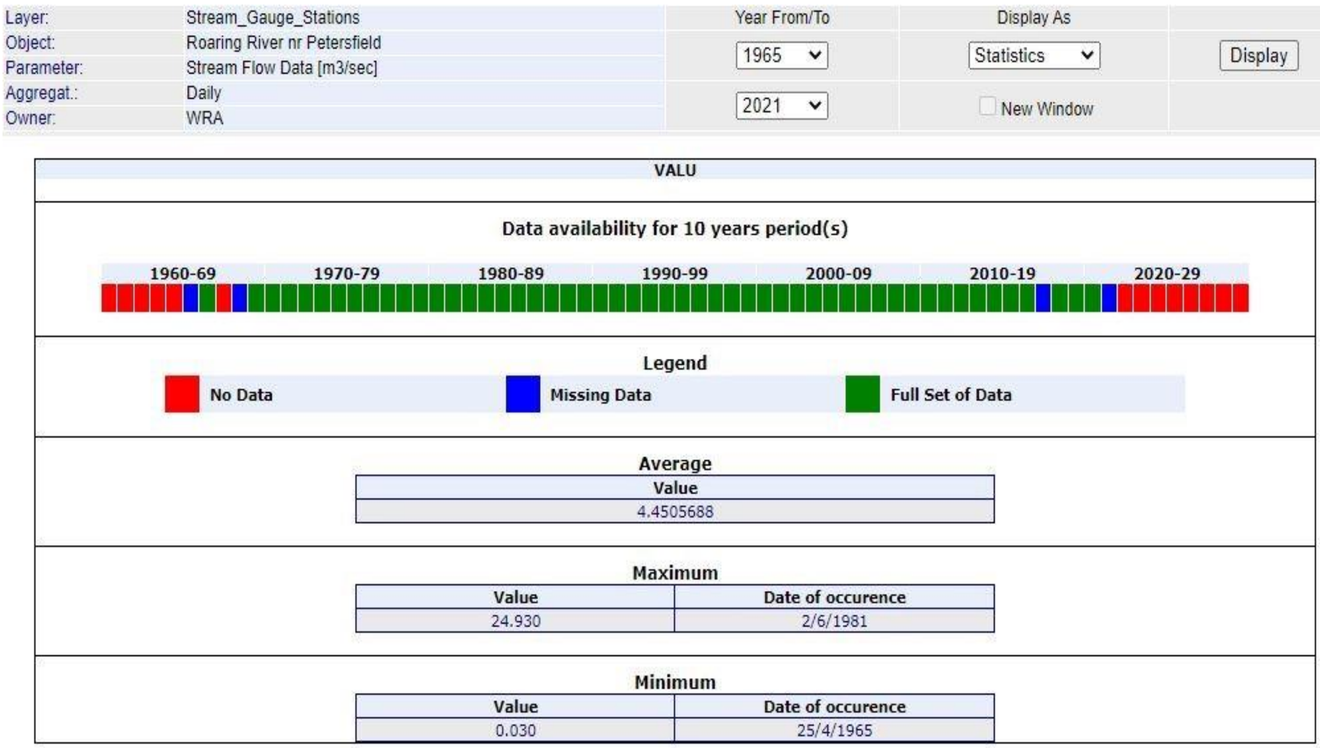
The reliable flow of a river at a particular location is defined as the flow that is equaled or exceeded for 95% of the time. This is estimated statistically, using the flow duration analysis method. The accuracy/reliability of the estimate is dependent on the length of the record and should be at least 10 years of continuous daily flow data. The reliability of the flows in the vicinity of the intake structure of the pulp mill site is based on the analysis of the combined flows for the Cabarita River at Grange and the residual Roaring River flows recorded at the Petersfield gauging station. For the Cabarita River, the data covers 54 years of data over the period 1968– 2021 as shown in Figure 29 below. The average flow is 1.62 cumecs (139,968 m^3/day), ranging from 50.09 cumecs to 0.02 cumecs or (4,327,776 m^3/day to 1728 m^3/day).

Figure 29 Cabarita River at Grange Flow Statistics

Source: WRA Water Information System (dyndns.pro)

For the Roaring River, the data covers 57 years of data over the period 1965– 2021 as shown in Figure 30 below. The average flow is 4.45 cumecs (384,480 m^3/day), ranging from 24.93 cumecs to 0.03 cumecs or (2,153,952 m^3/day to 2,592 m^3/day).

Figure 30 Roaring River near Petersfield flow Statistics



		Year From/To	Display As	
Layer:	Stream_Gauge_Stations			
Object:	Roaring River nr Petersfield	1965	Statistics	Display
Parameter:	Stream Flow Data [m3/sec]			
Aggregat.:	Daily	2021	New Window	
Owner:	WRA			

VALU

Data availability for 10 years period(s)

1960-69 1970-79 1980-89 1990-99 2000-09 2010-19 2020-29

Legend

No Data   Missing Data   Full Set of Data

Average

Value
4.4505688

Maximum

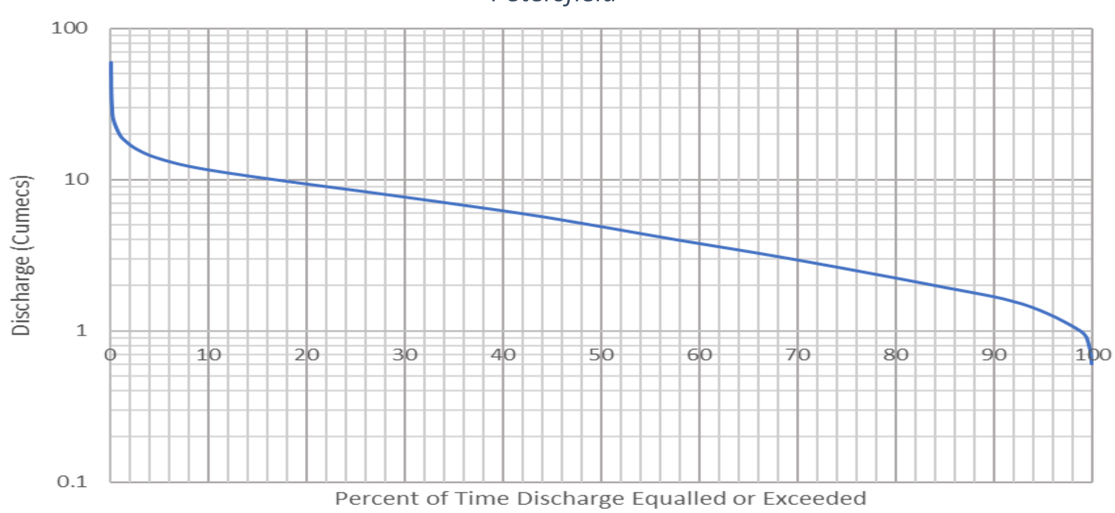
Value	Date of occurence
24.930	2/6/1981

Minimum

Value	Date of occurence
0.030	25/4/1965

For period the period between 1968 and 2021, where flow data were available for both stations, the daily mean flows were added to form a series of combined flows, representing the flow in proximity to the pulp mill site. The combined flows were statistically analysed to develop the flow duration curve shown in Figure 31.

Figure 31 Flow Duration Curve -Combined Cabarita at Grange and Roaring River at Petersfield



From the graphs, the reliable yield (Q95) of combined flow is 1.4 cumecs or (120,960 m^3/day). The requirement of the pulp mill being 14,200 cumecs is therefore 12% of the reliable combined flows.

It should also be noted that the New River tributary joins the Cabarita River below the gauging station at Grange and its flows should have been included in the combined flows. However, the period of record of the New River gauging station was too short for it to be included. Comparison of the New River and the combined flows for period of the New River data set, show that the New River flow is approximately 20% of the Combined flows. Hence the reliable yield of the Combined flows could be increased by a further 20% (i.e., 145,152 m^3/day).

The WRA has confirmed that the estimated municipal water demand for the Cabarita WMU in 2020 was 5.52 million cubic meters per Year (MCM) or 15,123 m^3/day, while for 2080, it would be 6.14 MCM or 16,822 m^3/day. The estimated irrigation demand is 10.7 MCM for 2020 or 29,315 m^3/day and 0 for 2080 based on the projected decline in irrigation demand. Although this demand will be significantly increased by the requirements of the pulp mill, the available resource is adequate to address this demand now and in the future.

5.3 Surface and Groundwater Quality Impact

In the assessment of the impact of the milling process during the operation phase, a knowledge of the process is very essential. Singh P. et al, 2019 (Ref 8) identifies five basic processing steps, each step of which can be carried out by a variety of methods and each releasing wastewater to the final effluent. These are summarised as follows:

i. ***Debarking,*** where the plant fibre is converted into chips and the bark removed. Raw materials include hard wood, softwood, and agro residues, which transfer tannins, resin, acids, etc. present in the bark to water.

ii. ***Pulping*** turns the chips into pulp by removing the lignin and hemicellulose content from the raw material, which results in a cellulose rich pulp. Pulping can be done by different methods, such as mechanical, semi chemical, kraft, sulphite pulping, etc

iii. ***Bleaching*** is engaged to meet the desired colour dictated by product standards. Several bleaching agents, including chlorine, chlorine dioxide, hydrogen peroxide, ozone, etc. may be used either singly or in combination. In this step, lignin, phenols, resin acids, etc. get chlorinated and transformed into extremely toxic xenobiotics.

iv. ***Washing*** removes the bleaching agents from the pulp. Generally, an alkali caustic soda is used to extract colour and bleaching agents from the pulp and hence, this process is also known as the alkali extraction stage

v. ***Paper and paper*** products are finally produced by mixing the washed pulp with appropriate fillers (clay, titanium dioxide and calcium carbonate) and sizing agents like rosin and starch.

Surface and ground water quality deterioration is a possible impact of the effluent discharge associated with the mill. The constituents of the effluent include:

- Suspended solids which consume oxygen when decaying
- Organic matter which also uses oxygen in water
- Nutrients such as Phosphorous and Nitrogen triggers algae bloom
- Toxins are associated with the chemical compound found in pulp and paper mill.

According to Singh et al (Ref 8), the effluent are mostly degrading products of lignin, cellulose, hemicellulose, and wood extractives. The lignin degradation includes compounds such as monomeric phenols, enol ethers, mercaptides, stilbene, quinone derivatives, chlorinated phenols, acetic acid, formic acid, acetaldehyde, methanol, furfural, and methyl glyoxal. The effluent also includes over 300 organochlorine and other unidentified compounds, some of which are extremely toxic and persistent.

NB. The chlorinated organic compounds are formed during chlorine bleaching stage of paper production; however the Bamboo Bioproducts Ltd. mill will not be using chlorine bleaching as stated (ESL 2020)

The Kraft pulping method generates significant amounts of solid, liquid and gaseous emissions, requiring treatment before release into the environment (Ref 9). Some inorganic solid wastes are of particular concern due to the high quantities generated, which are landfilled: green liquor dregs, slaker grits, lime mud, and boiler fly ash.

As shown in Figure 7, the Alluvium (Qa) over the limestone in the vicinity of the Mill Site is principally aquiclude material. This will offer some level of protection to the aquifer. The soft underlying limestone could also be of low permeability and thus offer additional protection to the Egb limestone. The presence of several pockets of aquifer material in the Alluvium under the Mill Site (as shown above in Figure 6) may however facilitate the movements of any spilled contaminants to the Limestone.

It is therefore recommended that in addition to the preventive spill measures to be employed, there should be a program of quarterly water quality monitoring of selected down gradient wells, as part of the milling operations.

6. IMPACT MITIGATION

6.1 Flood Impact Mitigation of the Mill Site

Mitigation efforts should be focused on the area of the development proposed for the treatment of wastewater as this is the area that will be impacted by flooding. The following actions can be taken:

1) Move the proposed wastewater to higher ground that is not impacted by the flooding
2) Move the proposed development to another area that is not impacted by the flooding
3) Use levee to protect the impacted area from the floodwaters. A levee with a minimum height of 2.0m located as shown in Figure 32 is recommended.

Figure 32 also shows the increase in the extent of flooding in the impacted area caused by the levee while Figure 33 and 34 shows the depth of flooding. Cross Sections A (x-sec A) of the levee area depicted in Figure 33 indicates that the increase in the depth of flooding because of the levee is approximately 0.4 meter. No flooding impact is expected in the flood prone areas of Georges Plane to Savanna-la – Mar (Figure 5), as Figure 34 shows no visible increase in the flood levels downstream of the levee.

Figure 32 Inundation Extent with Proposed Levee to Protect Vulnerable Area (100-year storm)

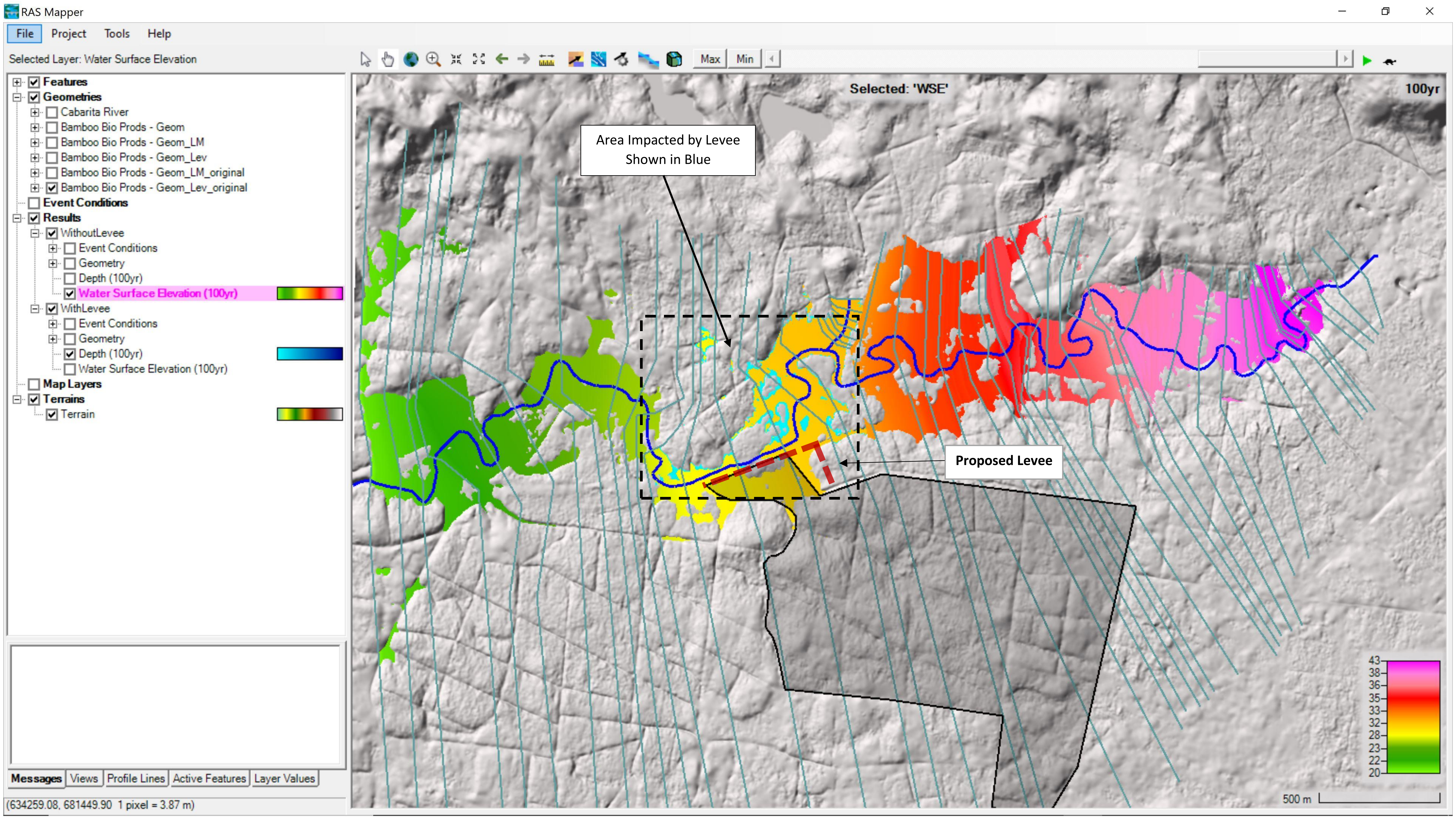


Figure 33 Inundation Depth with Proposed Levee to Protect Vulnerable Area (100-year storm)

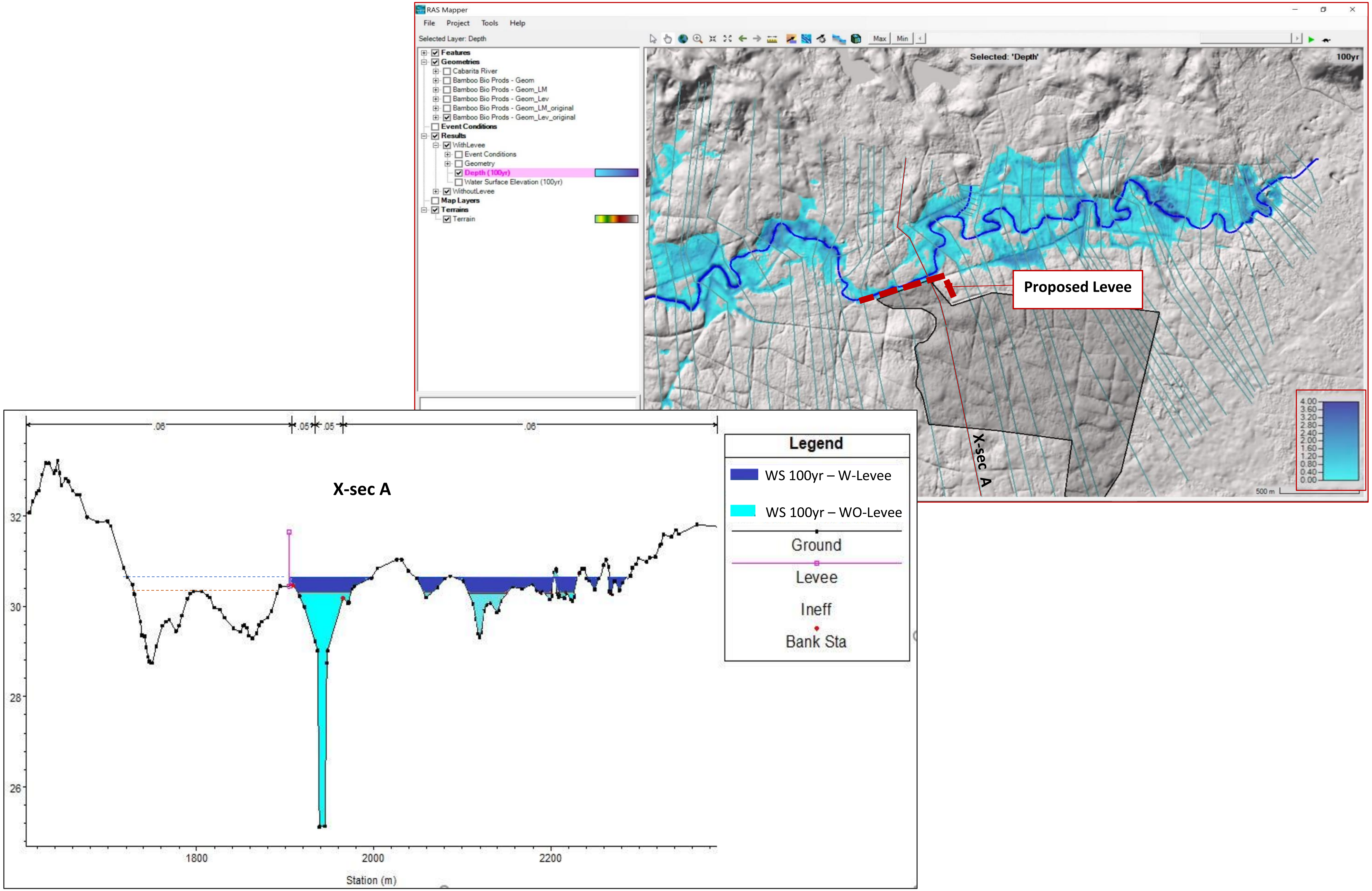
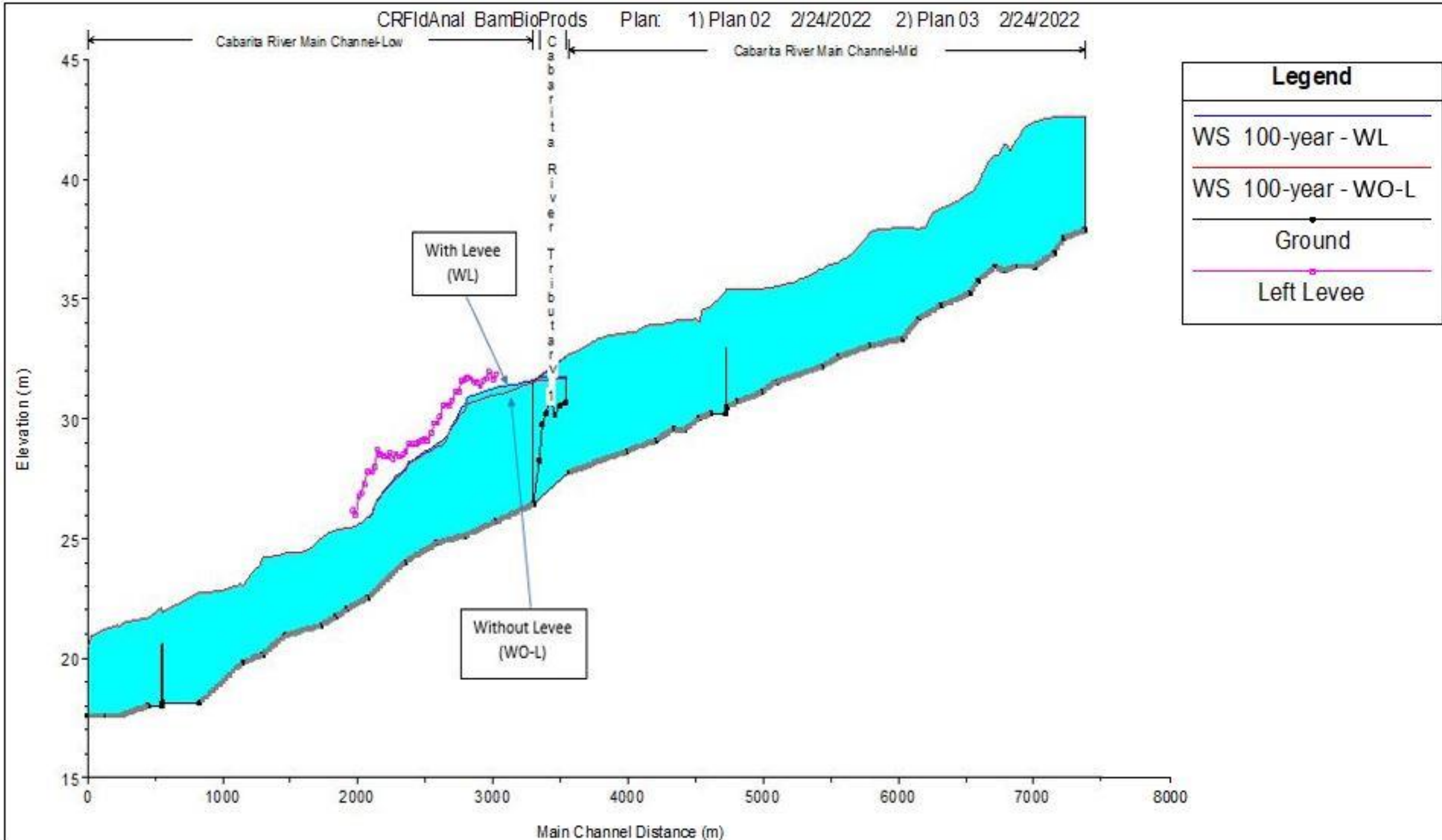


Figure 34 100-Year Water Surface Profile with And Without Levee Protection for The Vulnerable Area



6.2 Water Quality Impact Mitigation

1. Spill preventive measures should be determined and employed on the Mill site.
2. A program of water quality monitoring of selected down gradient wells should be carried out on a quarterly basis, as part of the milling operations.

7. APPENDECES

Appendix 1 Estimation of the Muskingum K

K is the Travel time of the flood wave**, given by K = L/Vw,**
L is the length of the reach (Rh)
Vw is flood wave velocity.
Vw = I / B (dQ/dy),
where B is top width of the water surface
and dQ/dy is the slope of the discharge rating curve at a representative channel cross section

Estimates of K for the reach lengths in the table were based on the following:
L were computed by the HECHMS model based of the DEM.
B - the top width of the channel was obtained from the Measurement Notes below
dQ/dy was obtained from the discharge rating curve.
Alternately an average of K (Kavg) was determined based on the average of the two velocities from the Measurement Notes below. These compared well with the values of K in the Table. The lower values were however as these resulted in higher peak flows which are the more conservative estimates.

Reach	Length(M)	K	Kavg
Rh11	1.82	4.3	5.07
Rh12	2.34	5.6	6.50
Rh10	3.10	7.4	8.61
Rh3	1.67	4.0	4.63
Rh15	0.38	0.9	1.06
Rh5	4.36	10.4	12.13
Rh13	3.48	8.3	9.68
Rh7	2.21	5.3	6.15
Rh6	1.66	4.0	4.62
Rh9	0.26	0.6	0.71
Rh8	1.06	2.5	2.94

Sept 3

WATER RESOURCES AUTHORITY

Jamaica

DISCHARGE MEASUREMENT NOTE

Meas. No. 587
Comp. By MP
Checked By B.MacL

Sta. No.

Cabarita River @ Georges

Date Aug 27 20.21 Party B.M, MS, TM

Width 26 Area 43 Vel. 2.88 G. H. 3.79 Disch 124

Method .6 No. secs 14 G. H. change — in. — hrs —

Method coef. 1.0 Hor. angle coef. 1.0 Susp. coef 1.0

Gauge Readings				
Time		Recorder	Inside	Outside
1430 Hr		—	—	3.79
		—	—	3.79
Weighted G. H.				
G. H. Correction				
Correct M. G. H.				

Susp. Rod

Meter No. Type 1-A

Date rated Used rating

For rod Susp. Meter ft

above bottom of weight.

Spin before meas. ✓ after ✓

Meas. plots % diff. from rating

Wading, cable, handline, boat, upstr, downstr bridge.

at feet, mile, metres, kilometres

Above, Below gage and Station

Measurement rated excellent (2%) good (5%) fair (8%): poor (over 8%), based on the following conditions: Cross Section Sandy

flow Weather Overcast

Other Air °F @ N/A

Gage Steady Water °F @

Record removed None Intake flushed N/A

Observer Not Seen

Control Recently Flooded, Sign of Scouring & Possible Deposition

Water sample taken

Remarks Bamboo Build up at Bridge & Gauge upstream & downstream

G. M. at zero flow 3.79-1.70= ft.

WATER RESOURCES AUTHORITY

Jamaica

DISCHARGE MEASUREMENT NOTE

Meas. No. 553
Comp. By DDM
Checked By ....

Sta. No. ....

Cabarita River at Grange

Date May 17 2018 Party D.Martin + L. Miller, M. Samuels

Width 33 Area 42.99 Vel. 2.94 ft/s G. H. 2.67 Disch. 126.40

Method 6 No. secs 18 G. H. change .... in .... hrs ....

Method coef 1 Hor. angle coel 1 Susp. coef 1

Time		Gauge Readings: Recorder	Inside	Outside
16:25 hrs				2.67
17:00 hrs				2.67
17:10 hrs				2.67
Weighted G. H.				
G. H. Correction				
Correct M. G. H.				

Susp. Rod

Meter No. Type AA

Date rated .... Used rating

For rod .... Susp. Meter .... ft

above bottom of weight.

Spin before meas. ✓ after ✓

Meas. plots .... % diff. from .... rating

Wading, cable, handline, boat, upstr, downstr bridge.

60 feet, mile, metres, kilometres

Above, Below gage and 60

Measurement rated excellent (2%) good (5%) fair (8%): poor (over 8%), based on the following conditions: Cross Section Sandy with Small Stones

flow Cyclical Weather Overcast

Other .... Air °F @ ....

Gage Stable Water °F @ ....

.... Record removed E Tacked Intake flushed ....

Observer none

Control Appears Normal

Water sample taken None taken

Remarks ....

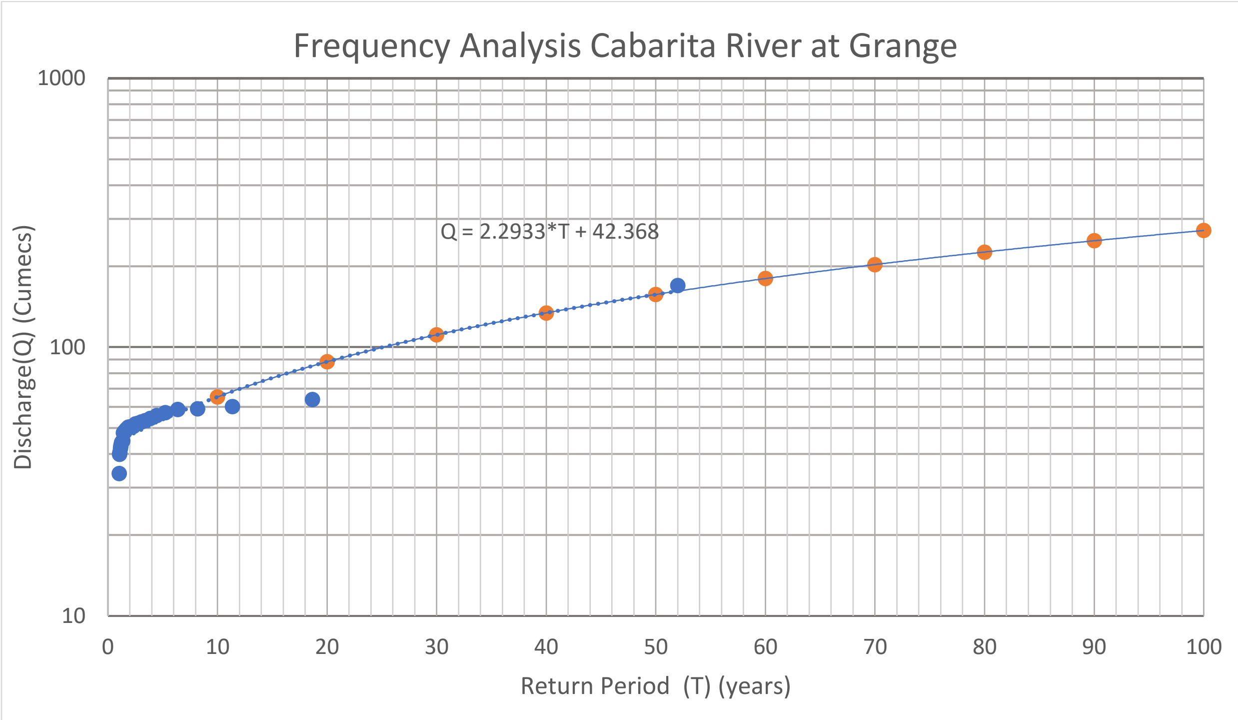
G. M. at zero flow .... ft.

Appendix 2

Frequency analysis of the annual maximum instantaneous discharge (Q) for Cabarita River at Grange

Q (cumecs)	*Rank*	*Prob(p)*	*Non-exceed (1-p)*	*Return Period (T)*
169.3	*29*	*0.98*	*0.02*	*52.0*
63.9	28.	*0.95*	*0.05*	*18.7*
60.1	27.	*0.91*	*0.09*	*11.4*
59.0	26.	*0.88*	*0.12*	*8.2*
58.6	25.	*0.84*	*0.16*	*6.4*
57.1	24.	*0.81*	*0.19*	*5.2*
55.6	23.	*0.77*	*0.23*	*4.4*
54.3	22.	*0.74*	*0.26*	*3.9*
53.2	21.	*0.71*	*0.29*	*3.4*
52.7	20.	*0.67*	*0.33*	*3.0*
52.1	19.	*0.64*	*0.36*	*2.8*
51.8	18.	*0.60*	*0.40*	*2.5*
50.7	17.	*0.57*	*0.43*	*2.3*
50.4	16.	*0.53*	*0.47*	*2.1*
50.4	15.	*0.50*	*0.50*	*2.0*
50.4	14.	*0.47*	*0.53*	*1.9*
50.0	13.	*0.43*	*0.57*	*1.8*
49.3	12.	*0.40*	*0.60*	*1.7*
48.5	11.	*0.36*	*0.64*	*1.6*
48.5	10.	*0.33*	*0.67*	*1.5*
47.9	9.	*0.29*	*0.71*	*1.4*
44.8	8.	*0.26*	*0.74*	*1.4*
44.4	7.	*0.23*	*0.77*	*1.3*
44.0	6.	*0.19*	*0.81*	*1.2*
43.1	5.	*0.16*	*0.84*	*1.2*
42.1	4.	*0.12*	*0.88*	*1.1*
40.6	3.	*0.09*	*0.91*	*1.1*
39.9	2.	*0.05*	*0.95*	*1.1*
33.9	1.	*0.02*	*0.98*	*1.0*

Data Source: Water Resources Authority. Jamaica


Frequency Analysis Cabarita River at Grange
Q = 2.2933*T + 42.368
Discharge(Q) (Cumecs)
1000
100
10
0
10
20
30
40
50
60
70
80
90
100
Return Period (T) (years)

Appendix 3 Depth Duration Frequency Estimation

The [4]Modified Chowdhury/IMD empirical reduction formula (1) was used for estimation of rainfall depths of shorter durations (Pd) from the 24-h annual maxima values (P24).

$$P_{\mathbf{d}} = P_{24}(\mathbf{d}/24)^{0.453} + 16.073 \text{ ....(1).}$$

Where P is the depth of rainfall in millimeters, for durations d in hours (h).

The application of this formula for converting the 24-hour annual maxima T-year rainfall for Sangster International Airport(SIA) based on data projected to 2100 is shown in Table 2 below:

Table 1 SIA DDF Table

	5yr	10yr	25yr	50yr	100yr
	P_{24} (up to 2100)				
Duration (d)	129	165.3	220.9	271	330.5
5 Mins	25.8	28.6	32.7	36.5	41.0
15 Mins	32.4	37.0	44.0	50.3	57.9
1 Hour	46.6	55.3	68.4	80.3	94.4
2 Hours	57.9	69.7	87.7	104.0	123.3
3 Hours	66.4	80.5	102.2	121.7	144.9
6 Hours	84.9	104.3	134.0	160.7	192.4
12 Hours	110.3	136.8	177.4	214.0	257.5
1 Day	145.1	181.4	237.0	287.1	346.6

The above table was normalised in Table 2 to produce the temporal distribution of 1 unit of rainfall over 24-hour for each designated Return Period.

Table 2Normalised DDF from SIA DDF

	5yr	10yr	25yr	50yr	100yr
5 Mins	0.18	0.16	0.14	0.13	0.12
15 Mins	0.22	0.20	0.19	0.18	0.17
1 Hour	0.32	0.30	0.29	0.28	0.27
2 Hours	0.40	0.38	0.37	0.36	0.36
3 Hours	0.46	0.44	0.43	0.42	0.42
6 Hours	0.59	0.57	0.57	0.56	0.56
12 Hours	0.76	0.75	0.75	0.75	0.74
1 Day	1.00	1.00	1.00	1.00	1.00

[4] C.P. Burgess et al. / Journal of Hydrology: Regional Studies 3 (2015) 424–443

8. REFERENCES

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2. Part 630 Hydrology National Engineering Handbook Chapter 7 Hydrologic Soil Group

3. ijaerv14n12_21.pdf (ripublication.com) and Rice Acreage Estimation of Jharkhand State Using RADARSAT Data (gyanvihar.org)

4. CEAC Solutions Co. Ltd./Christopher Burgess, PE, JP: Extremal Analysis of Jamaica's Rainfall and Estimation of Climate Change Impacts for the period 1992 to 2008

5. C.P. Burgess et al. / Journal of Hydrology: Regional Studies 3 (2015) 424–443

6. Journal of Hydrology: Regional Studies 3 (2015) 424–443

7. Jamaica WRA - Water Information System (dyndns.pro)

8. ijlrv12n1_01.pdf (ripublication.com)

9. Kraft Pulp Mill Process | Encyclopedia

Appendix O Social Impact Assessment Report

SOCIAL IMPACT ASSESSMENT (SIA) STUDY REPORT

Prepared for Bamboo Bioproducts International
On the proposed BBP Pulp Mill and Farms, Jamaica
November 2021

Prepared by The Leap Co

info@theleapco.com

TABLE OF CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS

BBP	Bamboo Bioproducts
LDA	Local Development Area
SIMP	Social Impact Management Plan
SIA	Social Impact Assessment
EIA	Environmental Impact Assessment
ESIA	Environmental Social Impact Assessment
SCJ	Sugar Company of Jamaica
SCJH	Sugar Corporation of Jamaica Housing
MoHW	Ministry of Health and Wellness
ECI	Early Childhood Institute
ROC	Rebuild, Overhaul and Construct
WMC	Westmoreland Municipal Corporation
KPI	Key Performance Indicator
RADA	Rural Agricultural Development Agency
JADEP	Jamaica Drug for the Elderly Programme
PATH	Programme Advancement through Health and Education
PWD	People living with Disabilities
JCPD	Jamaica Council for PWD
CARE	COVID-19 Allocation of Resources for Employees
UWI	University of the West Indies

1. Executive Summary

Bamboo Bioproducts was formed in 2020 and aims to be the first integrated Bamboo Market Pulp Mill in the western hemisphere by providing multi-national manufacturers with "sustainably produced, high-quality bamboo pulp." This may be achieved by planting and harvesting bamboo on farm sites and then processing this raw material in a world-class pulp mill in Westmoreland. Farm sites are expected to be located in the parishes of Westmoreland, Trelawny, St. Thomas and St. Elizabeth. The mill itself will be likely surrounded by the local development areas (LDAs) of Hertford, Friendship, Amity, Frome, Petersfield and Savanna-la-mar. This Social Impact Assessment (SIA) aims to highlight the history, culture, economic activities, social & physical amenities and environmental features of each of these areas in order to provide context to Bamboo Bioproducts when determining the potential effects of the mill's construction and eventual operations on these select locations.

Currently most Local Development Areas (LDAs) have low economic prospects as is evidenced by low levels of training and job opportunities, particularly in farming, construction, local business, tourism and factory work. BBP has the ability to meet local labour market needs through the direct hiring of hundreds of professionals, skilled workers and farmers for its mill. It also has the power to help to upskill the local labour force by partnering with select educational institutions to provide specific training opportunities that align with the labour needs of the mill. Social issues and gaps in the provision of public services related to road repairs and road safety, inadequate housing for locals, the inadequacy of medical institutions to withstand the fallout of the COVID-19, and the needs of vulnerable groups, were identified as matters for BBP to overcome for the sake of the smooth running of the mill as well as the development of the development areas. BBP can tackle these issues through the use of its BBP Community Fund which seeks to provide tangible support to the wider communities in which it operates. ***Stakeholders generally showed a high level of support but had some misgivings regarding the mill's impacts on the local environment, public resources, infrastructure and traffic***. These and other fears can mostly be quelled through the deployment of a strong communications strategy which is geared towards dispensing accurate, relevant information on an ongoing basis to stakeholders.

This Social Impact Assessment (SIA) details the historical, cultural, socioeconomic, and environmental context of the mill's local development areas and farming sites. Based on the assessment and the needs of each area, BBP will create opportunities to develop areas economically and socially; making sure to meet the needs of traditionally overlooked and vulnerable populations in the process (namely children, the elderly, people with disabilities and the economically disadvantaged). The mitigation plan contained in this report will guide the company as it aims to accomplish this while also trying to reduce the risk of its negative impacts on each site. ***It is predicted that the development and operations of BBP will have a positive impact on the area's economic and social development (including the health and safety of the population, social infrastructure, and the strengthening of social nets), while having some mild adverse effects on the natural environment and the conditions of roads***.

2. Introduction

In March 2021, Bamboo Bioproducts requested The Leap Co produce a Social Impact Assessment (SIA) which aims to highlight the impact of the BBP project on the history, culture, economic activities, social & physical amenities and environmental features of each of the mill's newly selected development areas (now within Westmoreland), as well as its farming sites. This was followed by a series of stakeholder engagement sessions with local government, other public sector and civil society representatives, and community members from each LDA. Insights and recommendations gleaned from these consultations will be used to inform the remaining developmental stages of the mill.

Prior to Bamboo Bioproducts' development of the first bamboo market pulp mill in the Western hemisphere, The Leap Co (who shall be referred to as the "Consultant" hereafter), was contracted to conduct community consultations with local stakeholders with an aim to gauge the potential effects of the mill's construction on the economic activities, social infrastructure and natural environment of Westmoreland, as well as to determine how the factory can best operate without harming surrounding communities. The consultations yielded a variety of key findings and recommendations which have been shared with stakeholders at BBP's 'Open Day' event and will be used to guide BBP's decision-making going forward as it relates to the mill. These findings & recommendations along with the stakeholder feedback in response to said findings would then culminate in the completion of the Social Impact Assessment followed by a Social Impact Management Plan.

The Social Impact Assessment outlines the project's methodology, each area's needs, the predicted positive and adverse impacts the project will have on communities, and BBP's mitigation plan moving forward.

3. Description of the Project

Bamboo Bioproducts was formed in 2020 and aims to be the first integrated Bamboo Pulp Mill in the western hemisphere by providing multi-national manufacturers with "sustainably produced, high - quality bamboo pulp." This will be achieved by planting and harvesting bamboo on farm sites and then processing the raw material in a world-class pulp mill in Westmoreland. Farm sites are expected to be located in the parishes of Westmoreland, Trelawny, St. Thomas, St. Catherine and St. Elizabeth. The mill itself will likely be surrounded by the local development areas (LDAs) of Hertford, Friendship, Amity, Frome, Petersfield and Savanna-la-mar.

Bamboo Bioproducts will manage its own farmlands as well as source from other farms. At full production, BBP will need to access approximately 25,000 acres / 10,000 hectares of bamboo per year. In conjunction with this, the company will provide opportunities for supply contracts to local farmers and it is estimated that the project will generate about 1000 direct paying Jamaican jobs, placing professionals, skilled labour and farm labour in year-round employment and indirectly many thousands of other employment opportunities across the island. This project is expected to have a major positive socioeconomic impact on the parish of Westmoreland.

The identification of social impacts was in general guided by IFC Performance Standard 1 Requirements: Assessment and Management of Social Risks, Impacts and Opportunities.

Ground-truthing observations and stakeholder engagements exercising professional skill, diligence, prudence and foresight balanced with stakeholder views and socio-economic baseline, and technical realities of the project, helped determine which social impacts were associated with the project.

4. Methods in Identifying Project Impacts

4.1. Socioeconomic survey and studies: Summary

The assessment commenced with a desk review which concentrated on outlaying the social, historical, cultural, economic and environmental context of each of the LDAs and farm sites in order create a baseline prior to the project's implementation. More specifically, the report shined a light on the sites' cultural heritage, social services, physical infrastructure, labour & working conditions, and issues regarding land acquisition. Based on these preliminary findings, implications for BBP's operations and role in targeted communities were clearly outlined. Data was collected from internal BBP documents, online maps, newspaper articles, the websites/social media platforms of different public & civil society organisations in each area etc. The findings were compiled and submitted in a ***Community & Needs Assessment Report*** (APPENDIX 1) to the BBP team in April 2021.

This report was followed by the production of a ***Community Consultation Report*** (APPENDIX 2) in September 2021, which detailed and assessed data collected from various community stakeholders through the organisation of several stakeholder meetings and via a survey which was taken by 102 individuals from the six LDAs. The questions posed to stakeholders during each consultation were formed based on the knowledge gained from the baseline report. The purpose of these consultations was to provide additional insights about community needs and implications for the company in each site. It also helped to fill gaps in knowledge which remained after the completion of the desk review. The report's findings and recommendations were then disclosed among stakeholders at an in-person event on October 23, where stakeholder feedback on the disclosed information was shared in an open-discussion format. Stakeholders were told that information regarding upcoming BBP plans and activities would continue to be shared with them in the future as a testament to the company's commitment to transparency and collaboration.

The second set of stakeholder feedback along with additional research conducted on the affected population, losses to households and losses to the community, have been used to inform the company's mitigation plan. This plan will guide BBP to mitigate the negative effects that the mill's construction and eventual operations may have on the economic activities, social amenities and environment of the sites. It will also guide BBP's activities in an endeavour to intentionally improve life in affected communities through the promotion of socioeconomic development.

4.2. CONSULTATION WITH PROJECT AREA PEOPLE

In order to produce the SIA, a strategy had to be created which would allow Bamboo Bioproducts to better understand the socioeconomic and environmental context of each LDA before determining the potential effects of the mill's construction and eventual operations on these select locations. As a means of garnering stakeholder feedback towards this end, a wide range of questions were prepared regarding various aspects of community life at each site; stakeholders' initial perceptions of BBP and this project; as well as stakeholders' questions and recommendations concerning the mill. New channels were also opened up (through the intake of stakeholders' contact information), to enable ongoing communication to occur beyond the initial stakeholder engagement. The collection of both quantitative and qualitative data (to form the baseline and consultation reports), had a complementary effect which, ultimately, helped to create a holistic portrait of the sites. A high value was placed on the data gleaned from community consultations due to BBP's confidence in the insights and perspectives which stakeholders had to offer as a result of their intimate knowledge of each community. This data definitely helped to fill in several gaps left by the baseline data. The knowledge created and recommendations formed in the development of the SIA should go on to guide BBP's decision making as it relates to the mill's operations.

The main purpose of the SIA is to deepen BBP's understanding of the LDAs and its various social, economic and environmental issues so as to increase and reduce the mill's positive and negative impacts on each of these locations respectively.

Objectives of the strategy included:

- Introduction of key stakeholders to the project in order to gauge support and buy-in;
- Determining early concerns for due consideration within the overall project design;
- Establishing ongoing lines of communication with stakeholders; and
- Establishing trusting relationships with stakeholders by being transparent and instilling in them the confidence that their concerns and opinions are being heard and taken on board.

Aspects of the methodology needed to achieve the above objectives included the following:

- The ability to directly engage stakeholders in a way that encouraged open dialogue and provided them the opportunity to ask questions with the expectation of getting immediate responses.
- The ability to alter the modes of communication to each stakeholder group.

- The ability to anticipate the main concerns and questions which each stakeholder group raised in consultation. This allowed for some pieces of pertinent information to be prepared beforehand and readily available at the time of each consultation.

While the team conducting the SIA would have preferred face-to-face consultations, the meetings with political representatives and members of the Westmoreland Chamber of Commerce were held virtually via video conferencing due, in part to an inability to overcome the large geographic disparities among attendees (who were dispersed among the likes of Kingston, Westmoreland and the United States). Fortunately, because of the population's growing reliance on digital platforms to host meetings since the COVID-19 outbreak, attendees were comfortable meeting online and, as such, each of these three meetings ran smoothly. Fortunately, however, face-to-face consultations were able to take place in Westmoreland in the forms of the ***General Parish Stakeholders Meeting and Community Surveys***. The former was conducted by the Consultant using the Source CRC's conference room in Savanna-la-Mar whilst taking into consideration physical distancing measures. The surveys were conducted in-person with the assistance of surveyors in Hertford, Friendship, Amity, Frome, Petersfield and Savanna-la-mar. These in-person points of contact afforded the Consultant the opportunity to observe more closely nuances in persons' non-verbal forms of communication, which contributes towards the interpretation of the data gleaned from them. In the case of the community surveys, asking the questions in person allowed the surveyors to further explain the intent or meaning behind questions and to seek clarification on persons' answers immediately after a response is given.

The first main limitation encountered by the Consultant came as she formally invited stakeholders to meet with her in Westmoreland. A few invitees were unable to be reached using the contact information available (some of which may no longer be up-to-date), while others did not respond to requests to meet possibly due to conflicting schedules or a lack of interest.

4.2.1. Survey

A total of 102 individuals across the six LDAs were surveyed between July 8th and July 10th. A total of 102 surveys were completed in Hertford, Friendship, Amity, Frome, Petersfield and Savanna-la -mar. The Consultant, along with three research assistants, approached persons in each of these sites with the questionnaire. As questions were asked, answers were entered into digital devices to be retrieved later for analysis.

Each survey contained questions aimed at determining respondents' demographic profiles, economic activities, positive and/or negative perceptions of the project, and questions concerning the project. The survey was also designed to garner data about the communities in which it was conducted. Questions meant to gather community data centred around issues such as land ownership, local economic activities, the provision of public services, social outreach efforts, and local healthcare.

The survey findings (which shed light on the social, economic and environmental realities of the LDAs), has implications for the ease with which Bamboo Bioproducts can develop and operate their planned mill and farms. Primarily, the proportion of locals who own land gives an idea of how many contracts could potentially be supplied to farmers in order for them to use their idle lands to grow bamboo on behalf of the company. The level of educational attainment and available opportunities for skills training speak to the degree of employability of the local labour force. Similarly, the degree of access to healthcare services may connote how healthy the work force is. On another note, the extent of pollution and crime as well as the availability and quality of social and physical infrastructure (e.g., public water supply, roads, post offices, garbage collection facilities etc.), will have an effect on the company's security of assets, transportation of materials and workers, disposal of waste, connection with surrounding areas and more. Likewise, the findings of these SIA interviews also have implications with regard to the company's potential impact on residents. Particularly in areas experiencing low skill and high unemployment levels, a noticeable difference may be created due to the mill's planned employment of hundreds of skilled and farm workers and due to Bamboo Bioproducts' possible collaborations with universities to develop a "Center of Excellence" in order to upskill the local labour force.

4.2.2. STAKEHOLDER MEETINGS

Throughout the month of July, in order to collect data for the purpose of the SIA, the Consultant discussed with local stakeholders the potential effects of the mill's construction on the economic activities, social infrastructure and natural environment of Westmoreland, as well as to determine how the factory can best operate without negatively impacting surrounding communities. This focused period of stakeholder engagement culminated in the following activities:

- Meeting with Political Representatives
- Meeting with General Parish Stakeholders
- Meeting with Agricultural Stakeholders
- Community Surveys

4.2.3. POLITICAL REPRESENTATIVES MEETING

On July 1, 2021 BBP team members met with local political representatives (including members of parliament) to give parties in Westmoreland a better understanding of the project. Attendees were briefed on the approximate number and types of jobs to be created during construction of the mill, at the mill once production commences and on bamboo grow sites. It was made clear that the BBP mill will not replace the sugar factory in Frome, as it will be built on separate land and will operate independently of the sugar factory. The other topic discussed was that of the formation of a co-operative model for small farmers and owners to supply bamboo to the mill.

4.2.4. GENERAL PARISH STAKEHOLDERS MEETING

The Consultant chaired a series of in-person discussions on July 9th at the Source CRC's in Savanna-la-Mar, Westmoreland. The first meeting, attended by Moses Chybar (President of Westmoreland Chamber of Commerce), the Rev. Canon Hartley Perrin (Custos of Westmoreland), Lyndon Johnson (President of Savanna-la- Mar Development Area Committee), and Linwall McFarlane (Campus Director of Montego Bay Community College, Frome Campus), was centred around training and job opportunities (especially through the Montego Bay Community College and associated secondary schools), the mill's potential environmental impact, the level of ease with which farmers will be able to transition in and out of planting bamboo, and the mill's use of and potential effects on local roadways.

4.2.5. AGRICULTURAL STAKEHOLDERS

Meeting as part of the aforementioned series of group interviews (held on July 9th), the Consultant met with Maxwell Rodney (Jamaica 4H Parish Manager, Westmoreland) and Dwaine Josephs (Westmoreland Marketing Officer for the Rural Agricultural Development Authority (RADA)). Issues raised included BBP's Community Consultation, intended agricultural practices (i.e., fertilization and harvesting methods etc.), along with negative practices which are common amongst local farmers. With respect to the latter, the Consultant was warned about farmers' tendency to use the "slash and burn" technique after harvests, the negative environmental effects of this, and the need for the development of a strategy to discourage this practice and/or mitigate its damage. Other topics covered included BBP's waste management strategy to reduce the risk of pollution in nearby rivers, the potential for vehicular damage to roads by BBP trucks, and the terms of reference for the farming contracts with bamboo suppliers (e.g., standard contract length).

4.2.6. WESTMORELAND CHAMBER OF COMMERCE MEETING

BBP team members met with several members of the Westmoreland Chamber of Commerce on July 21, 2021 to introduce them to BBP as a company and sensitize them to the main goals, objectives and activities planned for the mill. After a presentation by Chief Executive Officer, David Stedeford, an interactive discussion was moderated by the Consultant in which several questions were fielded in relation to the potential training and employment opportunities for locals, farming contracts with local bamboo suppliers, and the environmental impacts of the mill. Attendees also raised questions regarding BBP's selection of Jamaica to establish the mill, intentions to eventually manufacture finished tissue products in Jamaica and plans to further engage stakeholders even beyond the completion of the consultation report.

5. Anticipated Project Impacts

5.1. Positive Impacts

Through its business operations and corporate social responsibility activities, BBP is expected to create major socioeconomic impacts in each of the LDAs and farm sites with the potential to have latent effects on the wider parishes. This will help to create a spirit of genuine partnership and understanding between the communities and the company as well as fulfill the national mission to make Jamaica "the place of choice to live, work, raise families and do business."

Apart from benefitting local communities, social and economic development will provide BBP with a more skilled, healthier workforce comprised of individuals who will be more likely to remain in the development areas and farm sites rather than migrating to more developed locations. Moreover, developments in social infrastructure and health & safety will also eliminate/reduce potential impediments to the mill's operations later on.

5.1.1. Economic Development

BBP believes that it can add to the existing set of economic opportunities, not only by promoting the formal training of locals and employing residents in approximately 1000 direct paying jobs and thousands of indirect jobs, but also by entering into business contracts with other local companies as well as with residents who can farm bamboo on their own plots of land for BBP.

5.1.2. Health and Safety

Health

BBP will promote the health of locals by contributing to the improvement of available medical infrastructure and the promotion of vaccination among communities in the development areas.

Roads

BBP will help to increase the road safety levels for its truck drivers and workers, along with the general road users, whilst reducing environmental hazards through the use of improved green technology in transportation. Electric trucks will be used given that BBP will produce excess energy via its manufacturing process. BBP will also reduce its potential road usage volume by transporting bamboo by barge from farm sites in Parishes further away such as St. Thomas and St. Catherine.

The company will seek to lobby the government for improved law enforcement measures and the implementation of a road safety outreach programme in development areas and farm sites. It will also make contributions from the BBP Community fund towards the maintenance of heavily used roads most in need of repair as deemed necessary.

Pollution

BBP can reduce the reliance on harmful farming practices, both among their contracted farmers and the wider farming population, by training BBP farmers in environmentally sustainable techniques and by creating educational/sensitization campaigns which discourage the use of hazardous methods. As it specifically concerns efforts to mitigate and combat the practice of the 'slash and burn' method, the business will develop plans to control the spread of fires and refuse the purchase of burnt bamboo from local growers.

5.1.3. Social Infrastructure

Local Government Involvement

The fact that most survey respondents felt that there was a low level of local government involvement in their respective areas, coupled with some evidence of basic public service provision in several areas, could indicate that, if BBP were to partner with the public sector to address these and other issues, the company could expect to see a relatively low level of engagement on the part of government agencies.

On the other hand, if the inadequacy of governmental responses to these matters are the result of stretched resources (as opposed to the issues being marked as "low priority"), then BBP's future offers to channel company resources towards 'private-public' solutions could bolster their willingness and capacity to tackle these areas of need with greater urgency.

Water Supply

BBP will partner with the WMC to improve the sustainability of public water supply services (e.g., fixing/ replacing broken public water facilities).

Housing

BBP will help to increase housing solutions for residents in LDAs and farm sites by advocating for the expansion of SCJH Community Regularization Programme and the provision of affordable, temporary housing for select workers for the duration of their respective contracts.

5.1.4. Social Nets

BBP will endeavour to fill the gaps in governmental service provision to meet the needs of the most vulnerable groups in each LDA and farm site. These populations will consist of the elderly, children, disabled persons, and the poor are the most vulnerable groups in communities.

Figure 1- Identified Positive Impacts of the Project

Positive Impacts
Local Labour Market • The mill's operations (including its business dealings with local private-sector entities and individuals), will give LDAs and farm sites an economic boost. • Increased opportunities for year-round employment for professionals, skilled labour and farm labour. • New opportunities for economic growth locally may slow the rate of migration of residents to other areas.
Training Opportunities • More locals will gain opportunities to advance their level of education and training required to earn a good income.
Farming Contracts • Persons interested in farming contracts will gain assistance with acquiring ownership certificates for their land.
Local Government Involvement • Increased levels of local government involvement, especially in the areas of local employment, housing and road works.
Water Supply • Some public water facilities (e.g., water pumps and rain catchment tanks), in local communities will be repaired to improve the sustainability of public water supply services.
Pollution • Local landowners/ farmers will be trained in eco-friendly, sustainable bamboo farming techniques in lieu of harmful methods (e.g., 'slash and burn') which contribute to air pollution.
Health • Local healthcare providers will receive improved medical infrastructure and increased human resources in order to provide sufficient COVID-19 relief to locals. • Increased willingness to take vaccinations among BBP employees.
Social Nets • Provide aid and relief to vulnerable groups such as the elderly, Children, People with disabilities and the economically disadvantaged.
Road Safety • Improved conditions of heavily used roads in LDAs and farm sites. • Increased road safety in LDAs and farm sites.
Housing • Increased housing solutions for areas surrounding the BBP mill.

5.2. Adverse Impacts

As can be expected, there are still some amount of potential adverse effects on the local populations and natural environment. Such consequences, if left unchecked, will likely manifest themselves in the form of significant water & air pollution, economic barriers to BBP farmers upon the completion of their contracts, and road crashes.

5.2.1. Environmental Impacts

One major concern shared among stakeholders relates to the potential negative impacts the mill may have on the local environment – especially with respect to the mill's fluid waste and dust emissions. A number of survey respondents and attendees of the various stakeholder meetings expressed concerns regarding the potential for the fluid waste generated from the mill to contaminate local waterbodies (e.g., local revenue generators like the Carbarita River). While this is a legitimate concern, the company will put measures in place to mitigate the negative effects of this. The mill plans to recover 85% of its chemicals used on a continuous basis as water will be channeled through to a water treatment plant where residual bamboo waste (e.g., lime sludge) will be used to produce bioproducts (e.g., cementation, road infill, biofuel pellets, particleboard, Syngas, ethanol etc.), onsite. With regards to its dust emissions, dust from the mill will filter through an advanced dust collection system causing the dust emissions to be below the required legal amount based on worldwide standards.

5.2.2. Contracted Farmers

Concerns had been raised in the *General Parish Stakeholders Meeting*, regarding the ease with which contracted farmers will be able to transition from cultivating other crops (e.g., sugar cane), to planting bamboo on their lands. While this concern was assuaged by another stakeholder attendee in the meeting who assured that transition is expected to be fairly easy (due to sugar cane and bamboo being part of the same crop family), related concerns (such as the difficulty with which the land can transition to cultivating other crops once bamboo is farmed and the contracts end) remain.

5.2.3. Road Users

Unfortunately, there is a risk of the company's vehicles creating increased levels of deterioration on local roads. This would, especially on main roads, increase the risk for road crashes, not only for BBP drivers but other road users as well. BBP should aid in the maintenance of roadways which it will depend upon for the transportation of materials as a means of reducing any damage caused. It may also be advisable for mill trucks to look for alternative routes (i.e., other than commonly used ones) to and from the factory to avoid creating increased traffic – as is the case for the local sugar industry which uses designated, SCJ-owned "cane roads" to transport sugar cane.

Figure 2 - Identified Adverse Impacts of the Project

Adverse Impacts

Farming Contracts

- Potential difficulty with which contracted farmers' land can transition to cultivating other crops once bamboo is farmed and their contracts end.

Pollution

- Potential negative environmental and health impacts of the mill's dust emissions.
- Potential for the fluid waste generated from the mill to contaminate local waterbodies.

Road Safety

- BBP trucks may cause damage to roads over time due to increased wear and tear.

Traffic

- BBP trucks can significantly increase traffic on local roads.

In addition, in order to prevent an increase in traffic congestion as a result of the various commutes of BBP trucks, BBP materials to be transported via trucks will primarily be transported during off peak hours.

6. Affected Population

Survey respondents identified children, the elderly, people with disabilities and the economically disadvantaged as the main groups in need within the LDAs. In Petersfield, 29% indicated the need for members of the LGBTQ+ community to receive assistance. This is notable as none of the respondents from any of the other development sites chose this group. BBP could consider working with local business owners, local government entities, and churches to meet the needs of these groups of people as these generally serve as the main responders to community outreach needs. The mill is set to create a Community Fund in which $X/tonne of harvested green bamboo will be allocated for each parish and will be held by BBP. Using this Fund, BBP can try to fill some of the gaps left in the government's provision of social services for underserved groups.

Collaborating with others to satisfy the needs of vulnerable groups is likely to deepen the company's understanding of each local population, strengthen its relationships with stakeholders, and improve the public's perception and support of the business.

6.1. Elderly

In recent years, Jamaica has been reported to have an ageing population with the number of people over 60 years of age increasing by over 15% solely within the span of a decade (i.e., between 2001 and 2011)[1]. At present, the elderly are believed to comprise as much as 9% of the total population with about one third of households containing a minimum of one member who is 60 years or older[2]. This segment of the population is known to be most affected by chronic non-communicable diseases (e.g., arthritis, diabetes, heart disease and hypertension), to the extent that 72% of the elderly have suffered from "at least one chronic illness, with hypertension and diabetes being the most common[3]." Health concerns have only worsened in light of the elderly's high level of vulnerability to the COVID-19 virus, which has spread throughout the country.

Despite these health issues, access to long-term care is still limited. This is partly because younger generations are opting to stay home to care for elderly relatives at a lower rate than has been seen historically. This change is attributed to the reduced fertility rates (causing a decline in the number of family members who are able to act as caregivers), as well as to the growing trend among younger Jamaicans towards international migration. Other barriers to sustainable care for the elderly include the cost of medications; an issue which is compounded by the devaluation of the Jamaican dollar and the relatively weak purchasing power afforded to the elderly by their pensions. Additionally, elderly persons in rural areas are less likely to receive pensions, experience less food availability, have more "uncontrolled and undiagnosed disease," and have less geographical access to healthcare & treatment service providers than those in urban areas[4].

Fortunately, there are a number of targeted social interventions aimed at mitigating the effects of issues such as these. For instance, the Jamaica Drug for the Elderly Programme (JADEP) is a public-private sector initiative which subsidizes specific "essential drugs for several chronic illnesses" for Jamaicans over 60[5]. However, only 30% of eligible Jamaicans are part of this programme; most of which come from higher socio-economic backgrounds. Another bright spark is the fact that the number of people in receipt of health insurance has risen over the past couple of decades (i.e., only 4% of the aged population in 1995 had health insurance coverage versus 23% in 2012). Most of these insurance holders are covered

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[1] https://borgenproject.org/elderly-in-jamaica/).

[2] https://jis.gov.jm/information/get-the-facts/government-support-for-the-elderly/

[3] https://borgenproject.org/elderly-in-jamaica/

[4] https://borgenproject.org/elderly-in-jamaica/

[5] https://jis.gov.jm/information/get-the-facts/government-support-for-the-elderly/

by private sector providers[6]. BBP should consider meeting the socioeconomic needs of its employees as they age by developing a private pension and health insurance scheme for their workers. The company could also make donations to local elderly care facilities (e.g., the DCS Nursing Home in Amity) towards the maintenance of buildings, and the procurement of beds and equipment.

6.2. CHILDREN WITHOUT SUPPORT

According to a 2019 UNICEF report on "Children in Jamaica," 190,000 children were found to be living beneath the poverty line, the effects of which had a greater negative impact on children living in rural areas, as well as on those from households headed by females and those who are considered to be disabled. To combat this dire situation, low-income students receive needs-based financial support from the state-run Programme of Advancement Through Health and Education (PATH) programme. Formed in 2001, PATH has gone on to benefit 1 in 3 children (as of 2019), by enabling them to stay in school for longer. A number of students who reside within the LDAs are also PATH beneficiaries.

Other social interventions across the LDAs are implemented by actors like the Petersfield branch of the Westmoreland Parish Library which offer children various services through its outreach programmes (e.g., the National Reading Competition, homework assistance initiative, computer classes and book club). Likewise, in Savanna-La-Mar, "The Source Savanna-La-Mar" operates a homework centre, reference library and also hosts summer youth camps run by the Y's Menettes. Moreover, it offers training in computer and parenting skills along with skills covered under particular HEART Trust NTA Programmes. Eligible youth can also enroll in HEART Trust/NTA programmes at the Petersfield Vocational Training Center in Petersfield.

BBP can help to serve the needs of children in local development areas by engaging in the following activities:

- Partnering with local schools to sponsor school feeding programmes;
- Donating to local schools towards the maintenance of buildings, and the procurement of equipment and supplies;
- Sponsoring homework assistance programmes carried out by local community centres/outreach organisations (the Source Savanna-la-Mar, the Petersfield branch of the Westmoreland Parish Library etc.).;
- Creating training/job placement programme for unattached youth in LDAs – learn skills needed for BBP-related factory/farm/office jobs; and
- Lending financial support towards the PATH programme's interventions in Westmoreland, Trelawny, St. Elizabeth and St. Thomas to encourage kids to stay in school.

6.3. DISABLED

Since 2010, physical disability has consistently been found to be the most common form of disability (30%) in Jamaica. This prevalence is presumably due to the wide variety of events/contributing factors which can result in this disability type such as injuries, accidents and non-communicable diseases. The other most common forms of disability in the country include sight impairment/loss and intellectual disability. One quarter of the disabled population suffers from multiple disabilities[7].

Notably, in 2014, People with Disabilities (PWDs), were reported to have high unemployment rates, low educational attainment and reside in rural areas. Despite them being situated in remote rural locations,

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[6] https://mlss.gov.jm/wp-content/uploads/2017/11/Green-Paper-National-Policy-for-Senior-Citizens-1.pdf).

[7] https://www.unicef.org/jamaica/media/2221/file/I%20Am%20Able:%20Situational%20Analysis%20of%20Persons%20with%20Disabilities%20in%20Jamaica.pdf

the majority of services for PWDs are concentrated in urban areas such as in the Kingston Metropolitan Area, thus creating barriers to access for many. Programmes include the Ministry of Education, Youth and Information's Early Stimulation Programme which provides special early childhood education in communities, parent/staff training on disability issues, physical & speech therapy, family counselling and more[8] to children across the country. To empower PWDs economically, the Jamaica Council for Persons with Disabilities (JCPD) also offers scholarships, an entrepreneurship grant, and training & job placement programmes. Unfortunately, such government-run interventions have been found inadequate in their respective missions to serve the needs of PWDs. It has been said that economic welfare interventions provide too little funds to each beneficiary, and there is a need for more service providers and specialized schools (including "post-primary and post-secondary educational services, vocational training" institutions), in rural locations.

BBP can help to serve the needs of the local disabled population by engaging in the following activities:

- Promoting disability accessibility in the design of the mill via the inclusion of important physical infrastructure (e.g., ramps).
- Sponsoring the delivery of disability accessibility training sessions among schools, local businesses and local government bodies in partnership with the Combined Disabilities Association, the Jamaica Association for the Deaf, Jamaica Council for Persons with Disabilities etc.
- Advocate for increased disability accessibility in local public buildings – also through the installation of certain physical infrastructure.
- Donate to the Savanna-la-Mar Inclusive Infant Academy

6.4. THE VERY POOR

Nearly 20% of Jamaicans were found to be living in poverty in 2017, however, this number has since been on the decline[9]. Groups which are most at risk of living beneath the poverty line include youth (15– 24 years); Persons with Disabilities; women; children living in female-headed, single-parent households; and individuals living in rural areas[10]. Small producers (farmers and fishers) also have a high likelihood of living in poverty and are generally reported to lack capital to expand entrepreneurial operations; are dependent on seasonal employment; have low educational attainment; and are challenged by "praedial larceny, environmental hazards and risks, [and] little social security coverage." All of these pose barriers to economic advancement[11].

While there are many social interventions led by non-government organizations, poverty reduction programmes are mainly state-led. The aforementioned PATH programme stands out as the primary poverty reduction programme carried out by the Ministry of Labour and Social Security. Other private sector entities such as the Ministry of Local Government and Community Development, the Office of the Prime Minister and the Board of Supervision have also taken the lead in implementing different programmes. Nonetheless, such interventions have often suffered from a lack of proper monitoring and

[8] https://mlss.gov.jm/departments/early-stimulation-programme/),

[9] https://blogs.worldbank.org/latinamerica/return-paradise-poverty-perspective-jamaicas-covid-19-recovery-response

[10] https://www.pioj.gov.jm/wp-content/uploads/2019/09/NationalPolicyOnPovertyNationalPovertyReductionProgramme.pdf

[11] https://www.pioj.gov.jm/wp-content/uploads/2019/09/NationalPolicyOnPovertyNationalPovertyReductionProgramme.pdf

evaluation, weakened capacities, unsustainability due to heavy dependence on outside funders, duplication of efforts with other programmes, and an inability to provide sufficient benefits[12].

Since the spread of the COVID-19 pandemic in the island, and the consequent expectation for a reversal in poverty's downward trend in the country, the need for poverty-reduction initiatives is more pressing than ever. The Government of Jamaica has attempted to mitigate the negative economic effects of this health crisis through the implementation of the COVID-19 Allocation of Resources for Employees (CARE) Programme, which, as of November, 2020, lent support through cash transfers to almost 500,000 persons. These beneficiaries included PATH programme participants, small business operators, students, the elderly, and farmers. The programme was hailed as being the "largest social intervention ever in the history of Jamaica[13]".

7. Inventory of Losses to Households

7.1. Land

There have been impediments to locals' ability to own (and, in some cases, use), land. Regarding land ownership, many individuals in Westmoreland (especially those who have laboured as sugar workers), do not own land themselves nor can they afford to purchase their own land. According to the Westmoreland Western constituency's member of parliament, Moreland Wilson, this "has forced a large portion of his constituents into renting, leasing, and squatting on state-owned or private lands." This situation (particularly the capturing of lands) has been attributed to the government's failure to provide suitable and sustainable housing solutions for residents, dating back to the post-slavery era in the mid-1800's. What is more is that, to live on these plots of land, many individuals resort to building temporary structures as a result of their lease/rent agreements with their landlords which prohibits the construction of permanent structures. As a partial solution to this problem, Moreland Wilson has opined that he would advocate for underused plots on state-owned sugar lands to be set aside and sold at special rates to the public[14].

In the nearby parish of Trelawny, crime has led to some pieces of land being rendered useless. There have been several incidences in recent years of illegal sand mining in the region. However, in 2021 came a similar occurrence as it was discovered that criminals have been "illegally stripping the topsoil off lands owned by the Sugar Company of Jamaica (SCJ), which is earmarked for leasing to small farmers." This act ultimately serves to strip the land of its agricultural relevance[15]. These incidences, if left unchecked, may start to impact BBP operations and, therefore, to help prevent the illegal occupation of BBP lands by squatters, as well as to reduce the likelihood of topsoil mining on said lands, BBP should advocate for the expansion of the SCJ Housing Community Regularization Programme so that its reach extends to all LDAs; and invest substantially in securing company-owned or leased lands.

7.2. Houses

On the issue of housing, it was declared in 2017 by Jamaica's Prime Minister Andrew Holness, that "[Westmoreland], in particular, has a significant housing deficit and that housing deficit is driving the disorder growth of the parish, both in terms of urban development and residential development." This deficit is, in part, a result of the inability of residents to afford the payments associated with the rental and ownership of homes. Consequently, this issue has led to occurrences of squatting and as well as brain

[12] https://www.pioj.gov.jm/wp-content/uploads/2019/09/NationalPolicyOnPovertyNationalPovertyReductionProgramme.pdf

[13] https://blogs.worldbank.org/latinamerica/return-paradise-poverty-perspective-jamaicas-covid-19-recovery-response

[14] https://jamaica-gleaner.com/article/news/20210423/land-issues-foster-board-house-and-squatting-culture-mp).

[15] https://jamaica-gleaner.com/article/news/20210128/unknown-persons-stripping-topsoil-scj-lands-trelawny

drain due to the migration of people to other parishes with more affordable housing options[16]. While this problem is not unique to the parish (the unaffordability of housing has also been reported in Jackson Town, Trelawny while relatively high numbers of informal settlements have been found in St. Elizabeth's Lacovia and Black River areas), Westmorelanders do struggle significantly with it[17]. According to Prime Minister Holness, this sort of disorderly development naturally generates crime and violence and, as such, "quality housing stock" needs to be provided as part of the nation's plan to fight crime. To support this mission, BBP could provide temporary housing for select workers for the duration of their respective contracts. These workers can enter into leases with BBP which boast competitive rates.

7.3. INCOME AND LIVELIHOOD

In recent times, residents of LDAs and farm sites have experienced a loss or reduction in their income and livelihood due to a number of factors. One is the occurrence of natural disasters such as flooding – a phenomenon which has proven to be long-lasting in the parish of Westmoreland. An example of the negative impact such an event can have on persons' income and livelihood is the case of the flashflood which devastated areas (including Amity) on Christmas Eve and Christmas Day of 2019. The flood, which residents speculated to be caused by a failure to clean the nearby river, was not the first of its kind in the parish that year and resulted in the loss of dozens of livestock for at least one local farmer[18]. Natural disasters in the form of cane fires and flooding have also contributed to the underperformance of the Chinese Pan Caribbean Sugar Company's Frome sugar factory. These factors, combined with the reality of the industry's general decline over the past fifty years, do not bode well for the estate's future.

Crime is another contributor to losses in income as has been seen with cases of praedial larceny in Jackson Town. A fairly recent trend towards more violent crimes in Grange Hill as well as high rates of crime (especially robberies and break-ins), which have been reported in Lacovia could discourage investors from coming to these areas and may even cause businesses to lose their products/property (e.g., in robberies) along with their employees (i.e., some workers may opt to migrate to more peaceful areas of the country).

Losses or reductions in individuals' income and livelihood are also the consequences of the general demise of certain industries (as was the case for the sugar industry which specifically impacted Frome), along with the fallout from the COVID-19 pandemic. The pandemic's economic effects also extended to include the loss of jobs; something which was experienced by 22 survey participants. The local tourism industry in Friendship for instance, which is fueled by attractions like the Cabarita River, has also been weakened in light of the COVID-19 pandemic. Furthermore, the labour force may shrink or become weakened due to communal health problems as a result of the COVID-19 pandemic, and the lack of medical facilities to adequately tackle them.

7.4. SOCIAL NETWORKS

Losses to social networks in the LDAs and farm sites have been incurred largely because of the ongoing practice of rural to urban migration among residents. In places such as Wakefield, for instance, which witness high levels of adult and youth unemployment, skilled persons often opt to leave the area in search of better job opportunities in other parishes/regions; thus, leading to brain drain. This loss of skilled workers from a local labour force hampers the ability of the area in question to develop socially and economically. If opportunities to attract a younger workforce are not available, there is a risk of the

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[16] https://www.jamaicaobserver.com/westernnews/1-500-solutions-to-address-Westmoreland-housing-deficit_92554).

[17] https://ran-s3.s3.amazonaws.com/localauthorities.gov.jm/s3fs-public/resources/selsdp.pdf

[18] https://jamaica-gleaner.com/article/lead-stories/20191228/christmas-cancelled-property-damaged-livestock-killed-flood-rains

Westmoreland population becoming an ageing population, which further compounds issues around welfare and social protection.

8. Losses to the Community

8.1. Public buildings

In the past, losses to the community has come through the loss/degradation of publicly-owned buildings. This is sometimes caused by criminal activities such as burglaries and vandalisms. Such was the case in 2020 when the Little London Primary (in the Little London community), sustained damages to its classrooms as well as lost 16 computers, teaching aides and other items from their technology department in a series of burglaries[19]. Another staple of public life, the Petersfield Health Centre (in the Petersfield community), had fallen into a partial state of disrepair over time, thus hampering the quality and scope of its services. In response to this, members of the Jamaican diaspora made a donation to the clinic as part of the Ministry of Health & Wellness' (MoHW) Adopt-A-Clinic programme. This donation was made to pay for the Centre's roofing and plumbing repairs and new equipment, such as nebulisers[20]). Similarly, in Frome, the Westmoreland Municipal Corporation has also expanded and repaired several small, local early childhood institutions (e.g., the Frome and Three Miles River ECIs respectively[21]). Furthermore, the Savanna-La-Mar Police Station was marked to undergo the Ministry of National Security's nationwide Rebuild, Overhaul and Construct (ROC) project which aims to build, repair and renovate police facilities across the island[22].

8.2. Cultural property

A number of the LDAs and farming locations are home to historical and cultural sites such as Golden Grove (i.e., site of the historic Golden Grove Great House), Lacovia (i.e., site of an old Jewish cemetery), and Black River (i.e., known for its Georgian architecture such as the 19th Century Magdala House). Little London also has a number of historical sites (e.g., Little London Methodist Church, Little London Square, The St Paul's Church), while Amity Hall boasts the 18th century Amity Hall Great House. Fortunately, all of these sites are still intact. While there have been restorative projects undertaken in the past, none have been implemented in recent years. This may either point to a lack of degradation due to regular maintenance efforts, or a lack of resources/interest in restoration.

8.3. Infrastructure

Communities occasionally suffer a loss of infrastructure due to flooding which has the potential to damage roads, fell trees and create landslides. Residents from Lacovia were impacted by such an occurrence in October 2020 when the road from Lacovia to Mountainside was blocked by flooding and fallen trees due to days of heavy rainfall. The flooding may have been compounded by the fact that Lacovia has poor drainage facilities. Drainage systems have also been found to be inadequately maintained in Jackson Town; a fact which leads to flooding during rainy seasons. Promisingly, the Westmoreland Municipal Corporation (WMC), has been involved in drain cleaning in areas like Petersfield, Friendship and Frome, along with other ongoing activities towards the upkeep of physical infrastructure (e.g., road marling, bushing and the construction and repair of sidewalks).

[19] https://jamaica-gleaner.com/article/lead-stories/20200125/burglars-plunder-little-london-primary-crooks-clean-out-computers-and

[20] https://jamaica-gleaner.com/article/news/20180709/adopt-clinic-partners-uk-diaspora-company-improve-healthcare

[21] http://westmorelandmc.gov.jm/council-reporting/division-achievements

[22] https://jis.gov.jm/features/more-police-stations-to-be-built-renovated/

A loss of infrastructure may also be incurred due to gradual deterioration/dysfunction. As evidence of this, residents in a number of communities in the Friendship Division (such as Bath Mountain, Red Hills, Prospect and Blauwearie), began to experience a lack of piped water in August 2019. Not only does the public solar water pump placed at a spring head, frequently breakdown, but the area's rain catchment tank is in need of repair due to a leak. Because these two main water sources are now unable to supply these communities, residents have resorted to pooling together money in order to purchase truckloads of water and also collecting water themselves from the river.

9. PUBLIC CONSULTATION AND DISCLOSURE

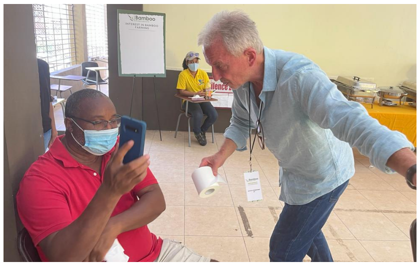
Table 1- Q&A from Community Open Day

ENVIRONMENTAL IMPACT	SALES
Q: How much energy will be generated to run the mill? Will some of it be given back to the community? A: *This is currently under discussion with the respective authorities*	Q: What is BBP's expected profitability margin? A: *This has not yet been determined.*
Q: How does the mill intend to control the amount of dust emissions it has? A: *Dust will filter through an advanced dust collection system causing the dust emissions to be below the legal amount based on work wide standards.*	Q: Does BBP have plans to start manufacturing and exporting finished products (rather than simply exporting raw materials), in its later stages of operations? A: *Trash from the bamboo will be used to make straws*
Q: Will BBP trade carbon credits? A: *This has not yet been determined.*	

FARMING	
Q: What guarantee of protection will farmers get from BBP (e.g., to protect against the possibility of farmers spending the first year growing bamboo only for BBP to later decide to go in another business direction)? A: *BBP will draw up long term, legally-binding contracts for farmers.*	Q: Approximately how many workers will be needed for factory? A: *The project will generate approx. 1,000 direct high paying Jamaican jobs, placing professionals, skilled labour and farm labour in year-round employment*
Q: Will farmers be trained based on ISO standards? A: *Yes.* Q: How will payment to farmers take place? E.g., Frequency etc. A: *This has not yet been determined.*	Q: How will we propagate the bamboo? A: *The propagation method(s) has not yet been decided upon. It should be noted, however, that methods may differ based on area in which it is farmed.*
Q: What will be the average yield per hectare? A: *BBP will have the final figure once the period of due diligence has finished.*	Q: Will farmers get better pay from planting bamboo than they would typically from planting cane? A: *Yes*
Q: Can small scale farmers (e.g., those who only own an acre or two of land), still eligible to enter into BBP farming contracts? A: *Yes, many people who have already expressed interest in entering into BBP farming contracts are small-scale farmers of such sizes.*	Q: How soon should farmers start looking into acquiring seedlings once the contracts are formed? A: *It is recommended this occurs immediately*

As was previously mentioned, in March 2021, Bamboo Bioproducts, requested The Leap Co produce a Social Impact Assessment (SIA) which aims to highlight any impact on the history, culture, economic activities, social & physical amenities and environmental features of each of the mill's newly selected development areas (now within Westmoreland), as well as its farming sites. This was followed by a series of stakeholder engagement sessions with local government, other public sector and civil society representatives, and community members from each LDA. Recommendations made through from these consultations will be used to inform the remaining developmental stages of the mill. The findings and recommendations gleaned from the community consultations were shared with stakeholders in Westmoreland at a 'Community Open Day' event towards which afforded persons the opportunity to dialogue further with members of the BBP team and offer additional feedback. Through this continued engagement with stakeholders, BBP has deepened its understanding of the LDAs, with the result being that the Bamboo Pulp Mill may provide positive benefit to many individuals affected by its operations.

The Community Meeting (held 23/10/2021) held at Frome Community College, was open to the local community, along with business owners, farmers and local government. The team was comprised of members of the BBP team including Chief Executive Officer David Stedeford and Chief Operating Officer Ron Slucky as well as representatives from Environmental Solutions, who are undertaking the Environmental Impact Assessment (EIA). A presentation was made on the origins of Bamboo Bioproducts; the benefits and marketability of bamboo and bamboo products; the mill's intended location and features; the expected product line to emerge as a result of the pulp produced by BBP's mill; the opportunities for BBP to partner with locals and, the ways in which Jamaica will benefit from the mill's operations.



Community Open Day, October 23, 2021

To promote involvement and engagement, attendees were invited to ask questions throughout the presentation. Based on the individuals who were present, the majority of the questions fielded concerned the farming contracts – specifically with regards to the terms of the contractual agreements and bamboo farming practices. Other questions centered on the mill's plans to mitigate its negative environmental impact as well as queries on the manufacturing process. Apart from these questions, feedback included a recommendation for the company to hire local individuals to grow seedlings for BBP and local farmers. Additionally, one person expressed some doubt regarding the likelihood of success of the farmer cooperative model which are a component of BBP plans to provide opportunities to small farmers. He opined that such cooperatives rarely succeed, however, was unable to recommend another model with which to replace it. This attendee in particular (who, it was later discovered to be the Chairman of a company involved in organic greenhouse farming and agricultural food processing), stood out as he seemed to take the lead in the questions asked; and posed a number of relevant, thought-provoking questions which sparked pertinent conversation. BBP could benefit from subjecting itself to his level of scrutiny and should therefore mark him as a valuable person to continue engaging as the mill's development goes on. Following the presentation and discussion, attendees left further comments on the feedback board.

10. Findings and Recommendations

10.1. Economy

As is too often the case in rural Jamaica, the economic development of multiple LDAs and farming areas has been stunted over the years, thus having a direct negative impact on the lives of the locals. The economy in most of these locations is heavily dependent on agriculture. However, this seems to have lost some of its appeal in the past few decades, especially due to the national decline of the sugar industry along with other issues such as praedial larceny. Tourism, a fairly prominent income generator in Petersfield, Black River Morass, Friendship, Lacovia and Little London, has, in a number of these places, been facilitated due to their proximity to local rivers which are used for recreational activities. This too, however, has declined somewhat due to the onset of the pandemic. Nowadays, most of the LDAs and farming areas have low levels of economic opportunities. Apart from the decline in traditional industries, this is partially due to a pervasive lack of training and employment opportunities. Youth and adult unemployment levels remain high in Frome, Wakefield, Duanvale and Jackson Town, which has led to several issues including brain drain and people resorting to illegal economic activities such as scamming. More jobs need to be provided in the fields of farming, construction, local business, tourism and factory work, and the existing jobs in the various development sites usually only allow people to earn fairly small incomes. There is a possibility that BBP can fill these economic gaps through the mill's employment of locals, partnerships with contracted farmers, and the implementation of technical skills training programmes.

10.1.1. BBP Partnerships with Individuals (Farmer contracts):

Partnership prospects with individuals who agree to farm bamboo on their own land look promising based on the moderately high rate of land ownership and self - employment among respondents. These two factors afford persons (who otherwise would have no access to farmlands and/or might be too occupied with other work obligations to farm), the freedom and flexibility required to enter into such contracts with BBP. Most of the survey respondents own the land they live (either personally or via family ownership), however, only a minority actually use their land for farming. While persons can be persuaded to utilize their land for agricultural purposes, it may be necessary to first train those who lack experience in sustainable, eco-friendly farming techniques.

10.1.2. Partnerships with Businesses & Individuals

As it now stands, the construction, agricultural, manufacturing and retail industries appear to be the main employers. This may mean that there are enough local businesses within each of these three sectors with which BBP can partner once the mill enters into development.

10.2. Local government involvement

Routine governmental activities in several of the LDAs and Farm sites generally include bushing, drain cleaning, repairing and constructing roads and upgrading public buildings. Despite these efforts, certain issues persist which local authorities have not been able to curb. According to the survey, locals generally perceive local government involvement in the lives of community members as being low and desire the government to be more involved in the areas of local employment, housing and road work. These findings could indicate that, if BBP were to partner with the public sector to address these and other issues, the company could expect to see a relatively low level of engagement on the part of government agencies. On the other hand, if the inadequacy of governmental responses to these matters are the result of stretched resources (as opposed to the issues being marked as “low priority”), then BBP’s future offers to channel company resources towards ‘private - public’ solution s could bolster their willingness and capacity to tackle these areas of need with greater urgency.

10.3. Social Infrastructure

10.3.1. Traffic & Road Safety

There is a medium level of road safety reported on average throughout the sites which indicates that, while BBP’s future employees (including its truck drivers and deliverymen) are not at high risk of encountering accidents whilst commuting to and from the mill, levels of safety can be improved to protect their lives, BBP resources as well as the lives of others in each community. Speeding, the presence of inexperienced/incompetent drivers, and deterioration of roads were identified as the main causes of accidents in most areas and motorcyclists/cyclists, public transport users and pedestrians were said to be the most common victims. As a means of increasing the overall road safety level (thus, benefitting BBP truck drivers and general employees as well as regular community members), BBP can help to implement safety measures which have the power to either reduce or prevent accidents. The Petersfield main road was found to be the most commonly used road in respondents’ daily commute in all areas except for Friendship. This and other commonly used roads (e.g., Shrewsbury, Hertford main road, Friendship main road, Great Georges Street, and Frome main road), were found to be in need of repair and were reported as being congested with the most traffic in their respective areas. Regular/seasonal instances of flooding also contribute to the overall poor condition of roads (many of which already suffer from a general lack of maintenance), which, in turn, hinders transportation in and out of each affected area.

One fear shared among attendees of the General Parish Stakeholders meeting was the company’s vehicles would create increased deterioration of the roads. It was suggested that BBP aid in the maintenance of roadways which it will depend upon for the transportation of materials as a means of reducing any damage caused. It may also be advisable for mill trucks to look for alternative routes (i.e., other than commonly used ones) to and from the factory to avoid creating increased traffic – as is the case for the local sugar industry which uses designated, SCJ-owned “cane roads” to transport tonnes of sugar cane.

10.3.2. Medical Services

Fortunately, it seems that healthcare, to some degree, is readily accessible to residents of most areas. Health centres can be found in all LDAs and Farm Sites with the exception of Hertford, Friendship, Amity, Winchester and Amity Hall. According to the survey, the Petersfield Health Centre, which is generally thought to provide patients with a medium level of care, was named as the main local health centre for Amity, Hertford and Petersfield. Furthermore, the Savanna-la-Mar Public General Hospital was identified as the main medical facility for people living in Savanna-la-Mar and serves the whole parish of

Westmoreland via its eponymous health centre and hospital. While this hospital was widely felt to provide a medium level of care, about a third of participants stated that it used insufficient, low-quality equipment and usually required patients to wait for long periods of time before being seen. To make matters worse, it, like local healthcare facilities, has suffered a severe strain on resources as a result of an influx of patients due, in turn, to Westmoreland's status as having one of the highest rates of COVID-19 deaths in the island. In fact, for several weeks, the Savanna-la-Mar Public General Hospital had been referred to as being in "crisis mode." As such, this and other high-priority local health facilities need forms of assistance to meet the rising demand for health services. To promote the sustainable health of the local labor force, improved medical infrastructure should be donated and vaccinations should be encouraged among communities in the development area.

10.3.3. Land Tenure and Acquisition

Concerning land acquisition, a significant fraction of the households in sites like Savanna-La-Mar, Wakefield, Duanvale, Lacovia and Black River Morass either own the houses in which they live or reside on family-owned land. Furthermore, the development of informal settlements has become a growing problem in areas such as Lacovia and Black River Morass. For decades, many residents in sugar-dependent areas have lived in small, wooden "barrack-style" houses which have limited access to utilities and have, over time, fallen into disrepair. Places like Hertford and Golden Grove have, therefore, benefitted from the "Barracks Relocation Programme," and "Community Regularization Programme," which rehouses and grants land titles to individuals respectively.

10.3.4. Water Supply

85% of all survey respondents indicated that water is piped to the residences; although, one third of them also collect water from nearby sources (such as rivers, wells etc.). This reliance on alternative supplies of water (most commonly seen among respondents from Hertford, Petersfield and Friendship), may be an occasional response to the frequent dysfunction of public facilities (e.g., water pumps and rain catchment tanks), seasonal climate change etc. Friendship, Little London, Winchester and – as is characteristic of most of St. Thomas – the areas of Amity Hall and Golden Grove have all been affected by a continual lack of public piped water; a reality which has been made even more dire in light of the COVID-19 pandemic. It will be in the best interest of BBP for these and other local facilities to be in proper working order so as to ensure a stable water supply to sustain both the mill's operations and the cultivation of bamboo by contracted farmers.

10.3.5. Pollution

The survey showed that most respondents dispose of their garbage in established receptacles and live in areas with generally low levels of pollution. Exceptions to this include the areas of Jackson Town, Black River Morass, and Duanvale; the latter two of which are plagued with issues such as the lack adequate garbage disposal facilities, improper garbage disposal practices and irregular garbage collection.

It was made evident in the Agricultural Stakeholders Meeting that there are concerns regarding the potential adverse environmental and health impacts of the mill's dust emissions and fluid waste as well as of the farming practices of the mill's contractors (specifically as it relates to the use of the "slash and burn" method).

10.3.6. Social Nets

According to the survey, the elderly, children, people with disabilities and the economically disadvantaged were seen as being the most vulnerable groups within the targeted communities. To help satisfy some of the social needs unable to be met by the government, multiple community-based civil society organisations have sprung up and have implemented a variety of social interventions over time. Petersfield, Wakefield, Duanvale, Jackson Town and Lacovia each have community centres and a number of local churches have become pillars in community life, not only for religious purposes but because of their involvement in social outreach and community development. Local businesses are also relied upon to meet the needs of these groups. BBP should seek to collaborate with these social actors to create/strengthen each location's social net and, ultimately, to fulfill its own corporate social responsibility.

The mill is set to create a Community Fund in which $X/tonne of harvested green bamboo will be allocated for each parish and will be held by BBP. Using this Fund, BBP can try to fill some of the gaps left in the government's provision of social services for underserved groups. Collaborating with others to satisfy the needs of vulnerable groups is likely deepen the company's understanding of each local population, strengthen its relationships with stakeholders, and improve the public's perception and support of the business.

10.3.7. Crime

Crime in each development area seems to be relatively low (except for in Savanna-la-Mar where 100% of survey respondents believed that crime was at a medium level), and the police is generally seen as maintaining good relations with residents. This, at the time of the survey, indicated a probable need for increased security measures for the mill's operations in Savanna-la-Mar. Since these findings were produced, crime in the parish's capital has intensified; moving towards the forefront of the island's attention as it was placed under an official State of Emergency (SoE) in the second week of November. Despite this seemingly drastic response, a mere two days after the SoE was declared, the nation was shocked to learn of the murder of an attendee during an anti-violence workshop in the city; making it appear as though local criminals are becoming increasingly brazen and fearless.

Opposition spokesman on National Security, Senator Peter Bunting has called the decision to enforce an SoE (an action which is part of a larger, crime-fighting trend in the island in recent years), "ineffective," going as far to label it as a "shallow PR gesture [and] an attempt to camouflage the Holness administration's failure to address violent crime, and the causes of crime." Whether the SoE is, indeed, capable of producing a lasting positive impact in Savanna-la-Mar remains to be seen. In the meantime, residents continue to live in fear. Local businesses have been negatively affected and, prior to the SoE, several individuals have expressed to the media that they especially feel unsafe when leaving on early morning commutes to work. Apart from having increased security for BBP resources in the area, BBP should also focus on helping to improve physical infrastructure as a means of crime prevention seeing as local communities which have been targeted by gangs have typically been reported to have poor infrastructure (e.g., bad lighting), thus increasing their vulnerability.

Concerningly, the farming sites of Little London (which has witnessed a trend towards more violent crimes in recent years) and Lacovia (which experiences significantly higher levels of crime as compared to its surrounding areas – i.e., mainly robberies and break-ins), also warrant increased security. Notably, it is in the company's best interest to begin building a strong relationship with the local police in each site.

10.4. Perceptions/Acceptance of Mill

Most people in each site indicated high levels of support for BBP proposed development of the mill. Such positive attitudes are primarily influenced by the hope of increased employment, training and economic activity to be brought on by the mill's development and eventual operations. However, persons have voiced concerns regarding the mill's potential negative impacts. The threat of increased pollution and/or other environmental problems was a prime concern (as indicated by over half of participants), followed by the mill's potential strain on public resources and infrastructure and the effects of increased traffic caused by many of the company's trucks coming in and out of each location.

Because of these concerns, BBP should make an effort to acknowledge the risks involved; to explicitly communicate contingency plans to mitigate such events; and to accept and respond to pertinent questions raised by the public (most of which, according to the survey findings, have to do with opportunities for employment and partnerships with local individuals/businesses). Positive public perceptions of the project can be further cultivated through the continuous engagement of stakeholders in which a space is provided for honest dialogue to occur between BBP and members of the public. In this vein, there is encouragement to be gleaned from the fact that 89% of all respondents shared their contact information due to an interest in receiving future updates on the progress of the project.

11. Mitigation Plan

11.1. Purpose

A mitigation plan, consistent with IFC's Performance Standard 1, its objectives and principles describes mitigation and performance improvement measures and actions that address the identified social risks and impacts of the project on the affected communities and other stakeholders.

The mitigation plan takes into account the engagement with the local community and identified stakeholders, and outlines relevant strategies to mitigate any potential negative impact, or strengthen positive impact where feasible. The objective of the mitigation plan is:

- To ensure the concerns of the local community are heard and strategies identified to mitigate potential fallout of negative impact;
- To determine historical pain points for the communities, and provide clear actions to be taken to ensure historical mistakes are not repeated;
- To generate awareness in local communities to ensure they are pro-active in managing their own expectations and concerns with regard to the project;
- To minimize the impacts on local culture as a result of the project and maximize the benefit of opportunities for local communities affected by the project;
- To manage any grievances arising from the project during its various lifecycles.

The Social Impact Management Plan (SIMP) predicts and plans responses for certain common and specific social impacts that may occur throughout the operations activities of the Project. The SIMP is necessary for adequate management of these social impacts and contains the measures to be implemented in the different phases of the project, in order to promote positive outcomes and decrease or minimize the adverse impacts that may arise. The table below summarizes the proposed mitigation measures. ***A final SIMP will follow the SIA, and will include allocation of responsibilities, time frame, reporting and monitoring of all potential impacts associated with the completion and operation of the Mill***.

Table 2 - Mitigation Plan: Solutions to Identified Issues & Challenges

Mitigation Plan – Solutions to Identified Issues & Challenges

Local Economy	Public Perceptions & Acceptance of Mill	Education and Training
Improve local economic prospects through the creation of jobs and business partnerships.	Keep the public well-informed and help to curate positive perceptions of the mill among the general public.	Develop the academic and vocational skills of the labour force to ensure that mill workers meet world-class industry standards.
• Use community information sessions to garner buy-in from entire households rather than the sole individuals who enter into farming contracts. • Partner with SCJH to aid in the distribution of certificates of land ownership to qualified residents in development sites. • Assist with technical set up of farms, not only through the provision of equipment/machinery, but by training landowners in sustainable, eco-friendly bamboo farming techniques.	• Give transparent and consistent reports on the mill's development, progress, activities and, ultimately, its economic and social impact (according to pre-established Key Performance Indicators – KPI's). • Provide ongoing engagement with stakeholders via a diverse set of mechanisms (e.g., in-person or digital public forums, direct contact with past survey respondents, small meetings with community groups/organisations, the BBP website & social media pages etc.). • Be direct in addressing and validating stakeholders' concerns regarding the risks/possible negative impacts of the mill. In response, create and publicize mitigation plans on each major concern raised.	Secondary Education • Collaborate with secondary schools to expose students to different areas of work associated with the mill through field trips, summer internships/trainee programmes; Promote the inclusion of more vocational skills components into local high school curricula Post-secondary Education • In partnership with local tertiary institutions (e.g., Montego Bay Community College, UWI Open Campus) and vocational training institutions (e.g., the Petersfield Vocational Training Center), use BBP Community fund to provide full/partial scholarships for certain courses/ degree programmes (e.g., engineering, construction, agriculture etc.). • Partner with the Montego Bay Community College & HEART NTA to develop additional courses that focus on the attainment of knowledge & skills needed by mill. • Centre of Excellence – BBP will partner with the UWI et al to establish Westmoreland as the hub of bamboo research and development

Social infrastructure - Ensure that adequate social services are provided at a high quality so that the needs of the mill and the residents are properly met.

Water

- Partner with the WMC to improve the sustainability of public water supply services (e.g., fixing/ replacing broken public water facilities).

Housing solutions

- Advocate for the expansion of SCJH Community Regularization Programme so that its reach extends to all LDAs.
- Provide temporary housing for select workers for the duration of their respective contracts. These workers can enter into leases with BBP which boast competitive rates.

Health

- Through the BBP Community fund, donate new pieces of equipment to the Savanna-la-Mar Public General Hospital based on their specific needs to offset the growing strain on resources.
- Encourage vaccinations among employees.

Roads

- Transport BBP materials via trucks primarily during off peak times.
- Make contributions from the BBP Community fund towards the maintenance of heavily used roads most in need of repair as deemed necessary. These roads include Petersfield: Shrewsbury and Petersfield main road; Hertford: Hertford main road; Friendship: Friendship main road; Savanna-la-Mar: Great Georges Street; Frome: Frome main road (B9).
- Make contributions from the BBP Community fund towards the maintenance of local drainage systems to reduce the risk of flooding during rainy seasons.
- Lobby the government for a donation of funds towards the construction of roads to transport bamboo to and from the LDAs. BBP can also contribute financially towards this endeavour.
- Sponsor certain aspects of the national Disaster Risk Management programme and recovery efforts for adverse hydrometeorological events (e.g., flooding), which has the potential to damage roads, houses and other property/infrastructure.

Road Safety

Promote increased road safety by:

- Advocate for improved law enforcement measures in LDAs (especially in Friendship).
- Advocate for the replication of the National Road Safety Council's Motorcycle Outreach in all 6 development areas. Initially piloted in Petersfield in 2020, this initiative will train motorcyclists in road usage and road safety measures and assess their ability to ride safely to decrease the number of road fatalities (especially among motorcyclists in Westmoreland).
- Partner with the Jamaica Automobile Association to increase the opportunities for mill workers to partake in driving lessons. Lessons could be offered at discounted rates to employees as made possible by partial sponsorships from BBP.

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Social infrastructure - Ensure that adequate social services are provided at a high quality so that the needs of the mill and the residents are properly met.

Pollution

- Discourage the use of the slash and burn method by carrying out educational/sensitization campaigns which highlight the negative economic, environmental and health effects of the practice.
- Develop plans to control the spread of fires (e.g., through overhead sprinklers, fire breaks, etc.) and establish a mandate to refuse the purchase of burnt bamboo from local growers as part of company policy.

Disaster Preparedness

- Ensure that a disaster risk management business continuity plan is developed in accordance with the guidelines of the Office of Disaster Preparedness and Emergency Management (ODPEM).
- Sponsor drain cleaning programmes leading up to the rainy season as drainage systems are inadequately maintained leading to flooding during rainy seasons.

Citizen Security

- Increase security around BBP Resources in Savanna-la-mar, Lacovia and Little London
- Improve infrastructure in hot spot/volatile communities in Savanna-la-mar
- Build a strong relationship with the local police in each LDA and farm site.

Social Protection

Serve the needs of the impoverished by:

- Partnering with local businesses and academic institutions to design and implement programmes for impoverished persons which focus on financial literacy, entrepreneurial training, job readiness, and job placement.
- Collaborating with local schools to sponsor and implement seasonal adult literacy programmes.
- Donating small conditional and unconditional grants to local non-profit organisations and the outreach ministries of local churches.

Serve the needs of the local disabled population by:

- Promoting disability accessibility in the design of the mill via the inclusion of important physical infrastructure (e.g., ramps).
- Sponsoring the delivery of disability accessibility training sessions among schools, local businesses and local government bodies in partnership with the Combined Disabilities Association, the Jamaica Association for the Deaf etc.
- Advocating for increased disability accessibility in local public buildings – also through the installation of certain physical infrastructure

Serve the needs of children in local development areas by:

- Partnering with local schools and government agencies to sponsor school feeding programmes.
- Making donations to local schools towards the maintenance of buildings, and the procurement of equipment and supplies.
- Sponsoring homework assistance programmes carried out by local community centres/outreach organisations (the Source Savanna-La-Mar, the Petersfield branch of the Westmoreland Parish Library etc.).
- Developing training/job placement programme for unattached youth in LDAs and encourage learning of skills needed for BBP-related mill/farm/office jobs.

Serve the needs of the local elderly population by:

- Making donations to local elderly care facilities (e.g., the DCS Nursing Home in Amity) towards the maintenance of buildings, and the procurement of beds and equipment.
- Creating a private pension and health insurance scheme for BBP workers.
- Advocating on behalf of the elderly populations in LDAs and Farm sites to National Council for Senior Citizens.

12. Conclusion

The BBP project provides a unique opportunity for Westmoreland to develop a modern, technology focused business with the provision of agricultural jobs historically provided within the area, as well as the introduction of new, STEM based highly skilled roles. Having been in a state of economic decline for over 50 years, the Parish seems ready to welcome Bamboo as its newest industry. The opportunities are clear to see. The Mill will replace sugar production as the main income earner for the eastern part of the Parish, and will replace what is an old, outdated industry with a modern, sustainable mill, supported by sustainable farming practices and ongoing community development and support.

Sound environmental and social practices will need to be the hallmark of BBP identify, and its policies, systems and corporate culture must support agreed standards. The Company has already started to make commitments to stakeholders and the community, indicating its promise to be transparent and inclusive in its processes, with sustainability at the core of how it builds relationships and conducts business.

Whilst the benefits are many, there are some concerns associated with the project. These concerns are well founded by the community, yet there are solutions that will reduce or mitigate the negatives. BBP will prepare a Social Impact Management Plan which will be used to guide its development over the coming months and years, and will be a commitment to the community, partners and investors.

The BBP project is one which is likely to have a net positive impact on the Parishes and communities in which it operates, and will be a model for the design, development and implementation of sustainable industry. In an emerging market such as Jamaica, the BBP project can demonstrate how industry can transition from traditional systems with primarily capitalist objectives, towards a more sustainable, inclusive and beneficial model using the principles of sustainability – or more specifically, it demonstrates where people, planet and profit intersect.

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APPENDICES

APPENDIX 1- COMMUNITY & NEEDS ASSESSMENT REPORT

COMMUNITY AND NEEDS ASSESSMENT REPORT

A Component of the Social Impact Assessment (SIA) for Bamboo Bioproducts Pulp Mill and Farm, Jamaica

May 2021

Prepared by The Leap Co

info@theleapco.co

1. Summary of Baseline

Bamboo Bioproducts was formed in 2020 and aims to be the first completely integrated Bamboo Market Pulp Mill globally by providing multi-national manufacturers of tissue products with "sustainably produced, high-quality bamboo pulp.[i]" This may be achieved by planting and harvesting bamboo on farm sites and then processing this raw material in a world-class pulp mill in Westmoreland. Farm sites are expected to be located in the parishes of Westmoreland (i.e., in Little London and Grange Hill), Trelawny (i.e., in Wakefield, Duanvale and Jackson Town), St. Thomas (i.e., in Winchester, Amity Hall and Golden Grove), and St. Elizabeth (i.e., in Lacovia and Black River Morass). The mill itself will be likely surrounded by the **local development areas (LDAs)** of Hertford, Friendship, Amity, Frome, Petersfield and Savanna-la-mar. This Social Impact Assessment (SIA) aims to highlight the history, culture, economic activities, social & physical amenities and environmental features of each of these areas in order to provide context to Bamboo Bioproducts when determining the potential effects of the mill's construction and eventual operations on these select locations.

1.1. Baseline on Social and Historical Impact

1.1.1. Indigenous People & Cultural Heritage

Several of the farming/ development areas were once home to indigenous people and/or early settlers who ultimately made up the social and historical fabric of Jamaican society. The indigenous Taino people once resided in the area which is now known as Wakefield. Maroons have lived in various locations across St. Elizabeth and St. Thomas for hundreds of years and Lacovia used to house one of the island's largest communities of Jamaican-Jews. Additionally, Westmoreland was the site of Jamaica's19th century German settlement and Little London, in particular, witnessed an influx of Chinese and East Indian migrants also within the same time period. Much of the cultural heritage in the LDAs stems from early economic activity – particularly from the production and export of goods (e.g., sugar). Savanna-la-Mar and Lacovia (both of which were made parish capitals), were developed primarily to facilitate the exportation of sugar and other products, while the town of Petersfield was built, ultimately, to facilitate the operations of the Roaring River Estate. On another note, remnants of Jamaica's bygone eras in the form of centuries-old church buildings. Great Houses and other historical sites can still be seen to this day in areas like Little London, Amity Hall, Golden Grove, and Black River Morass.

1.1.2. Social Risks & Impact

There is a clear disparity between rural and urban sites as is evidenced by the quality and quantity of physical and social infrastructure present. Basic social amenities such as healthcare facilities, educational institutions and others can play a significant role in determining the standard of living and opportunities for social advancement available to residents. Fortunately, it seems that healthcare, to some degree, is readily accessible to residents of most areas. Health centres can be found in all LDAs and Farm Sites with the exception of Hertford, Friendship, Amity, Winchester and Amity Hall. Notably, Savanna-la-Mar serves the whole parish of Westmoreland via its eponymous health centre and hospital. It also features a local private hospital and the Westmoreland Health Department. Similarly, Black River Morass boasts of multiple medical service providers such as the Black River Hospital and the All American Institute of Medical Sciences. Notable local educational institutions, which mainly range from primary to secondary levels, are situated in Frome, Petersfield, Savanna-la-Mar, Little London and Grange Hill. Savanna-la-Mar, having a greater variety of academic options, also caters to special-needs individuals through its Savanna-la-Mar Inclusive Infant Academy and to tertiary students through the local branch of the University of the West Indies at Mona Open Campus and the Westmoreland Business College. Rural Westmorelanders who live in or around Frome also have some ease of access to tertiary education via the Montego Bay Community College (Frome Campus).

Local government is relatively active in several of the LDAs and Farm sites – most notably Petersfield, Friendship, Frome and Savanna-la-Mar. Routine governmental activities generally include bushing, drain cleaning, repairing and constructing roads and upgrading public buildings. Despite these efforts, certain issues persist which local authorities have not been able to curb. Friendship, Little London, Winchester and – as is characteristic of most of St. Thomas – the areas of Amity Hall and Golden Grove have all been affected by a continual lack of public piped water; a reality which has been made even more dire in light of the COVID-19 pandemic. High levels of pollution, blocked drainage systems and flooding also occur in several places, in large part, due to irregular garbage collection and improper disposal methods. Regular/seasonal instances of flooding also contribute to the overall poor condition of roads (many of which already suffer from a general lack of maintenance), which, in turn, hinders transportation in and out of each affected area. Regarding public safety, police stations are located in Frome, Savanna-La-Mar, Wakefield, Little London, Grange Hill, Lacovia and Black River and fire stations can be found in Black River and Savanna-la-Mar respectively – the latter of which contains a station which serves the entirety of Westmoreland (with the exception of Negril). To help satisfy some of the social needs unable to be met by the government, multiple community-based civil society organisations have sprung up and have implemented a variety of social interventions over time. Petersfield, Wakefield, Duanvale, Jackson Town and Lacovia each have community centres and a number of local churches have become pillars in community life, not only for religious purposes but because of their involvement in social outreach and community development. Other social amenities which can be found in a number of LDAs and Farm Sites include tax offices, public libraries and post offices.

1.1.3. LAND TENURE AND ACQUISITION

Concerning land acquisition, a significant fraction of the households in sites like Savanna-La-Mar, Wakefield, Duanvale, Lacovia and Black River Morass either own the houses in which they live or reside on family-owned land. Furthermore, the development of informal settlements has become a growing problem in areas such as Lacovia and Black River Morass. For decades, many residents in sugar-dependent areas have lived in small, wooden “barrack-style” houses which have limited access to utilities and have, over time, fallen into disrepair. Places like Hertford and Golden Grove have, therefore, benefitted from the “Barracks Relocation Programme,” and “Community Regularization Programme,” which rehouses and grants land titles to individuals respectively.

1.1.4. LABOUR & WORKING CONDITIONS

As is too often the case in rural Jamaica, the economic development of multiple LDAs and farming areas has been stunted over the years, thus having a direct negative impact on the lives of the locals. The economy in most of these locations is heavily dependent on agriculture. However, this seems to have lost some of its appeal in the past few decades, especially due to the national decline of the sugar industry along with other issues such as praedial larceny. Tourism, a fairly prominent income generator in Petersfield, Black River Morass, Friendship, Lacovia and Little London, has, in a number of these places, been facilitated due to their proximity to local rivers which are used for recreational activities. This too, however, has declined somewhat due to the onset of the pandemic. Apart from this, most LDAs and farm sites feature several small businesses ranging from eating and drinking establishments to supermarkets and retail outlets. The existence of local businesses does not necessarily denote that these places have commercial hubs, however. In fact, neither Duanvale nor Jackson Town have commercial hubs, therefore, forcing residents to commute to Falmouth and Brown Town respectively. Youth and adult unemployment levels remain high in Frome, Wakefield, Duanvale and Jackson Town, which has led to several issues including brain drain and people resorting to illegal economic activities such as scamming. A major factor contributing factor to the problem of unemployment in these regions is a lack of training & employment opportunities. As is to be expected, such opportunities appear to be much more present in the urban centres of Petersfield, Black River Morass and Savanna-La-Mar.

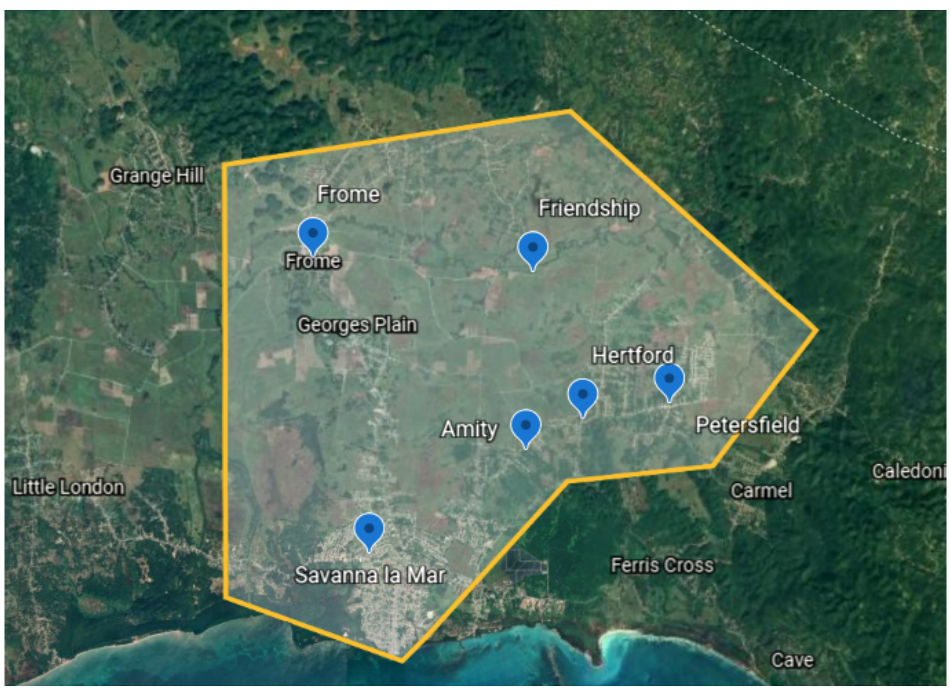
1.2. Implications for Bamboo Bioproducts

The social, cultural and economic realities of the LDAs and Farm Sites have major implications for the ease with which Bamboo Bioproducts can develop and operate their planned mill and farms. Primarily, the proportion of locals who own land gives an idea of how many contracts could potentially be supplied to farmers in order for them to use their idle lands to grow bamboo on behalf of the company. The level of educational attainment and available opportunities for skills training speak to the degree of employability of the local labour force. Similarly, the degree of access to healthcare services may connote how healthy the work force is. On another note, the extent of pollution and crime as well as the availability and quality of social and physical infrastructure (e.g., public water supply, roads, post offices, garbage collection facilities etc.), will have an effect on the company's security of assets, transportation of materials and workers, disposal of waste, connection with surrounding areas and more. Likewise, the findings of this Social Impact Assessment also have implications with regard to the company's potential impact on residents. Particularly in areas experiencing low skill and high unemployment levels, a noticeable difference may be created due to the mill's planned employment of hundreds of skilled and farm workers and due to Bamboo Bioproducts' possible collaborations with universities to develop a "Center of Excellence" in order to upskill the local labour force.

2. Situational Analysis

Jamaica's eighth largest parish, Westmoreland, is, as its name suggests, the westernmost parish in the island and is located south of Hanover and northwest of St. Elizabeth in the country of Cornwall[ii]. Founded in 1703[iii], Westmoreland contains 84 districts which are populated by an estimated 145,628 residents[iv], most of whom live in rural districts and 8,404 of whom are unemployed[v]. The natural environment, which consists of fertile soils, several rivers, beaches and hilly areas, has heavily influenced the parish's main economic activities (i.e., agriculture, manufacturing and tourism)[vi]. Notably, in recent decades, tourism and other service-oriented industries have taken economic precedence over natural, resource-based industries like agriculture. Within the parish can be found the areas of Hertford, Friendship, Amity, Petersfield, Frome and Savanna-la-mar; all of which are in close proximity to the planned construction site of Bamboo Bioproducts of Jamaica's proposed bamboo mill.

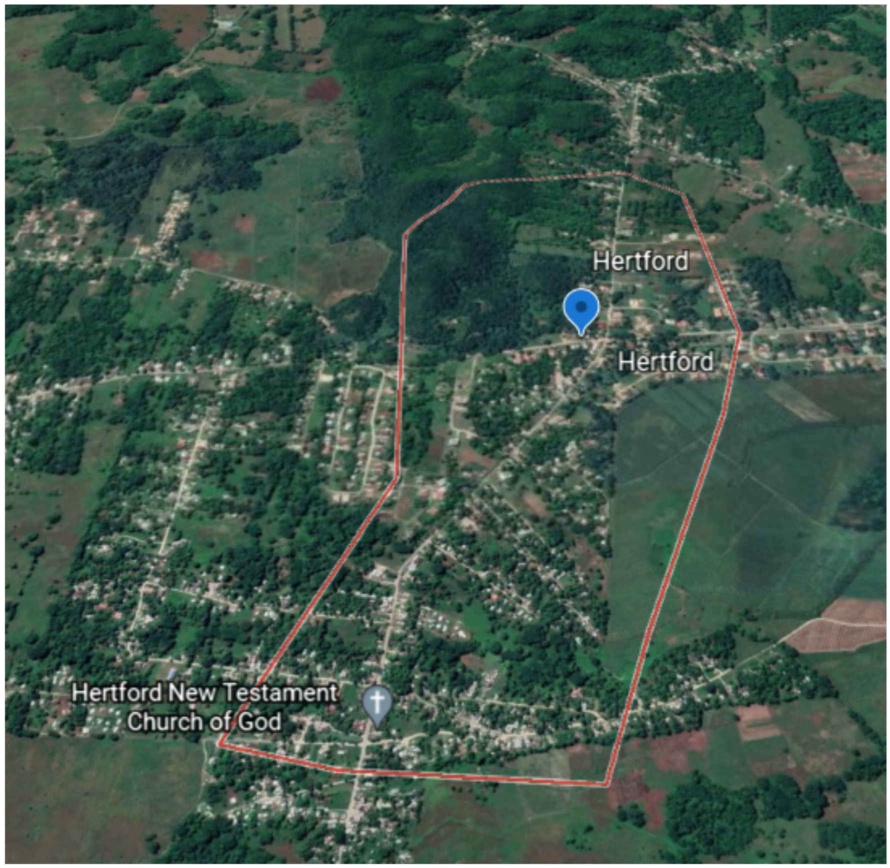
Map 1- Mill Site sphere of influence



2.1. HERTFORD

Hertford is a small region located between Petersfield and Amity. The two major roads running through the area are Torrington to Galloway Road (which leads into Hertford), and Hertford to Flowerhill Road which allows for transport into Friendship. Throughout its history, the sugar industry has played a significant role the economic development of the area and, for much of its history, hundreds of residents have lived in houses (commonly referred to as "barracks"), on sugar estates. Many of these housing units fell into various states of disrepair as time wore on and the sugar industry began to decline. These lodgings were originally intended to be temporary places of residence for sugar workers and, therefore, provided restricted access to several amenities[vii]. Fortunately, by 2015, 650 sugar workers had received newly constructed houses free of cost under the government's "Barracks Relocation Programme,"; an initiative to re-house 2,850 sugar workers in sugar-dependent communities across Westmoreland[viii]. In a similar vein, that year also saw 455 individuals residing in the Hertford/Morass Lane community being chosen to receive land titles as part of the Sugar Company of Jamaica (SCJ) Holdings Limited's "Community Regularization Programme," which aimed to "regularise land-ownership in former sugar communities," in Westmoreland and other parishes in the hopes to provide citizens with greater economic opportunities by using their land for agricultural and other activities[ix]. Aside from housing, the area also features churches such as the Hertford New Testament Church of God and Wesleyan Holiness Church, along with several small business establishments.

Map 3 - Map of Hertford Westmoreland



2.2. AMITY & PETERSFIELD

Amity, southwest of Hertford, is a small region, cut through by the Torrington to Galloway Road which connects the area to Hertford and allows for transport into Savanna-la-Mar. Amity Square, the heart of the community, is close to a housing scheme along with particular social facilities including a supermarket, nursing home and two main eating establishments.

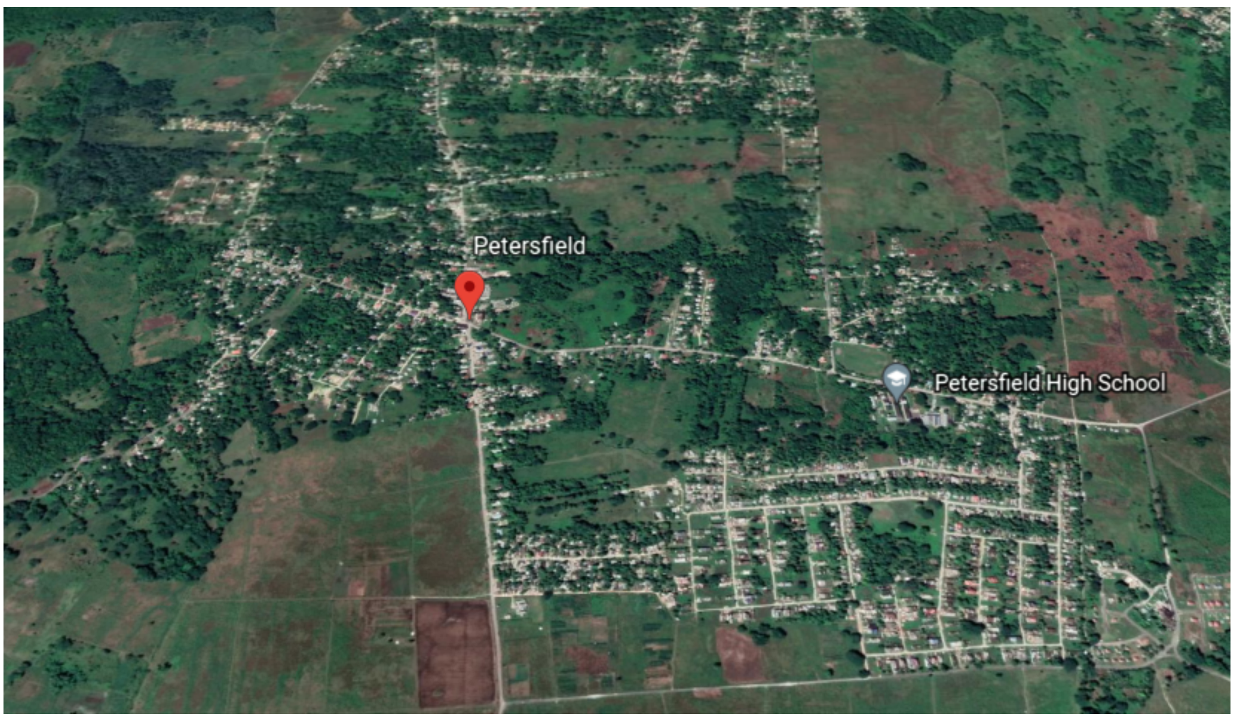
To the east of Hertford is the community of Petersfield; an old township which was developed in the 17th century to provide housing for the Roaring River Estate workers[x]. This estate – once owned by Colonel Peter Beckford (i.e., The first Custos of Kingston, from whom Petersfield derived its name), – was one of Jamaica's largest sugarcane plantations[xi]. The eponymous, miles-long Roaring River surfaces near the town in an area around which an abundance of green vegetation grows and the Roaring River Cave can be found. The cave consists of underground limestone caverns and a small mineral spring[xii]. Once used as a water source to irrigate the Roaring River Estate, this body of water now supplies Central Westmoreland. Today, the Roaring River Estate operates as the Roaring River Park (managed by the Tourist Product Development Company), which attracts approximately 2,500 tourists annually who visit to learn about the area's history, explore the aforementioned limestone caverns and swim in the river's "bottomless" sinkhole. This brings economic opportunities to residents of the area, several of whom work as vendors along the river[xiii].

There has been evidence of the local government's involvement in community life throughout the years; particularly as it relates to the maintenance of the town's physical and social infrastructure. In 2012, a new Petersfield Post Office was constructed to replace the previous building which had become dilapidated over time. The current post office not only serves the town of Petersfield, but also 11 other areas including Amity[xiv]. Furthermore, the Westmoreland Municipal Corporation (WMC), cleaned the Petersfield cemetery under a larger parish-wide initiative in 2004 to beautify local cemeteries[xv]. The WMC has also been involved in bushing, drain cleaning, repairing the Roaring Park and Cave, painting the Petersfield Health Centre and doing road work (e.g., on the Hertford to Flower Hill main road)[xvi]. The Torrington to Galloway Road is another major cross-cutting road in Petersfield which allows for residents to commute to and from Hertford. Other main roads include William Road and Frome Drive, both of which are part of a close network of roads adjacent to the Petersfield high school. The high school caters to approximately 1,700 students (ages 11 to 19)[xvii], 40% of whom receive needs-based financial support from the state-run Programme of Advancement Through Health and Education (PATH) programme, and who generally live in nearby communities like "Darliston, Frome, Birds Mountain, Montego Bay, Burnt Savannah, Friendship and more[xviii]." The Petersfield Vocational Training Center in Westmoreland (offering HEART Trust/NTA programmes), and the Petersfield Primary & Infant School are two other main educational/training institutions in the town.

Map 4 - Map of Amity, Westmoreland

A significant pillar in the lives of residents is the Petersfield Galloway Benevolent Society (PGBS) (formerly known as the Association of Clubs), which revived the Petersfield Community Center in 1989 (post its destruction by Hurricane Gilbert), has made donations to the high school, repainted the post office, developed skills training and Village Tourism initiatives, and developed the "Pride of Petersfield" park – now the site of their annual youth summer camp[xix] among several other interventions. Also important to social life in the community is the Petersfield Health Centre. Classified as a Type 2 health institution,[xx] this clinic received additional funding in 2018 from members of the Jamaican diaspora in response to the Ministry of Health & Wellness' (MoHW) Adopt-A-Clinic programme which calls upon local and international Jamaicans to help meet the needs of their former communities by focusing on the gaps which the government is unable to fill with their limited resources. This donation was made to pay for the Centre's roofing and plumbing repairs and new equipment, such as nebulisers).[xxi] Other important local facilities available for public use include the Petersfield Community Centre, St. Peter's Anglican church and the Petersfield branch of the Westmoreland Parish Library; the last of which offers free computer and internet access along with services such as printing and photocopying, reference and lending, and scanning. Moreover, the public benefits from particular outreach programmes led by this library, like its National Reading Competition, homework assistance initiative, computer classes and book club.[xxii]

Map 5 - Map of Petersfield, Westmoreland



2.3. Friendship

Towards the north of Westmoreland, is Friendship. Located by the Cabarita River, the area attracts a variety of tourists who visit the river and, specifically, a site known as the Cabarita River Adventure & Mesopotamia Leisure Farm[xxiii]. This tourist attraction allows people to rest alongside the riverbank and go swimming, tubing and boating. The farm also grows a wide variety of crops including plantain, pumpkins, corn, pineapple, guava, breadfruits, yams, bananas and sugar cane. Taking its name from a nearby community's original name of Mesopotamia (prior to it being changed to Barham District – based on the 19th century plantation owner, Joseph Foster Barham II),[xxiv] the Cabarita River Adventure & Mesopotamia Leisure Farm definitely plays a role in generating revenue for the area. Unfortunately, in light of the economic impact of the COVID-19 pandemic, many workers in the tourism sector who live in Friendship have become unemployed[xxv].

Despite the closeness of the river, residents in a number of communities in the Friendship Division (such as Bath Mountain, Red Hills, Prospect and Blauwearie), began to experience a lack of piped water in August 2019. Not only does the public solar water pump placed at a spring head, frequently dysfunction, but the area's rain catchment tank is in need of repair due to a leak. Because these two main water sources, are now unable to supply these communities, residents have resorted to pooling together money in order to purchase truckloads of water and also collecting water themselves from the river. In 2020, due to the health concerns that this deficit raised during the COVID-19 pandemic, the then Member of Parliament for Westmoreland Western organised an imitative to have water trucked into the affected communities[xxvi]. Promisingly, plans are being made to find a more sustainable solution[xxvii]. Notwithstanding this ongoing issue, there has been some progress made regarding the local physical and social infrastructure throughout the years. The Westmoreland Municipal Corporation in the Friendship division, has installed grills at the Bleawarrie Primary School and Bath Mountain Community Center respectively, and painted part of the Mount Grace Junior High and Primary school; among other ongoing activities like road marling, bushing and drain cleaning[xxviii]. On a separate note, in their daily lives, Friendship's residents have ease of access to facilities such as the Strawberry Postal Agency and places of worship like the Friendship Apostolic Church and the Friendship Seventh Day Adventist Church.

Map 6 - Friendship, Westmoreland

2.4. FROME

Frome, approximately 5 miles from Savanna-la-Mar and consisting of five districts, is centred around the Frome Sugar Estate (i.e., a property on which stands one of Jamaica's last remaining sugar factories[xxix]. Once the centre of Westmoreland's economic development, the estate was first owned by Christopher Morris who arrived in Jamaica along with the British army in 1655. The 1930s saw a revival of the estate's operations due to the factory being merged with a number of other factories, resulting in the construction of the Frome Central Sugar Factory. Unfortunately, this merger caused a loss of jobs for many sugar workers which lead to the deadly 1938 labour riots in Frome. This sparked a flame which set off a series of labour riots across Jamaica, resulting in universal adult suffrage in 1944, followed by a new constitution and, ultimately, Jamaica's independence[xxx]. Today, Frome stands as one of the largest estates in Jamaica, produces one third of the country's homegrown sugar and is Westmoreland's main single source of employment[xxxi]. Now owned by the Chinese Pan Caribbean Sugar Company (PCSC)[xxxii], the factory has been underperforming for the past several years, in spite of multi-million-dollar rehabilitation efforts made in 2015. Its low performance levels are due to incidences of cane fires, a decrease in cane-cutting employees[xxxiii], sugar trafficking and, as of 2020, flooding[xxxiv]. These factors, combined with the reality of the industry's general decline over the past few decades, do not bode well for the estate's future. This raises a variety of concerns for the region's overall economic development as, with a population of about 1,460 inhabitants, 21% of Frome's 417 households are headed by unemployed individuals and youth unemployment remains high[xxxv].

The Frome Sugar Estate is adjacent to a network of roads which serves as the site for much of community life. Daily life typically centres around work, places of worship, sporting events and school[xxxvi]. Within the network can be found the Townhead Baptist Church, Ricketts River Wesleyan Holiness Church as well as the Frome Sports Complex – a multi-use stadium that is often used to host football matches. The town is also home to the Three Miles River Early Childhood Institution, Frome Post Office, Frome Police Station and the Gamertsfelder Mission Center (which contains an eye clinic). Academic institutions in the area include the Frome Preparatory school, Frome Technical High School, and the Montego Bay Community College (Frome Campus). The Community College offers a diverse set of programmes comprising clothing & fashion, environmental studies, social work, practical nursing, computer technology, accountancy, early childhood education and more[xxxvii]. Despite these and other options for educational attainment, Frome is still described as having "limited/no opportunity for training & employment," by the Social Development Commission (SDC). The SDC has also described residents as having "poor representation by elected political leaders[xxxviii]." Nonetheless, local government has been instrumental in certain developmental activities such as the construction and repair of sidewalks, drains and roads (e.g., the patching of a road leading from Frome's Three Miles River area through Georges Plain). The WMC has also expanded and repaired a number of small, local early childhood institutions (e.g., the Frome and Three Miles River ECIs respectively)[xxxix].

Map 7 - Frome, Westmoreland

Locals typically live in wooden, "barracks-style houses[xl]," 73.8% of which are owned by their occupants, according to the SDC. Regarding land ownership, on the other hand, only 26.8% of residents were said to own the land on which they lived[xli]. A common way for people to commute in Frome is via bike taxis[xlii] and, with respect to utilities, about three quarters of Frome's households have direct access to piped, public water and the vast majority use electricity for lighting. Finally, garbage is collected by truck from most houses[xliii] and there may be plans being developed to construct a garbage transfer station in Frome to allow more efficiency in the garbage removal process in the future[xliv].

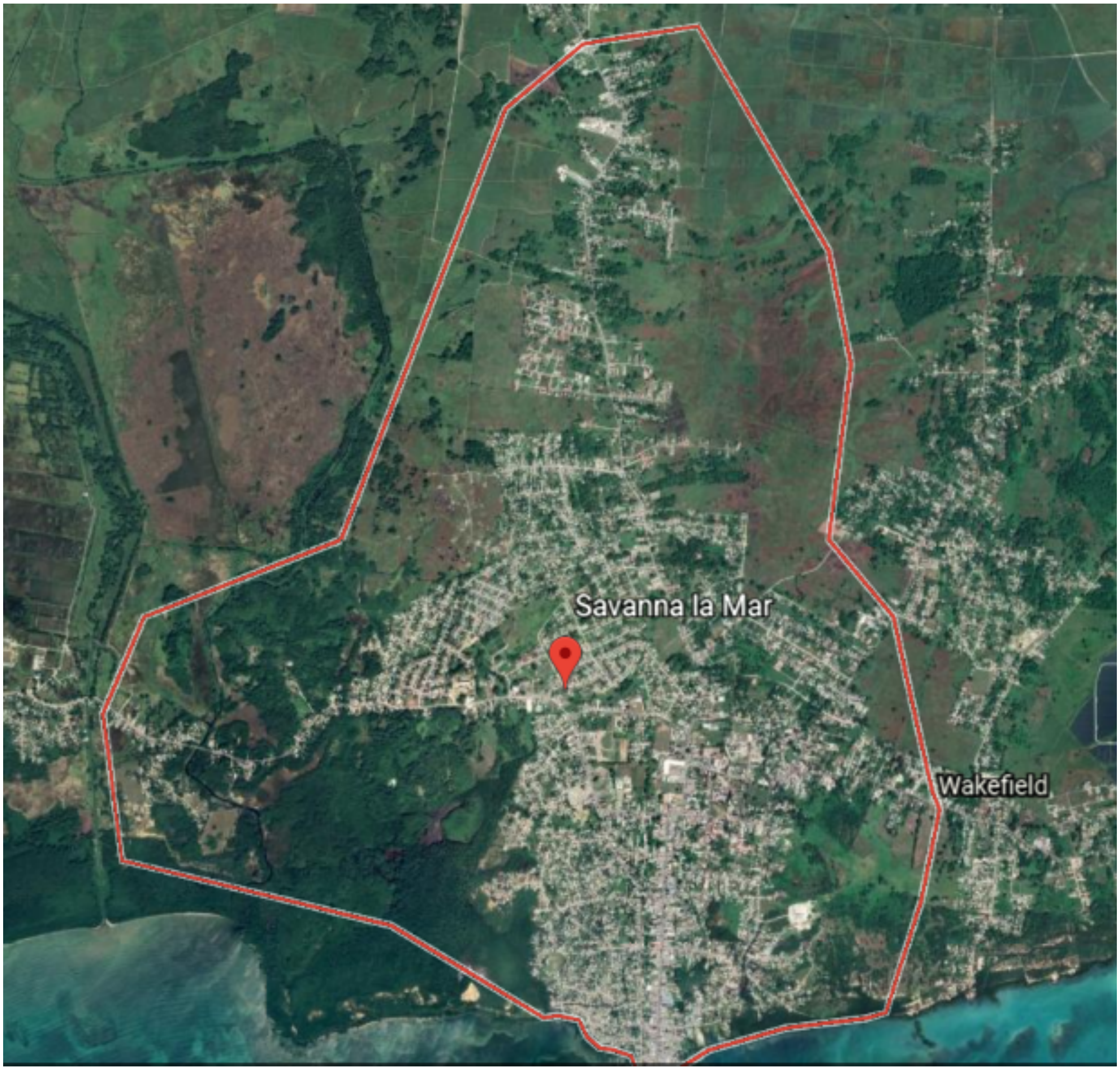
2.5. SAVANNA-LA-MAR

Savanna-la-Mar, the administrative capital of Westmoreland, was developed in the early 1700s as a port used to facilitate the export of sugar. With a Spanish name meaning "Plain by the sea," the town was built up close to the coastline (which is lined by a number of mangrove swamps[xlv]), and has grown to have a population of 19,893 (as of 2001). According the SDC, of its estimated 41,319 households in 2001, 30% were headed by unemployed individuals while 40% were headed by occupants without academic qualifications. 70% of the SDC's survey respondents owned their houses (most of which were made from boards) and all households represented benefitted from garbage collection facilities. Most households have access to a public, piped water supply[xlvi]. Today, other social and physical amenities include the Savanna-la-Mar Health Centre and the Savanna-la-mar Hospital; both of which serve the entire parish of Westmoreland. The former remains the parish's only Type 4 health centre and offers child health, pre-natal health, public health, dental, family planning services among others – as well as all the services offered by the Parish Health Department. The hospital is classified as a Type B medical institution which serves as the parish's only public hospital and provides in-patient and out-patient services in "general surgery, internal medicine, obstetrics and gynecology and pediatrics." As of 2008, it held 150 beds. The capital is also the site of the privately-owned Royale Medical Centre[xlvii].

The Savanna-la-mar Fire Station is another such institution in service of all of Westmoreland (with the exception of Negril). However, in spite of it undergoing rehabilitation in 2015[xlviii], there are still concerns that it, along with the station located in Negril, lack the necessary capacity to effectively serve the entire parish[xlix] and, as such, the Jamaica Fire Brigade has recently expressed a desire to have a new station constructed in Bethel Town, Westmoreland[l]. On a separate note, the Savanna-la-Mar Post Office, located on Great George Street (i.e., one of the town's major streets[li]), provides townspeople with bulk and expedited mail services, distribution of JUTC Smart Cards and the local and international delivery of parcels, among other services[lii]. Great George Street, situated in the historical Norman Square[liii], is also the site of the Westmoreland Parish Library[liv], Savanna-la-mar Court House[lv], Westmoreland Municipal Corporation and the Savanna-La-Mar Police Station. Additionally, beyond this square can be found other publicly-owned buildings such as the head office of the Registrar General's Department, the Westmoreland Family Court, Savanna La Mar Tax Office, Transport Authority's Satellite Office, HEART Trust NTA Parish Office and the Westmoreland Health Department.

In the way educational offerings, Savanna-la-Mar boasts a variety of academic institutions such as the 18th century constructed Manning's School[lvi] and the Savanna-la-Mar Inclusive Infant Academy which strives to meet the educational requirements of children with special needs through academics and physical & speech therapy[lvii]. Other notable schools in the area are the Savanna-la-Mar Primary School, Godfrey Stewart High School, Savanna-la-Mar High School, UWI Open Campus (Savanna-La-Mar), and the Westmoreland Business College. Moreover, skills training is also provided by a local community resource centre named "The Source Savanna-La-Mar" which operates as a social enterprise and offers training in business, computer and parenting skills along with skills covered under particular HEART Trust NTA Programs. The centre also contains an Internet Café, auditorium and meeting rooms, homework centre, reference library and hosts summer youth camps[lviii]. Regarding places of worship, various denominations are represented in the town, as is evidenced by the presence of the Savanna-la-mar New Testament Church of God, Savanna La Mar Methodist Church, Savanna la mar Seventh-day Adventist Church, St. Joseph Catholic Church, St. George's Anglican Church and more. Other points of interest include the Savanna-la-mar ITA Examination Depot, National Commercial Bank and Sagicor Bank.

Map 8 - Savanna-la-Mar, Westmoreland



Within the areas of Hertford, Friendship, Amity, Petersfield, Frome and Savanna-la-mar, life still seems to be influenced by the historical, economic activities around which Westmoreland was developed. There are obvious differences in the pace and quality of life experienced by those living in the quieter, rural areas of Hertford, Friendship, Amity and Frome and the busier, more densely populated and more developed townships of Petersfield and Savanna-la-mar. This disparity is indicative of the socioeconomic rural versus urban divide experienced throughout parish – most of which is rural. This issue has not gone unnoticed. In 2014, the then custos of Westmoreland decried its "slow pace of infrastructure development," and noted that greater development is needed, in part, to allow for new economic activities to open up within the parish[lix]. While these issues have been and continue to be addressed by the local government, the rate of their progress should remain a point of focus for Bamboo Bioproducts (and other incoming businesses), as they may prove to be hindrances to the efficiency of the Bamboo Mill's construction and operations in these areas.

3. BASELINE

3.1. MAIN MILL SITE

3.1.1. SOCIAL RISKS AND IMPACTS

Hertford

List 3 - Community Assets Hertford

Places of Worship
- Hertford New Testament Church of God
- Wesleyan Holiness Church
- Petersfield Seventh-day Adventist Church

Major Roads
- Torrington to Galloway Road
- Hertford to Flowerhill Road

Schools
- Bastard Cedar Walk Early Childhood Institution

Hertford is dissected by the Torrington to Galloway Road (which connects the area to Amity and Petersfield), and the Hertford to Flowerhill Road which facilitates transportation to Friendship. Local places of worship include the Hertford New Testament Church of God and Wesleyan Holiness Church and, while this area does not have much social infrastructure, residents can access postal, healthcare and other service facilities in the neighbouring town of Petersfield.

Amity

The Torrington to Galloway Road also cuts across Amity – connecting it to Hertford and allowing residents ease of access to Savanna-la-Mar. Amity Square is the main site of community life and is situated near a tight network of houses. It also contains the DCS Nursing Home which cares for elderly residents.

Petersfield

The town of Petersfield comprises a variety of social amenities to help sustain and improve community life. The Petersfield Post Office – which began operating out of a newly constructed building in 2012 – serves Petersfield, Amity and 10 surrounding areas. The eponymous Petersfield High School serves the academic needs of about 1,700 male and female students (ranging from ages 11 to 19), and has about 80 teaching and administrative professionals on staff. Aside from more traditional offerings, the institution also teaches students technical and supplemental skills through subjects like Agriculture, Cosmetology, Food & Nutrition and Health & Family Life Education as well as through extra-curricular activities such as the Business, 4-H, Spanish and Tourism clubs. A reflection of the wider socio-economic reality of the region, approximately 40% of the student population (many of whom reside in Petersfield and surrounding areas including Darliston, Frome, Burnt Savannah and Friendship), qualify for financial aid through the government's Programme of Advancement Through Health

List 2- Community assets, Petersfield

Places of Worship
- St. Peter's Anglican Church
- Spiritual Church of the Nazarenes

Major Roads
- Torrington to Galloway Road
- Hertford to Flowerhill Road
- William Road

Educational/Training Institutions
- Petersfield High School
- Petersfield Vocational Training Center
- Petersfield Primary & Infant School

Other community assets
- Petersfield Post Office
- Petersfield Health Centre
- Westmoreland Parish Library (Petersfield)
- Petersfield Galloway Benevolent Society (formerly known as the Association of Clubs)
- Petersfield Community Centre
- Petersfield cemetery
- "Pride of Petersfield" Park

and Education (PATH). Other avenues for academic and vocational development within Petersfield include the Petersfield Primary & Infant School and the Petersfield Vocational Training Center which offers HEART Trust/NTA programmes.

Another pillar of community life is the Petersfield Galloway Benevolent Society which was formed in the aftermath of the 1988 Hurricane Gilbert as a community-based disaster relief response. Since then, PGBS (formerly known as the Association of Clubs), has, among other things, revived the Petersfield Community Center, collaborated with the Petersfield high school in the formation of its Village Tourism programme, contributed to the upkeep of the local post office, and created the Pride of Petersfield" park (at which they now host a yearly youth summer camp). Additionally, residents have access to the Petersfield branch of the Westmoreland Parish Library which offers a variety of services like free internet access, computer usage, printing and photocopying, reference and lending, and scanning. The branch also meets community needs by organizing outreach programmes and activities like their homework assistance programme, National Reading Competition, computer classes and book club. The Petersfield cemetery, Petersfield Health Centre (i.e., a Type 2 health institution), Petersfield Community Centre and St. Peter's Anglican church are also regularly relied upon to serve the varying needs of locals. Roads running through the community include the Hertford to Flower Hill main road, Torrington to Galloway Road (which facilitates transport to and from Hertford) and William Road.

Friendship

List 3- Community Assets, Friendship

Places of Worship

- Friendship Apostolic Church
- Friendship Seventh Day Adventist Church
- Friendship Assemblies of Holiness

Major Roads

- Truro Gate to Locust Tree Road

Educational/Training Institutions

- Bleawarrie Primary School
- Friendship Primary & Infant School

Other community assets

- Bath Mountain Community Center
- Mount Grace Junior High and Primary school
- Strawberry Postal Agency

Access to public piped water has been an ongoing issue in Friendship. A result of the area's impaired solar water pump and leaky rain catchment tank, this issue forced residents to collectively pay for trucked water and manually collect river water. A lack of water also poses a real threat to the health of the community, especially now, in the midst of COVID-19. In response to this crisis, the local government representatives began to truck water to residents in 2020 and are currently trying to create a more permanent solution.

On a lighter note, Friendship consists of physical and social infrastructure like the Bleawarrie Primary School, Mount Grace Junior High & Primary school, Bath Mountain Community Center, Strawberry Postal Agency, Friendship Apostolic Church and the Friendship Seventh Day Adventist Church; all of which contribute to the improvement of daily local life.

Frome

Community life is situated near to the Frome Sugar Estate and is mainly focused on working, going to school, attending sporting events and worshiping in church. To this end, Frome boasts of prominent features such as the Townhead Baptist Church, Ricketts River Wesleyan Holiness Church, Frome Post Office, Frome Police Station and Gamertsfelder Mission Center (which includes an eye clinic). Students may enroll in the local Three Miles River Early Childhood Institution, Frome Preparatory school, Frome Technical High School, or the Montego Bay Community College (Frome Campus). Those enrolled in the community college are able to choose from a diverse selection of academic programmes from fields like clothing & fashion, environmental studies, social work, practical nursing, computer technology, accountancy and early childhood education. A popular site is the Frome Sports Complex. This multi-purpose stadium is generally the site of football matches and can seat up to 2,000 individuals. Most people have access to piped, public water and use electricity for lighting in their households. The majority of households are also provided with garbage collection services. On this point, the NSWMA has expressed a desire to make the garbage removal process more efficient by building a garbage transfer station in Frome.

List 4 - Community Assets, Frome

Places of Worship

- Townhead Baptist Church
- Ricketts River Wesleyan Holiness Church
- Water works Seventh-Day Adventist Church
- St. Patrick's Methodist Church
- Burnt Savanna Nazarene Church
- Truro Seventh-Day Adventist Church
- Burnt Savannah Wesleyan-Holiness Church
- Kingdom Hall of Jehovah's Witnesses

Major Roads

- Truro Gate to Locust Tree Road

Educational/Training Institutions

- Frome Technical High School
- Frome Preparatory School
- Montego Bay Community College (Frome Campus)
- Frome Early Childhood Institution
- Three Miles River Early Childhood Institution

Other community assets

- Frome Police Station
- Frome Post Office
- Frome Sports Complex

Savanna-la-Mar

As of 2001, almost an entire third of Savanna-la-Mar's households were headed persons who were without jobs. Equally as concerning, was the fact that 40% were headed by individuals who lacked academic qualifications. There are a variety of facilities and services in place, however, to meet many of the socioeconomic needs of the town. Water is piped into the majority of households by the National Water Commission and health services are provided to the parish as a whole by the Savanna-la-Mar Health Centre and the Savanna-la-Mar Hospital; both of which serve the entire parish of Westmoreland. In particular, the Health Centre (i.e., Westmoreland's only Type 4 health centre), serves the population in the areas of child health, pre-natal health, public health, dentistry, family planning and more. It also offers the same selection of services which the Parish Health Department provides. A Type B institution that holds 150 beds (as of 2008), the Savanna-la-Mar Hospital offers in-patient and out-patient services in "general surgery, internal medicine, obstetrics and gynaecology and paediatrics," and remains the Westmoreland's only public hospital. The Royale Medical Centre also serves the residents of Savanna-la-mar and is privately-owned.

The Savanna-la-Mar Fire Station is currently one of only two stations which serves the whole parish. Despite the station's major upgrade in 2015, the Jamaica Fire Brigade has deemed it necessary to construct a new station in Bethel Town due to the two existing stations being seen as inadequate to meet the needs of all Westmoreland residents. Great George Street, a major street which is located in Norman

Square, is the site of numerous state-owned buildings including the Westmoreland Parish Library, Savanna-la-Mar Court House, Westmoreland Municipal Corporation, Savanna-La-Mar Police Station and the Savanna-la-Mar Post Office. This post office benefits locals through the provision of bulk and expedited mail services, distribution of JUTC Smart Cards and the local and international delivery of parcels, among others. Other buildings to be found there are the head office of the Registrar General's Department, the Savanna-La-Mar Police Station, Westmoreland Family Court, Savanna-La-Mar Tax Office, Transport Authority's Satellite Office, HEART Trust NTA Parish Office and the Westmoreland Health Department.

Concerning education, the capital is home to the historic Manning's School along with the Savanna-la-Mar Primary School, Godfrey Stewart High School, Savanna-la-Mar High School, UWI Open Campus (Savanna-La-Mar), and the Westmoreland Business College. Also present is the Savanna-la-Mar Inclusive Infant Academy; the latter of which is tailored towards children with special needs. Specifically, as it relates to vocational training, "The Source Savanna-La-Mar," trains students in business, computer and parenting skills as well as those included in select HEART Trust NTA Programs. As a community resource centre, The Source also features an internet café, auditorium and meeting rooms, homework centre, reference library for beneficiaries to use and hosts summer youth camps. On a separate note, residents have several local churches from which to choose. Some examples are the Savanna-la-Mar New Testament Church of God, Savanna La Mar Methodist Church, Savanna-La-Mar Seventh-day Adventist Church, St. Joseph Catholic Church and St. George's Anglican Church. Other points of interest include the Savanna-la-Mar ITA Examination Depot.

List 5 - Community Assets, Savanna-la-Mar

Places of Worship

- Savanna-la-Mar New Testament Church of God
- Savanna La Mar Methodist Church
- Savanna la Mar Seventh-day Adventist Church
- St. Joseph Catholic Church
- St. George's Anglican Church
- Footprints Seventh-day Adventist Church
- Savanna-la-Mar United Church
- Church of Jesus Christ of Latter-day Saints (Savannah-la-Mar Branch)
- Kingdom Hall of Jehovah's Witnesses

Major Roads

- Great George Street
- Rose Street
- Barracks Road
- Strathbogie Road
- Seaton Street
- Darling Street

Educational/Training Institutions

- Manning's School
- Godfrey Stewart High School
- Savanna-la-Mar High School
- Savanna-la-Mar Primary School
- Unity Primary School
- Sir Clifford Campbell Primary School
- Kiddies Preparatory School
- Llandilo School of Special Education
- Savanna-la-Mar Inclusive Infant Academy
- Supreme Kids Kindergarten
- UWI Open Campus (Savanna-La-Mar)
- Westmoreland Business College
- Westmoreland Driving Institute

Medical Services

- Savanna-la-Mar Hospital
- Royale Medical Centre
- Savanna-la-Mar Health Centre
- Westmoreland Infirmary
- TRVALA Health Clinic
- Urgent Care 360+ Family Medicine
- Sav Gynae Center

Other community assets

- Savanna-La-Mar Police Station
- Savanna-la-Mar Fire Station
- Savanna-la-Mar Post Office
- Savanna La Mar Tax Office
- Savanna-la-mar Court House
- Westmoreland Family Court
- Westmoreland Parish Library
- Westmoreland Municipal Corporation
- Westmoreland Health Department
- Registrar General's Department
- HEART Trust NTA Parish Office
- Westmoreland Youth Innovation Centre
- Llandilo Sports Complex
- West Palm Memorial Garden
- Independence Park

3.1.2. Labour and Working Conditions

Amity

Amity has a very small number of enterprises which may signal a lack of economic opportunities in the area. These include small food establishments, a local supermarket and a nursing home.

List 6 - Local businesses, Amity

- DCS Nursing Home
- Amity Jerk Centre
- Sirju Supermarket
- Devon House I Scream

Hertford

Hertford has historically been heavily dependent on the sugar industry. Besides this, there is evidence of entrepreneurial activity throughout the area in the form of local bars and a supermarket.

List 7 - Hertford local businesses

- Fenton's Enterprises
- Tim Bar & Restaurant
- Touch of Class Executive Lounge & Bar
- Dean's Shop

Petersfield

One of the prominent employers in Petersfield is the tourism industry. Managed by the Tourist Product Development Company, the Roaring Park Estate brings over 2,000 tourists to the area annually due to its cultural heritage and natural features. This allows residents the opportunity to sell products along the riverside to visitors. Yardy River Adventure Tours also plays a role in the local economy by attracting local and international tourists through its tubing activities on the Roaring River and spa treatments since 2015[lx]. Other tourist attractions include the RastaSafari Experience, which aims to educate visitors about Rastafarian culture[lxi], and the Amizade Village Tourism initiative which sends American university students to Petersfield in order to help serve the needs of local schools in exchange for a cultural experience in which they live in the homes of locals[lxii]. The few other businesses present in the town range from small retail establishments to restaurants and bars.

List 8 - List of businesses, Petersfield

- Roaring Park and Cave
- RastaSafari Experience
- Yardy River Adventure Tours
- Main Hara's Saving Supermarket
- Whild Cherry2 Sport Bar
- Singh Mini Mart
- Indian Jerk and Curry Restaurant and Lounge
- IslandGirl's Boutique

Friendship

Friendship has benefitted economically from its close proximity to the Cabarita River; a body of water which has been capitalized upon by the local tourism industry. The Cabarita River Adventure & Mesopotamia Leisure Farm cultivates a diverse set of crops (e.g., plantain, pumpkins, corn, pineapple, guava, breadfruits, yams, bananas and sugar cane), and facilitates recreational uses of the river such as swimming, tubing and boating. However, many tourism workers in Friendship have lost their jobs over the past year due to the pandemic's negative effect on the sector. Beyond this, a small number of other business exist in the area like the "New Level Sports Bar & Grill."

Frome

Frome's economy has, for decades, been anchored by the operations of the Frome Sugar Estate which, today, houses one of the country's last and largest existing sugar factories and is considered the parish's main single source of employment. Unfortunately, due the overall decline of the sugar industry in Jamaica, the factory has suffered major losses in recent years, notwithstanding the 2015 multi-million-dollar rehabilitation initiative implemented by its parent company (i.e., the Chinese Pan Caribbean Sugar Company). Its inability to perform according to the standards set has also been attributed to local cane fires, a lack of cane cutters, the trafficking of sugar by criminal elements, and recent flooding. This has grave implications for the local economy as youth unemployment is already high, 21% of Frome's households are headed by unemployed occupants and there are limited opportunities for training and employment. Some of the other economic opportunities which are present come from small businesses such as local food establishments.

List 9 - List of businesses, Frome

- The Frome Sugar Estate
- Jamaica Wedding Photographers: Diana Campbell
- Shortman & Arlene Cookshop
- Di Endz Bar
- Danny's Bar & Grill
- Legendary Sports Bar

Savanna-la-Mar

As an urban centre, Savanna-la-Mar boasts a set of economically diverse activities relative to surrounding areas in the parish. These come in the form of retail establishments, commercial centres, eating establishments/clubs, financial institutions and more. Some prominent financial institutions in the town include the National Commercial Bank and Sagicor Life Jamaica Limited while commercial centres include the "Theio Doxa Opportunity" Shopping Mall and Beckford Plaza. Notably, the aforementioned community resource centre (i.e., the Source: Savanna-La-Mar), operates as a social enterprise and, therefore, aims to generate a profit from their operations in order to continue providing services that meet the needs of the wider community.

List 10 - Businesses, Savanna-la-mar

Supermarkets/Retail Establishments

Super Plus Supermarket | Long Peng Supermarket | Daley's Mini Mart | Bashco Trading Co Ltd | Courts Jamaica Limited, Savanna-la-Mar | Fontana Savanna-la-Mar | Payless Jamaica | Singer Furniture store | Ferretería Alexdel Electronics store | Alexdel Limited Hardware and Home Centre

Commercial Centres

"Theio Doxa Opportunity" Shopping Mall | Beckford Plaza | Hendon Mall | Savanna-La-Mar Market

Eating Establishments/Clubs

Guango's Jerk | The Farmer's Kitchen restaurant | Mission Bar | Fuyan Chinese Restaurant | The Gazebo Garden Restaurant & Grill | Two to One Restaurant | The Embassy Night Club

Financial Institutions

National Commercial Bank | CIBC First Caribbean International Bank | Sagicor Life Jamaica Limited | Insurance Company of the West Indies Limited | Victoria Mutual Building Society | JN Bank

Other

The Source: Savanna-La-Mar | Easispice Manufacturers Limited | Western Union | Royale Savanna Inn | Superior Internet Access (Internet service provider) | Casric Auto Parts | Echo Vehicle Spray and Body Works | Venom Intl Sound (DJ service)

3.1.3. LAND TENURE AND ACQUISITION

Hertford

A significant portion of Hertford locals have lived, for generations, in houses known as "barracks." These houses were initially given to sugar workers by the estate as a means of temporary housing and therefore did not give occupants much access to basic facilities. Over time, these lodgings grew older and more dilapidated, fell into various states of disrepair and, in turn, created an environment which was considered untenable by many occupants. In response to this, the government launched its "Barracks Relocation Programme," which aimed to build and donate new houses to 2,850 former sugar workers in sugar-dependent Westmoreland communities. In conjunction to this, the Sugar Company of Jamaica (SCJ) Holdings Limited's "Community Regularization Programme," bestowed land titles to 455 residents of the Hertford/Morass Lane community in an effort to "regularise land-ownership in former sugar communities," and create more economic opportunities for them through the use of their land for agriculture.

Frome

Like Hertford, many Frome residents live in wooden barracks. Approximately 74% of locals own their own houses however, only 26.8% owned the land on which they lived.

Savanna-la-Mar

Based on an SDC survey conducted with residents of Savanna-la-Mar, 70% of the respondents owned their houses.

3.1.4. INDIGENOUS PEOPLES

Westmoreland is home to a significant number of Jamaicans of German descent. From 1834 to 1838, over 1,200 Germans arrived in the island to work as indentured labourers and, in 1835, Lord Seaford allocated 500 acres of his estate for the development the Seaford Town German settlement which soon became the home of more than 200 Germans[lxiii]. As the years went by, a portion of this German population left the island for North America. those Who remained further assimilated to Jamaican culture, although some remnants of German vocabulary are still used in daily speech and, for many, their European heritage is still evident in their physical features[lxiv].

3.1.5. CULTURAL HERITAGE

Petersfield

Petersfield was developed in the 17th century as a space in which to house workers of the Roaring River Estate. The estate was known as one of the largest sugarcane plantations in Jamaica and was once the property of the first Custos of Kingston (i.e., Colonel Peter Beckford). In fact, Petersfield derived its name from Colonel Beckford.

Frome

Life in Frome has long been dependent on the Frome Sugar Estate which started operations in the 17th century under the ownership of Christopher Morris who came to Jamaica with the British army. During the early 20th century, the factory was merged with several small factories in the island which led to the formation of what became known as the Frome Central Sugar Factory. The centralization of operations caused by the merger led to a number of workers becoming unemployed. This, in turn, sparked the now infamous 1938 labour riots which then inspired several other labour riots to occur throughout the nation. The result of this unrest was the eventual passing of universal adult suffrage in 1944, a new constitution and, ultimately, Jamaica's independence from Britain.

Savanna-la-Mar

Savanna-la-Mar was developed near to the parish coastline in 1703 as a port export of sugar.

COMMUNITY CONSULTATION REPORT & FINDINGS

A Component of the Social Impact Assessment (SIA) for Bamboo Bioproducts Pulp Mill and Farm, Jamaica

September 2021

Prepared by The Leap Co

info@theleapco.com

1. EXECUTIVE SUMMARY

Prior to Bamboo Bioproducts' development of the first bamboo market pulp mill in the Western hemisphere, The Leap Co (who shall be referred to as the "Consultant" hereafter), was contracted to conduct community consultations with local stakeholders with an aim to gauge the potential effects of the mill's construction on the economic activities, social infrastructure and natural environment of Westmoreland, as well as to determine how the factory can best operate without harming surrounding communities. These consultations would then culminate in the completion of the Social Impact Assessment. The consultations yielded a variety of key findings and recommendations.

Currently most Local Development Areas (LDAs) have low economic prospects as is evidenced by low levels of training and job opportunities, particularly in Farming, Construction, Local businesses, Tourism and Factory work. BBP has the ability to meet local labour market needs through the direct hiring of hundreds of professionals, skilled workers and farmers for its mill. It also has the power to help to upskill the local labour force by partnering with select educational institutions to provide specific training opportunities that align with the labour needs of the mill. Social issues and gaps in the provision of public services related to road repairs and road safety, inadequate housing for locals, the inadequacy of medical institutions to withstand the fallout of the COVID-19, and the needs of vulnerable groups, were identified as matters for BBP to overcome for the sake of the smooth running of the mill as well as the development of the development areas. BBP can tackle these issues through the use of its BBP Community Fund throughout the coming years. Stakeholders generally showed a high level of support but had misgivings regarding the mill's impacts on the local environment, public resources and infrastructure, and traffic. These and other fears can mostly be quelled through the deployment of a strong communications strategy which is geared towards dispensing accurate, relevant information on an ongoing basis to stakeholders.

The findings and recommendations gleaned from these consultations will be used to guide BBP's decision-making going forward as it relates to the mill. They will also be shared with stakeholders in Westmoreland at an upcoming 'Open Day' event which will afford persons the opportunity to dialogue further with members of the BBP team and offer additional feedback. Through this continued engagement with stakeholders, BBP is sure to deepen it understanding of the LDAs so that the Bamboo Pulp Mill may benefit everyone affected by its operations as much as possible.

2. BACKGROUND

2.1. THE PROJECT

Bamboo Bioproducts was formed in 2020 and aims to be the first completely integrated Bamboo Market Pulp Mill globally by providing multi-national manufacturers of tissue products with "sustainably produced, high-quality bamboo pulp." This may be achieved by planting and harvesting bamboo on farm sites and then processing this raw material in a world-class pulp mill in Westmoreland. Farm sites are expected to be located in the parishes of Westmoreland (i.e., in Little London and Grange Hill), Trelawny (i.e., in Wakefield, Duanvale and Jackson Town), St. Thomas (i.e., in Winchester, Amity Hall and Golden Grove), and St. Elizabeth (i.e., in Lacovia and Black River Morass). The mill itself will be likely surrounded by the local development areas (LDAs) of Hertford, Friendship, Amity, Frome, Petersfield and Savanna-la-mar.

Bamboo Bioproducts will manage its own and SCJ leased bamboo farm lands (approximately 20,000 acres / 8,000 hectares). In conjunction with this, the company will provide opportunities for supply contracts to local farmers. The project will generate about 500 direct paying Jamaican jobs, placing professionals, skilled labour and farm labour in year-round employment and indirectly many thousands of other employment opportunities. This project is expected to have a major positive socioeconomic impact on the parish of Westmoreland.

2.2. Background

In March 2021, Bamboo BioProducts, requested The Leap Co produce a Social Impact Assessment (SIA) which aims to highlight the history, culture, economic activities, social & physical amenities and environmental features of each of the mill's newly selected development areas (now within Westmoreland), as well as its farming sites. This was followed by a series of stakeholder engagement sessions with local government, other public sector and civil society representatives, and community members from each LDA. Insights and recommendations gleaned from these consultations will be used to inform the remaining developmental stages of the mill.

3. STAKEHOLDER CONSULTATION APPROACH

3.1. Strategy

In order to produce the Social Impact Assessment, a strategy had to be created which would allow Bamboo Bioproducts to better understand the socioeconomic and environmental context of each LDA before determining the potential effects of the mill's construction and eventual operations on these select locations. As a means of garnering stakeholder feedback towards this end, a wide range of questions were prepared regarding various aspects of community life in each site, stakeholders' initial perceptions of BBP and this project, as well as stakeholders' questions and recommendations concerning the mill. New channels were also opened up (through the intake of stakeholders' contact information), to enable ongoing communication to occur beyond this initial stakeholder engagement. The collection of both quantitative and qualitative data (to form the baseline and consultation reports), had a complementary effect which, ultimately, helped to create a holistic portrait of the sites. A high value was placed on the data gleaned from community consultations due to BBP's confidence in the insights and perspectives which stakeholders had to offer as a result of their intimate knowledge of each community. This data definitely helped to fill in several gaps left by the baseline data. The knowledge created and recommendations formed in the development of Social Impact Assessment will go on to guide BBP's decision making as it relates to the mill's operations.

3.2. Consultation goal and objectives

Consultation goal:

The main purpose of the consultation is to deepen BBP's understanding of the LDAs and its various social, economic and environmental issues so as to increase and reduce the mill's positive and negative impacts on each of these locations respectively.

Objectives of the consultation strategy:

- To introduce key stakeholders to the project in order to gauge support and buy-in.
- To determine early concerns for due consideration within the overall project design.
- To establish ongoing lines of communication with stakeholders.
- To establish trusting relationships with stakeholders by being transparent and instilling in them the confidence that their concerns and opinions are being taken in consideration

Aspects of the methodology needed to achieve the above objectives include the following:

- The ability to directly engage stakeholders in a way that encourages open dialogue and gives them the opportunity to ask questions with the expectation of getting immediate responses.
- The ability to alter the modes of communication to each stakeholder group.
- The ability to anticipate the main concerns and questions which each stakeholder group is likely to raise in consultation. This allows for some pieces of pertinent information to be prepared beforehand and readily available at the time of each consultation.

3.2.1. Outline of activities

Throughout the month of July, in order to collect data for the purpose of the SIA, the Consultant discussed with local stakeholders the potential effects of the mill's construction on the economic activities, social infrastructure and natural environment of Westmoreland, as well as to determine how the factory can best operate without negatively impacting surrounding communities. This focused period of stakeholder engagement culminated in the following activities:

- Meeting with Political Representatives
- Meeting with General Parish Stakeholders
- Meeting with Agricultural Stakeholders
- Community Surveys

3.2.2. Social Impact Assessment interviews

Political Representatives Meeting

On July 1, 2021 BBP team members met with nine local political representatives (including members of parliament) to give parties in Westmoreland a better understanding of the project. Attendees were briefed on the approximate number and types of jobs to be created during construction of the mill, in the mill once production has started and on bamboo grow sites. It was made clear that the BBP mill will not replace the sugar factory in Frome, as it will be built on separate land and will operate independently of the sugar factory. The other topic discussed was that of the formation of a co-operative model for small and owners to supply bamboo to the mill.

General Parish Stakeholders Meeting

The Consultant chaired a series of in-person discussions on July 9th at the Source CRC's conference room in Savanna-la-Mar, Westmoreland. The first meeting, attended by Moses Chybar (President of Westmoreland Chamber of Commerce), the Rev. Canon Hartley Perrin (Custos of Westmoreland), Lyndon Johnson (President of Savanna-la-Mar Development Area Committee), and Linwall McFarlane (Campus Director of Montego Bay Community College, Frome Campus), was centred around training and job opportunities (especially through the Montego Bay Community College and associated secondary schools), the mill's potential environmental impact, the level of ease with which farmers will be able to transition into and out of planting bamboo, and the mill's use of and potential effects on local roadways.

Agricultural Stakeholders Meeting

As part of the aforementioned series of group interviews (held on July 9th), the Consultant met with Maxwell Rodney (Jamaica 4H Parish Manager, Westmoreland) and Dwaine Josephs (Westmoreland Marketing Officer for the Rural Agricultural Development Authority). Issues raised included BBP's intended agricultural practices (i.e., fertilization and harvesting methods etc.), along with negative practices which are common amongst local farmers. With respect to the latter, the Consultant was warned about farmers' tendency to use the "slash and burn" technique after harvests, the negative environmental effects of this, and the need for the development of a strategy to discourage this practice and/or mitigate its damage. Other topics covered included BBP's waste management strategy to reduce the risk of pollution in nearby rivers, the potential for vehicular damage to roads by BBP trucks, and the terms of reference for the farming contracts with bamboo suppliers (e.g., standard contract length).

Community Surveys

A total of 102 individuals across the six LDAs the were surveyed between July 8th to July 10th. A total of 102 surveys were completed in Hertford, Friendship, Amity, Frome, Petersfield and Savanna-la-mar.

The survey findings (which shed light on the social, economic and environmental realities of the LDAs), have major implications for the ease with which Bamboo Bioproducts can develop and operate their planned mill and farms. Primarily, the proportion of locals who own land gives an idea of how many contracts could potentially be supplied to farmers in order for them to use their idle lands to grow bamboo on behalf of the company. The level of educational attainment and available opportunities for skills training speak to the degree of employability of the local labour force. Similarly, the degree of access to healthcare services may connote how healthy the work force is. On another note, the extent of pollution and crime as well as the availability and quality of social and physical infrastructure (e.g., public water supply, roads, post offices, garbage collection facilities etc.), will have an effect on the company's security of assets, transportation of materials and workers, disposal of waste, connection with surrounding areas and more. Likewise, the findings of these Social Impact Assessment interviews also have implications with regard to the company's potential impact on residents. Particularly in areas experiencing low skill and high unemployment levels, a noticeable difference may be created due to the mill's planned employment of hundreds of skilled and farm workers and due to Bamboo Bioproducts' possible collaborations with universities to develop a "Center of Excellence" in order to upskill the local labour force.

Westmoreland Chamber of Commerce Meeting

BBP team members met with several members of the Westmoreland Chamber of Commerce on July 21, 2021 to introduce them to BBP as a company and sensitize them to the main goals, objectives and activities planned for the mill. After a presentation by Chief Executive Officer, David Stedeford, an interactive discussion was moderated by the Consultant in which several questions were fielded in relation to the potential training and employment opportunities for locals, farming contracts with local bamboo suppliers, and the environmental impacts of the mill. Attendees also raised questions regarding BBP's selection of Jamaica to establish the mill, intentions to eventually manufacture finished tissue products in Jamaica and plans to further engage stakeholders even beyond the completion of the consultation report.

3.2.3. General consultation for the project

3.2.3.1. Communication tools

While the Consultant believes that face-to-face consultations are ideal, the meetings with political representatives and members of the Westmoreland Chamber of Commerce were held virtually via video conferencing due, in part to an inability to overcome the large geographic disparities among attendees (who were dispersed among the likes of Kingston, Westmoreland and the United States). Fortunately, because of the population's growing reliance on digital platforms to host meetings since the COVID-19 outbreak, attendees were comfortable meeting online and, as such, each of these three meetings ran smoothly.

Fortunately, however, face-to-face consultations were able to take place in Westmoreland in the forms of the General Parish Stakeholders Meeting and Community Surveys. The former was conducted by the Consultant using the conference room and facilities at the Source CRC's conference room in Savanna-la-Mar and taking into consideration social distancing measures. The surveys were conducted in-person with the assistance of surveyors in Hertford, Friendship, Amity, Frome, Petersfield and Savanna-la-mar. These in-person points of contact afforded the Consultant the opportunity to observe more closely nuances in persons' non-verbal forms communications, which contributes towards the interpretation of the data gleaned from them. In the case of the community surveys, asking the questions in person allowed the surveyors to further explain the intent or meaning behind questions and to seek clarification on persons' answers immediately after a response is given.

3.2.3.2. Influence of stakeholder and community consultation

Community consultations help to inform BBP's understanding of key issues in the following ways:

- Specific training opportunities through partnerships with local educational institutions were identified.
- Social issues and gaps in the provision of public services were identified, thus pointing towards ways in which BBP can offer solutions for the benefit of the mill and its stakeholders. This includes the evidenced-based allocation of money from the BBP Community Fund.

- Major issues (e.g., common fears regarding the risks associated with the mill) to be addressed in BBP's communication/public relations strategy were identified.

3.2.3.3. CONSTRAINTS

The first main limitation encountered by the Consultant came as she formally invited stakeholders to meet with her in Westmoreland. A few invitees were unable to be reached using the contact information available (some of which may no longer be up-to-date), while others did not respond to requests to meet possibly due to conflicting schedules or a lack of interest.

4. KEY ISSUES RAISED

4.1. SUMMARY OF ISSUES RAISED

Most areas have low levels of economic opportunities. This is partially due to a pervasive lack of training and employment opportunities. Regarding the latter, more jobs need to be provided in the fields of farming, construction, local business, tourism and factory work, and the existing jobs in the various development sites usually only allow people to earn fairly small incomes. There is a possibility that BBP can fill these economic gaps through the mill's employment of locals, partnerships with contracted farmers, and the implementation of technical skills training programmes.

Local government involvement in the lives of community members for most of the development sites is perceived as being low. There is a medium level of road safety reported on average throughout the sites which indicates that, while BBP's future employees (including its truck drivers and deliverymen) are not at high risk of encountering accidents whilst commuting to and from the mill, levels of safety can be improved to protect their lives, BBP resources as well as the lives of others in each community.

In spite of a high level of support amongst residents and stakeholders for the mill's development, there are still concerns over its potential negative impacts on the local environment, public resources and infrastructure, and traffic.

4.2. KEY ISSUES RAISED DURING SOCIAL IMPACT ASSESSMENT INTERVIEWS

A Need for Greater Economic Opportunities

Education/Training

Most respondents have at least achieved part of a high school education and, as it relates to the attainment technical skills, about half of respondents in each location received technical training (mostly via informal teaching), in areas such as Food services, Welding, Mechanics and Construction. Nevertheless, 42% of people still believe that there is an acute need for the provision of more training opportunities in their respective communities.

Labour Market

As was previously mentioned, a significant portion of respondents indicated there is a widespread lack of economic and employment opportunities and existing jobs are typically low paying. Common occupations among respondents included business owners (many of whom own retail outlets), retail employees, taxi operators, construction workers, carpenters and students. In spite of the identification of the farming and construction industries as major employers, many persons still believed that they needed to provide greater employment opportunities, along other industries like manufacturing, retail and tourism. Based on the aforementioned findings concerning training and employment/experience, BBP is likely to make local hires relatively easily in technical fields such as construction and carpentry.

Memberships in labour unions seem to be extremely rare in the selected areas as only one of the 102 survey participants indicated that they belonged to a union; one which they declined to identify. This may signify the fact that seeking relationships with unions prior to the employment of mill workers, may prove to be a lower priority issue than was originally thought.

BBP Partnerships with Individuals (Farmer contracts):

Partnership prospects with individuals who agree to farm bamboo on their own land for BPP, look promising based on the moderately high rate of land ownership and self-employment among respondents. These two factors afford persons (who otherwise would have no access to farmlands and/or might be too occupied with other work obligations to farm), the freedom and flexibility required to enter into such contracts with BBP. 65% of respondents own the land they live (either personally or via family ownership), however, only a minority actually use their land for farming. While persons can be persuaded to utilize their land for agricultural purposes, it may be necessary to first train those who lack experience in sustainable, eco-friendly farming techniques.

Public Services & Social Infrastructure

75% of participants rated local government involvement as being low. This was particularly observed in Petersfield, Hertford and Frome. Although there seems to be a basic level of the provision of public services across all six locations (as is evidenced by the fact that most respondents receive piped water, dispose of their garbage in established receptacles and live in areas with generally low levels of pollution), generally people have expressed a desire for the government to be more involved in the areas of local employment, housing and road works.

43% of all respondents listed the Petersfield Health Centre as being one of the main local health centres. The general consensus among these specific respondents (all of whom are concentrated the locations of Amity, Petersfield and Hertford), was that the centre, on average, provides a medium level of care to patients, has sufficient amounts of quality equipment and is able to attend to patient needs within reasonable amounts of time. The Savanna-la-Mar Public General Hospital and Williamsfield Health Centre were also viewed by most as some of the main health institutions which serve local needs across all development sites. This has minor implications related to the general health of the communities (specifically, the labour force), and indicates which medical facilities are most accessible and suitable for attending to the needs among future mill employees.

Road safety

Typically, persons believed that roads in their respective communities were somewhat safe to use, with 47% reported a medium level of road safety. They indicated that the main causes of crashes are speeding, the presence of inexperienced/incompetent drivers, and deterioration of roads while the most vulnerable groups to road injuries are motorcyclists/cyclists, users of public transport and pedestrians.

Crime

Most areas were reported to have low levels of crime (with the exception of Savanna-la-Mar in which all of the respondents indicated there being a medium level). Additionally, 84% of people felt the local police forces typically maintain a good relationship with residents in their respective communities.

Social Nets

The elderly, children, people with disabilities and the economically disadvantaged were seen as being the most vulnerable groups within the targeted communities. Particular actors within civil society and the public sector (i.e., business owners, local government entities, and churches), are usually the most relied upon to meet the needs of these groups and, resultantly, BBP should seek to collaborate with these social actors to create/strengthen each location's social net and, ultimately, to fulfill its own corporate social responsibility.

Perceptions/Acceptance of Mill

Most people in each site indicated high levels of support for BBP proposed development of the mill. Such positive attitudes are primarily influenced by the hope of increased employment, training and economic activity to be brought on by the mill's development and eventual operations. However, persons have voiced concerns regarding the mill' potential negative impacts. The threat of increased pollution and/or other environmental problems was a prime concern (as indicated by over half of participants), followed by the mill's potential strain on public resources and infrastructure and the effects of increased traffic caused by many of the company's trucks coming in and out of each location.

Because of these concerns, BBP should make an effort to acknowledge the risks involved; to explicitly communicate contingency plans to mitigate such events; and to accept and respond to pertinent questions raised by the public (most of which, according to the survey findings, have to do with opportunities for employment and partnerships with local individuals/businesses). Positive public perceptions of the project can be further cultivated through the continuous engagement of stakeholders in which a space is provided for honest dialogue to occur between BBP and members of the public. In this vein, there is encouragement to be gleaned from the fact that 89% of all respondents shared their contact information due to an interest in receiving future updates on the progress of the project.

4.3. MORE DETAILED OUTLINE OF ISSUES RAISED IN CONSULTATION

Education/Training

Consistent with the general findings gathered from other areas, most respondents received, at the very least, a secondary level school education. Reasons for this limited attendance in universities in these areas most likely include financial and geographic barriers to access as well as the fact that the major local industries usually offer employment opportunities that are reliant on persons' knowledge of skilled trades, rather than on their possession of tertiary degrees. Industries such as farming, construction and manufacturing which comprise some of the major employers in these communities, are likely more focused on filling positions for the likes of mechanics, welders, electricians, cane cutters and others whose qualifications are largely based on their level of technical skills training. Such training opportunities may present themselves at the secondary level (especially at technical high schools like Frome Technical High School), in post-secondary institutions (e.g., the Petersfield Vocational Training Center) and through informal/formal apprenticeship. Unfortunately, regarding the last avenue, most respondents admitted to undergoing only informal apprenticeships. Although, this can be an effective avenue for training, the ultimate lack of certification does not meet companies' needs to maintain a uniformed, industry standard of quality.

In spite of the fact that approximately half of all respondents from each site have received training in at least one skilled trade, over 40% of participants felt that "many locals lack the education and training needed to earn a good income." This view was especially expressed regarding the communities of Frome, Petersfield, Hertford and Savanna-la-mar. The prevalence of this view in Savanna-la-mar (as was evidenced by 41% of its resident respondents), is somewhat surprising due to the comparatively high number of schools and training facilities it contains. Because there is value to be gained from a diverse labour force which contains a mix of members with tertiary qualifications and vocational skills, efforts should be made to decrease the barriers to courses from both tertiary institutions and accredited trade schools – especially courses which align with the mill's staffing needs (e.g., in engineering, agricultural science, project management etc.).

BBP has already established plans to broker a partnership between the University of West Indies and the University of Maine, USA to create a 'Center of Excellence' for the industry and an exchange graduate course scheme. Additionally, according to Linwall McFarlane from the Frome Campus of the Montego Bay Community College (MCC), the college, in its ongoing mission to meet the need of its populace, could venture towards developing courses that are more directly related to bamboo processing. Mr. McFarlane also suggested that, through MCC's relationships with local high schools in the parish, BBP and the College could propose that students participate in special field trips, internships/ trainee programmes in areas which suit their professional interests and the hiring needs of the mill.

Local Economy

Apart from limited education and training among locals, economic challenges have also stemmed from the decline of traditional industries and an insufficient number of local businesses to hire people. The latter is, in part, the consequence of the demise of certain industries (as was the case for the sugar industry which specifically impacted Frome), along with the fallout of the COVID-19 pandemic. The pandemic's economic effects also extended to include the loss of jobs; something which was experienced by 22 survey participants. The local tourism industry in Friendship for instance, which is fueled by attractions like the Cabarita River, has also been weakened in light of the COVID-19 pandemic.

Moreover, the majority of participants in each area (with the exception of Savanna-la-mar), agreed that there are not many employment opportunities in their respective areas. As is to be expected for the more developed urban centre/parish capital, the situation was more promising as half of the people surveyed in Savanna-la-mar said there is a medium level of opportunities. On a similar note, in Hertford, surprisingly, 21% rated the level of job opportunities as being high. Overall, however, the insufficient number of businesses set up locally along with the general dearth of employment opportunities has resulted in the frequent migration of residents from some sites such to other areas. This ongoing cycle of migration will ultimately hamper the company's prospects of employing many skilled locals for long periods of time. As only one respondent admitted membership in a labour union, it is reasonable to assume that the unionization of workers remains low in each of the development sites. Nonetheless, local unions should be engaged during the mill's development as a form of due diligence. BBP believes that it can add to the existing set of economic opportunities, not only by promoting the formal training of locals and employing residents in approximately 500 direct high paying jobs and thousands of indirect jobs, but also by entering into business contracts with other local companies as well as with residents who can farm bamboo on their own plots of land for BBP.

Partnerships with Businesses & Individuals

As it now stands, the construction, agricultural, manufacturing and retail industries appear to be the main employers. This may mean that there are enough local businesses within each of these three sectors with which BBP can partner once the mill enters into development. Additionally, the fact that 65% of all surveyed individuals live on land that either they or their family owns collectively, and used their respective plots for farming or business activities, may speak to the ease with which residents, on a wider scale, may be able to enter into farming contracts with the mill as a means of generating additional revenue. Due to the prevalence of respondents living on family-owned lots, BBP will need to garner buy-in from entire households rather than the sole individuals who enter into the contracts. The rates of both land ownership and possession of land ownership certificate were highest among respondents in Friendship, Petersfield and Frome. Residents of Petersfield have already benefitted from the provision of housing solutions under the Sugar Company of Jamaica Holdings Limited's (SCJH) "Community Regularization Programme," which aims to "regularise land-ownership in former sugar communities." BBP should capitalize on the partnership opportunities present, not only in these areas, but also in others which may require greater efforts to remove barriers to farming contracts.

Concerns had been raised in the General Parish Stakeholders Meeting, regarding the ease with which contracted farmers will be able transition from cultivating other crops (e.g., sugar cane), to planting bamboo on their lands. While this concern was assuaged by another stakeholder attendee in the meeting who assured that transition is expected to be fairly easy (due to sugar cane and bamboo being part of the same crop family), un-informed locals are likely to also wonder about this. That being said, a point should be made in BBP's communication strategy aimed at community members to address this and other related concerns (such as the difficulty with which the land can transition to cultivating other crops once bamboo is farmed and the contracts end). On another note, individuals who are either inexperienced farmers or are, simply, unfamiliar with bamboo will require training and, possibly, the requisite equipment from BBP.

It should be made clear to farmers that, once contracted, they will receive transitional funds prior to the first harvest as well as technical support to ensure the required quality and yield targets are met. Payments are estimated to be on a quarterly basis and will be backed by 10-year long term contracts. This information, along with answers to the following questions (which were raised in Agricultural Stakeholders Meeting), will also help to inform a person's decision regarding their entrance into such contracts:

- What type of bamboo will be planted?
- What equipment or machinery will the contracted farmers need for bamboo cultivation?
- When will fertilization take place?
- How is harvesting carried out?

The public communications strategy should take care to anticipate and address these and other pertinent questions on the matter. The agricultural advantages of planting bamboo should also be emphasized, such as bamboo's positive effect on soil and its tendency to produce bigger yield than can be gained from cane cultivation.

Social infrastructure

It was generally felt among the entire surveyed population that public sector entities should be more active in increasing employment, improving the state of roads and providing adequate housing for locals. To a lesser extent, other issues like social outreach and COVID-19 relief were also identified in relation to the need for more local government involvement. In spite of this, there is evidence of at least basic level of the provision of public services as most participants receive piped running water and have garbage receptacles available to them for disposal purposes. These findings could indicate that, if BBP were to partner with the public sector to address these and other issues, the company could expect to see a relatively low level of engagement on the part of government agencies. On the other hand, if the inadequacy of governmental responses to these matters are the result of stretched resources (as opposed to the issues being marked as "low priority"), then BBP's future offers to channel company resources towards 'private-public' solutions could bolster their willingness and capacity to tackle these areas of need with greater urgency.

Garbage Collection/Pollution

Uniquely, however, garbage collection/pollution control was seen, by as many as two fifths of participants, as one of the major issues in need of more government intervention in Savanna-la-Mar. Moreover, although 93% of all respondents use garbage bins as their mode of disposal, 23% also rely on burning garbage; a practice which, if not stemmed, will continue to contribute to environmental decay and ill health effects on residents.

Both Maxwell Rodney (Jamaica 4H) and Dwaine Josephs (Rural Agricultural Development Authority), both pointed out that the "slash and burn" method is commonly observed on sugar cane farms and may be deeply entrenched in local farming practices. While this technique is used primarily for its convenience and short-term nourishing effects on soil, it also causes soil to lose nutrients after a number of years, thus threatening the sustainability of the land. Furthermore, the uncontrolled spread of fires could contribute towards deforestation which can, in turn, damage local watersheds, thus potentially leading to contaminated water, floods or even drought. Their proposed solutions for combatting this includes educational/sensitization campaigns which discourage the use of the method, the development of plans to control the spread of fires and the establishment of a mandate to refuse the purchase of burnt bamboo from local growers as part of company policy.

Linwall McFarlane, requested that BBP make known its plans to mitigate the potential adverse environmental and health impacts of the mill's dust emissions. According to him, MCC, which is located across from the Frome Sugar Factory, has suffered the ongoing negative effects of their high dust emissions. On a separate note, Mr. Chybar suggested that BBP support local efforts to 'go green' by allocating some pulp towards local needs (as opposed to using it solely to meet the needs of the global market). This likely reflects what will be a larger desire from the public in general to see the same. BBP should, therefore, make it known in its public marketing strategy that prior to processing bamboo, the mill will use residual twigs and branches to support a Jamaican cottage industry that produces straws and stirrers.

Water Supply

Water is piped to the residences of 85% of all respondents; although, one third of them also collect water from nearby sources (such as rivers, wells etc.). This reliance on alternative supplies of water (most commonly seen among respondents from Hertford, Petersfield and Friendship), may be an occasional response to the frequent dysfunction of public facilities (e.g., water pumps and rain catchment tanks) as is the case in Friendship, seasonal climate change etc. In areas like Friendship, which have experienced a deficit in their water supply, water is routinely trucked into communities. It will be in the best interest of BBP for these and other local facilities to be in proper working order so as to ensure a stable water supply to sustain both the mill's operations and the cultivation of bamboo by contracted farmers.

A number of survey respondents and attendees of the various stakeholder meetings expressed concerns regarding the potential for the fluid waste generated from the mill to contaminate local waterbodies (e.g., local revenue generators like the Carbarita River). The public, as were these key stakeholders, should be informed that the mill actually plans to recover 85% of its chemicals used on a continuous basis as water will be channeled through to a water treatment plant, residual bamboo waste (e.g., lime sludge) will be used to produce bioproducts (e.g., cementation, road infill, biofuel pellets, particleboard, Syngas, ethanol etc.), onsite.

Medical facilities

Regarding healthcare facilities, the Petersfield Health Centre, which is generally thought to provide patients with a medium level of care, was named as the main local health centre for Amity, Hertford and Petersfield. Also, according to survey findings, the Savanna-la-Mar Public General Hospital was identified as the main medical facility for people living in Savanna-la-Mar and was the second main facility for those in Frome and Petersfield. While this hospital was widely felt to provide a medium level of care, about a third of participants stated that it used insufficient, low-quality equipment and usually required patients to wait for long periods of time before being seen. As such, the hospital may benefit from the donation of new pieces of equipment to properly serve the needs of the parish. Other, less commonly used health centres identified include the Baulk and Georges Plain Health Centres which help to serve the areas of Friendship and Frome respectively.

These findings likely speak towards the state of healthcare under normal circumstances – as opposed to being an up-to-date snapshot of the facilities during the COVID-19 pandemic. Currently, Westmoreland (in which, at the time of August 9th, less than 10% of residents had been vaccinated), is one of three parishes which have the highest rates of COVID-19 deaths in the island. Due to the strain on resources brought about by the admission of COVID-19 patients, local hospitals are stretched to capacity and are in need of additional staff, beds and equipment. This is particularly true for the Savanna-la-Mar Public General Hospital which has been referred to as being in "crisis mode" for several weeks. As of August 19th, it was reported as experiencing 130% occupancy with 17% of its nurses and 15% of its doctors being placed under isolation due to them either contracting the virus or being in contact with infected persons. As the situation worsens, health authorities have appealed to medical professionals from within the private sector to lend their time and expertise to the hospital. Reassuringly, the Government of Jamaica has plans to build a COIVD hospital in Savanna-La-Mar to increase bed count in the area. In the meantime, however, local health facilities need other forms of assistance to meet the rising demand for health services which is expected due to the recent spread of the Delta variant. It should be said that improved medical infrastructure alone is not enough to tackle the effects of the pandemic. To promote the sustainable health of the local labor force, vaccinations should be encouraged among communities in the development area.

Roads

While road safety was generally determined to be at a medium level, outliers were noted in the cases of Frome and Petersfield (in both of which, approximately a third of participants rated it as being low), and Friendship which saw 71% of respondents rate road safety as high. Speeding, the presence of inexperienced/incompetent drivers, and deterioration of roads were identified as the main causes of accidents in most areas and motorcyclists/cyclists, public transport users and pedestrians were said to be the most common victims. As a means of increasing the overall road safety level (thus, benefitting BBP truck drivers and general employees as well as regular community members), BBP can help to implement safety measures which have the power to either reduce or prevent accidents.

The Petersfield main road was found to be the most commonly used road in respondents' daily commute in all areas except for Friendship. 21% of the people who identified this as a main road in their commute, also said it was in need of repair. Besides this, other commonly used roads such as Shrewsbury in Petersfield, Hertford main road in Hertford, Friendship main road in Friendship, Dean's Valley in Amity, Great Georges Street in Savanna-la-Mar, and Frome main road (B9) in Frome were also found to be in need of repair. Unsurprisingly, several of these roads (barring the Dean's Valley road), were reported as being congested with the most traffic in their respective areas. One fear shared among attendees of the General Parish Stakeholders meeting was the company's vehicles would create increased deterioration of the roads. It was suggested that BBP aid in the maintenance of roadways which it will depend upon for the transportation of materials as a means of reducing any damage caused. It may also be advisable for mill trucks to look for alternative routes (i.e., other than commonly used ones) to and from the factory to avoid creating increased traffic – as is the case for the local sugar industry which uses designated, SCJ-owned "cane roads" to transport tonnes of sugar cane.

Crime

Crime in each development area seems to be relatively low (except for in Savanna-la-Mar where 100% of respondents believed that crime was at a medium level), and the police is generally seen as maintaining good relations with residents. This may indicate the need for increased security measures for the mill's operations in Savanna-la-Mar. It is in the company's best interest to begin building a strong relationship with the local police in each site.

Corporate Social Responsibility: Development of Social Safety Nets

The mill is set to create a Community Fund in which $X/tonne of harvested green bamboo will be allocated for each parish and will be held by BBP. Using this Fund, BBP can try to fill some of the gaps left in the government's provision of social services for underserved groups. Vulnerable groups within the LDAs, children, the elderly, people with disabilities and the economically disadvantaged were identified as the main groups in need. In Petersfield, 29% indicated the need for members of the LGBTQ+ community to receive assistance. This is notable as none of the respondents from any of the other development sites chose this group. BBP could consider working with the local business owners, local government entities, and churches to meet the needs of these groups of people as these generally serve as the main responders to community outreach needs.

Collaborating with others to satisfy the needs of vulnerable groups is likely deepen the company's understanding of each local population, strengthen its relationships with stakeholders, and improve the public's perception and support of the business.

Perceptions/Acceptance of Mill

Despite the main concerns expressed (i.e., the risk of increased pollution and other environmental issues, a strain on public resources, and the effects of increased traffic), 66% of persons who rated their level of support for the mill's development displayed a high level of support. This was followed by another 16% who shared a medium level of support. Support among stakeholders is largely due to the greater training, employment and partnership opportunities which the mill presents. By directly addressing their concerns and questions regarding the risks involved in the mill's development and operations, BBP will build trust with stakeholder and help to form an authentic and positive public perception of the project.

5. RECOMMENDATIONS

Education/Training
***Objective**: Develop the academic and vocational skills of the labour force to ensure that mill workers meet world-class industry standards*
Secondary Education
• Collaborate with secondary schools to expose students to different areas of work associated with the mill through field trips, summer internships/trainee programmes • Promote the inclusion of more vocational skills components into local high school curricula • Sponsor the development of after-school clubs in local high schools which concentrate on imparting certain technical skills.
Post-secondary Education

• In partnership local tertiary institutions (e.g., Montego Bay Community College and UWI Open Campus) and vocational training institutions (e.g., the Petersfield Vocational Training Center), use BBP Community fund to provide full/partial scholarships for certain courses/ degree programmes (e.g., engineering, construction, agriculture etc.).
 	
• Partner with the Montego Bay Community College to develop additional courses and/or replicate courses solely taught at the Montego Bay campus that focus on the attainment of knowledge & skills needed by mill e.g., courses offered by the following faculties:
    o Computer & Technical Studies (e.g., in the fields of Management Information Systems, Engineering, Architectural & Construction Technology etc.)
    o Business & General Studies (e.g., in the field of Accountancy)
    o The Arts, Natural & Social Sciences faculty (e.g., in the field of Agricultural Technology)

Local Economy
***Objective**: Improve local economic prospects through the creation of jobs and business partnerships.*
Farming contracts • Use community information sessions to garner buy-in from entire households rather than the sole individuals who enter into the contracts • Partner with SCJH to aid in the distribution of certificates of land ownership to qualified residents in development sites. • Assist with technical set up of farms, not only through the provision of equipment/machinery, but by training landowners in sustainable, eco-friendly bamboo farming techniques.
Social infrastructure
***Objective**: Ensure that adequate social services are provided at a high quality so that the needs of the mill and the residents are properly met.*
Water
Partner with the WMC to improve the sustainability of public water supply services (e.g., fixing/ replacing broken public water facilities).
Housing solutions
• Advocate for the expansion of SCJH Community Regularization Programme so that its reach extends to all LDAs. • Provide temporary housing for select workers for the duration of their respective contracts. These workers can enter into leases with BBP which boast competitive rates.

<table>
<tr><th>Health</th></tr>
<tr><td>Through the BBP Community fund, donate new pieces of equipment to the Savanna-la-Mar Public General Hospital based on their specific needs to offset the growing strain on resources.
Encourage vaccinations among employees. Join the Private Sector Organisation of Jamaica membership to grant employees access to the PSOJ vaccination program</td></tr>
<tr><th>Roads</th></tr>
<tr><td>Transport BBP materials via trucks primarily at night
Make contributions from the BBP Community fund towards the maintenance of heavily used roads most in need of repair as deemed necessary. These roads are:
Petersfield: Shrewsbury and Petersfield main road
Hertford: Hertford main road
Friendship: Friendship main road
Savanna-la-Mar: Great Georges Street
Frome: Frome main road (B9)
Lobby the government for a donation of funds towards the construction of roads to transport bamboo to and from the LDAs. BBP can also contribute financially towards this endeavour.</td></tr>
<tr><td>Promote increased road safety by:
Advocating for improved law enforcement measures in LDAs (especially in Friendship).
Advocating for the replication of the National Road Safety Council's Motorcycle Outreach in all 6 development areas. Initially piloted in Petersfield in 2020, this initiative will train motorcyclists in road usage and road safety measures and assess their ability to ride safely to decrease the number of road fatalities (especially among motorcyclists in Westmoreland).
Partner with the Jamaica Automobile Association to increase the opportunities for mill workers to partake in driving lessons. Lessons could be offered at discounted rates to employees as made possible by partial sponsorships from BBP.</td></tr>
<tr><th>Pollution</th></tr>
<tr><td>Discourage the use of the slash and burn method by doing the following:
Carrying out educational/sensitization campaigns which highlight the negative economic, environmental and health effects of the practice
Developing plans to control the spread of fires (e.g., through overhead sprinklers, fire breaks, etc.)
Establishing a mandate to refuse the purchase of burnt bamboo from local growers as part of company policy.</td></tr>
<tr><th>Social Nets</th></tr>
<tr><td>Serve the needs of the impoverished by:
Partnering with local businesses and academic institutions to design and implement programmes for impoverished persons which focus on financial literacy, entrepreneurial training, job readiness, and job placement.
Collaborating with local schools to sponsor and implement seasonal adult literacy programmes
Donating small conditional and unconditional grants to local non-profit organisations and the outreach ministries of local churches</td></tr>
<tr><td>Serve the needs of the local disabled population by:
Promoting disability accessibility in the design of the mill via the inclusion of important physical infrastructure (e.g., ramps)
Sponsoring the delivery of disability accessibility training sessions among schools, local businesses and local government bodies in partnership with the Combined Disabilities Association, the Jamaica Association for the Deaf etc.
Advocate for increased disability accessibility in local public buildings – also through the installation of certain physical infrastructure</td></tr>
</table>

Serve the needs of children in local development areas by: • Partnering with local schools to sponsor school feeding programmes • Make donations to local schools towards the maintenance of buildings, and the procurement of equipment and supplies • Sponsor homework assistance programmes carried out by local community centres/outreach organisations (the Source Savanna-La-Mar, the Petersfield branch of the Westmoreland Parish Library etc.).
Serve the needs of the local elderly population by: • Make donations to local elderly care facilities (e.g., the DCS Nursing Home in Amity) towards the maintenance of buildings, and the procurement of beds and equipment
Public Perceptions & Acceptance of Mill ***Objective***: *Keep the public well-informed about the mill's development and operations and help to curate positive perceptions of the mill among the general public.*
• Hire a Communications Specialist to develop a strategy which focuses on continuous stakeholder engagement via a whole-community approach in which a wide variety of population segments are targeted (i.e., local businesses, landowners, schools, public and social sector groups etc.) in different ways to discuss opportunities presented by the mill's development as it uniquely relates to each of them. • Give transparent and consistent reports on the mill's development progress, activities and, ultimately, its economic and social impact (according to pre-established Key Performance Indicators). • Engage with stakeholders via a diverse set of mechanisms (e.g., in-person or digital public forums, direct contact with past survey respondents, small meetings with community groups/organisations, the BBP website & social media pages etc.). • Be direct in addressing and validating stakeholders' concerns regarding the risks/possible negative impacts of the mill. In response, create and publicize mitigation plans on each major concern raised.

6. APPENDIX

6.1. TABLE: SUMMARY OF RISKS AND OPPORTUNITIES FOR POPULATION AND COMMUNITIES, INDICATORS AND MEASUREMENT

Risks, Opportunities and Indicators for Population		
Risks	**Opportunities**	**Impact Indicators**
Local Labour Market		
Lack of employment opportunities and the prevalence of fairly low-paying jobs in LDAs may signify an small/inadequate local labour force as some areas have experienced brain.	BBP can increase local employment opportunities by hiring residents of LDAs and surrounding areas to work on the development and running of the BBP mill. This will help to retain the local populations of workers and may attract persons from other parts of Westmoreland to the LDAs.	• # of persons hired in each occupational field needed for the development and running of the BBP mill. • # of persons hired by BBP who resided in LDAs prior to hiring versus # of those who resided in LDAs upon/after hiring. • # of persons hired by BBP who commute from outside communities.
Farming Contracts		
• There may be an insufficient number of land-owners who are willing to farm for BBP. • Contracted farmers may opt to practice of negative agricultural methods • Upon their contracts' completions, farmers may experience difficulty in transitioning their lands from those used to grow bamboo to those which will be used to farm other crops.	• BBP can boost economic opportunities by contracting the services of local land-owners to cultivate bamboo on their land. • BBP will discourage the use of the slash and burn method and teach contracted farmers eco-friendly bamboo farming techniques. • BBP can increase the likelihood of contracting local farmers by helping to provide housing solutions and assisting with the technical set up of farms.	• # of contracted farmers • # of land titles distributed in LDAs since BBP's commencement of a partnership with SCHJ • % of contracted farmers who received land titles since BBP's commencement of a partnership with SCHJ
Lack of Training		
Lack of training opportunities may signify a lack of skilled/professional workers in LDAs to meet BBP's hiring needs.	BBP can increase local training opportunities by partnering with secondary and post-secondary institutions.	# of people who have successfully completed BBP-sponsored training programs
Local Government Involvement		
BBP, in its mission to fill gaps in the provision of social services, may experience a relatively low level of engagement on the part of government agencies.	BBP can advocate for the governmental prioritization of specific issues and assure GoJ that BBP will offer assistance in finding/providing solutions.	# of formal partnerships embarked upon between BBP and GoJ regarding local social issues.
Water Supply		
The frequent dysfunction of public facilities aimed to supply water in some LDAs may disrupt/slow mill's operations.	BBP can partner with the WMC to improve the sustainability of public water supply services.	# of impaired public water facilities which are fixed/replaced due to BBP's collaboration with WMC.

Pollution		
• The mill's dust emissions may create negative environmental and health impacts. • The fluid waste generated from the mill may contaminate local waterbodies.	BBP mill plans to recover 85% of its chemicals used on a continuous basis by channeling water through to a water treatment plant. This will lead to residual bamboo waste (e.g., lime sludge) being used to produce bioproducts onsite.	• % of chemicals recovered • # of bioproducts produced onsite.
Health		
Labour force may shrink or become weakened due to communal health problems (e.g., the COVID-19 pandemic), and the lack of medical facilities to adequately tackle them.	• BBP can help to improve the medical infrastructure and increase human resources at hospitals which serve the LDAs. • BBP can help to encourage/facilitate vaccinations among local populations.	• # of hospital staff hired (permanently /temporarily), at the Petersfield Health Centre and the Savanna-la-Mar Public General Hospital respectively • # of pieces of equipment donated by or purchased as a result of BBP • Average wait times for patients to be seen by hospital staff. • Number of persons in each LDA who have been vaccinated since BBP's vaccine promotions. • % of patient occupancy since BBP's interventions • # of COVID-19 cases in LDAs per month since BBP's interventions • # of BBP employees who have applied for extended sick leaves since the company's health interventions
Social Nets		
Specific social ills in LDA communities may threaten the mill's productivity levels (e.g., low educational/ training opportunities).	BBP can provide assistance to the most vulnerable groups in each LDA.	• # of elderly beneficiaries of BBP-sponsored intervention • # of child beneficiaries of BBP-sponsored intervention • # of disabled beneficiaries of BBP- sponsored intervention • # of economically disadvantaged beneficiaries of BBP- sponsored intervention
Road Safety		
Insufficient levels of road safety may jeopardize the safety of BBP employees (esp. truck drivers), and other road users.	BBP can help to increase road safety through advocacy and the provision of increased training opportunities for drivers.	• # of accidents on local roads • # of improved law enforcement measures implemented in LDAs • The # of LDAs in which the National Road Safety Council's Motorcycle Outreach was replicated. • # of motorcyclists in each LDA who have been successfully

		completed the Motorcycle Outreach programme in LDAs in which it was replicated. • # of BBP employees who receive driver's licenses since BBP's partnership with the Jamaica Automobile Association.
Traffic		
BBP trucks may cause increased levels of traffic and road deterioration.	• BBP can prevent increased traffic by transport BBP materials via trucks primarily at night and requesting that GoJ build separate 'bamboo roads' for BBP trucks. • BBP can help to maintain heavily used roads most in need of repairs	• # of BBP-sponsored road repairs • # of 'bamboo roads' built

6.2. TABLE: SUMMARY OF TOP 10 ISSUES RAISED IN STAKEHOLDER INTERVIEWS

<table>
<tr><th>Top 10 Issues Raised in Stakeholder Interviews</th></tr>
<tr><td>Local Labour Market</td></tr>
<tr><td>Lack of employment opportunities and the prevalence of fairly low-paying jobs in LDAs.</td></tr>
<tr><td>Lack of Training</td></tr>
<tr><td>Lack of training opportunities in LDAs.</td></tr>
<tr><td>Farming Contracts</td></tr>
<tr><td>Concerns regarding the difficulty with which contracted farmers' land can transition to cultivating other crops once bamboo is farmed and their contracts end.</td></tr>
<tr><td>Local Government Involvement</td></tr>
<tr><td>Low levels of local government involvement, especially in the areas of local employment, housing and road works.</td></tr>
<tr><td>Water Supply</td></tr>
<tr><td>Some LDAs may experience the frequent dysfunction of public facilities aimed to supply water.</td></tr>
<tr><td>Pollution</td></tr>
<tr><td>Concerns regarding the environmental and health impacts of the mill's dust emissions.
Concerns regarding the potential for the fluid waste generated from the mill to contaminate local waterbodies
Concerns regarding the practice of negative agricultural methods among contracted farmers (e.g., the 'slash and burn' technique which can result in air pollution)</td></tr>
<tr><td>Health</td></tr>
<tr><td>The Petersfield Health Centre needs improved equipment and, possibly, increased human resources.
The Savanna-la-Mar Public General Hospital is in need of improved medical infrastructure and increased human resources in order to provide sufficient COVID-19 relief to the parish.</td></tr>
<tr><td>Social Nets</td></tr>
<tr><td>The following vulnerable groups are in need of social aid:
The elderly
Children
People with disabilities
The economically disadvantaged</td></tr>
<tr><td>Road Safety</td></tr>
<tr><td>Levels of road safety can be improved upon. Issues like speeding, incompetent driving, and road deterioration need to be tackled.</td></tr>
<tr><td>Traffic</td></tr>
<tr><td>Concerns expressed regarding the mill's potential to increase traffic due to the commutes of BBP trucks</td></tr>
</table>

6.3. Table: Stakeholders issues and responses

Issue	Stakeholders Who Raised Issue	Response (avoid, mitigate, manage, communicate)
Local Labour Market		
Lack of employment opportunities and the prevalence of fairly low-paying jobs in LDAs.	• Surveyed Community members • Political Representatives • General Parish Stakeholders • Westmoreland Chamber of Commerce	BBP will increase local employment opportunities by hiring residents of LDAs and surrounding areas to work on the development and running of the BBP mill.
Farming Contracts		
Concerns regarding the practice of negative agricultural methods among contracted farmers	Agricultural Stakeholders	BBP will discourage the use of the slash and burn method and teach contracted farmers eco-friendly bamboo farming techniques.
Lack of Training		
Lack of training opportunities in LDAs.	• Surveyed Community members • Political Representatives • General Parish Stakeholders • Westmoreland Chamber of Commerce	BBP will increase local training opportunities by partnering with secondary and post-secondary institutions.
Local Government Involvement		
Low levels of local government involvement, especially in the areas of local employment, housing and road works.	Surveyed Community members	BBP will advocate for the governmental prioritization of specific issues and will offer assistance in finding/providing solutions.
Water Supply		
Some LDAs may experience the frequent dysfunction of public facilities aimed to supply water.	Surveyed Community members	BBP can partner with the WMC to improve the sustainability of public water supply services.
Pollution		
Concerns regarding the potential for the fluid waste generated from the mill to contaminate local waterbodies	• Surveyed Community members • General Parish Stakeholders • Agricultural Stakeholders • Westmoreland Chamber of Commerce	BBP mill plans to recover 85% of its chemicals used on a continuous basis by channeling water through to a water treatment plant. This will lead to residual bamboo waste (e.g., lime sludge) being used to produce bioproducts onsite.
Health		
• The Petersfield Health Centre needs improved equipment	Surveyed Community members	• BBP can help to improve the medical infrastructure and

and, possibly, increased human resources. • The Savanna-la-Mar Public General Hospital is in need of improved medical infrastructure and increased human resources in order to provide sufficient COVID-19 relief to the parish.		increase human resources at hospitals which serve the LDAs. • BBP can help to encourage/facilitate vaccinations among local populations.
Social Nets		
• The following vulnerable groups are in need of social aid: ○ The elderly ○ Children ○ People with disabilities ○ The economically disadvantaged	Surveyed Community members	BBP will provide assistance to the most vulnerable groups in each LDA.
Road Safety		
Levels of road safety can be improved upon. Issues like speeding, incompetent driving, and road deterioration need to be tackled.	• Surveyed Community members • General Parish Stakeholders • Agricultural Stakeholders	BBP can help to increase road safety through advocacy and the provision of increased training opportunities for drivers.
Traffic		
Concerns expressed regarding the mill's potential to increase traffic due to the commutes of BBP trucks	Surveyed Community members	• BBP can prevent increased traffic by transport BBP materials via trucks primarily at night and requesting that GoJ build separate 'bamboo roads' for BBP trucks. • BBP can help to maintain heavily used roads most in need of repairs

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Appendix P Social Impact Management Plan Report

SOCIAL IMPACT MANAGEMENT PLAN (SIMP)

Prepared for Bamboo Bioproducts Limited
on the proposed Bamboo Pulp Mill and Farms, Jamaica

December 2021

Prepared by The Leap Co

info@theleapco.com

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List of Acronyms and Abbreviations

BBP	Bamboo Bioproducts Limited
LDA	Local Development Area
SIMP	Social Impact Management Plan
SIA	Social Impact Assessment
EIA	Environmental Impact Assessment
ESIA	Environmental Social Impact Assessment
SCJH	Sugar Company of Jamaica Holdings
WCC	Westmoreland Chamber of Commerce
MoEYI	Ministry of Education Youth and Information
MCC	Montego Bay Community College
RADA	Rural Agricultural Development Agency
UWI	University of the West Indies
ODPEM	Office of Disaster Preparedness and Mitigation
JAA	Jamaica Automobile Association
WMC	Westmoreland Municipal Corporation
NWC	National Water Commission
JCC	Jamaica Chamber of Commerce
JMEA	Jamaica Manufacturing and Exporters Association
PSOJ	Private Sector Organisation of Jamaica
FSC	Forest Stewardship Council

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1. Executive Summary

Bamboo Bioproducts was formed in 2020 and aims to be the first integrated Bamboo Market Pulp Mill in the western hemisphere by providing multi-national manufacturers with “sustainably produced, high-quality bamboo pulp.” This will be achieved by planting and harvesting bamboo on farm sites and then processing this raw material in a world-class pulp mill in Westmoreland. Farm sites are expected to be located in the parishes of Westmoreland, Trelawny, St. Thomas and St. Elizabeth. The mill itself will be surrounded by the local development areas (LDAs) of Hertford, Friendship, Amity, Frome, Petersfield and Savanna-la-mar. A Social Impact Assessment (SIA) has been completed and highlighted the history, culture, economic activities, social & physical amenities and environmental features of each of these areas in order to provide context to Bamboo Bioproducts when determining the potential effects of the mill’s construction and eventual operations on these select locations.

Currently most Local Development Areas have low economic prospects as is evidenced by low levels of training and job opportunities, particularly in farming, construction, local business, tourism and factory work. BBP has the ability to meet local labour market needs through the direct hiring of hundreds of professionals, skilled workers and farmers for its mill operations. It also has the power to help to upskill the local labour force by partnering with select educational institutions to provide specific training opportunities that align with the labour needs of the mill. Social issues and gaps in the provision of public services related to road repairs and road safety, inadequate housing for locals, the inadequacy of medical institutions to withstand the fallout of the COVID-19 pandemic, and the needs of vulnerable groups, were identified as matters for BBP to overcome for the sake of the smooth running of the mill as well as the development of the development areas. BBP will make a targeted contribution to these issues through the use of its BBP Community Fund which seeks to provide tangible support to the wider communities in which it operates. Throughout the assessment, ***Stakeholders generally showed a high level of support for the project but had some misgivings regarding the mill’s impacts on the local environment, public resources, infrastructure and traffic***. These and other concerns can be responded to through the deployment of a strong communications strategy which is geared towards dispensing accurate, relevant information on an ongoing basis to stakeholders.

The Social Impact Management Plan (SIMP), which follows the production of the recent Social Impact Assessment (SIA), predicts and plans responses for certain common and specific social impacts that may occur throughout the operations activities of the Project. It will specifically focus on the impact of the company on the local economy, education & training opportunities and local social infrastructure as well as on the public perceptions & acceptance of the mill. The SIMP is necessary for adequate management of these social impacts and contains the measures to be implemented in the different phases of the project, in order to promote positive outcomes and decrease or minimize the adverse impacts that may arise. This Plan will include allocation of responsibilities, time frame, monitoring and reporting of potential impacts associated with the completion and operation of the Mill.

2. The Requirement for a Plan

This SIMP has been to cover:

- assignment of accountability and resources;
- updates on activities and commitments;
- mechanisms to respond to public enquiries and complaints;
- mechanisms to resolve disputes with stakeholders;
- periodic evaluation of the effectiveness of community engagement processes;
- practical mechanisms to monitor and adjust mitigation strategies and action plans; and
- action plans to implement mitigation strategies and measures.

2.1. Objectives of the SIMP

The purpose of the SIMP is to identify and define the roles of BBP, the government and the community in the mitigation and management of social impacts throughout construction and operation of the Project. The SIMP also aims to promote an active and on-going role for communities, local authorities and government throughout the life of the revised Project.

2.1.1. Outline of the Plan

The SIMP for the Project has been compiled according to the following sections:

- Project Summary;
- Existing Social Values;
- Stakeholder Engagement Outcomes;
- Impact Identification and Management;
- Monitoring and Reporting;
- Stakeholder Engagement Strategy; and
- Complaint Resolution.

3. Project Overview

This Section provides a brief overview of the Project. It includes details of the Project's workforce, expected accommodation and transport arrangements, as well as the potential economic contributions associated with the Project.

3.1. Key Components

The Project involves the generation of thousands of direct and indirect jobs for Jamaicans who live in and around BBP mill and farm sites and LDAs. Furthermore, BBP plans to support improved access to affordable housing for skilled workers as well as make housing more accessible for other locals through a potential partnership with Sugar Company of Jamaica (SCJH). This project is expected to have a major positive socioeconomic impact on the parish of Westmoreland.

3.1.1. Workforce Profile

The construction phase of the Project will extend over approximately two years. The Project will require a number of skilled and unskilled workers for construction and farming. An average construction workforce of approximately 700 people and a peak workforce in the vicinity of 2,000 people is anticipated over the construction phase. BBP's intention is to use local employment options where possible, but will also require employment from outside the area for certain specialised jobs.

It is expected that up of 100 persons in commercial, admin and finance positions; 150 in manufacturing; 100 in agriculture and 100 in logistics will be employed throughout the operation of the Project.

Partnerships with local educational institutions will be developed to ensure the skills required are being acquired locally so as to reduce the need for overseas recruitment.

The position skill requirements will determine from where employees will be sourced however if operational requirements allow, a number of positions will be made available to people without previous industry experience. Contractors may also be employed for some specialist activities in line with current practices at the mill.

BBP will adopt an equal opportunity approach to all recruitment and will support a diverse workforce that includes vulnerable population groups including people from culturally and linguistically diverse backgrounds, Indigenous peoples, women, school leavers, people with disabilities, the unemployed and underemployed.

3.1.2. Housing and Accommodation

Employees of the Project will be given freedom of choice in sourcing accommodation in and around the farm sites and LDA's. BBP appreciate the need for more affordable housing solutions for locals and, as such, will work to support the government's *SCJH Community Regularization Programme* as well as to provide BBP-owned or leased, affordable housing for select skilled workers for the duration of their respective contracts. These housing solutions will be a significant improvement to the barrack-style housing in which many former sugar workers (e.g., cane-cutters) still reside and to the expensive housing developments currently on the market which many struggle to afford.

BBP's intention is to use local employment options wherever possible, however it is expected that some construction and operational workers may need to be sourced from outside the area to meet position skill requirements.

Expats will be in leased homes or hotels thereby contributing to the local economy.

3.1.3. Workforce Transport

As the Mill site is not remote, and is surrounded by a road network used by public passenger vehicles, it is not intended that there would be any company-provided transport, and workers will be free to commute to and from the Project site as they choose. It is expected that those workers living in the area will commute in private and public vehicles from their residence, however, based on need, BBP would be open to providing shuttle services from agreed pick up points.

3.2. Potential Economic Contribution

BBP believes that it can add to the existing set of economic opportunities in Westmoreland and other LDA's, not only by promoting the formal training of locals and employing residents in approximately 1,000 direct paying jobs and thousands of indirect jobs, but also by entering into business contracts with other local companies as well as with residents who can farm bamboo on their own plots of land for BBP.

4. Existing Social Values

This Section describes the SIA study area, and the existing values and issues identified in this area.

4.1. Study Area

Bamboo Bioproducts aims to plant and harvest bamboo on farm sites and then process this raw material in a world-class pulp mill in Westmoreland. Farm sites are expected to be located in the parishes of Westmoreland, Trelawny, St. Thomas and St. Elizabeth. The mill itself will be likely surrounded by the local development areas of Hertford, Friendship, Amity, Frome, Petersfield and Savanna-la-mar. Several of these local study areas are rural – with the exception of Savanna-la-mar – and are home to mostly low to middle income residents who live in relatively small communities.

4.2. Existing Social and Cultural Values

Stakeholder consultation, field trips and desktop research were undertaken as part of the SIA to identify the baseline social and cultural environment of the SIA study area. The population and age structure of the LDAs are typical of rural towns, with there being fewer people aged 25 to 44 years, a greater proportion of families and children, and more people aged 65 years and over.

Key social values and patterns that were identified for people living in the SIA study area include:

- Slow pace of life experienced by residents in several LDAs;
- Strong agricultural lifestyle;

- Concerns regarding road safety and traffic issues (e.g., Speeding);
- Concern for the protection of the environment from pollution;
- Community cohesion, including involvement in volunteer activities, community groups and clubs;
- The aforementioned sense of community cohesion is threatened by the existence of gangs and the resultant rise in crime in areas such as Little London and, to a greater extent, in Savanna-La-Mar;
- Need for increased access to adequate social infrastructure, health and education services;
- Need for more local employment and business opportunities; and
- Need for more education and training opportunities, particularly for young adults and school leavers.

As summarised in **Table 1**, social values and issues varied according to each stakeholder's direct interest.

Table 1-Summary of Stakeholder Values and Issues

Stakeholder Issue, Value or View	Stakeholder Group
Local Labour Market	
Lack of employment opportunities and the prevalence of fairly low-paying jobs in LDAs.	Community I Local Government I Business owners I Educational providers
Lack of Training	
Lack of training opportunities in LDAs.	Local Government I Community I Business owners I Land owners
Farming Contracts	
Concerns regarding the practice of negative agricultural methods among contracted farmers.	Agricultural Stakeholders
Hopes that the provision of BBP contract opportunities will not only be aimed at large-scale farmers.	Agricultural Stakeholders
Hopes that bamboo farming for BBP will provide local famers with a higher paying alternative to farming in the sugar industry.	Local Government I Agricultural Stakeholders
Local Government Involvement	
Low levels of local government involvement, especially in the areas of local employment, housing and road works.	Community
Water Supply	
Some LDAs may experience the frequent dysfunction of public facilities aimed to supply water.	Community
Pollution	
Concerns regarding the potential for the fluid waste generated from the mill to contaminate local waterbodies.	Community I Business owners I Agricultural Stakeholders
Concerns regarding the mill's contribution to air pollution due to the amount of dust it may emit unchecked.	Agricultural Stakeholders
Interest in the energy generated from the mill's operations being given back to the community.	Agricultural Stakeholders
Interest in whether or not BBP will trade carbon credits.	Agricultural Stakeholders
Health	
The Petersfield Health Centre needs improved equipment and, possibly, increased human resources.	Community
The Savanna-la-Mar Public General Hospital is in need of improved medical infrastructure and increased human resources.	Community
Social Nets	
The vulnerable groups in need of social aid are the elderly, children, people with disabilities and the economically disadvantaged.	Community
Road Safety	
Levels of road safety can be improved upon. Issues like speeding, incompetent driving, and road deterioration need to be tackled.	Agricultural Stakeholders I Community
Traffic	
Concerns expressed regarding the mill's potential to increase traffic due to the commutes of BBP trucks.	Community
Other	
Preference for nationalized versus internationally-owned companies manufacturing in Jamaica as a means of benefiting citizens.	Community

Interest in the prospect of BBP manufacturing and exporting finished products (rather than solely producing and exporting raw materials).	Community

5. STAKEHOLDER ENGAGEMENT

BBP is committed to engaging with communities and stakeholders in those areas affected by its operations, including local communities, industry organisations, local council and academic institutions. Consultation feedback on the Project indicates that many stakeholders are optimistic about the opportunities for employment, training, community investment and business. BBP is addressing opportunities provided by the Project through consideration of local employment and business opportunities as well as the establishment of a Community Investment Fund.

The main issues raised in consultation on the Project to date relate to: **Local Labour Market I Lack of Training I Farming Contracts I Local Government Involvement I Water Supply I Pollution I Health I Social Nets I Road Safety I Traffic I Crime I Disaster preparedness.**

The majority of people in each site indicated high levels of support for BBP proposed development of the mill due to the hope of increased employment, training and economic activity to be brought on by the mill's development and eventual operations. However, persons have voiced concerns regarding potential negative impacts of the mill. The threat of increased pollution and/or other environmental problems was a concern, along with the mill's potential strain on public resources and infrastructure and the effects of increased traffic caused by many of the company's trucks coming in and out of each location.

Because of these concerns, BBP should make an effort to acknowledge the risks involved; to explicitly communicate contingency plans to mitigate such events; and to accept and respond to pertinent questions raised by the public (most of which, according to the survey findings, have to do with opportunities for employment and partnerships with local individuals/businesses). Positive public perceptions of the project can be further cultivated through the continuous engagement of stakeholders in which a space is provided for honest dialogue to occur between BBP and members of the public.

5.1. TARGETED CONSULTATION

A ***Community Consultation Report*** was produced in September 2021, and detailed and assessed data collected from various community stakeholders through the organisation of several stakeholder meetings and via a survey which was taken by 102 individuals from the six LDAs. The questions posed to stakeholders during each consultation were formed based on the knowledge gained from the baseline report. The purpose of these consultations was to provide additional insights about community needs and implications for the company in each site. It also helped to fill gaps in knowledge which remained after the completion of the desk review. The report's findings and recommendations (including its proposed mitigation and management measures for the Project), were then disclosed among stakeholders at an in-person event on October 23, where stakeholder feedback on the disclosed information was shared in an open-discussion format. The stakeholders and community members understood the range of management measures presented and seemed generally satisfied that the proposed strategies would be successful in managing potential impacts associated with the Project. The outcomes of the community and stakeholder consultations as well as the feedback gained from the Community Open Day, significantly helped to inform the SIA which was generated in November. Stakeholders were told that information regarding upcoming BBP plans and activities would continue to be shared with them in the future as a testament to the company's commitment to transparency and collaboration.

Table 2 provides a summary of the activities undertaken thus far as part of the stakeholder engagement process.

Table 2 - Summary of Stakeholder Engagement Activities

Activity	Detail	Timing
Website Bamboobioproducts.com	An official website for BBP was developed to keep the public informed of BBP related activities. It includes the the origins and goals of Bamboo Bioproducts; an introduction to members of the BBP project team; BBP's sustainability practices; a registration form on which persons can make their interest to become a bamboo supplier known; links to the latest news and discussion on Bamboo Bioproducts in the press; Blog posts regarding the many uses of bamboo and about Jamaica; Links to BBP's social media accounts and a contact page.	2020
Social media @bamboobp Bamboo-bioprocts	A Twitter and LinkedIn profile has been created to share news and updates along with facts about the uses of bamboo.	July 2020
Community Survey	A total of 102 individuals across the six LDAs were surveyed by the Consultant, along with three research assistants Each survey contained questions aimed at determining: Community members' demographic profiles; economic activities; Community members' positive and/or negative perceptions of the project; questions concerning the project; land ownership issues; local economic activities; the provision of public services locally; local social outreach efforts and local healthcare.	July 8^{th} to July 10^{th}
Stakeholder Meetings	Throughout the month of July, in order to collect data for the purpose of the SIA, the Consultant discussed with local stakeholders: the potential effects of the mill's construction on the economic activities, social infrastructure and natural environment of Westmoreland; and ways in which the mill can best operate without negatively impacting surrounding communities. This focused period of stakeholder engagement culminated in the following activities: • Meeting with Political Representatives • Meeting with General Parish Stakeholders • Meeting with Agricultural Stakeholders • Community Surveys	July 1, 2021 July 9, 2021 July 21, 2021
Community Open Day	The findings and recommendations gleaned from the community consultations were shared with stakeholders in Westmoreland at a 'Community Open Day' event which afforded persons the opportunity to dialogue further with members of the BBP team and offer additional feedback. Through this continued engagement with stakeholders, BBP has deepened its understanding of the LDAs, with the result being that the Bamboo Pulp Mill may provide positive benefit to many individuals affected by its operations.	October 23, 2021
WhatsApp broadcast	A WhatsApp group was created for BBP stakeholders (including past survey participants, political representatives, agricultural & business stakeholders and Open Day attendees), as a means of sending them updates on the BBP project, as well as opportunities for the company to work alongside their community throughout the project.	November 15, 2021

Table 3 provides a summary of the stakeholders consulted for the SIA.

Table 3 - Consultation undertaken for SIA

Stakeholder group	Name	Date consulted
Political Representatives	Sharon Hay-Webster	July 1, Oct 23
Political Representatives	George Wright (Member of Parliament for Westmoreland Central)	July 1, Oct 23
Political Representatives	Rudolph Uter (Councillor for Frome Division)	July 1
Political Representatives	Morland Wilson (Member of Parliament for Westmoreland Western)	July 1, Oct 23
Political Representatives	Godfrey Walters (Councillor for the Darliston Division)	July 1
Political Representatives	Dawnette Foster (Councillor for the Cornwall Mountain)	July 1
Political Representatives	Kevin Murray (Councillor of the Friendship division)	July 1
Political Representatives	Junior Anthony Clarke	July 1
Political Representatives	Daniel Lawrence (Member of Parliament for Westmoreland Eastern)	July 1, Oct 23
General Parish Stakeholders	Moses Chybar (President of Westmoreland Chamber of Commerce)	July 9, Oct 23
General Parish Stakeholders	The Rev. Canon Hartley Perrin (Custos of Westmoreland)	July 9
General Parish Stakeholders	Lyndon Johnson (President of Savanna-la-Mar Development Area Committee)	July 9
General Parish Stakeholders	Linwall McFarlane (Campus Director of Montego Bay Community College, Frome Campus)	July 9, Oct 23
Agricultural Stakeholders	Maxwell Rodney (Jamaica 4H Parish Manager, Westmoreland)	July
Agricultural Stakeholders	Dwaine Josephs (Westmoreland Marketing Officer for the Rural Agricultural Development Authority)	July 9
Community Survey Respondents	102 individuals from Hertford, Friendship, Amity, Frome, Petersfield and Savanna-la-mar participated in the survey.	July 8 to July 10
WCC	Asandry Ellis, Camille Ambersley, Carla Drummond, Cosmond Jackson, Delmarie Rowe Lewis, Dwight Muschette, Jasper Smith, Joan Jackson, Mellissa Anderson, Moses Chybar, Neville Perue, Rosalee Wood, Schion Spence, Simone Beecher-Wright, Oliver Williams, Oral Myles, Russell Hammond	July 21
Open Day Attendees	Approximately 20 individuals attended the Open Day	October 23

6. Impact Identification and Management

This Section of the SIMP summarises the key social benefits and impacts that were identified as part of the SIA process.

6.1. Impact Identification and Rating

BBP has undertaken a comprehensive stakeholder engagement process to inform the identification of key issues and impacts associated with the Project. In particular, impacts were assessed according to their nature, duration, extent, severity and likelihood. This allowed an overall significance rating to be calculated (i.e., low, medium, high or very high).

An evaluation of impacts was undertaken that considered both the impacts before and after the application of mitigation measures. Each identified impact was assessed according to:

- project phase (construction, operation, decommissioning);
- affected stakeholder groups;
- nature of impact (positive, negative or neutral);

- consequence;
- probability; and
- mitigation and enhancement measures.

Evaluation was undertaken considering the results of stakeholder consultation, and with consideration of the cumulative impacts that may be experienced in the SIA study area. The results of this evaluation have been summarised according to the overall significance of each impact before the application of mitigation measures, as shown in **Table 1**, and has included both real and perceived issues identified by stakeholders.

6.1.1. Positive Impacts

Table 4 - Summary of Key Positive Impacts

HIGH	**Local Labour market** • The mill's operations (including its business dealings with local private-sector entities and individuals), will give LDAs and farm sites an economic boost. • Increased opportunities for year-round employment for professions, skilled labour and farm labour. • New opportunities for economic growth locally may slow the rate of migration of residents to other areas.
	Training opportunities • More locals will gain opportunities to advance their level of education and training required to earn a good income.
	Road safety • Improved conditions of heavily used roads in LDAs and farm sites. • Increased road safety in LDAs and farm sites.
	Local Government Involvement • Increased levels of local government involvement, especially in the areas of local employment, housing and road works.
	Health • Local healthcare providers will receive improved medical infrastructure and increased human resources in order to provide sufficient COVID-19 to locals • Increased willingness to take vaccinations among BBP employees
MEDIUM	**Farming Contracts** • Persons interested in farming contracts will gain assistance with acquiring ownership certificates for their land.
	Water Supply • Some public water facilities (e.g., water pumps and rain catchment tanks), in local communities will be repaired to improve the sustainability of public water supply services.
	Social Nets • Provide aid and relief to vulnerable groups such as the elderly, children, people with disabilities and the economically disadvantaged through the community fund/
	Housing • Increased housing solutions for areas surrounding the BBP mill.
LOW	**Pollution** • Local landowners/ farmers will be trained in eco-friendly, sustainable bamboo farming techniques in lieu of harmful methods (e.g., 'slash and burn').

6.1.2. Negative Impacts

Table 5 - Summary of Key Negative Impacts

HIGH	**Farming contracts** • Potential difficulty with which contracted farmers' land can transition to cultivating other crops once bamboo is farmed and their contracts end.
MEDIUM	**Road Safety** • BBP trucks may cause damage to roads over time due to increased wear and tear.
	Traffic • BBP trucks can significantly increase traffic on local roads.
LOW	**Pollution** • Potential negative environmental and health impacts of the mill's dust emissions. • Potential for the fluid waste generated from the mill to contaminate local waterbodies.

6.2. Action Plans

BBP has developed mitigation and management strategies for the key social benefits and impacts identified. To simplify this process, and increase practical implementation, action plans have been developed according to the broad categories: **Education/Training | Local Economy | Social Infrastructure**

6.2.1. Education/Training Action Plan

Consistent with the general findings gathered from other areas, most respondents received, at the very least, a secondary level school education. Reasons for this limited attendance in universities in these areas most likely include financial and geographic barriers to access as well as the fact that the major local industries usually offer employment opportunities that are reliant on persons' knowledge of skilled trades, rather than on their possession of tertiary degrees. Unfortunately, most survey respondents admitted to undergoing only informal apprenticeships. Although, this can be an effective avenue for training, the ultimate lack of certification does not meet companies' needs to maintain a uniformed, industry standard of quality. Moreover, more than 40% of participants felt that "many locals lack the education and training needed to earn a good income."

BBP has already established plans to broker a partnership between the University of West Indies and the University of Maine, USA to create a 'Center of Excellence' for the industry and an exchange graduate course scheme. Additionally, BBP will liaise with academic and training institutions such as HEART NTA, regarding partnership opportunities (e.g., summer internships/trainee programmes, additions to curricula, BBP sponsored after-school clubs).

Impact Management Plan

Objective	**Enhance employability of the labour force to ensure that mill workers meet world-class industry standards**
Potential impacts/ Outcomes	• Increased community knowledge of areas of work/study which are relevant to the mill's operations • Increased skill level among local labour force • Higher rates of local employment • Increased quality of work

	• Influx of students (both local and new to LDAs/ farm sites), to educational institutions that are BBP partners • Reduced rate of migration from LDAs and/or farm sites • Increased income earned among locals
Monitoring & Reporting	Monitoring will depend on the submission of reports from BBP HR department and partnering schools concerning the following: • Summer internships/trainee programmes • After-school clubs • The progress of scholarship recipients • The introduction of new modules and/or courses of study at secondary and post-secondary institutions

Mitigation and Management Activities

Action	Parties Engaged in Action	Timeframe
Develop a listing of skills and academic qualifications needed from local labour force to work for BBP.	BBP technical team	Q1
Map local academic & vocational skills training institutions in LDAs and farm sites.	BBP Social Development team	Q1
Meet with academic and training institutions regarding partnership opportunities (e.g., summer internships/trainee programmes, additions to curricula, BBP sponsored after-school clubs).	BBP Social Development team Mapped academic and training institutions	Q1
Meet with local secondary schools to advocate for the inclusion of more vocational skills components (i.e., for BBP-related skills), into their curriculum Meet with government stakeholders to advocate for the inclusion of more vocational skills components (i.e., for BBP-related skills), into the national high school curriculum.	BBP Social Development team Representatives from local secondary schools Representatives from the Ministry of Education, Youth and Information (MoEYI)	Q1-Q3
Allocate a portion of the **BBP Community fund** to provide sponsorship for the development of after-school clubs in local high schools which concentrate on imparting certain technical skills.	BBP Social Development team Representatives from local secondary schools	Q2-Q4
Partner with the Montego Bay Community College (MCC) to develop additional courses and/or replicate courses solely taught at the Montego Bay campus that focus on the attainment of knowledge & skills needed by mill. Meet with MCC stakeholders to identify courses for development/ replication based on established criteria such as associated costs, estimated demand among students, level of need for specific skills at BBP and in wider industries. Allocate BBP Community funds to help to offset some of the costs associated with the hiring of new teaching staff; -procurement of programmatic materials needed to facilitate/enhance learning and the provision of scholarships to select students.	BBP Social Development team Representatives from the MCC	Q1-Q3
Develop a BBP scholarship programme to provide full/partial scholarships for BBP-related courses/ degree programmes (e.g.,	BBP Social Development team Representatives from local tertiary institutions	Q3-Q6

Action	Parties Engaged in Action	Timeframe
engineering, construction, agriculture etc.) for tertiary/post-secondary students. Allocate a portion of the BBP Community fund to go towards the scholarships Invite other stakeholders (e.g., private and public sector entities), to contribute to the scholarship fund Create criteria with partnering institutions (e.g., level of economic need, academic qualifications, quotas for academic category, disability type, gender etc.)	Potential donors from private and public sectors	
Develop a BBP internship/trainee programme which allows participants to work at the mill temporarily. Identify clear areas in the mill's operations in which participants could work/be trained. Collaborate with partners (e.g., HEART Trust NTA), to include the BBP internship as a component in their skills training programmes. Partner with academic institutions and youth development stakeholders to promote the programme among students and unattached youth/young adults	BBP Social Development team BBP heads of departments Local academic institutions Local vocational skills training institutions Local youth development stakeholders	Q8-12
Collaborate with local academic institutions to sponsor and implement seasonal child and adult literacy programmes.	BBP Social Development team Local academic institutions	Q5

Indicators

Outcome	Indicator
Increased skill level among labour force	# of people who have successfully completed BBP-sponsored training programmes % of locals in occupations requiring a medium/high level of skill in a skillset(s) related to BBP operations # of job applications from skilled workers to BBP 5 years following the start of the company's skills training activities
Higher rates of local employment	% of employed residents from LDAs and farm sites
Influx of students to educational institutions that are BBP partners	# of students at partnering educational institutions
Reduced rate of migration from LDAs and/or farm sites	# of residents in LDAs and farm sites
Increased income earned among locals	% of senior management team comprising of local hires in 3 years % of middle management team comprising of local hires in 3 years
Increased community knowledge of areas of work/study which are relevant to the mill's operations	% of students enrolled in relevant degree programmes at local tertiary institutions % of participants enrolled in relevant skills training programmes at local training institutions % of locals in occupations related to BBP operations # of BBP sponsored after-school clubs established # of local secondary schools which include vocational skills components (which are relevant to BBP operations), in curricula

6.2.2. Local Economy Action Plan

As is too often the case in rural Jamaica, the economic development of multiple LDAs and farming areas has been stunted over many years, thus having a direct negative impact on the lives of locals. The economy in most of these locations is heavily dependent on agriculture. However, this seems to have lost some of its appeal in the past few decades, especially due to the national decline of the sugar industry along with other issues such as praedial larceny. Nowadays, most of the LDAs and farming areas have low levels of economic opportunities. Apart from the decline in traditional industries, this is partially due to a pervasive lack of training and employment opportunities. Youth and adult unemployment levels remain high in central and eastern Westmoreland, which has led to brain drain and people resorting to illegal economic activities such as scamming. More jobs need to be provided in the fields of farming, construction, local business, tourism and factory work, and the existing jobs in the various development sites usually only allow people to earn fairly small incomes. There is a possibility that BBP can fill these economic gaps through the mill's employment of locals, partnerships with contracted farmers, and the implementation of technical skills training programmes.

Local Employment

Through its workforce management strategies, the Project aims to achieve the provision of employment opportunities for diverse population groups (such as people with disabilities, school leavers and people that were previously unemployed), as well as the retention of a more skilled workforce. By adopting flexible and fair work arrangements which are designed to assist employees with maintaining work/life balance and help disadvantaged groups transition to the workforce, the company will not only attract workers (both from local areas and external regions), but also prevent high turnover rates.

BBP Partnerships with Individuals (Farmer contracts)

Partnership prospects with individuals who agree to farm bamboo on their own land look promising based on the moderately high rate of land ownership and self-employment among respondents. These two factors afford persons (who otherwise would have no access to farmlands and/or might be too occupied with other work obligations to farm), the freedom and flexibility required to enter into such contracts with BBP. Most of the survey respondents own the land they live on (either personally or via family ownership), however, only a minority actually use their land for farming. While persons can be persuaded to utilize their land for agricultural purposes, it may be necessary to first train those who lack experience in sustainable, eco-friendly farming techniques.

Contracts will be long-term (i.e., approximately 5-10 years), with clauses which allow the company to reserve the right to penalize, terminate or replace the contractor if standards or targets are not met. The standards that will be applied to BBP farmlands as well as contractors' lands will be high and will require close monitoring, with all BBP associated and independent farmlands expected to be Forest Stewardship Council (FSC) certified. These standards are particularly important regarding issues such as methods of land clearing prior to cultivation, encroachments into neighbouring lands, the practice of fire precautions, worker health & safety measures etc. Once farmers have registered their interest, they will be provided with information on the typical services that the contractor is looking to source, the general terms of reference of the contract and any pre-tender requirements. Some stakeholders have expressed concern regarding the potential difficulty with which contracted farmers' land can transition to cultivating other crops once bamboo is farmed and their contracts end. However, as BBP cannot prevent this, it should be reiterated that the company's commitment is long term with scope for expansion and that farmers will be trained based on world-class agricultural standards. Thus, the potential benefits seem to outweigh the challenges which may be experienced upon termination.

Partnerships with Businesses & Individuals

As it now stands, the construction, agricultural, manufacturing and retail industries appear to be the main employers. This may mean that there are enough local businesses within each of these three sectors with which BBP can partner once the mill enters into development.

Impact Management Plan

Objective	Improve local economic prospects through the creation of jobs and business partnerships.
Potential impacts/ Outcomes	• Increased local employment levels • Increased employment opportunities for diverse population groups • Renewed interest in farming as a viable means of income generation for land-owning locals • Increased formalisation of land ownership

Mitigation and Management Activities

Action	Parties Engaged in Action	Timeframe
Bamboo Farming Contracts		
Create framework for bamboo farming agreement Draft a model contract that sets out mutual expectations of BBP and suppliers. Amongst other important factors will be treatment of workforce and community.	BBP team	Q1
Promote the opportunity for local farmers to become contracted BBP bamboo suppliers among LDAs and farm sites. Use traditional and digital media to invite potential suppliers to register online their interest to farm bamboo as a BBP contractor. Partner with key community stakeholders to put on community information sessions (preferably in each LDA), in order to explain what opportunities are available for local contractors, the anticipated timelines, and to invite potential suppliers to express their interest to farm bamboo as a BBP contractor. Include information on the typical services that the constructor is looking to source, the general terms of reference of the contract and any pre-tender requirements. At the end of each contract cycle, search for new contractors via a new round of media promotions and community information sessions. Develop a model for small scale, independent bamboo contract farming alongside RADA to help small and medium sized farmers access farming contracts to deliver bamboo to BBP.	BBP team: Media & Communications Officer Community Benevolent Associations Media outlets Rural Agricultural Development Authority (RADA)	Q1-Q4
Increase the capability of locals to become BBP suppliers. Partner with SCJ Holdings Limited (SCJH), to aid in the distribution of certificates of land ownership to qualified residents in development sites. Conduct site visits and individual interviews to assess needs of each farmer so as to inform BBP's means of support regarding the technical set up of farms and farmer training. Design and implement a series of free workshops training landowners in sustainable, eco-friendly bamboo farming techniques. Evaluations should be held at the end of the training to certify farmers as being ready to formally start bamboo farming for BBP.	BBP team Representatives from SCJH Land-owning residents of LDAs and farm sites. Trainers	Q1-Q2
Recruitment strategies		
Increase employment opportunities for diverse population groups, such as people with disabilities, school leavers and people that were previously unemployed. Map a wide variety of public and civil society stakeholders through which job postings can be advertised to a diverse cross section of the local workforce and	BBP team - Media & Communications Officer Local academic and vocational	Q2 – engagement with stakeholder organisations

Action	Parties Engaged in Action	Timeframe
arrange with local academic institutions to promote job opportunities among final year students/incumbent university graduates. Partner with educational institutions for the inclusion of BBP related fields within curriculum and degree modules. Partner with social impact groups, community groups and public sector agencies to promote and make job opportunities accessible to vulnerable groups (e.g., persons with disabilities, unattached youth, those who have been unemployed long-term etc.). Advertise current job postings via traditional and digital media (e.g., newspapers, social media etc.).	training institutions e.g. UWI, MCC, HEART NTA Community Benevolent Associations Government agencies Media outlets	Q8 – mill opening: advertising job listings
Develop and adopt employee management strategies which facilitate the continued support of a diverse workforce and keeps turnover low. Partner with social impact groups, community groups and public sector agencies to assess the needs of each segment of the workforce (e.g., vulnerable populations), and use findings to inform the development of the employee management plans. Ensure mill design provides disability accessible (i.e., the installation of ramps). Allocate space in budget to make workplace more disability accessible (e.g., the training of customer service employees in Jamaican Sign Language, etc.) Develop plans to continue the practice of up-skilling and training staff to progress to new positions.	BBP team Disability organisations (e.g., Combined Disability Association) Community Benevolent Associations Government agencies	Q8
Business Partnerships		
Map businesses in and around the LDAs and farm sites. Register BBP to be part of the Westmoreland Chamber of Commerce to gain access to their extensive network of local enterprises. Liaise with relevant local businesses to propose partnership opportunities.	BBP team WCC Local businesses	Q2-Q6

Indicators

Outcome	Indicator	Means of Verification
Increased local employment levels	% of local population employed in each LDA and farm sites	Reports from the Statistical Institute of Jamaica and/or the Social Development Commission BBP-sponsored surveys
Increased influx of persons from external areas	# of persons hired by BBP who resided in LDAs prior to hiring versus # of those who resided in LDAs upon/after hiring # of persons hired by BBP who commute from outside communities	Employee records
Increased employment opportunities for diverse population groups	% of BBP employees who live with disabilities % of BBP employees which constitute unskilled labour # of unattached youth who became BBP hires after participating in the BBP internship programme	Employee records Employment contracts BBP internship programme certifications
Renewed interest in farming as a	# of contracted farmers per contract cycle	BBP Farming contracts

viable means of income generation for land-owning locals	# of local population working in the agricultural sector	Reports from the Statistical Institute of Jamaica and/or the Social Development Commission BBP-sponsored surveys
Increased formalisation of land ownership	% of contracted farmers who received land titles since the commencement of BBP's partnership with SCHJ	Dated land titles

6.2.3. Social Infrastructure Action Plan

Traffic & Road Safety

There is a medium level of road safety reported on average throughout the sites which indicates that, while BBP's future employees (including its truck drivers and deliverymen) are not at high risk of encountering accidents whilst commuting to and from the mill, levels of safety can be improved to protect their lives, BBP resources as well as the lives of others in each community. Speeding, the presence of inexperienced/incompetent drivers, and deterioration of roads were identified as the main causes of accidents in most areas and motorcyclists/cyclists, public transport users and pedestrians were said to be the most common victims. Regular/seasonal instances of flooding contribute to the overall poor condition of roads (many of which already suffer from a general lack of maintenance), which, in turn, hinders transportation in and out of each affected area.

As a means of increasing the overall road safety level (thus, benefitting BBP truck drivers and general employees as well as regular community members), BBP will utilize electric trucks which produce lower emissions and reduced noise pollution. BBP will monitor and control the inflow and outflow of truck movements to minimize congestion to include truck parks at the Mill and in Montego Bay. BBP can also seek to complement public-sector work by helping to implement safety measures which have the power to either mitigate endemic risks (i.e., those related to wear and tear and natural disasters), or prevent accidents. It should be made clear, however, that BBP does not have the financial capacity to spearhead major infrastructure upgrades.

Medical Services

Fortunately, it seems that healthcare, to some degree, is readily accessible to residents of most areas. Health centres can be found in all LDAs and Farm Sites with the exception of Hertford, Friendship, Amity, Winchester and Amity Hall. In light of the COVID-19 pandemic, local health facilities need various forms of assistance to meet the rising demand for health services. To promote the sustainable health of the local labor force, improved medical infrastructure should be donated and vaccinations should be encouraged among communities in the development area.

Land Acquisition & Involuntary Resettlement

Concerning land acquisition, a significant fraction of the households in sites like Savanna-La-Mar either own the houses in which they live or reside on family-owned land. The development of informal settlements has become a growing problem in communities in St. Elizabeth for example. For decades, many residents in sugar-dependent areas have lived in small, wooden "barrack-style" houses which have limited access to utilities and have, over time, fallen into disrepair. Places like Hertford and Golden Grove have, therefore, benefitted from the "Barracks Relocation Programme," and "Community Regularization Programme," which rehouses and grants land titles to individuals respectively.' BBP seeks to provide increased access to quality yet affordable housing by lobbying for the expansion of the Community Regularization Programme to all eligible LDAs to ensure land tenure for field workers who have lived in the area for many years. The company will also provide temporary housing for select, skilled BBP workers who can enter into affordable lease agreements with BBP. The implementation of these solutions will work towards achieving a neutral impact on housing affordability and availability for locals as well as additional business opportunities for local accommodation providers.

Water Supply

85% of all survey respondents indicated that water is piped to the residences; although, one third of them also collect water from nearby sources (such as rivers, wells etc.). This reliance on alternative supplies of water (most commonly seen among respondents from Hertford, Petersfield and Friendship), may be an occasional response to the frequent dysfunction of public facilities (e.g., water pumps and rain catchment tanks), seasonal climate change etc. Little London, Winchester and – as is characteristic of most of St. Thomas – have all been affected by a continual lack of public piped water; a reality which has been made even more dire in light of the COVID-19 pandemic. It will be in the best interest of BBP for these and other local facilities to be in proper working order so as to ensure a stable water supply to sustain both the mill's operations and the cultivation of bamboo by contracted farmers.

Pollution

The survey showed that most respondents dispose of their garbage in established receptacles and live in areas with generally low levels of pollution. Exceptions to this include areas in Trelawny and St. Elizabeth which are plagued with issues such as the lack of adequate garbage disposal facilities, improper garbage disposal practices and irregular garbage collection. It was made evident in the Agricultural Stakeholders Meeting that there are concerns regarding the potential adverse environmental and health impacts of the mill's dust emissions and fluid waste as well as of the farming practices of the mill's contractors (specifically as it relates to the use of the "slash and burn" method).

Social Nets

According to the survey; the elderly, children, people with disabilities and the economically disadvantaged were seen as being the most vulnerable groups within the targeted communities. To help satisfy some of the social needs unable to be met by the government, multiple community-based civil society organisations have sprung up and have implemented a variety of social interventions over time. BBP should seek to collaborate with these social actors to create/strengthen each location's social net and, ultimately, to fulfill its own corporate social responsibility. BBP seeks to incentivize workers to participate in the delivery of various community outreach interventions spearheaded by partnering organisations or BBP itself that target their own communities. This will increase BBP's local visibility and, essentially, convert every worker into a BBP ambassador. The mill is set to create a Community Fund in which a certain value of harvested green bamboo will be allocated for each parish and will be held by BBP. Using this Fund, BBP can try to fill some of the gaps left in the government's provision of social services for underserved groups.

Finally, a community-run social enterprise will be established (with branches in each of the LDAs), and will sell bamboo straws and other bamboo products and employ members of vulnerable populations.

Crime

Crime in each development area seems to be relatively low (except for in Savanna-la-Mar where 100% of survey respondents believed that crime was at a medium level), and the police is generally seen as maintaining good relations with residents. This, at the time of the survey, indicated a probable need for increased security measures for the mill's operations in Savanna-la-Mar. Since these findings were produced, crime in the parish's capital has intensified; moving towards the forefront of the island's attention as it was placed under an official State of Emergency (SoE) in the second week of November. Apart from having increased security for BBP resources in the area, BBP should also focus on helping to improve physical infrastructure as a means of crime prevention seeing as local communities which have been targeted by gangs have typically been reported to have poor infrastructure (e.g., bad lighting), thus increasing their vulnerability. Concerningly, the farming sites of Little London (which has witnessed a trend towards more violent crimes in recent years) and Lacovia (which experiences significantly higher levels of crime as compared to its surrounding areas – i.e., mainly robberies and break-ins), also warrant increased security. Notably, it is in the company's best interest to begin building a strong relationship with the local police in each site.

Impact Management Plan

Objective	**Ensure that improved social services are provided so that the needs of the mill and the residents are properly met.**
Potential impacts/ Outcomes	• Improved/more sustainable access to water in targeted communities • Increased access to quality yet affordable housing • Increased levels of health among locals • Reduction in traffic accidents across LDAs and Farm sites • Greater adoption of eco-friendly farming practices among local farmers • Reduced risk of deforestation, flooding etc. due to harmful farming methods • Greater levels of socioeconomic advancement and social inclusion among vulnerable groups • Increased citizen security in LDAs and farm sites • Increased disaster preparedness • Increased awareness and positive perceptions of BBP among the general public • Increased economic activity along coastal towns

Mitigation and Management Activities

Action	Parties Engaged in Action	Timeframe
Social Nets		
General		
Create a Community Fund in which a certain value of the harvested green bamboo will be allocated for each parish and will be held by BBP. Map and liaise with local development stakeholders to identify partnership opportunities, especially groups which target At-risk children; the elderly; people with disabilities; the economically disadvantaged. Develop a Community Development Fund Framework which includes stakeholder involvement and ownership, along with areas for focus. Create a mechanism to incentivize workers to participate in the delivery of various community outreach interventions spearheaded by partnering organisations or BBP itself.	BBP Social Development team Local community development stakeholders	Q5 - ongoing
Poverty		
Promote the reduction of poverty in local communities. Map organisations which specialize in meeting the needs of the impoverished. Partner with poverty-reduction stakeholders to assess the needs of people living in poverty in LDAs and farm sites.	BBP Social Development team Local poverty-reduction organisations	Q5 - ongoing

Action	Parties Engaged in Action	Timeframe
Establish a community-run social enterprise (with branches in each LDAs and farm site), which sells bamboo straws and other BBP products and employs members of vulnerable populations. Develop and submit a proposal for the Community Enterprise Model to partners (e.g., HEART Trust NTA), and key community stakeholders to gain feedback and consensus. Partner with local businesses and academic institutions to design and implement programmes for impoverished persons which focus on financial literacy, entrepreneurial training, job readiness, and job placement. Collaborate with local schools to sponsor and implement child and adult literacy programmes. Donate small conditional and unconditional grants to local non-profit organisations and the outreach ministries of local churches.	BBP Social Development team Local stakeholder organisations (including the HEART Trust NTA, churches and non-profit organisations) Local businesses Local academic institutions	Q5 - ongoing
People Living with Disabilities		
Serve the needs of the local disabled population. Map organisations which specialize in meeting the needs of people living with disabilities. Partner with disability stakeholders to assess the needs of people living with disabilities in LDAs and farm sites.	BBP Social Development team Local disability-related stakeholder organisations	Q5 - ongoing
Promote disability accessibility in the design of the mill via the inclusion of important physical infrastructure (e.g., ramps). Sponsor the delivery of disability accessibility training sessions to BBP staff, and to local schools, local businesses and local government bodies in partnership with the stakeholder agencies. Meet with local government bodies to advocate for increased disability accessibility in local public buildings – also through the installation of certain physical infrastructure.	BBP team Local disability-related stakeholder organisations Local government bodies (e.g., Ministry of Labour and Social Security)	Q1- ongoing
At-risk Children		
Serve the needs of children in local development areas. Partner with academic and child welfare stakeholders to assess the needs of at-risk children in LDAs and farm sites.	BBP Social Development team Local academic and child welfare stakeholders	Q5 - ongoing
Partner with local schools to sponsor school feeding programmes (e.g., partially sponsoring the PATH programme's delivery at local schools) Make contributions (e.g., cash donations, sweat equity from volunteer BBP construction workers etc.), to local schools towards the maintenance of buildings, and the procurement of equipment and supplies. Sponsor homework assistance programmes carried out by local community centres/outreach organisations (the Source Savanna-La-Mar, the Petersfield branch of the Westmoreland Parish Library etc.).	BBP Social Development team Local schools BBP workers Local community centres/outreach organisations (e.g., the Source, Parish Library etc.)	Q9 - ongoing
The Elderly		

<table>
<tr><th>Action</th><th>Parties Engaged in Action</th><th>Timeframe</th></tr>
<tr><td>Serve the needs of the local elderly population.
Map organisations which specialize in meeting the needs of the elderly.
Partner with key stakeholders to assess the needs of the elderly in LDAs and farm sites</td><td>BBP Social Development team
Local stakeholder organisations that target elderly beneficiaries</td><td>Q5 - ongoing</td></tr>
<tr><td>Make donations to local elderly care facilities (e.g., the DCS Nursing Home in Amity) towards the maintenance of buildings, and the procurement of beds and equipment.
Create a private pension and health insurance scheme for BBP worker.
Advocate on behalf of the elderly populations in LDAs and farm sites to the National Council for Senior Citizens.</td><td>BBP Social Development team
Local local elderly care facilities
National Council for Senior Citizens</td><td>Q4 - ongoing</td></tr>
<tr><td colspan="3">Water</td></tr>
<tr><td>Improve community access to water in targeted communities.
Partner with the National Water Commission and the WMC to identify problems and develop strategies to improve the sustainability of public water supply services (e.g., fixing/ replacing broken public water facilities)</td><td>BBP team
National Water Commission
Westmoreland Municipal Corporation</td><td>Q3- ongoing</td></tr>
<tr><td colspan="3">Roads</td></tr>
<tr><td>BBP will help to implement safety measures which have the power to either reduce or prevent crashes across LDAs and Farm sites.
Develop a Traffic and Road Management Plan
Lobby the National Works Agency (NWA), regarding the repair of sections of heavily used roads most in LDAs and farm sites
Meet with local police force to advocate for improved road law enforcement measures in LDAs (especially in Friendship) - e.g., the increased presence of traffic control officers in certain areas.
Meet with representatives from the National Road Safety Council to discuss the possible scaling of its Motorcycle Outreach to all 6 LDAs.</td><td>BBP team
National Works Agency
Local police force
National Road Safety Council</td><td>Q3- ongoing</td></tr>
<tr><td>To complement public sector interventions, make contributions from the BBP Community fund towards the maintenance of heavily used sections of roads most in need of repair. These roads are: Petersfield: Shrewsbury and Petersfield main road; Hertford: Hertford main road; Friendship: Friendship main road; Savanna-la-Mar: Great Georges Street and Frome: Frome main road.
Partner with the Jamaica Automobile Association (JAA) to increase the opportunities for mill workers to participate in driving lessons.
Prior to proposing this to JAA, assess the demand for such an initiative among workers.
Offer to partially sponsor the initiative so that lessons can be offered at discounted rates to employees.
Sponsor certain aspects of the National Disaster Risk Management programme and recovery efforts for adverse hydrometeorological events (e.g., flooding), which has the potential to damage roads, houses and other property/infrastructure</td><td>Westmoreland Municipal Corporation
Jamaica Automobile Association
Office of Disaster Preparedness and Emergency Management (ODPEM)</td><td>Q4 - ongoing</td></tr>
</table>

Action	Parties Engaged in Action	Timeframe
Health		
Help to increase levels of health among local workforce and communities. Partner with local community clinics to assess their infrastructural needs. Register BBP in the Private Sector Vaccine Initiative (PSVI) which will facilitate the company's purchase of vaccines for staff and their dependents Allocate money from the BBP Community fund to help upgrade community clinics with the most pressing needs	BBP Social Development team Local community clinics Representatives of the Private Sector Vaccine Initiative	Q8 - Needs assessment
Housing		
Help to increase access to quality yet affordable housing. Meet with representatives from SCJH to advocate for the expansion of their Community Regularization Programme to all LDAs. Establish a set of criteria to inform the selection process of which employees qualify for BBP housing. Partner with locally-based developers and architects to find ways of designing and constructing affordable but quality houses.	BBP team Representatives from SCJH Housing developers	Q1-ongoing
Pollution		
Minimize the risk of fluid waste from the mill contaminating local waterbodies (e.g., local revenue generators like the Carbarita River). Channel fluid waste through to a water treatment plant on a continuous basis in order to recover 85% of the chemicals used. Use residual bamboo waste (e.g., lime sludge) to produce bioproducts (e.g., cementation, road infill, biofuel pellets, particleboard, Syngas, ethanol etc.), onsite.	BBP team Environmental Solutions Limited	Q1-ongoing
Reduce the mill's overall dust emissions. Develop an advanced dust collection system through which dust can be filtered, causing the dust emissions to be kept at a minimum.	BBP team Environmental Solutions Limited	Q1-Q2
Discourage the use of harmful farming practices (e.g., the slash and burn method) by doing the following: Use traditional & digital media and community sensitization sessions to carry out public educational campaigns which highlight the negative economic, environmental and health effects of each practice. Establish a company mandate to refuse the purchase of burnt bamboo from local growers as part of company policy.	BBP team Rural Agricultural Development Authority	Q3-ongoing
Crime		
Reduce and/or **mitigate the effects of the rising crime rates** in LDAs and farm sites. Meet with local public-sector entities to advocate for the improvement of infrastructure in hot spot/volatile communities in Savanna-la-Mar.	BBP team Local police force	Q1 - ongoing

Action	Parties Engaged in Action	Timeframe
Build a strong relationship with the local police in each LDA and farm sites through periodic meetings. Allocate money in BBP budget to establish increased security around BBP Resources in Savanna-la-Mar, Lacovia and Little London. Proving ongoing community engagement strategies to ensure community support for BBP. Contract with a security company to cover security matters related to company personnel, contractors, visitors, farm lands, mill infrastructure and assets.	Local public-sector entities (e.g., Ministry of Labour and Social Security)	
Disaster risk management		
Ensure that a disaster risk management business continuity plan is developed in accordance with the guidelines of the Office of Disaster Preparedness and Emergency Management (ODPEM). Partner with the Westmoreland Municipal Corporation to sponsor drain cleaning programmes leading up to the rainy season as drainage systems are inadequately maintained leading to flooding during rainy season.	BBP Social Development team Westmoreland Municipal Corporation ODPEM	Q2-ongoing

Indicators

Outcome	Indicator	Means of Verification
Improved/more sustainable access to water in targeted communities	# of impaired public water facilities which are fixed/replaced due to BBP's collaboration with NWC	BBP reports
Increased access to quality yet affordable housing	# of BBP housing units leased by workers Level of certification awarded to BBP housing	Lease agreements Quality assessment results and certifications
Increased levels of health among locals	# of pieces of equipment donated by or purchased as a result of BBP # of in each LDA/farm site who have been vaccinated under BBP's collaboration with PSVI # of COVID-19 cases in LDAs per month since BBP's interventions	Invoices, receipts and photographs of donated items and money to beneficiary organisations PSVI reports MoHW reports regarding number of COVID cases
Reduction in traffic accidents across LDAs and Farm sites	# of accidents on local roads # of new/reformed law enforcement measures implemented in LDAs # of LDAs in which the National Road Safety Council's Motorcycle Outreach was replicated # of motorcyclists in each LDA who have successfully completed the Motorcycle Outreach programme # of BBP employees who receive driver's licenses after the commencement BBP's partnership with the JAA	National Road Safety Council reports Jamaica Automobile Association reports and registration documents BBP reports

Outcome	Indicator	Means of Verification
	# of BBP-sponsored road repairs	
Greater adoption of eco-friendly farming practices among local farmers	% of chemicals recovered # of bioproducts produced onsite # of attendees at community sensitization sessions	BBP mill operations reports BBP records for community sensitization sessions
Greater levels of socioeconomic advancement and social inclusion among vulnerable groups	*General* # of branches of the community-run social enterprise established # of branches of the community-run social enterprise which have turned profitable within first 3-5 years of operation # of persons who complete BBP-sponsored financial literacy training sessions # of persons who operate a profitable business 3 years after completing BBP-sponsored entrepreneurial training sessions # of persons who are employed within one year of completing the BBP-sponsored job readiness programme # of persons who are successfully matched with jobs via BBP-sponsored job placement programme # of persons who complete BBP-sponsored adult literacy training sessions # of local non-profit organisations and the outreach ministries of local churches who received BBP funding	*General* Registration certificates for each branch of the community-run social enterprise Financial reports for each branch of the community-run social enterprise BBP reports for financial literacy training programme BBP reports for entrepreneurial training programme BBP reports for job readiness programme BBP reports for job placement programme BBP reports for adult literacy training programme BBP financial records and contracts regarding the awarding of grants to beneficiary organisations
	Elderly # of pieces of equipment donated by or purchased as a result of BBP # of BBP employees on private pension and health insurance scheme	*Elderly* Invoices, receipts and photographs of donated items and money to beneficiary organisations BBP insurance and pension scheme records
	Children # of students in LDAs/farm sites registered for local BBP-sponsored school feeding programmes # of pieces of equipment donated by or purchased as a result of BBP to local schools $X donated by BBP to local schools # of volunteers from BBP staff worked towards the maintenance of schools # of BBP sponsored homework assistance programmes	*Children* BBP records for school feeding programmes Invoices, receipts and photographs of donated items and money to beneficiary organisations BBP records for sponsored school maintenance projects BBP records for sponsored homework assistance programmes
	Disabled Persons # of infrastructural modifications to design of the mill to facilitate disability accessibility	*Disabled Persons* Architectural plans for design of the mill

Outcome	Indicator	Means of Verification
	# of BBP-sponsored disability accessibility training sessions # of persons who complete BBP-sponsored disability accessibility training sessions	BBP records for sponsored disability accessibility training sessions
Increases citizen security in LDAs and farm sites.	# of meetings held with the local police in each LDA and farm sites	Minutes from meetings held with the local police in each LDA and farm sites
Increased disaster preparedness	The production of one Disaster risk management business continuity plan # of completed BBP-sponsored drain cleaning activities	Disaster risk management business continuity plan Site reports
Increased awareness and perceptions of BBP among the public	# of Followers on social media # people attending BBP community events	Official BBP social media analytics

7. Community Investment and Partnerships

In order to successfully implement the management plans outlined in this SIMP, BBP will implement a number of key mechanisms or tools, including:

- a Community Investment Fund, to channel financial resources into the community;
- key partnerships with government agencies and non-government organisations in the
- local community; and
- on-going provision of a Community Liaison Officer to provide information to the public and deal with stakeholder issues and grievances.

Further information on each of these implementation measures is provided below.

7.1. BBP Community Fund

The implementation of a community investment fund will allow BBP to contribute to social infrastructure and service development, and optimise the Project’s benefits in the local community.

The BBP Community Fund is subject to the following process:

- community members and groups are invited to submit written applications outlining the nature and scale of support requested;
- the Board of the BBP Community Fund assess requests as they are received based on agreed criteria and areas of focus;
- the Board ensures adequate due diligence has been completed;
- a decision on the approval of applications is made; and
- a database of successful applications is kept by BBP for record-keeping purposes.

BBP’s Community Fund prioritises support for communities in the immediate vicinity of the operations and those operating farm sites. Support is provided in the areas of community and welfare services, environment, education, health, infrastructure and workforce development. As part of the Community Fund, material will be developed and publicised to advise the community on:

- how and when to apply for funding;
- priority areas and criteria for funding;
- geographical extent of the funding program (i.e. which communities are included);
- funding amounts; and
- application closing dates.

7.2. Key Partnerships

Private sector

The private sector will be engaged primarily via BBP's linkages with local businesses; several of which may become suppliers of materials needed in both the construction and operation of the mill, as well as in areas dealing with shipping, fleet management, security etc.. Beyond this, the BBP will join local private sector bodies such as the Jamaica Chamber of Commerce (JCC) Westmoreland Chapter, the Jamaica Manufacturing and Exporters Association (JMEA) and the Private Sector Organisation of Jamaica (PSOJ), the umbrella group for private sector in Jamaica.

Civil society

One of BBP's goals is to partner with local academic institutions which can feed their graduates into a larger pipeline of local mill workers. The company's social development team has already met with the HEART Trust NTA to discuss their provision of training opportunities for relevant skill sets required by BBP. They, having responded favourably to the presence of the mill here and its implications for the local work force, already offer some training in bamboo shoot harvesting, cultivation and pre-processing operations etc. As was previously mentioned, BBP has already established plans to create a 'Center of Excellence' for the industry and an exchange graduate course scheme with the University of West Indies and the University of Maine, USA. The Montego Bay Community College has also expressed a level of openness to BBP's proposal to replicate or develop degree programmes which are relevant to mill operations at their Frome campus. Furthermore, BBP will collaborate with academic and training institutions regarding the development of summer internships/trainee programmes, additions to curricula, BBP sponsored after-school clubs etc.

Community clinics will be partnered with to assess the health needs of the communities as well as to evaluate their own infrastructural needs so that BBP can help with their upgrade and, ultimately, with the improvement of community health. Churches, non-profit organisations and community outreach groups (e.g., the Source Savanna-La-Mar), will also be approached with various opportunities to partner with BBP in the provision of needs for local vulnerable populations. Concerning the mill's environmental impact, Environmental Solutions Limited (an established BBP partner), will continue be engaged with regards to the development of systems by which dust from the mill can be filtered and fluid waste can be treated on a continuous basis. On another note, media outlets will be reached out to for the publicization of public education campaigns and job opportunities.

Public sector

BBP will seek to form partnerships with various public sector stakeholders, mainly in the interest of ensuring that adequate social services are provided at a high quality so that the needs of the mill and the residents are properly met. The WMC, will be consulted, lobbied and/or partnered with on a variety of issues and activities in the parish including the company's endeavour to sponsor drain cleaning programmes leading up to the rainy season as drainage systems are inadequately maintained leading to flooding during rainy season. In order to improve community access to water in targeted communities, the company plans to partner with both the NWC and the WMC to identify problems and develop strategies to improve the sustainability of public water supply services (e.g., fixing/ replacing broken public water facilities). Additionally, BBP aims to increase the opportunities for mill workers to participate in driving lessons through a long-standing collaboration with the JAA, and RADA will be asked to collaborate on the design of BBP's public education campaigns which highlight the negative economic, environmental and health effects of certain farming practices (e.g., 'slash-and-burn').

Other public sector entities will be engaged mainly due to advocacy needs. The National Works Agency will be lobbied regarding the repair of sections of heavily used roads most in LDAs and farm sites, whereas the National Road Safety Council will be lobbied to replicate the its Motorcycle Outreach in all of the LDAs. Similarly, there is a plan to seek an audience with representatives from SCJH Housing developers in order to advocate for the expansion of their Community Regularization Programme to all LDAs. Moreover, the MoEYI will be engaged in an effort to advocate for the inclusion of more vocational skills components (i.e., for BBP-related skills), into the national high school curriculum. Finally, the local police force will be continually engaged so as to form a good relationship with them throughout the mill's development and operation as well as to advocate for improved road law enforcement measures in LDAs.

7.3. Dedicated Community Information Office and Liaison Officer

BBP will establish a **Community Information Office** to facilitate transparent and regular communication with local communities. The office will supply a range of information materials for interested stakeholders. Opening hours are scheduled with consideration to normal working hours as well as shift work patterns.

The office is to be staffed by a dedicated Community Liaison Officer, who is available to deal with stakeholder issues, concerns and suggestions. The Community Liaison Officer is also responsible for documenting community issues, as well as ensuring the satisfactory resolution of issues received through the community grievance mechanism as discussed further in **Section 10**.

8. Monitoring and Reporting

This Section describes the specific measures that will be undertaken to manage the social performance of the Project. The monitoring, review and reporting mechanisms described will help ensure that the SIMP responds appropriately to internal and external changes for the duration of the Project.

8.1. Monitoring and evaluation

The monitoring and evaluation of social management measures is important to understand how individual programmes are tracking against overall Project objectives. This allows BBP to respond to both internal project changes and external community feedback.

In particular, robust monitoring and evaluation of activities will allow:

- identification and response to issues at an early stage;
- effective forward planning;
- recording of programme inputs, outputs, outcomes and impacts;
- understanding and justification of whether a programme is meeting initial objectives;
- increased accountability by staff and teams;
- understanding whether community and stakeholder expectations are being met; and
- increased levels of transparency.

Detailed monitoring plans have been outlined in each action plan above. These plans provide a framework for performance targets, data sources, data collection mechanisms and frequency of data collection. The action plans will be reviewed on an annual basis. The key monitoring mechanisms proposed in these action plans are summarised in **Table 6**.

Table 6 - Summary of Key Monitoring Mechanisms

Monitoring Mechanism	Data Type	Purpose
Employment records	Quantitative	Monitor employment diversity.

Procurement spend reports	Quantitative	Monitor project spend on goods and services with local and regional providers.
Project safety reporting	Quantitative	Monitor safety incidents and near misses that may impact on workforce health and wellbeing, as well as on the general community.
Training records	Quantitative	Reflect workforce and community participation in education programmes, training, induction and safety sessions.
Environmental monitoring reports	Quantitative	Report on results of dust, noise and air quality monitoring to evaluate potential impacts on amenities.
Community grievance mechanism	Qualitative	Monitor specific community complaints, issues, suggestions and comments regarding the revised Project.
Social Impact Report	Qualitative & quantitative	Quarterly report which reports on the SIMP and its indicators, along with report on Community Fund, Community Enterprise and Community relations. (To include energy & climate targets to be determined).

8.2. Reporting

Communicating the findings of the monitoring process is important for providing key stakeholders with information on how social management activities are progressing. Internally, for BBP, it shows how funds are being used to achieve key objectives. Additionally, the findings generate knowledge of what works, what does not work and why; helping the project team to appropriately manage impacts.

Internal reporting on this SIMP will be undertaken regularly throughout construction and operation, through middle management meetings, community updates and stakeholder reporting. Where appropriate, summary and quarterly reports will also be discussed at Senior Management Team meetings and will also be incorporated in the company's annual reports.

External reporting during construction and operation will take place through providing a summary of performance and progress via website and social media postings as well as a regular community newsletter and WhatsApp group broadcasts and in person community and stakeholder update sessions.

8.2.1. Annual Reporting

Reporting on performance against mitigation and management activities and indicators outlined in the SIMP is required on an annual basis. A reporting template is included in **Appendix A.**

The indicators for each of the objectives will be monitored to assess BBP's progress. The results will be reported to higher management, along with any recommendations regarding necessary changes to the indicators. The results may also be made publicly available. Where adverse effects are identified, any mitigating action(s) will also be reported.

9. Stakeholder Engagement Strategy

This Section of the SIMP provides an overview of the range of stakeholder groups that may be affected by or interested in the Project. It also outlines the specific mechanisms that will be used to ensure that stakeholders continue to be involved throughout the life of the revised Project.

9.1. Engagement Principles and Strategy

BBP will seek to involve the community during the planning, construction, operation and decommissioning of the revised Project.

In particular, BBP will seek to understand and address community concerns about the environmental and social impacts of project activities. BBP will seek to engage with stakeholders via a diverse set of mechanisms (e.g., in-person or digital public forums, direct contact with past survey respondents, small meetings with community groups/organisations, the BBP website & social media pages etc.), and give transparent and consistent reports on the mill's development progress, activities and, ultimately, its economic and social impact (according to pre-established Key Performance Indicators).

The implementation of stakeholder engagement was in general guided by IFC Performance Standard 1 Requirements: Assessment and Management of Social Risks, Impacts and Opportunities.

9.2. Stakeholder Engagement Mechanisms

BBP will use a range of engagement mechanisms throughout the Project as detailed in **Table 7**.

Table 7 - Key Stakeholder Engagement Mechanisms

Stakeholder Group	Primary Interest	Engagement Mechanisms
Community	Local Labour Market Training opportunities Farming Contracts Social infrastructure Crime	BBP website BBP social media BBP WhatsApp group BBP newsletter Community stakeholder meetings
Local Government	Local Labour Market Training opportunities Farming Contracts Social infrastructure Crime	Government stakeholder meetings Community stakeholder meeting
Business owners	Local Labour Market Training opportunities Social infrastructure Crime	Private sector stakeholder meetings
Land owners (potential suppliers)	Farming Contracts	BBP website Direct outreach BBP WhatsApp Group BBP newsletter Community stakeholder meetings
Agricultural Stakeholders	Farming Contracts Social infrastructure	BBP Website BBP Newsletter BBP WhatsApp Group Agricultural Stakeholder meetings Direct outreach

The stakeholder engagement strategy will be reviewed and revised internally on an ongoing basis.

9.3. Community engagement evaluation

It will be critical to continually monitor and evaluate the effectiveness of the communication and engagement programme with the local stakeholders in order to ensure impacts and concerns raised are considered and acted upon where appropriate. The communication and engagement programme will be reviewed on an annual basis.

9.4. EVALUATION METHODS

A number of methods will be used to evaluate the effectiveness of the engagement programme with local stakeholders. These methods include:

- **Database records:** Database records with an analysis of feedback forms submitted, website hits, telephone calls, incoming emails, tone of enquiries and key issues raised.
- **Benchmarking activities:** Benchmarking activities will be undertaken using questions on any feedback forms and activities to determine changes in local community attitude, knowledge and behaviours.
- **Informal feedback:** All significant informal feedback received from local stakeholders regarding consultation activities will be recorded in the revised Project database and reported and analysed.
- **Observations:** Team members will record their observations during local stakeholder engagement activities. These observations will detail what happened during the activity, who was involved and how they reacted. Team members will also record 'stand out moments' and quotes.
- **Media analysis:** Analysis of negative versus positive media coverage.

9.4.1. *EVALUATION CRITERIA*

The evaluation criteria for each objective are identified in **Table 8**.

Table 8 - Evaluation Criteria

Objective	Method of evaluation	Key indicators
1. Inform the local stakeholders about revised Project benefits and opportunities	Database records Benchmarking activities Informal feedback Observations	Level of local stakeholder awareness of the revised Project Information disseminated as per this strategy
2. Provide open, honest and timely communication with local stakeholders	Database records Benchmarking activities Informal feedback	Amount of communication with local stakeholders and its effectiveness Local stakeholders satisfaction levels with the revised Project communication Response times to local stakeholder enquiries
3. Engage local stakeholders to capture their views and ensure they are understood by the Project team and considered in decision making where possible	Database records Benchmarking activities Informal feedback Observations	Amount of feedback received and how it has been acted upon How and if local stakeholder feedback is successfully communicated to the revised Project team
4. Ensure early identification of potential local stakeholder issues and implementation of appropriate mitigation strategies	Database records Benchmarking activities Observations	How feedback has been acted upon How local stakeholders have influenced Project decisions and mitigation measures

9.5. Adjusting mitigation strategies and action plans

The community engagement feedback will be used to monitor the effectiveness of the Project's mitigation strategies and action plans. If feedback indicates a need to adjust the mitigation strategies and action plans the following process will be followed:

- community feedback on the mitigation measure will be reviewed further to better understand the issue;
- the feedback will be investigated further through discussions with stakeholders, community members, government agencies and other groups, field investigations, further technical monitoring or data collection as required; and
- following the investigation, recommendations will be made to BBP regarding the appropriate course of action. If necessary, Action Plans will be updated as needed and communicated to the relevant BBP staff for implementation.

10. Complaint Resolution

To facilitate open communication and active complaint resolution, it is important that local stakeholders are able to raise issues and complaints in a formal way. The Project has a dedicated Community Liaison Officer with whom local stakeholders can raise issues and concerns relating to the Project.

The Community Liaison Officer is available to receive complaints and can be contacted in person at the Community Information Centre, by email or telephone. The Community Liaison Officer ensures that all issues are conveyed to the appropriate sectors of BBP, including management in the event an issue relates to operational issues.

The following are key principles adhered to by BBP in responding to issues or concerns raised by local stakeholders:

- timeliness – complaints will be dealt with in a timely and efficient manner;
- sensitivity – ensure that both parties feelings and perspectives are respected;
- fairness and impartiality – both parties will be afforded substantive and procedural fairness in the resolution process; and
- confidentiality – only parties directly involved in the complaint or those involved in decision making about outcomes will have access to information about the complaint.

Appendix A Instructions for Completing Annual Monitoring Reports

The following outlines a template for completing annual monitoring reports.

Template Preparation

Enter the reporting year on the front page and in any other themes stating „[Year]".

Wherever possible, it is recommended that the annual reports build on previous years reports, particularly with regard to indicators to enable tracking over time. Therefore, it is recommended that new columns are added in the indicator data tables with additional data added annually.

Results Summary

Summarise, at the highest level, the key achievements, challenges and any other detail that BBP wishes to highlight across the year.

In particular, it is recommended that BBP provides details on actions that cut across multiple themes e.g. the Stakeholder Engagement Plan, the Road and Traffic Management Plan, the Community Fund, the Community Enterprise et al.

Mitigation and Management Actions - Progress Summary

Enter a summary of progress with expected completion date and next steps, including noting whether the action is:

- Scheduled;
- In progress;
- Complete; or
- Overdue.

If additional management actions are initiated during the year enter these at the bottom of the table.

Indicators

- Data [Year] - Enter data available for each indicator. Where data is not available, state as such with a reason and anticipated first year in which the data will be reported.
- Comment - Detail notes of trends and causes where material changes are seen (if known).
- If additional indicators are identified during the year enter these at the bottom of the table.

Summary

Discussion - Detail the key achievements, challenges and any other information you wish to highlight across the year for each theme.

Compliance - Provide summary results of relevant compliance activities that are reported through other mechanisms and that relate to the theme.