ENVIRONMENTAL IMPACT ASSESSMENT

PROPOSED SOUTH JAMAICA POWER COMPANY LIMITED 360 MW COMBINED CYCLE PLANT, OLD HARBOUR BAY, ST. CATHERINE

Submitted to:

SJPC

South Jamaica Power Company Limited

6 Knutsford Blvd. Kgn 5

CL ENVIRONMENTAL

Taking Care of You and Your Environment.

OCTOBER 2012

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Submitted to:
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1.0 EXECUTIVE SUMMARY

INTRODUCTION

South Jamaica Power Company Limited (SJPC), a business enterprise duly incorporated under the laws of Jamaica, with registered office at 6 Knutsford Boulevard, Kingston 5, in the parish of St. Andrew, has applied to NEPA for the required permits to undertake a project to Build Own and Operate a 360 MW Combined Cycle Power Plant at Old Harbour, Jamaica.

The Jamaica National Environment and Planning Agency (NEPA) is the main government agency responsible for granting Permits and Licenses for development projects. NEPA required that an Environmental Impact Assessment (EIA) report be prepared so as to study and disclose pertinent information regarding the environmental, social and economic aspects, as a basis for granting construction permits and operating licenses for the proposed project. This Executive Summary is intended to provide a concise description and assessment of the direct and indirect impacts that could result from construction and operation of a 360 MW Combined Cycle Power Plant at the proposed site in Old Harbour Bay, and of the proposed mitigatory measures that would be applied to deal with any significant negative impacts that this development might bring to the natural and human environment.

THE PROJECT PROPONENTS

The shareholders of SJPC are **Korea East-West Power Co. Ltd**., (40**%); Marubeni Corporation** of Tokyo, Japan, (40%); and **Jamaica Public Service Company Limited,** (20%).

Korea East West Power Co. Ltd. (EWP) is a Korean power generation company founded in 2001 EWP specializes in a wide range of power generation facilities from coal-fired and LNG based to renewable energy such as photovoltaic and wind power. EWP operates 5 power plants with 8,815 MW, accounting for 11.1% of Korea's total power generation facilities contributing to the stable power supply in Korea. In the overseas market, EWP has participated in 19 overseas projects with 7,740 MW in five different continents. EWP currently owns 40% of JPS.

Marubeni is a Japanese trading house founded in 1858 which has 120 offices in 67 countries/areas. It operates in very diversified industries such as food, textile, chemicals, oil & gas, mining and heavy machinery/plants. Power sector investment is one of Marubeni's strategic focuses. Marubeni owns and operates 40 power plants with 29,511 MW of gross capacity and 8,753 MW of net capacity in its global portfolio. In the Caribbean region, Marubeni currently owns 40% of JPS .

JPS is an integrated electric utility and the sole distributor of electricity in Jamaica. JPS also purchases power from a number of IPPs.

The principal activities of JPS are generating, transmitting, distributing and supplying electricity. A License granted to JPS in 2001 gives the company exclusive rights to transmit and distribute electricity in Jamaica through at least 2027. The government of Jamaica owns 20% of JPS.

THE MOTIVATION FOR THE PROJECT

In the Generation Expansion Plan prepared in 2010, the Office of Utilities Regulation,(OUR), concluded that "the national power grid which supplies electricity throughout Jamaica urgently requires new power generators to assure system, reliability to prevent future brown & black outs and bring new and more cost efficient technology into Jamaica". To fulfill these needs, OUR issued a request for proposal for interested parties to tender for providing a total of 480 MW of new base-load power plant generation capacity. In December of 2011 the OUR awarded the Jamaican Public Service (JPS) the right to develop and provide one 360 MW LNG fired power plant facility. Subsequently JPS has assigned its rights to undertake the proposed 360MW power plant project to South Jamaica Power Company (SJPC) Limited, which will be the Independent Power Producer having ownership of the proposed new power plant. The Jamaican Government was originally expected to provide the liquefied natural gas for the new power generation plant. However, due to the shift in the Governments' LNG plan, SJPC, going forward has committed to source and provide their own supply of natural gas for operating the proposed 360 MW power plant.

As a backup the new 360 MW power plant can also operate on liquid automotive diesel oil (i.e. "ADO") when the LNG supply might be interrupted, for example during a hurricane.

BENEFITS THAT CAN BE EXPECTED FROM THE PROJECT

Some very significant environmental, economic and social benefits will come from implementation of the proposed project:

1). <u>The new plant will be much more environmentally friendly than the existing.</u>

When the proposed 360 MW LNG plant comes on stream, it will replace all of the existing aged (avg. 41 years)HFO steam units at Old Harbour, (total 223.5 MW), and also the 36 year old B6 unit at Hunts Bay in Kingston, (68.5 MW). This means that a). There will be much less greenhouse gases put out in the stack emissions from the new plant at Old Harbour, and there will be much less noise and vibration from operations of the new machinery;

b). The new plant will have a closed-loop cooling water system, which means that there will be much less demand for fresh water for plant operations.

c). The new plant will have built-in continuous emissions monitoring systems, that will give instant warning whenever emissions standards are being exceeded, thereby safeguarding against the possibility of pollutants being discharged to air, land and water without being detected.

2). Enhancement of energy security

Currently 95% of the electricity produced in Jamaica is from imported fuel oil with only 5% from renewable sources. Given the high price and volatility of oil, this situation is untenable and is a barrier to economic growth and well-being of the country.

The introduction of LNG creates an opportunity to create significant fuel diversity thus enhancing energy security of the country.

The proposed LNG project will add 360 MW capacity to the grid in 2015, at which time 292 MW of old generation units will be de-commissioned. This will bring improved reliability to the power grid, due to the extra margin of 68 MW that will become available for future growth, spinning reserve, and prevention of brown or blackouts that may be caused by trips of other power stations connected to the grid.

3). Reduction in the cost of electricity to consumers

High electricity tariffs are a concern in Jamaica, and affect the life of residents, as well as the competitiveness of businesses and industries throughout the country. Current electricity tariffs (including fuel and non-fuel related costs) range from US$0.32 – US$0.39 per kWh (depending on the type of customer). The main reason electricity costs are high in Jamaica is due to the heavy reliance on oil-based fuels that are very expensive. This proposed 360 MW plant will reduce existing power generation costs by changing the fuel source from HFO to LNG, and installing a more fuel-efficient, technologically advanced, power generating system.

4). Introduction of LNG expected to bring 30-40% reduction in overall cost of electricity to Jamaica

Based on an analysis done by JPS, the new plant will help achieve a 30% reduction in the system heat rates by 2015 when operating with natural gas. Such reduction would be achieved as a result of a) improved operational efficiency: and b) the cheaper fuel source relative to oil. Therefore it is expected that the introduction of natural gas to Jamaica will result in a 30 – 40% reduction in the overall cost of electricity for Jamaica, depending on the final burner tip price of natural gas.

5). Improvement in the country's Balance of Payments

It has been estimated that implementation of this project could result in an annual reduction of around US$217 million in the cost of imported fuel, thereby bringing significant improvement in country's balance of payments situation.

Further, a substantial reduction in energy costs, resulting in improvement in the country's balance of payments position, will serve as a catalyst for growth and development in Jamaica.

6). The proposed project will provide employment opportunities.

During construction the community and country will also benefit from the creation of over 1200 job opportunities (400 skilled; 800 unskilled) and creating opportunity for craft skills training and the positive impacts to multiple indirect benefits to service industries (restaurants, taxes, housing).

THE LOCATION OF THE PROJECT SITE

The proposed 360 MW plant will be constructed on a coastal property in Old Harbour Bay, which is a fishing village located at a distance of about 76 km along the highway going out westward from Kingston. The property owned by JPS, is comprised of two separate plots totalling approximately 300 acres. The property has a common boundary on the eastern side with the plant site of the existing JPS Old Harbour power station, and is bounded by the Bowers Gully on the western side.

The property is located within the boundaries of the Portland Bight Protected Area (PBPA), which covers approximately 1,876 square kilometres of terrestrial and marine environment, which makes it the largest designated Protected Area in Jamaica. The proposed project site is bounded on the northern and western sides by industrial lands, to the south by salinas and mangroves, and to the east by industrial lands and informal settlements.

The area is zoned in the Highway 2000 Corridor Development Plan (2004 – 2025) for heavy industrial use.

The Project Schedule.

Site preparation is scheduled to commence by December 2012. Construction of the SJPC 360 MW power plant is scheduled to commence in the second quarter of 2013.

Commercial operation is expected to commence 24 months after the commencement of construction.

Provisions for mitigating sensitive issues.

Surveys carried out amongst stakeholders in communities adjacent to the proposed plant site have revealed that in regard to possible negative impacts that the project might bring to their communities, the issues about which they expressed most concern were:

- The possibility of polluted wastewater being discharged from the plant into the nearshore environment, thus adversely affecting the livelihood of the many who depended on the fish catch from those waters to earn their living;
- That particulates (soot) in aerial emissions from the plant stacks might cause respiratory health problems;
- That noise and vibration from operating machinery might be intolerable.

Information contained in the EIA document gives assurance that the Developers have made satisfactory provisions in the design of the plant to mitigate the above impacts:

<u>Effluent Quality</u>

All wastewater from the plant will be collected in a concrete tank and pre-treated to a satisfactory level and routed through a holding pond to make it fully compliant with NEPA effluent quality standards before being discharged into Bowers Gully. The effluent quality will also be monitored by a continuous monitoring system.

<u>Aerial Emissions</u>

A Continuous Emissions Monitoring System (CEMS) will be provided for measuring levels of pollutants in the exhaust stacks of each HRSG, thereby ensuring that non-compliant emissions will be detected and remedial measures taken to prevent harmful dispersions.

All emissions were compliant with national air quality standards when the plant was modelled to run on LNG. When the new plant comes online and the old plant is decommissioned, there will be an improvement in the air quality within the air shed.

Noise and Vibration

The EIA documents indicate that the Developers have made adequate provisions for mitigating noise and vibration from the proposed new plant. The Developers' design documents anticipate that the levels of noise and vibration that will be coming from the new plant will be significantly less than the levels that are currently being generated by the existing Old Harbour power generation machinery.

Noise mitigative measures will be put in place to make noise emissions complaint with national and international guidelines. This is expected to cost an additional US$8 million.

The plant technology and equipment.

The technology to be used is combined cycle dual fuel capable gas turbine plant in three blocks of 2x2x1 configuration (two gas turbines, two heat recovery steam generators and one steam turbine per block) for a total net output of 360 MW. Combined cycle technology uses heat recovery steam generators, also referred to as waste heat boilers to capture the waste heat in the gas turbine exhaust to generate steam which is used to operate a steam turbine generator. By utilizing the waste heat in this manner, the combined cycle unit achieves superior efficiency compared to conventional competing technologies such as steam boilers and reciprocating engines.

The dual fuel gas turbine units are each 40 MW class, providing nominal 120 MW block sizes in the 2x2x1 configuration. This provides for the best combination of economies of scale while also complying with the OUR requirement that no single event can result in the loss of more than 120 MW to the grid. Each 120 MW nominal block will be designed to operate independently of one another, further enhancing reliability of supply.

Fuel supply.

Recent efforts by the responsible government agencies to procure a reliable supply of natural gas at a price that would result in lowering the price of electricity for Jamaican consumers, have been unsuccessful. Consequently, in order to move forward with their plans to implement this proposed 360 MW LNG project, SJPC is striving to conclude arrangements for providing their own supplies of the necessary LNG. SJPC continues to show full commitment to the objective of providing a 360 MW power plant at Old Harbour, which will primarily be fuelled by natural gas.

The proposed plant will also be able to run on automotive diesel oil as back-up fuel for emergency situations when LNG is unavailable.

Supplies of ADO can be obtained locally from Petrojam. An 18 day ADO fuel tank storage capability will be maintained on site.

Fresh Water supply.

The proposed 360 MW plant will require 13,500m^3/day of freshwater for its operations. JPS has license from WRA to extract a total of 12,000m^3 /day from two existing wells in the Bodles area. The existing Old Harbour plant uses 2,500 m^3/day of freshwater which it extracts from a well also located in the Bodles area in addition to seawater for cooling. Currently, this water is conveyed via pipeline in a right-of-way corridor traversing southwards from Bodles down into the existing power station at Old Harbour Bay. When the proposed new plant comes on stream, and the existing power generation units are de-commissioned, this 2,500m^3/day supply will become available to SJPC from which can be drawn the additional 1,500m^3/day needed for operation of the new plant. The new pipeline coming down from the two new well sources at Bodles will be 18" in diameter (≈45.72 cm). It will be installed within the same right-of-way corridor in which the line supplying the existing plant is laid.

Access Road

The access road will have a width of 9 m, and way-leave requirements of 11 meters. The existing parish council access road will not be used to access the site based on the proximity to the informal settler. The Owner intends to build a new access road from the existing power plant to the new site and to make provisions for the existing access road to be connected to the roadway around the plant on the south boundary.

Physical Environment

Physiography and Topography

The property on which the development will take place is located on south western margins of the Rio Cobre Alluvial Fan complex. It is bounded to the south by the sea and to the west by the seasonal Bowers Gully. The section of the Bowers Gully between the sea and the pipe bridge is an estuary with saline water. Above that point the gully channel only carries water during periods of heavy rainfall. The coast in that area is low-lying, characterized by sand flats, salt marsh/pans and mangrove backing the beaches. Behind the coastal area there are remnants of freshwater fishponds, that are dry and partially filled in. The land slopes gently up from the coastline to reach a maximum elevation of six metres above mean sea level (AMSL) at the northern edge of the property. The property is generally flat with slopes of less then 2%. The elevations of the plant site vary from 0.5m in the disused fishpond and 1.8m on the edge of the ponds to 3.8m AMSL at the northern edge.

Geology and Geotechnical Assessment

The geology of the property consists of Quaternary sediments of the Rio Cobre alluvial fan and the Holocene beach deposits near the coast. The

Quaternary sediments are estimated to be in excess of 100m thick and overlay the limestones of the White Limestone group. Boreholes drilled in the footprint of the proposed power plant to a depth of 30m show a 5 to 7 m thick top zone of very soft and loose clays and silts. Very stiff to hard silty clays were found below these soft deposits all the way to the bottom of the borehole. The deposits were tested for their plastic and liquid limit and were classified as inorganic clays of medium to high plasticity. Peat was found to overlay the very stiff to hard silty clays in some of the boreholes. Ground water was encountered in the boreholes at an average depth of 1.75 m below existing ground elevation which is approximately at sea level.

To overcome the low bearing capacity of the top layer, the main structures of the power plant will be constructed on pile foundations.

Soils

Two soil types occur in the footprint of the power plant: the Lodge Clay (POC1), a deep reddish brown plastic clay which is very hard when dry and very sticky when wet and the Whim Clay Loam (PRb3), a dark to yellowish brown sandy loam or sandy clay with moderate internal drainage. Salina consisting of strongly sodic saline soils of varying textures and colours are present on the SJPC property up to 150m from the coast but not in the footprint of the power plant.

Vulnerability to Natural Hazards

The site is vulnerable to riverine flooding, storm surge, hurricane, earthquake and tsunami. SJPC has taken the necessary measures to minimize the vulnerability associated with these natural hazards.

Biological Environment

Portland Bight Protected Area

The project site is located in the Portland Bight Protected Area (PBPA), which is approximately 187,615 hectare, making it the largest protected area in Jamaica (C-CAM, 2012). The protected area is an important habitat for wetland, sea birds and terrestrial birds (C-CAM, 2012). The PBPA is an environment management zone encompassing large sections of southern St. Catherine and Clarendon, totalling 519.8 km2 of land (IVM, 2000).

Due to the size and diversity of the PBPA, baseline data is sparse and specific to entities/habitats identified as sensitive and of either national or international significance. Large expanses of the area have no baseline data and only generalizations of the identified ecosystems have been used for designated zoning/land uses guidelines. Several faunal species have been identified either by historical evidence or actual on site observations. This includes the Jamaican iguana, once thought to be extinct, and now was rediscovered in the Hellshire Hills. These hills represent the only known habitat of the iguana and are a dry limestone forest of global significance. This is in stark contrast to Old Harbour Bay an area zoned for industrial activities which includes an Ethanol plant and the JPS Power-plant within disturbed coastal systems. The marine environment in the area has also suffered from severe anthropogenic influences, including dynamiting and over fishing as well as hurricane damage. The coral cays in the bight also suffer from similar pressures but again in contrast are home to important birds, turtles and potentially manatees.

Flora

The Flora on the SJPC property consists of a 3 distinct communities of severely disturbed, secondary-succession vegetation types. These communities include a salina that transitions into a degraded wetland near the coast and a patchwork of savannah and thorn savannah in the northern section of the property above the parochial road.

The Degraded Wetland is located towards the southern perimeter of the property but does not occur within the foot print of the planned power plant. Red mangroves gradually changing to black mangroves and white mangroves are present along the banks of the mouth of the Bowers Gully. The Salina ecosystem includes several abandoned ponds which exist as poorly defined depressions (pond basins). The flora consisted mainly of herbaceous, secondary pioneer species. The halophyte, Jamaican Sapphire and the grass, *Sporobolus sp.* are the primary constituents of the flora in the pond basins.

Thorn savannah flora in the northern section of the property consisted mainly of large stands of the thorny leguminous phanerophyte, *Acacia tortuosa* surrounded by several introduced grass species.

The vegetation present within the SJPC property exhibits high levels of persistent anthropogenic influence in the form of tree cutting, charcoal burning, grazing by domestic livestock, fish farming activity and path through the property. This was also evidenced by the secondary communities dominating the flora within and around the property. No endemic or endangered plants were encountered during the assessment. While clear cutting in the footprint of the power plant will be unavoidable it will not result in the loss of endemic, endangered, threatened or rare species. A landscaping plan with indigenous plant species has been proposed for restoration of vegetation around the edges of the plant site.

Fauna

No sea turtles nor crocodiles or signs of their presence were seen within the property boundaries. However four (4) nests of crocodiles and eight (8) juvenile (30 cm long) were observed in the lower, estuarine, section of the Bowers gully. The nests were located on the banks of the gully up to four hundred (400) metres inland measured along the river.

The number of wetland birds seen was very low. This could be because the survey was carried out during the dry season when water levels were low and the wetland dry. In total fourteen (14) birds were observed on the coast, mangrove forest and Salina. The only birds seen in the river were the Great Egret, Little Blue Heron and Yellow- crowned night Heron. Birds which are common in fresh water bodies and rivers such as the Coots, Common Morehen or Grebes were not observed. The salinity of the river may have been attributing to their absence as well as the predation by crocodiles in the river.

Twenty nine terrestrial bird species were observed during the survey of the property. The bird species diversity consisted of 10 endemic birds, 1 endemic/sub species, 15 residents, and 3 migrants. Although the vegetation consists of *Acacia* scrubland, the birds observed during the assessment were typical of a dry limestone forest.

The terrestrial invertebrate fauna is very limited. Fifty four (54) species of insects, five (5) species of spiders and two (2) species of land snails were recorded. The insects were dominated by the Coleoptera and Lepidoptera. The two butterfly species (the Pygmy Blue and The West Indian Buckeye), which are restricted to this type of habitat have a wide Jamaican distribution.

The construction of the plant is not expected to affect in a significant way the fauna in the wetlands and the Bowers River. It is only expected to displace mainly the terrestrial birds living in the woodland vegetation in the northern section of the plant site (approximately 10 acres). The woodland vegetation and the forest adjacent to plant site do provide a habitat option for the forest specialist to migrate to. In addition the landscape plan will contribute to the restoration of that habitat.

The backreef and the coral community has a low biodiversity. The reef is characterised by coral rubble, dispersed small patch reef formations and an unconsolidated substrate dominated by fleshy algae. This characterization corresponds with the finding of the 2005 JCRMN6 (Jamaica Coral Reef Monitoring Network). A total of seven hard coral species were observed. Gorgonians (Sea whips) along with some seagrasses were also observed in the backreef area. The reef appears to have suffered severe damage as a result of natural and anthropogenic impacts, including wave damage during storms and hurricanes, possible dynamiting, nutrient loading and unsustainable fishing practices but no disease or bleaching was observed during the survey. The poor substrate condition makes the settlement and recruitment of coral larvae difficult. Crustose coralline algae which provide a more suitable coral recruitment environment were observed but their occurrence was low. The lack of a stable substratum is further compounded by the large algal mats, sponges and other encrusting organisms which prevent the settlement of larvae. In general, it can be concluded that the reef is severely degraded and would require drastic changes/rehabilitation in order to begin to re-establish a healthy community.

Fish and Invertebrates

The reef fish diversity was also low. The numbers of fish observed were very low and most of these were small adult herbivores indicating that the reef and surrounding areas are overfished and that the nursery function of the habitat is severely reduced. Damselfish were the most abundant. Sea urchins were the most abundant invertebrate, however, no *Diadema* were observed. Other invertebrates observed include; starfish, sea cucumbers and brittle stars. No commercially important species (lobster or conch) and no invasive species (Lionfish or Green Mussel) were observed.

IMPACTS AND MITIGATION

Site Preparation and Construction:

Impact	Mitigation
Soil Erosion and Siltation	• Stockpile fine grained materials away from drainage channels • limits the time that loose material are stored onsite • Install sediment traps on drains which are susceptible to high silt loading • Install trash racks/screens on drains leaving the site • Remove trees only as necessary • Trees with trunks of DBH 20cm and greater should be left intact as much as possible
Water Resources	• Installation of oil separators or interceptors within the drainage system
Vegetation/Habitat Disturbance	• Vegetation mapping should be done prior to site clearance • Fencing off of site area to limit disposal of solid waste into plant communities and restrict encroachment of humans and livestock • Avoid removal of endemic species • If removal is necessary, a nursery should be established for maintenance and propagation of endemic and naturally occurring plants • A buffer area should be established and maintained between the project area and surrounding vegetation • Proper planning regarding access points to construction site should be established • Further planning required to establish development zones within nearby lands, villages and towns to prohibit development of nearby areas
Fauna (removal of habitats)	• Crocodiles are present in the river and nesting occurs on the banks. • Signage and fencing should be erected around the site. • The nesting site should be protected from the development. • The fishermen/locals in the area need to inform about the legal implications of killing crocodiles. • Construction workers will be sensitized to the presence of crocodiles in the area • Some of the infrastructure on the property should be designed with the wildlife in mind such as the drains and the location of the garbage area.

Impact	Mitigation
	• A few of the temporary ponds in the wetland should be left as is for the wetland birds during the wet season.
Excavation works	• Oil and leaking machinery should be prevented from entering the construction area.
Noise Pollution	• Use equipment with low noise emissions as stated by manufacturer, and fitted with noise reduction devices such as mufflers • Operate noise-generating equipment during regular working hours (e.g. 7am – 7pm) to reduce potential of creating noise nuisance at night • Construction workers operating noise-generating equipment should be equipped with noise protection (ear muffs, ear plugs)
Air Quality	• Areas should be dampened every 4-6 hours or within reason to prevent a dust nuisance, and on hotter days this frequency should be increased • Minimize cleared areas to those that are needed to be used • Cover or wet construction materials such as marl • Where unavoidable, construction workers working in dusty areas should be provided and fitted with N95 respirators
Solid Waste Generation	• Skips and bins should be strategically placed within the campsite and construction site, and adequately designed and covered to prevent access by vermin and minimise odour • The skips and bins at both the construction campsite and construction site should be emptied regularly to prevent overfilling • Disposal of the contents of the skips and bins should be done at an approved disposal site
Wastewater Generation/Disposal	• Provide portable sanitary conveniences for the construction workers for control of sewage waste. A ratio of approximately 25 workers per chemical toilet should be used
Storage of Raw Material/Equipment	• A central area 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. • Raw materials that generate dust should be covered or wet frequently to prevent them from becoming air or waterborne • Fine grained materials (sand, marl, etc.) will be stockpiled away from drainage

Impact	Mitigation
	channels such as the Bowers Gully 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 and equipment should be placed on hardstands 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 berms to contain the volume being stored in case of accidental spillage.
Transport of Raw Material/Equipment	• Paths of the planned roadways should be used, rather than creating temporary pathways just for equipment access. • Adequate and appropriate road signs should be erected to warn road users of the construction activities. For example reduced speed near the construction site. • 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 be 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. • Crossing guards will be used to ensure safety of school children crossing Terminal Road
Worker Safety	• The provision of lifelines, personal safety nets or safety belts and scaffolding for the construction workers. • Adequate communication with workers and signage should be put in place to alert/inform workers of the time, location of such blasting and instructions.
Traffic Management	• Any detours should be done to minimize any increase in travel distance when compared to the existing routes. • Place adequate and appropriate construction warning signs. • Give adequate and ample notice of the pending road works and detours. • Delivery trucks and heavy equipment delivery should happen during off peak hours. • Loading of truck as per NWA axel load guidelines.

Impact	Mitigation
Cultural and Historical	• Monitoring should be conducted during clearing and grubbing stages in areas where historic artefacts were discovered. • Watching briefs should be carried out by the JNHT during clearing and grubbing stages of the proposed Project.

Operation:

Impact	Mitigation
Stormwater Runoff and Flooding	• In light of these increases it is recommended that the newer rainfall return intensities obtained from the Met office datasets be used for hydrological models. • Flood plain analysis should be conducted to identify the areas which are prone to flooding and install suitable drainage infrastructure Consider the use of detention ponds or retarding basins which aid in the reduction of the peak flows in the drains • A containment bund as well as oil-water separators should be installed for containment and treatment • Detention areas should be included to reduce the peak discharge to Bowers Gully
Natural Hazards	• Ensure that the new structures can withstand hurricane, flood and earthquake impacts. • Ensure that the new structures are designed to withstand a 50 –100 year flood event. • An emergency response plan to address natural and man-made disaster and possible evacuation is required by NEPA and should be developed in close consultation with the Office of Disaster Preparedness and Emergency Management (ODPEM).
Polluted runoff from wash down activities	• Drains should be connected to oil water separators
Water quality	• Conduct water quality assessments to determine if the operations are having a negative impact on the environment.
Vegetation maintenance	• Suitable trees and shrub shall be identified and used for onsite revegetation.

Impact	Mitigation
Fauna (increased access to wildlife)	• Staff should be sensitized to contact with fauna in an around the work area. • The fishermen/locals in the area need to inform about the legal implications of killing crocodiles. • Proper warning signage and fencing should be erected on and around the power plant site. • Trees should be planted to encourage birdlife in the area after the development.
Increased noise pollution	• Conduct noise assessments to determine if the operations are having a negative impact on the environment. • Where necessary, noise mitigative structures should be put in place such as noise barriers, etc. • Use equipment that has low noise emissions as stated by the manufacturers. • Use equipment that is properly fitted with noise reduction devices such as mufflers. • Work with the equipment manufacturer to sound proof selected equipment namely the steam turbines, gas turbine and generator, HRSG and cooling tower.
Noise exposure	• Provision of Personal Protective Equipment (PPE) e.g. noise muffs, plugs, helmets and Personal fall arrest systems (PFAS). • Establish a hearing conservation programme. • Work with the equipment manufacturer to sound proof selected equipment namely the steam turbines, gas turbine and generator, HRSG and cooling tower.
Occupational Health and Safety	• Provision of Personal Protective Equipment (PPE) e.g. noise muffs, plugs, helmets and Personal fall arrest systems (PFAS). • Establish a hearing conservation programme. • Ensure adequate ventilation within the work area. • A programme to monitor the thermal comfort of workers will be implemented. • Lighting levels (illumination) should be area specific and will be a function of the nature of activity that is being conducted. It should be adequate to enable a safe, comfortable and productive workers environment. • A confined space policy will be developed and implemented. • Use the Occupational Safety and Health Administration (OSHA) standard 1910 as a

Impact	Mitigation
	guide to Occupational Health and Safety matters.
Potential for oil spills	• Containment bunds and oil water separators should be installed • The bund shall be impermeable with no apertures and should be able to contain 110% of the volume of the capacity of the petroleum storage tank. • If it is more than one tank, the area for storage should also be impermeable and be able to contain 100% of the capacity of the largest tank plus 10 percent of the capacity of the remaining tanks.
Solid waste disposal	• Provision of solid waste storage bins and skips. • Contracting a private contractor to collect solid waste in a timely fashion to prevent a build-up. • Ensure that the solid waste collected is disposed in an approved dumpsite such as the Riverton dump in Kingston.
Wastewater Discharge	• The drains should be connected to oil water separators. • Containment areas should be installed for any spillage of hazardous materials.
Thermal exposure	• A programme to monitor the thermal comfort of workers will be implemented.

2.0 INTRODUCTION

The Office of Utilities Regulation (OUR) invited proposals for the Supply of up to 480 MW of Base-Load Generating Capacity on a Build, Own and Operate (BOO) basis to increase the generating capacity on the island on December 13, 2011. This development will be undertaken over the next five years from 2011 to 2016 in two tranches. The first tranche (360MW) is proposed for completion in 2014 and the second tranche in 2016. This new capacity will be base-load and is intended for the replacement of approximately 292 MW of inefficient heavy fuel oil burning aged plants with the remainder to provide for load growth. Jamaica Public Service Company Limited (JPS) was awarded the right to go forward with the project – 360 MW Combined Cycle Plant.

"The gross peak demand to date is 644 MW and the average system load factor is approximately 74%. JPS supplies this demand from a functional firm system capacity 2 of approximately 785MW of which 190MW is provided by Independent Power Producers (IPPs). Of the 595 MW of capacity owned by JPS 292MW of its base-load capacity is over thirty-three (33) years old and represents some of the most inefficient plants on the system.

There is also a number of self-producers of electricity in the country, with the largest being the bauxite alumina companies and the sugar refineries" (Office of Utilities Regulation, December 2010).

South Jamaica Power Company (SJPC) Limited is an Independent Power Producer to which JPS has assigned its project rights to undertake the proposed 360 Power Generation Project.

3.0 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

3.1 BACKGROUND

An Environmental Impact Assessment (EIA) is “a structured approach for obtaining and evaluating environmental information prior to its use in decision-making in the development process. This information consists, basically, of predictions of how the environment is expected to change if certain alternative actions are implemented and advice on how best to manage environmental changes if one alternative is selected and implemented” (Bisset, 1996).

The basis and rationale of an EIA has been summarised as follows[1]:

- Beyond preparation of technical reports, EIA is a means to a larger end - the protection and improvement of the environmental quality of life.
- It is a procedure to discover and evaluate the effects of activities on the environment - natural and social. It is not a single specific analytical method or technique, but uses many approaches as appropriate to the problem.
- It is not a science but uses many sciences in an integrated inter-disciplinary manner, evaluating relationships as they occur in the real world.
- It should not be treated as an appendage, or add-on, to a project, but regarded as an integral part of project planning. Its costs should be calculated as a part of adequate planning and not regarded as something extra.
- EIA does not ‘make’ decisions, but its findings should be considered in policy - and decision-making and should be reflected in final choices. Thus, it should be part of decision-making processes.

[1] Wood, C., “Environmental Impact Assessment: A Comparative Review” p. 2. (from Caldwell, 1989, p.9)

- The findings of EIA should focus on the important or critical issues, explaining why they are important and estimating probabilities in language that affords a basis for policy decisions.

3.2 PLANNING AND DEVELOPMENT

3.2.1 Introduction

This section will deal with planning and development issues that can affect the establishment of a Power Generating Plant at Old Harbour Bay. Several development and planning related laws and regulations may affect the project. The applicability of these laws is dependent on the location of the development chosen, social and socio-economic issues as well as the availability of land for acquisition. Listed below are the relevant legislations and regulations that may affect the project.

3.2.2 Relevant Legislation

3.2.2.1 Town and Country Planning Act (TCP Act), 1957 (Amended 1987)

This act provides the statutory requirements for the orderly development of land (planning) as well as guidelines for the preparation of Development Orders, stipulations for Advertisement Control Regulations, Petrol Filling Stations and Tree Preservation Orders. It makes provisions for the establishment of a Town and Country Planning Authority, which in conjunction with the Local Planning Authorities, (Parish Councils), prepare Development Orders for various areas of the country. These Orders are legal documents which govern land development in such areas. The St. Catherine Coast Development Order Map is depicted in Figure 3-1.

3.2.2.2 Local Improvement Act, 1944

The Local Improvements Act is the primary statute that controls the subdivision of land.

3.2.2.3 Parish Council Act

Under the Parish Council Act each Local Planning Authority may revoke or alter regulations concerning the construction and restrictions as to the elevation, size and design of buildings built with the approval of the relevant Minister. It may also make regulations concerning the

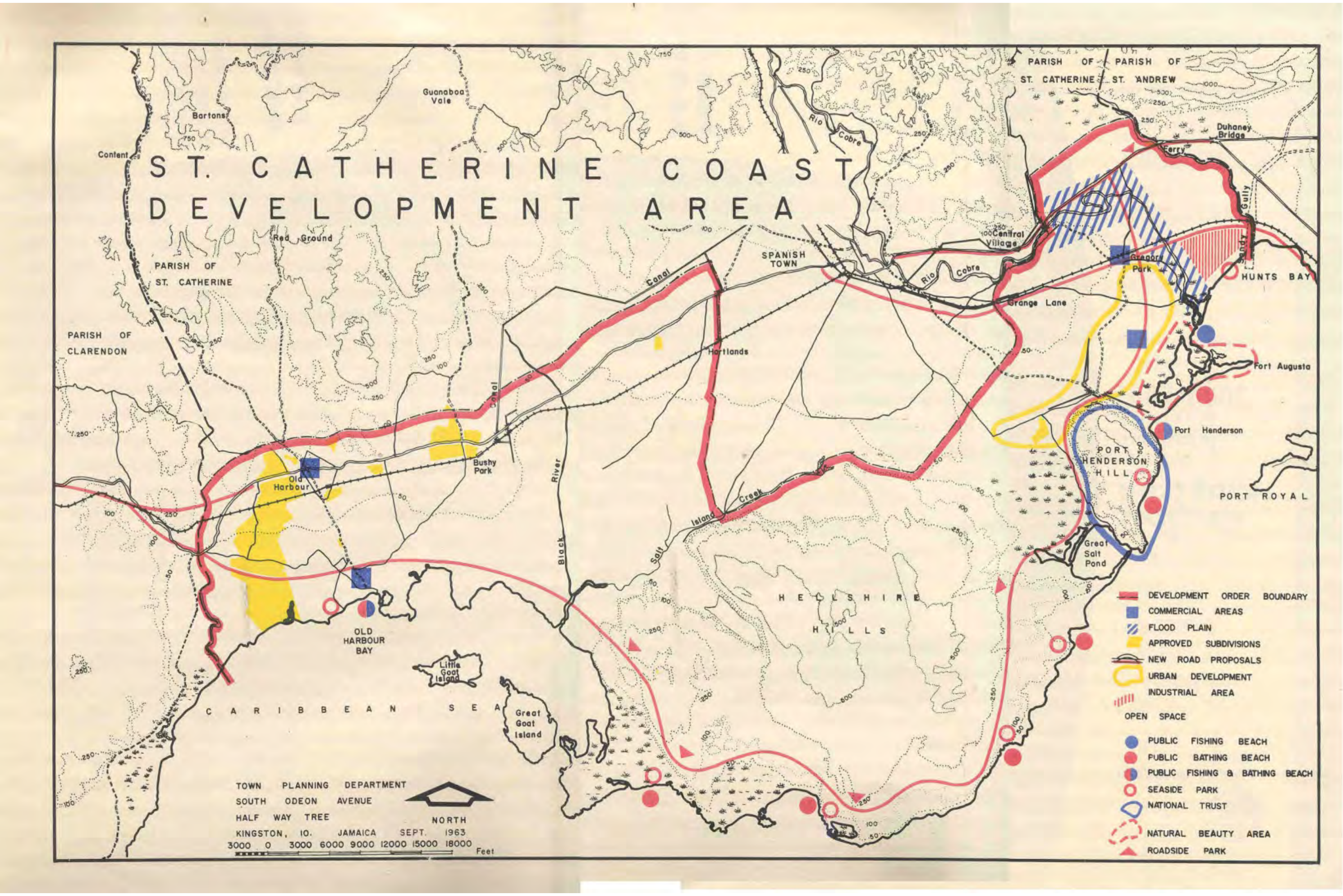


Figure 3-1 – St Catherine Coastal Development Order map installation of sewers on premises.

3.2.2.4 Office of Utilities Regulation (OUR) Act 1995 (Amended 2000)

This Act was promulgated in 1995. Under this legislation, the OUR:

- Receives and processes applications for a licence to provide a prescribed utility service and make such recommendations to the Minister in relation to the application as the Office considers necessary or desirable.
- Carry out, on its' own initiative or at the request of any person, such investigations in relation to the provision of prescribed utility services as will enable it to determine whether the interests of consumers are adequately protected.
- In relation to environmental management and protection, the OUR may, where it considers necessary, give directions to any licensee or specified organization with a view to ensuring that the prescribed utility service operates efficiently and in a manner designed to:
    1. Protect the health and well-being of users of the service and such elements of the public as would normally be expected to be affected by its operation;
    2. Protect and preserve the environment; and
    3. Afford to its consumers economical and reliable service.

3.2.2.5 Vision 2030 and National Energy Policy

Vision 2030 is a National Development Plan for Jamaica, promoting four National Goals as well as associated National Outcomes for each goal, to be achieved by 2030, with the objective of developing Jamaica into a country with a vibrant and sustainable economy, society and environment; a high level of human capital development; greater opportunities and access to these opportunities for the population; and a high level of human security. Of the aforementioned outcomes, two apply directly to the proposed 360 MW Power Generation Project:

- National Outcome 10: Energy Security and Efficiency (under Goal 3: "Jamaica's Economy is prosperous.") and;

- National Outcome 13: Sustainable Management and Use of Environmental and Natural Resources (under Goal 4: “Jamaica has a healthy natural environment.”)

The proposed development will replace approximately 292 MW of heavy oil burning plants with a 360 MW combined cycle plant, that will be dual fuel capable, with natural gas as the primary fuel and automotive diesel oil (ADO) as the back-up fuel. The outcomes outlined above are incorporated by directly increasing the country’s energy efficiency, as well as considering environmental repercussions and outlining mitigation activities throughout the development of this plant.

In further accordance with Vision 2030, the proposed development also aligns with the Ministry of Energy and Mining’s National Energy Policy, created under the umbrella of Vision 2030. A synopsis of the goals and elements of the National Energy Policy (Vision of Jamaica’s Energy Sector 2009 – 2030) is as follows:

- Goal 1: Jamaicans use energy wisely and aggressively pursue opportunities for conservation and efficiency.
- Goal 2: Jamaica has a modernized and expanded energy infrastructure that enhances energy generation capacity and ensures that energy supplies are safely, reliably, and affordably transported to homes, communities and the productive sectors on a sustainable basis.
- Goal 3: Jamaica realizes its energy resource potential through the development of renewable energy sources and enhances its international competitiveness, energy security whilst reducing its carbon footprint.
- Goal 4: Jamaica’s energy supply is secure and sufficient to support long-term economic and social development and environmental sustainability.
- Goal 5: Jamaica has a well-defined and established governance, institutional, legal and regulatory framework for the energy sector that facilitates stakeholder involvement and engagement.
- Goal 6: Government ministries and agencies are a model/leader in energy conservation and environmental stewardship in Jamaica.

- Goal 7: Jamaica's industry structures embrace eco-efficiency for advancing international competitiveness and moves towards building a green economy.

The long-term strategic vision is built on ten (10) fundamental elements as follows[2]:

1. An energy sector that provides affordable energy supplies to all consumers throughout Jamaica with the capacity to meet long-term growth in demand; and one that contributes to the international competitiveness of the productive sectors of the economy.
2. An energy sector that is supported by greater awareness by the Jamaican public of the importance of energy and its use in their daily lives and the contribution that each can make to the responsible and efficient use of this vital commodity.
3. An energy sector that is focused on the modernization and expansion of the energy infrastructure (e.g. generation, transmission and distribution systems) to ensure safety, affordability, reliability and competitive advantage.
4. An energy sector that is driven by private sector investment within a policy and regulatory framework that fosters investments, competition, efficiency, a level playing field and transparency.
5. An energy sector that provides long-term energy security to producers and consumers in Jamaica, including security of supply and to the fullest extent possible, long-term price stability.
6. An energy sector supported by databases that are accurate and precise to enable analysis, forecasting and overall management of the sector, especially information related to the transportation sector.
7. An energy sector that is environmentally sustainable with significantly increased use of economically viable renewable energy sources.
8. An energy sector that reflects a sustained improvement in the ways in which energy is used, through greater energy efficiency,

[2] Source: http://ocs.mona.uwi.edu/public/conferences/12/schedConfs/11/energyPolicyOctober212009.pdf (July 19, 2012)

reduced energy intensity and better energy conservation and management.

9. An energy sector that possesses the flexibility and creativity to adopt and adapt to new and appropriate energy technologies (such as fuel cells, small nuclear plants) that may emerge over the long-term.
10. An energy sector with an appropriate institutional framework to support and facilitate the effective implementation of the policy supported by all relevant stakeholders, including the public and private sectors, educational institutions as well as non-governmental and community based organizations. The institutional framework will include among others: mechanisms for improved coordination and organization between and within energy agencies; capacity building to face the challenges regarding fossil fuel supplies and costs.

The National Energy Policy seeks to develop a modern, efficient, diversified and environmentally sustainable energy sector providing affordable and accessible energy supplies, with long-term energy security and supported by informed public behaviour on energy issues and an appropriate policy, regulatory and institutional framework. This expansion project being undertaken fulfils the goal of modernizing the energy sector as well as making it more efficient through the primary use of LNG and allowing energy to be more accessible through the replacement of an older, less efficient, power plant with a newer, higher capacity, dual fuel capable plant.

3.2.2.6 Office of Utilities Regulation (OUR) Act

This Act was promulgated in 1995. Under this legislation, the OUR:

- Receives and processes applications for a licence to provide a prescribed utility service and make such recommendations to the Minister in relation to the application as the Office considers necessary or desirable.
- Carry out, on its' own initiative or at the request of any person, such investigations in relation to the provision of prescribed utility services as will enable it to determine whether the interests of consumers are adequately protected.

- In relation to environmental management and protection, the OUR may, where it considers necessary, give directions to any licensee or specified organization with a view to ensuring that the prescribed utility service operates efficiently and in a manner designed to:
    - Protect the health and well-being of users of the service and such elements of the public as would normally be expected to be affected by its operation;
    - Protect and preserve the environment, and;
    - Afford to its consumers economical and reliable service.

3.2.3 Agencies and Their Functions

The list below indicates the relevant Agencies that may be encountered for planning and development approvals:

- St. Catherine Parish Council (Local Planning Authority - LPA) – All development applications are made through the LPA which include enquiries, planning, building and subdivision approvals.
- National Environment and Planning Agency (NEPA) - Applications reviewed by NEPA include enquiries, planning applications, and building and subdivision applications.
- Factories Cooperation of Jamaica- Guidelines for safety, health and welfare of factory employees.

3.3 ENVIRONMENTAL

3.3.1 Introduction

This section will deal with environmental related laws and regulations that may affect the project. Listed below are the relevant legislations and regulations that may affect the project.

3.3.2 Relevant Legislation

3.3.2.1 Natural Resources Conservation Act (1991)

The Natural Resources Conservation Act (NRCA) may be considered Jamaica's umbrella environmental law. The purpose of the Act is to provide for the management, conservation and protection of the natural resources of Jamaica. This Act was passed in the Jamaican Parliament in

1991 and subsequent to this, the Natural Resources Conservation Authority (NRCA) was established with the function of taking necessary steps to ensure the sustainable development of Jamaica through the protection and management of Jamaica's physical environment. The NRCA Act, under Sections 9 and 10 specifies that an Environmental Impact Assessment (EIA) is required from an applicant for a permit for undertaking any new construction, enterprise or development.

3.3.2.2 The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order (1996)

Section 9 of the NRCA Act declares the entire island and the territorial sea as 'prescribed area', in which specified activities require a permit and for which activities an environmental impact assessment may be required. The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order (1996) and the Permits & Licensing Regulations (Section 2.2) was passed as a result of section 9 of the NRCA Act.

3.3.2.3 The Natural Resources Conservation Authority (Air Quality) Regulations, 2002

Under section 38 of the NRCA Act, regulations pertaining to air quality in Jamaica are stipulated. The National standards, known as the National Ambient Air Quality Standards (NAAQS) are categorized into two groups.

Part I of the NRCA Air Quality Regulations (2002) instructs on license requirements and indicates that every owner of a major or significant facility shall apply for an air pollutant discharge license. Part II makes reference to the stack emission targets, standards and guidelines.

3.3.2.4 Water Quality Standards

The NRCA has primary responsibility for control of water pollution in Jamaica. National Standards for industrial and sewage discharge into rivers and streams, in addition to standards for ambient freshwater exist. For drinking water, WHO Standards are utilized and these are regulated by the National Water Commission (NWC).

Since 1996, Jamaica has had draft regulations governing the quality of the effluent discharged from facilities to public sewers and surface water systems. These draft guidelines require the facility to meet certain basic water quality standards for trade effluent including sewage.

3.3.2.5 Wild Life Protection Act (1945)

The Wild Life Protection Act of 1945 is mainly concerned with the protection of specified faunal species. Under this Act, the removal, sale or possession of protected animals; use of dynamite, poisons or other noxious material to kill or injure fish; and the discharge of trade effluent or industrial waste into harbours, lagoons, estuaries and streams are prohibited. In addition, this Act protects several rare and endangered faunal species including six species of sea turtle, one land mammal, one butterfly, three reptiles and a number of game birds. The establishment of Game Sanctuaries and Reserves is authorized under this Act.

3.3.2.6 The Endangered Species Act (2000)

The Endangered Species (Protection, Conservation and Regulation of Trade) Act was created in 2000 in order to ensure the codification of Jamaica's obligations under the Convention for the International Trade in Endangered Species of Wild Fauna and Flora. This Act governs international and domestic trade in endangered species in and from Jamaica. Under this act, the functions of NEPA include the grant of permits and certificates for the purpose of international trade, the determination of national quotas and the monitoring of the trade in endangered species. Sea turtles, in addition, to yellow snakes and parrots are often traded illegally internationally and are endangered.

3.3.2.7 Water Resources Act (1995)

The Water Resources Act (1995) was promulgated in the Jamaican Parliament in September 1995 and ratified in April 1996. This Act established the Water Resources Authority (WRA), which is authorized to regulate, allocate, conserve and manage the water resources of the island. The WRA is also responsible for water quality control; as stipulated under Section 4 of the Act the WRA is responsible for providing any department or agency of Government, technical assistance for any projects, programmes or activities relating to development, conservation and the use of water resources.

Section 25 advises that a proposed user will have to obtain planning permission, if this is a requirement, under the Town and Country Planning Act. In addition, under Section 21 it states that if the water to be used will result in the discharge of effluents, an application for a license to discharge effluents will have to be made to the Natural Resources Conservation Authority or any other relevant body as indicated by the Minister.

3.3.2.8 The Beach Control Act (1956)

This Act was passed in 1956 to ensure the proper management of Jamaica's coastal and marine resources by means of a licensing system. This system regulates the use of the foreshore and the floor of the sea. In addition, the Act speaks to other issues including access to the shoreline, rights related to fishing and public recreation and establishment of marine protected areas. The Beach Control Authority (Licensing) Regulations of 1956 require a permit for any works on a beach, coastline or foreshore. Application for this permit must be made to NEPA. The requirements of the permit include a Notice of Application to be posted on the landward and seaward sides of the property and said Notice should be served on adjoining neighbours.

3.3.2.9 Noise Abatement Act (1997)

The Noise Abatement Act of 1997 was created in order to regulate noise caused by amplified sound and other specified equipment. This act has been said to address "some concerns but is too narrow in scope and relies on a subjective criterion" (McTavish). Given this, McTavish conducted a study to recommend wider and more objective criteria in accordance with international trends and standards, but tailored to Jamaica's conditions and culture. To date, apart from the Noise Abatement Act (1997), Jamaica has no other National legislation for noise, but World Bank guidelines have been adopted by NEPA and are used for benchmarking purposes along with the draft National Noise Standards that are being prepared.

3.3.2.10 Public Health Act

The Public Health (Air, Soil and Water Pollution) Regulations (1976) aims to control, reduce or prevent air, soil and water pollution in all forms. Under the regulations:

- No individual or organization is allowed to emit, deposit, issue or discharge into the environment from any source;
- Whoever is responsible for the accidental presence in the environment of any 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; and
- No industrial waste should be discharged into any water body, which will result in the deterioration of the quality of the water.

3.3.2.11 The Clean Air Act (1964)

The Clean Air Act (1964) refers to premises on which there are industrial works, the operation of which is, in the opinion of an inspector, likely to result in the discharge of smoke, fumes, gases or dust in the air. An inspector may enter any affected premises to examine, make enquiries, conduct tests and take samples of any substance, smoke, fumes, gas or dust that may be considered necessary or proper for the performance of his/her duties.

3.3.2.12 The National Solid Waste Management Authority Act (2001)

The National Solid Waste Management Authority Act of 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 and for matters connected therewith or incidental thereto”. The National Solid Waste Management Authority (NSWMA) was established in April 2002 as a result of this Act to effectively manage and regulate the collection and disposal of solid waste in Jamaica. As such, the NSWMA aims to safeguard public health and the environment by ensuring that domestic waste is collected, sorted, transported, recycled, reused or disposed of in an environmentally sound manner. In addition, public awareness and education is a part of their responsibilities.

3.3.2.13 Cartagena Convention (Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region) (1983)

Adopted in March 1983 in Cartagena, Colombia, the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, more commonly referred to as the Cartagena Convention, is the sole legally binding environmental treaty for the Wider Caribbean. The Convention came into force in October 1996 as a legal instrument for the implementation of the Caribbean Action Plan and represents a commitment by the participating countries to protect, develop and manage their common waters individually and jointly. The Convention was ratified by twenty (20) countries and acts as a framework agreement that sets out the political and legal foundations for actions to be developed.

The operational Protocols, which direct these actions, are designed to address special issues and to initiate concrete actions. The Convention is currently supported by three Protocols as follows:

- The Protocol Concerning Co-operation in Combating Oil Spills in the Wider Caribbean Region (The Oil Spills Protocol), which was adopted and entered into force at the same time as the Cartagena Convention;
- The Protocol Concerning Specially Protected Areas and Wildlife in the Wider Caribbean Region (The SPAW Protocol), which was adopted in two stages, the text in January 1990 and its Annexes in June 1991. The Protocol entered into force in 2000;
- The Protocol Concerning Pollution from Land-based Sources and Activities in the Wider Caribbean Region (LBS Protocol), which was adopted in October, 1999.

3.3.2.14 The Convention on Biological Diversity

Signed by 150 government leaders at the 1992 Rio Earth Summit, the Convention on Biological Diversity (CBD) is committed to promoting sustainable development. The CBD is regarded as a means of translating the principles of Agenda 21 into reality and recognizes that “biological diversity is about more than plants, animals and microorganisms and their ecosystems – it is about people and our need for food security, medicines, fresh air and water, shelter and a clean and healthy environment in which to live".

The CBD may be considered the first global, comprehensive agreement which focuses on all aspects of biodiversity, to include genetic resources, species and ecosystems. In order to achieve its main goal of sustainable development, signatories are required to:

- Develop plans for protecting habitat and species.
- Provide funds and technology to help developing countries provide protection.
- Ensure commercial access to biological resources for development.
- Share revenues fairly among source countries and developers.
- Establish safe regulations and liability for risks associated with biotechnology development. Jamaica's Green Paper Number 3/01, 'Towards a National Strategy and Action Plan on Biological Diversity in Jamaica', is evidence of Jamaica's continuing commitment to its obligations as a signatory to the Convention.

3.3.2.15 Factories Act (1961)

The Factories Act guides employers operating factories in safety, health and welfare provisions. Any plans for new factories need to be provided to the Chief Factory Inspector. Some of the issues outlined under safety include having proper fire escapes and that all electrical apparatus must be properly installed. Under health and welfare, issues such as suitable sanitary conveniences, effective lighting, reasonable temperatures shall be maintained and personal protective equipment (PPE) shall be provided where applicable.

3.3.2.16 Protected Areas and Management Policy

According to the NRCA, a protected area is "an area of land or water that is managed for the protection and maintenance of its ecological systems, biodiversity and/or specific natural, cultural or aesthetic resources."

A variety of organisations manage Jamaica's several existing types of protected areas.

Areas authorised in the Natural Resource Conservation Authority Act of 1991. The national system also encompasses areas established under other legislation and will continue to do so. The NRCA has responsibility under the Wild Life Protection Act, the Watersheds Protection Act and the Beach Control Act for certain protected areas, including game sanctuaries and game reserves. Management authority for other areas is conferred on the responsible agency by its establishing legislation, such as the Fishing Industry Act (1975), the Forest Act (1937), and the Jamaica National Heritage Trust Act (1985).

- Designates, by regulation, areas for environmental preservation and conservation. The Portland Bight Protected Area was declared in 1999 because of its rich natural resources and biodiversity. The NRCA has designated the Non-Governmental Organization (NGO) Caribbean Coastal Area Management Program (CCAMP) as co-managers with themselves.

3.3.2.17 Jamaica National Heritage Trust Act (1985)

The Jamaica National Heritage Trust Act has been in operation since 1985 with the main goal of preserving and protecting the country's national heritage. This Act established the Jamaica National Heritage Trust (JNHT) whose functions are outlined in Section 4 of the Act as follows:

- To promote the preservation of national monuments and anything designated as protected national heritage for the benefit of the Island;
- To conduct such research as it thinks necessary or desirable for the purposes of the performance of its functions under this Act;
- To carry out such development as it considers necessary for the preservation of any national monument or anything designated as protected national heritage;
- To record any precious objects or works of art to be preserved and to identify and record any species of botanical or animal life to be protected.

The Act also states the following offences are liable to a fine and/or imprisonment:

- Wilfully defacing, damaging or destroying any national monument or protected national heritage;
- Wilfully defacing, destroying, concealing or removing any mark affixed or connected to a national monument or protected national heritage;

- Altering any national monument or marking without the written permission of the Trust;
- Removing any national monument or protected national heritage to a place outside of Jamaica.

3.4 INTERNATIONAL GUIDELINES

3.4.1 Overview of Equator Principle Requirements

The Equator Principles (EPs) is 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 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

(http://www.equator-principles.com/index.php/about-ep).

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 Guidelines (EHS Guidelines).

3.4.1.1 IFC Performance Standards on Social and Environmental Sustainability

Of the eight (8) Performance Standards, seven (7) are applicable (1, 2, 3, 4, 5, 6 and 8). These standards relate to;

Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts

Performance Standard 2: Labor and Working Conditions

Performance Standard 3: Resource Efficiency and Pollution Prevention

Performance Standard 4: Community Health, Safety, and Security

Performance Standard 5: Land Acquisition and Involuntary Resettlement

Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources

Performance Standard 8: Cultural Heritage

3.4.2 Regulatory Requirements

The Jamaican EIA process has been strongly influenced by the original World Bank Guidelines on EIAs. This EIA report has been reviewed for compliance with International Finance Performance (IFC) Standards 2012 and The World Bank Group Environmental, Health and Safety Guidelines (2007 & 2008) and meets all requirements for the Project from design to implementation.

The outline of the EIA report includes;

- Executive Summary
- Policy, legal and administrative framework
- Project description
- Baseline data
- Environmental Impacts
- Analysis of Alternatives
- Environmental Management Plan (called Action Plan in this document) considering:
    - Mitigation
    - Monitoring
    - Capacity development and training (to ensure maintenance)
    - Implementation Schedule and Cost Estimates for mitigation, monitoring and capacity building
    - Integration of the Plan with the Project
- Appendices including report preparers, references, record of meetings, data, list of associated reports.

The Bank also provides guidelines which promote minimal resource consumption, including energy use, and the elimination or reduction of pollutants at the source. Pollution control systems are required to meet these specified emission limits. All of the maximum levels should be achieved for at least 95% of the time that the plant or unit is operating. Guidelines are provided for the following pollution factors (Appendix 1).

- Air Emissions
- Liquid Effluents
- Hazardous Materials and Wastes
- Solid Wastes
- Ambient Noise
- Occupational Health and Safety

The power plant is more than 50MW.

3.5 EIA PROCESS

3.5.1 NRCA/NEPA Process

Under Section 9 of the NRCA Act, all activities associated with Power Plant facilities (e.g. wind farms, hydro, thermal, nuclear) such as the SJPC Power Plant will require a Permit for construction and may, under Section 10 of the Act, require an EIA. The EIA Process is described below:

- The NRCA permit procedure is initiated by the submission of the Project Information Form (PIF) to the Authority. The PIF screening form is reviewed to determine whether an EIA is required and to begin determining areas of environmental significance, especially in waste discharge.

Based on the review of the PIF, the NRCA advised SJPC that an EIA would be required for their development. The consultant then liaises with the NRCA to determine the scope of the EIA through proposed Terms of Reference (TORs). The TORs are proposed by the consultant using NRCA guidelines and are approved by the NRCA.

- Appendix 2 gives the approved TORs for the proposed power plant development.
- The EIA is then prepared by a multi-disciplinary team of professionals (Appendix 3). The NRCA requires that the EIA include the following:
- A description of the present environment, i.e. physical, biological and social environment. This includes, for example, consideration of economic situations, cultural heritage and ecological preservation;
    - A description of the significant impacts the environmental professionals expect the development to have on the environment, compared to the environment that would remain if there were no development. This will include indirect and cumulative impacts;
    - An analysis of alternatives that were considered in order to consider means of minimising or eliminating the impacts identified above; and
    - An Environmental Management Plan, which includes a Monitoring & Hazard Management Plan and an Auditing schedule.
- The NRCA guidance on EIAs states that this process "should involve some level of stakeholder consultation in either focus groups or using structured questionnaires." A draft EIA is submitted to the developer to solicit the proponents' input into the description of the project (to check for accuracy of statements, and to enter into realistic discussions on the analysis of alternatives, as well as to inform the proponents of any other relevant legislation with which they must comply).
- Fourteen copies of the finalised draft are then submitted to NRCA, two to the client, and the consultant keeps one (17 in all are produced). The NRCA distributes these to various other public sector institutions who sit on the Technical Committee (e.g. Water Resources Authority (WRA), Environmental Control Division in the Ministry of Health (ECD), Jamaica National Heritage Trust (JNHT)) for their comments. Typically this depends on the nature of the project.
- As deemed necessary by the NRCA, Public Meetings are then held, following the deposition of the Draft EIA at Parish Libraries (by the NRCA). A verbatim report of the public meetings is required,

as well as a summary report of the main stakeholder responses which emerged.

- The comments of the NRCA, the other GOJ interests and the public are compiled and submitted in writing to the consultant not only for finalisation of the report, but for incorporation into the development's design.
- The NRCA then reviews this report again, and if further clarifications are needed, these are again requested. Once the NRCA is satisfied, the EIA is submitted to the Technical Committee of the NRCA Board for final approval. If the EIA is not approved, the proponents may appeal to the Office of the Prime Minister.

3.5.1.1 Public Participation in EIA's

There are usually two forms of public involvement in the EIA process. The first is direct involvement of the affected public or community in public consultations during the EIA study. These consultations allow the developer to provide information to the public about the project and to determine what issues the public wishes to see addressed. The extent and results of these consultations are included in the documented EIA report.

The second level of involvement is at the discretion of the NRCA and takes place after the EIA report and addendum, if any, has been prepared and after the applicant has provided the information needed for adequate review by NRCA and the public.

Community interaction and transparency is a critical area of focus for the success of this development and the second level of involvement described above is possible. Please see Appendix 4 for the NRCA reference document entitled "Guidelines for Public Participation" in EIAs.

4.0 COMPREHENSIVE DESCRIPTION OF THE PROPOSED PROJECT

4.1 THE PROPONENT

South Jamaica Power Company

South Jamaica Power Company Limited (SJPC) is a company duly incorporated under the laws of Jamaica with registered office at 6 Knutsford Boulevard, Kingston 5 in the parish of St. Andrew. SJPC is a special purpose company, with shareholders being East West Power (Barbados) (40%), Marubeni (40%) and JPS (20%). The company is to build, own and operate the proposed 360MW power generation facility at Old Harbour in the parish of St. Catherine.

Marubeni Corporation

Marubeni Corporation is one of the world's largest companies and is involved in wide-ranging business fields including energy. Marubeni is located in 71 countries with its headquarters based in Tokyo, Japan. The company has more than 5,000 employees worldwide and annual trading transaction volume in excess of US$80 billion. The Caribbean region is one of Marubeni's target regions for growth.

Marubeni Corporation has significant experience in Independent Power projects development and operations. Marubeni operates wide range of generating plant technologies and large installed capacity of which Marubeni ownership amounts to 7,671 MW.

Korea East West Power Company

Korea East-West Power Company Ltd now holds 40% shares in the Jamaica Public Service. The company's core focus is on providing efficient and secure power and energy. Korea East-West Power (EWP) spun off from Korea Electric Power Corporation (KEPCO) in 2001 and has continued to strengthen the competitiveness of its workforce and services through management reform and enhancing management efficiency. Korea East-West Power has several overseas interests and operations; it was the first Korean energy company in the North American power market. EWP is working tremendously to become a global leading energy company.

EWP operates 5 power plants, accounting for 11.5% of Korea's total power generation facilities contributing to the stable power supply in Korea. EWP has been assiduously working to secure technologies related to new and renewable energy power plants by participating in various solar, hydro, wind, biomass, RDF (Refused Derived Fuel) and landfill gases projects across the world.

EWP's vision is to overcome market saturation of the domestic power industry and become a global top 10 energy company by 2020 based on accumulated experience and world class competency. EWP has experienced many successes within the power industry in Korea and across the world. The company has successfully delivered substantial results from its overseas markets such as technological consulting, technological advisory service and power plant construction management.

EWP is committed to the growth and sustainable development of the Jamaica Public Service and by extension Jamaica

Jamaica Public Service Company

JPS is the sole distributor of electricity in Jamaica and is a proud inheritor of a tradition that dates back to 1892, when Jamaica first received electricity. This placed Jamaica in the enviable position of being one of the first in the world to have electricity, and only thirteen years after American scientist Thomas Edison had invented the electric lamp. In that year, the first electricity service in the island was supplied by the Jamaica Electric Light Company from a plant at Gold Street, in Kingston.

In 1897, another company, the West India Electric Company, established an office in Kingston at 151 Orange Street. They built the hydroelectric plant on the Rio Cobre River at Bog Walk, which consisted of three machines, each with the capacity to deliver over 300 kilowatts of energy. West India Electric not only extended electricity service to other areas, but also introduced a new element to the city scene – electric tramcars. Tramcars later replaced the horse drawn cabs, which had been providing public transport, and remained in service until 1948.

THE EARTHQUAKE

Early in 1907, a severe earthquake destroyed a section of Kingston, disrupting city life and public services. Following this, West India Electric leased the property and businesses of Jamaica Light & Power Company Ltd, successors to the Jamaica Electric Light Company and integrated the Gold Street station into the Bog Walk Supply system. This resulted in a significant improvement in the service available to customers.

PRIVATIZATION

In the early days, several towns had their own electric companies; but through a process of consolidation, buy-outs and amalgamations, Jamaica Public Service Company Limited emerged and was registered in 1923. At that time, JPS had 3,928 customers, a far cry from today's customer base of over 585,000. JPS was granted an all-island franchise in 1966, and today remains the sole public supplier of electricity.

The nature of the ownership of JPS has changed several times throughout time. The company started out as a private company, owned by foreign shareholders. In 1970, the Government of Jamaica acquired controlling interest. In 2001, ownership of JPS returned to private hands when Mirant Corporation, a US-based energy service provider acquired 80 percent of the company, with the Government retaining almost 20 percent. The remainder, amounting to less than 1 percent, is owned by a small group of shareholders.

In 2007, Mirant sold its majority shares to Marubeni Caribbean Power Holdings (MCPH) Inc., a subsidiary of Marubeni Corporation of Japan. In early 2009 Abu Dhabi National Energy Company (TAQA) of the United Arab Emirates, joined Marubeni as co-owner of the Jamaica Public Service Co. Ltd. Majority shares were therefore jointly held by Marubeni TAQA Caribbean.

In the first quarter of 2011, TAQA withdrew from the partnership with Marubeni in the Caribbean, due to a change in its corporate strategy. TAQA signaled its intention to focus primarily on the power sector in the Middle East and North Africa region. In the second quarter of 2011, Korea East West Power (EWP) entered into a Purchase and Sale Agreement with Marubeni Corporation for joint ownership of majority shares (80%) in the company. Today, Marubeni Caribbean and Korea

East-West Power Company Ltd are the majority shareholders in the Jamaica Public Service Company Ltd with the Government of Jamaica owning most of the remaining shares and a small group of minority shareholders maintains a less than 1 percent stake (Source: http://www.jpsco.com/ accessed July 258, 2012).

4.2 PROJECT CONCEPT AND DESCRIPTION

The proposed project is the construction and operation of a 360 MW Combined Cycle Plant, awarded to the Jamaica Public Service Company Limited by the Office of Utilities Regulation. The award was given on a Build, Own and Operate (BOO) basis, for the purpose of increasing the islands' generating capacity. The project is proposed to be done in two stages, with the 360 MW Plant being the slated as the first to be completed within three years. As described further in the sections below, the 360 MW Combined Cycle Plant will replace the current 292 MW heavy fuel burning plants.

4.2.1 Existing Power Plants

The existing Jamaica Public Service Company Old Harbour/Jamaica Energy Partners complex is located approximately 400m south east of the Proposed 360 MW site. This complex is on approximately 10.6 ha (≈ 26.1 acres) of land and two floating barges.

4.2.1.1 JPSCo Old Harbour

The Old Harbour Power Station is located on the shoreline in the parish of St. Catherine south of the town of Old Harbour (50 km west of Kingston) and has a complement of four heavy fuel oil fired steam generating units with a total installed capacity of 230 MW. Maximum continuous rating (MCR) is currently 223.5 MW. The non reheat condensing turbines have once-through condenser cooling systems with two-pass condensers using sea water from the bay.

Table 4-1 – Old Harbour plant data

	Make		Date	Capacity
Unit	**Boiler**	**Turbine**	**Commis.**	**MCR**
OH 1	Francotosi	Francotosi	1968	30
OH 2	Mitsubishi	Hitachi	1970	60
OH 3	Foster Wheeler	GE	1972	65
OH 4	Foster Wheeler	GE	1973	68.5

Fuel to the plant is supplied from Port Esquivel located 4 km to the west of the site where there are harbour facilities to accommodate ships of up to 35,000 ton capacity. The harbour is used mainly by WINDALCO for the export of Alumina and here JPS has a heavy fuel oil storage tank with capacity of 100,000 bbls. From Port Esquivel the oil is pumped through a JPS owned undersea pipeline to three storage tanks within the power station area. These tanks have a total capacity of 100,000 bbls. In addition, there are two tanks for diesel oil (No.2) with a capacity of 16,250 imperial gallons. No.2 fuel is used for start up purpose.

4.2.1.2 Jamaica Energy Partners – Doctor Bird Facility

Jamaica Energy Partners (JEP) owns and operates two power barges, Doctor Bird I and Doctor Bird II. These barges are each self-contained floating facilities with eight and three medium speed diesel engines, respectively. Both have the capability to use either diesel or heavy fuel oil ("bunker C"). The primary fuel source being used currently is heavy fuel oil (HFO) which is supplied to the barges through an undersea pipeline from a mooring. The fuel is stored in tanks unboard the barges.

The initial net electrical output was 74.2MW generated by eight reciprocating engine generating sets (Doctor Bird I). The company's generating capacity was expanded in March 2006 with the addition of three generating units totaling 50.2MW on Doctor Bird II.

Both barges results in a total generating capacity of 124.4 MW making JEP the largest independent power producer (IPP) producing almost 20% of the electrical energy on the Island's Power Grid.

4.2.2 Rationale

The rationale behind the project is to increase the island's generating capacity as well as to replace old and inefficient units on the grid with more efficient power generation equipment.

4.2.3 Project Location and Siting

The Old Harbour 360 MW combined cycle power plant is to be located approximately 75.6 km (47 miles) from the city of Kingston near the community of Old Harbour on the south coast (Figure 4-1). The proposed plant is near to JPS' existing Old Harbour facility, which currently has 220 MW of generation and houses major transmission and distribution operation along with a privately owned diesel power plant. The project site consists of 81 hectares (200 acres) of contiguous piece of real estate owned by JPS.

The community of Old Harbour Bay, located on the south-western coast of Jamaica in the parish of St. Catherine, was estimated to have a total population of 8,537 in 2009. Located approximately 5km from the town of Old Harbour, the Old Harbour Bay community consists of twenty-four (24) smaller communities, which include Blackwood Gardens, Kelly Pen, Thompson Pen, Bay Bottom, Terminal, Dagger Bay, More Pen Lane, Peter's Land, Sal Gully, Cross Road and Panton Town. The community is bordered by the Colbeck Castle community to the east and Burkesfield to the southeast. The Old Harbour Bay community is one of many residential fishing villages found along the coast in Jamaica, and is considered the largest fishing village on the island. The other industries and sources of employment include mining, manufacturing, small retail shops and subsistence farming.

This proposed development is located within the boundaries of the Portland Bight Protected Area (PBPA). It is Jamaica's largest protected area and has been in existence since April 1999. The area covers approximately 1,876 km2 of terrestrial and marine environment.

The proposed project site is bounded on its northern and western boundaries by industrial lands, to the south by salinas and mangroves and to the east by industrial lands and informal settlements. It is a largely flat area with clay type soils and poor drainage with site elevation varying from approximately 1.5 meters to 3.0 meters (5 to 10 ft.) above mean sea level.

The proposed site is located in an Intermediate Acacia Forest ecosystem. This ecosystem is comprised mainly of Acacia sp. trees and stands. The Intermediate is distinguished from the Secondary Acacia Forest ecosystem in three main ways: (i) the under storey vegetation tends to be more pioneer, monocotyledonous, vegetation (i.e. grass, etc.), (ii) the canopy is more open, and (iii) the trees are more low-profile (i.e. only a couple of meters high). Typical bird species within this zone of vegetation are warblers. The Intermediate Acacia Forest ecosystem is less significant/ecologically important than the Mangrove Ecosystem and Salina Ecosystem.

The proposed site showed significant evidence of anthropogenic disturbance, with illegal dumping occurring in the site, charcoal burning, logging, subsistence farming, establishment an air quality monitoring station, well water transfer pipes and the Parish Council roadway that runs through the site. In the past the area also had fish ponds.

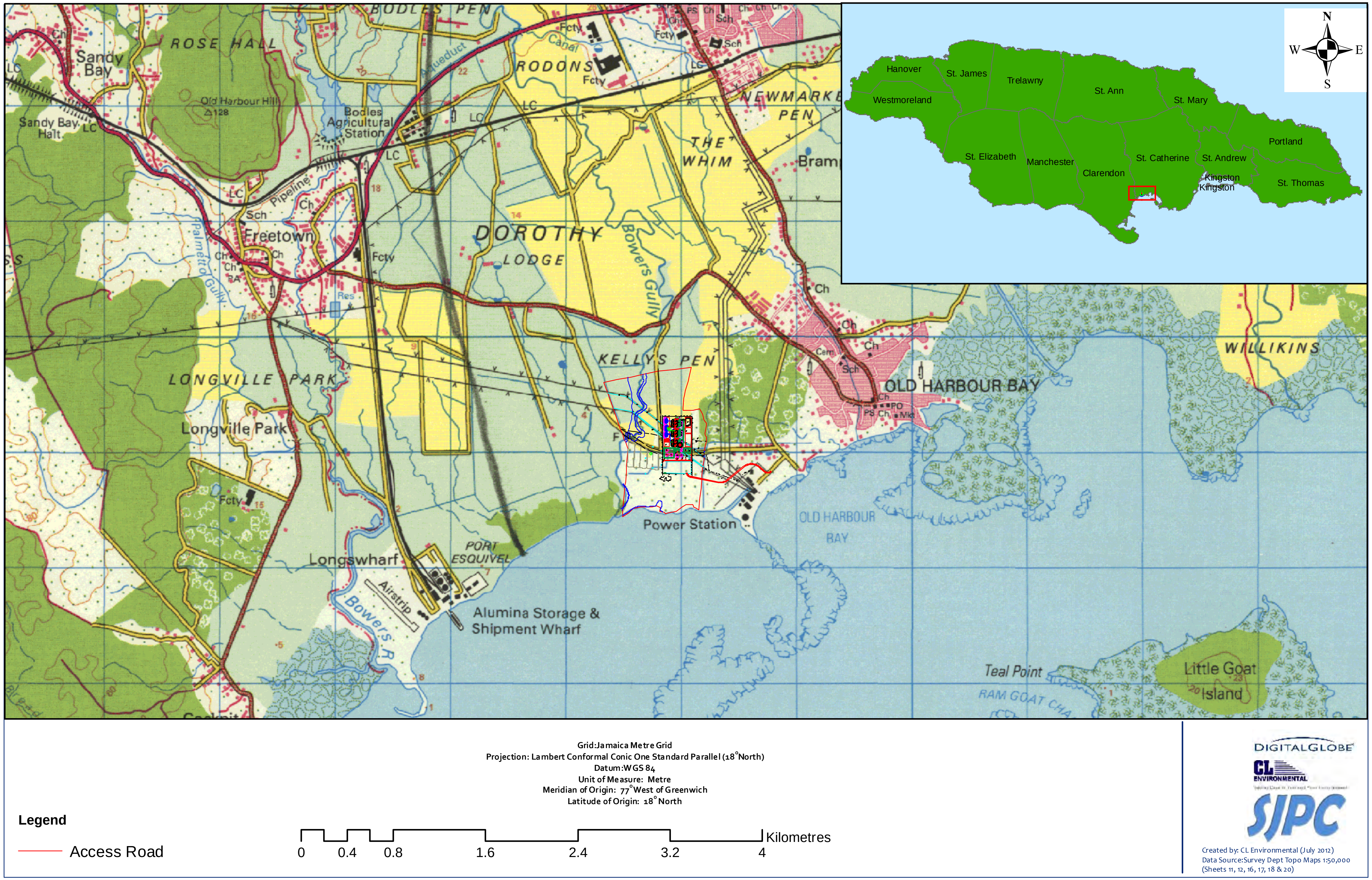


Figure 4-1 - Map showing the location of the Proposed SJPC 360 MW LNG Power Plant and the Portland Bight Protected Area

4.3 PROJECT SCHEDULE

Site prepararton will commence by December 2012 and construction of the SJPC power plant is scheduled to commence in by the second quarter of 2013. Commercial operation of Unit #1 is expected 22 months after the commencement of construction and the commercial operation of the other two units are slated one month after each other.

4.4 PROJECT INFRASTRUCTURE, EFFLUENT AND EMISSIONS

The proposed plant will consist of three (3) blocks of nominal 120MW Combined Cycle Power Plant, each block will comprise two (2) Gas turbine modules, two (2) Heat Recovery Steam Generators (HRSG) and one (1) Condensing Steam Turbine Generator (STG) and associate auxiliaries that will generate approximately 360MW. The plant will have the following equipment for the successful functioning of the designated operating systems:

- **Condensate System**: surface condensers, condensate extraction pumps and condensate water control system with all valves, actuators etc.
- **Condensate Air Removal System**: vacuum pump, seal water recirculation pump, seal heat exchanger and moisture separator.
- **Feed Water System**: Boiler feed water pumps, Auto Recirculation Valve (ARC), Feed water control system with all valves, actuators etc.
- **Cycle Chemical Injection System**: Phosphate Dosing Tank with agitator, HP and LP Drum Phosphate Dosing pump, Oxygen Scavenger Dosing pump with and without agitator, Amine Dosing tank with and without agitator.
- **Circulating Water System**: Circulating Water pump, Cooling Tower, Auxiliary Cooling Water pump, cooling water control system with all valves, actuators etc., NaOCl Dosing tank with agitator, NaOCl Dosing pump, Inhibitor Dosing tank with Agitator and Inhibitor Dosing pump

- **Closed Cooling Water System**: Closed Cooling, Water Heat Exchanger, Closed Cooling Water head Tank, Closed Cooling Water head Tank and Closed Cooling Water Pump.
- **Compressed Air System**: Air Compressor, Air Dryer, Instrument Air Receiver Tank and Service Air Receiver Tank.
- **Fuel Gas (LNG) Supply System**: Fuel Gas inlet Filter, Fuel gas calorie meter, Fuel gas flow meter and Fuel gas drain tank.
- **Automotive Diesel Oil (no.2 oil) Supply system:** Fuel oil storage tank, Fuel oil forwarding pump and Fuel oil supply pump.
- **Raw Water Supply System:** Raw water storage tank, Raw water supply pump and Cooling water make-up pump. The raw water tank will also act as a fire water tank.
- **Water Treatment System:** Raw water storage tank, Raw water supply pump, Cooling water make-up pump, Multi-media filter, Backwash (B/W) pump, Backwashed water pond, B/W water pump, Potable water supply pump and Potable water tank.
- **Demineralizing System:** Demin feed pump, Ultra filtration Filtered water tank, NaOCl injection tank, NaOCl injection pump, 1st Reverse Osmosis (RO) Feed pump, 1st RO micro filter, 1st RO HP pump, 1st RO unit, Degasifier with degasified water tank, Degasifier fan, 2nd RO feed pump, 2nd RO micro filter, 2nd RO HP pump, 2nd RO unit, RO permeate tank, Electro-deionization (EDI) feed pump, EDI unit, Clean-In-Place (CIP) tank, CIP filter, CIP pump, Chemical Injection (SBS injection tank, SBS injection pump, Scale inhibitor tank, Scale Inhibitor pump), PLC based instrumentation and control, Piping valves and Demineralized water storage tank.
- **Potable Water System:** Potable water tank, Potable water pumps for plant, Distribution Networks consisting of piping, valves, actuators, instruments, cabling and all other accessories. Potable water will be chlorinated.
- **Service Water System**: Service & Fire water tank, Service water pumps, Distribution Networks consisting of piping, valves, actuators, instruments, cabling and all other accessories.
- **Waste Water Neutralization subsystem**: Reaction and Coagulation tank, Clarifier, Acid solution tank, Caustic solution tank, Alum tank, IAF oil separator, sand filter, Activated Carbon filter, Polymer tank, Chemical pumps, Thickener, Dehydrator

package, Oily waste water pump, Normal waste water pump and Abnormal waste water pump.

4.4.1.1 Distribution Control System (DCS)

The DCS shall be a microprocessor-based direct digital control system capable of controlling all of the major equipment that comprises the Balance of Plant ("BOP"). The DCS shall additionally be capable of communicating with the proprietary control systems provided by major equipment suppliers, such as the combustion turbine generators, steam turbine generators, and water treatment system; for monitoring and ancillary control purposes. Major Plant Systems to be controlled and/or monitored by the DCS include, but are not limited to, the following:

- Closed Cooling Water Systems
- Circulating Water System
- Combustion Turbine Generator Systems
- Feed Water Systems
- Fuel Transfer Systems
- Heat Recovery Steam Generator Systems
- Steam Turbine Generator Systems
- Switchyard Systems
- Water Treatment Systems
- Continuous emissions monitoring on stacks
- Continuous wastewater monitoring for pH and temperature before discharge

4.4.2 On Site Construction

4.4.2.1 Earthworks

4.4.2.1.1 Excavation and Shoring

As the existing soil condition is expected to be fair and naturally stabilized with a few partial places with weak surface soil, open excavation with stable side slope without shoring will be executed by means of machine excavation regardless of the excavation depth for the areas where sufficient space is available. Excavation pits will be maintained dry during construction if needed by means of bailing out. However, excavation pit will be protected by shoring work for the excavation of congested area or ground water infiltration is too heavy to cope with. The removal of all vegetation, top soil and existing facilities on the proposed site will also be involved.

4.4.2.1.2 Backfilling and Disposal

Excavated soil will be re-used for backfilling selectively. Weak areas of soil will be removed and suitable backfilled to form a level area. Soil not suitable for backfilling and surplus will be disposed of at a designated location.

The site will be cleared of all brush and trees to remove all vegetation and top soil and provide a level cleared site. The site will then be backfilled with selected granular materials to above the flood levels and also above the surge level. The power block will be designed to ensure the foundations are above the 100 year flood levels with appropriate free board levels. The design 1 in 100 year flood level in the north of the site is 4.2 m amsl and 3.6 m amsl in the south. The 100 year surge level is 3.6 m amsl. The site will be done at slit levels to accommodate the bower block at 4.2 m amsl and the water treatment area at 3.6 m amsl plus an appropriate free board levels to accommodate any water movement and wave effect.

4.4.2.2 Foundation General

The foundations will be built in accordance with the national building code and the Universal Building Code in accordance with the detailed geotechnical investigations. The power block major equipment such as the gas turbines, steam turbines and the heat recovery steam generators will be supported by friction bearing piles. The balance of plant and building foundations will be designed as raft and strip foundations based on loading requirements.

4.4.2.3 Equipment Foundation for power block area

4.4.2.3.1 Steam/Gas Turbine Generator Foundation

This category involves 3 sets of STG, 6 sets of GTG and their ancillaries' foundation work. The foundations for the STG/GTG will be of mat footing. Foundations for rotating equipment will be designed so as to ensure that the dynamic deflections from the machinery loads will be within the limits prescribed by the machinery manufacturers and relevant international codes.

4.4.2.3.2 HRSG, Stack and Ancillary Equipment Foundations

The foundations for the HRSG, stack and its ancillary's equipment will be of isolated footing or mat foundation or combined footing according to best technical justification. Hard standing for access, erection and lay down of equipment will be provided for the area.

4.4.2.3.3 Transformer Compound

This category involves transformer foundation and associate firewall work. In order to retain the normal and abnormal oil leak as well as fire water, adequately sized pits will be provided for covering transformer compounds. Oily water leading pipes, manhole will be provided and connected with the site drainage system via oil separators. Manholes will be provided for the full collection of oil in the event of damage to the transformer.

All transformers are connected to a buried grounding grid.

4.4.2.4 Materials

Portland cement type I will be used for all concrete, which is classified as Lean concrete, Slab (on grade, trench, paving, duct bank etc.) or reinforced concrete for structural use. Reinforcement for all concrete will comply with international codes. Underground pipes are locally available and are adequate for various fluids. Piles will be solid precast concrete piles and or structural steel as designed.

4.4.3 Building Structures

An administration building, complete with control room, offices, conference room, men's and women's restrooms, kitchen, etc., as required for a staff of 25 to 30 operating personnel, complete with appropriate air conditioning and humidity control will be constructed based on the governing codes, standards and regulations. Fences and gates will be constructed around and within the perimeters of the property. The implementation of underground cable & pipe corridor will also be done throughout the property.

The substation steel structures to be constructed will be done in such a way that the design, detailing and fabrication will comply with recommendations contained in American Society of Civil Engineers

(ASCE) manuals and reports on engineering practice, No. 52 “Guide for Design of Steel Transmission Towers”, second edition, latest revision, and all relevant American Institute of Steel Construction (AISC) standards. Materials shall be new and shall comply with the latest provision of ASTM A36 and BS-4360, (BSEN 10113, 10155, ADM 6825, 6884), or equivalent. All parts shall be hot-dipped galvanized after fabrication according to specification clause TS.011.6.

4.4.4 Road and Paving

All roads inside battery limit will be of asphalt pavement. Main road of asphaltic concrete with 6 m width will be provided for site boundary and plant circulation. Secondary road of asphaltic concrete with 3 - 4 m width will be provided for access to each isolated area. Inside of oil tank dike and oil spillage area will be paved with concrete and provided with concrete spill containment dike. Gravel surface will be provided in the power block area and 5 meter band on the periphery of each building. All other areas will be kept uncovered.

4.4.4.1 Access Road

The access road width is 9 m and way-leave requirements is 11 meters. The existing parish council access road will not be used to access the site based on the proximity to the informal settlement. The Owner intends to build a new access road from the existing power plant to the new site and to make provisions for the existing access road to be connected to the roadway around the plant on the south boundary.

4.4.5 Water Supply

The proposed 360 MW plant will require 13,500m^3/day of freshwater for its operations. JPS has license from WRA to extract a total of 12,000m^3 /day from two existing wells in the Bodles area. The existing Old Harbour plant uses 2,500 m^3/day of freshwater which it extracts from a well also located in the Bodles area. Currently, this water is conveyed via pipeline in a right-of-way corridor traversing southwards from Bodles down into the existing power station at Old Harbour Bay. When the proposed new plant comes on stream, and the existing power generation units are de-commissioned, this 2,500m^3/day supply will become available to SJPC from which can be drawn the additional 1,500m^3/day needed for operation of the new plant. The new pipeline coming down from the two new well sources at Bodles (Bodles Rosehall and the Bodles Experimental wells) will be 18" in diameter (≈45.72 cm) (Figure 4-2). It will be installed (buried) within the same right-of-way corridor in which the line supplying the existing plant is laid.

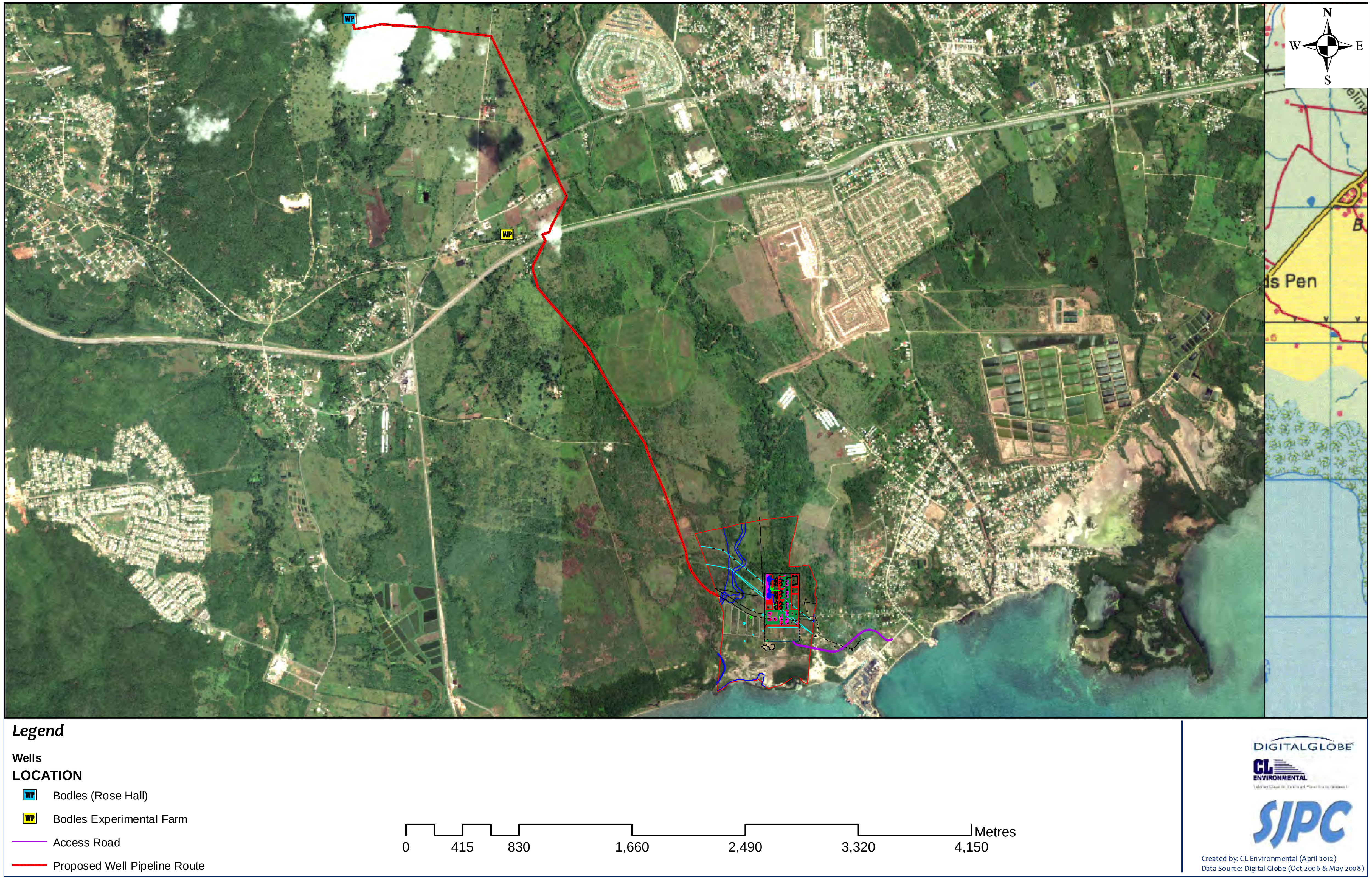


Figure 4-2 - Map showing location of wells and proposed pipeline

Appendix 5 and Appendix 6 contain the letters from the National Land Agency and the Water Resources Authority transferring the interest of the wells to the JPSCo. and the transfer of water rights.

4.4.6 Fire Fighting System

The fire protection systems will be designed in accordance with the latest editions of the following National Fire Protection Association (NFPA) codes and standards:

NFPA Codes:

- NFPA 10 Standard for Portable Fire Extinguishers
- NFPA 11 Low Expansion Foam System
- NFPA 12 Standard on Carbon Dioxide Extinguishing System
- NFPA 14 Installation of Standpipe and Hose System
- NFPA 15 Water Spray Fixed System
- NFPA 20 Installation of Stationary Pumps for Fire Protection
- NFPA 24 Installation of Private Fire Service Mains
- NFPA 30 Flammable and Combustible Liquids Code
- NFPA 70 Electric Code
- NFPA 72 Fire Alarm System
- NFPA 850 Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations
- NFPA 2001 Clean Agent Fire Extinguishing System

Design Basis

The fire protection facilities will be designed by considering a single major fire philosophy in ordinary complexes as follows:

Largest single fire risk means that the fire protection facilities shall be designed to control a single major fire in the plant which is surrounded by main access road.

Fire Water System

Fire water for the plant will be supplied from firefighting water tank via fire water pumping system.

The proposed assumption of fire water consumption is based on the following:

a. Water Spray System for Transformer System = 1,500 gpm

b. Hose stream demand (as per NFPA 850) = 500 gpm

c. Total Maximum Water Demand = 2,000 gpm

Fire water tank will be designed with a capacity equivalent to the maximum fire water demand for a period of 2 hours as per NFPA 850. Fire water tank will be filled with potable water.

The firefighting equipment of the plant section will consist of the following equipment:

- Fire Water Pumps
- Ring main
- Post indicator valves (PIV) to be used as section valves
- Fixed Water Spray System
- Hydrants
- Gas Suppression System (Clean Agent)
- CO2 Extinguishing System
- Semi Fixed Foam System
- Portable DCP Fire Extinguishers
- Traffic protection piles

Fire Water Pumps

One electric motor driven horizontal water jockey pump will be designed for a capacity of 250 gpm at 10 barg at design discharge pressure.

One horizontal electric driven pump and one diesel engine driven pump shall be provided. Each pump shall have a design capacity of 2000 gpm at 10 barg.

The fire water pumps shall be provided with a minimum flow, pressure relief and non-return valve on the discharge of the pumps. The diesel engine fire water pump shall include a daily fuel tank with appurtenances and capacity in accordance with NFPA 20.

Pressure switches are used to initiate automatic start-up of the firewater pumps on pressure drop in the distribution system.

Ring Main

The ring main of the complex will cover plant. A looped fire water distribution system will be provided for all areas of the plant. The ring main will be equipped with post indicator valves as section valves.

The post indicator valves will be operable from grade and will be provided with a valve position indicator at grade to indicate full open and closed positions.

The capacity of the ring main is proposed to meet the needs for one major fire at a defined time ("one fire philosophy").

The working pressure of the ring main will be approximately 10 barg. It is assumed, that the ring main is capable to deliver fire water at a minimum rate of 2000 gpm *(*454m^3/hr*)* at the most remote area of the plant. The minimum size of the ring main in the fire water distribution network shall be 010". At this rate and size, the velocity of flow will be approximately 3.5 m/s.

Post Indicator Valve

Gate valve has been considered as post indicator valve for ring main.

Fixed Water Spray System

Fixed Water Spray System will be provided for fire protection of transformer and fuel oil tank. Fixed water spray system will be installed to provide cooling of equipment or control of fire intensity.

Hydrants

Hydrants will be located around plant area. The distance between the neighbored hydrants will be approximately 90 meters. The hydrants shall be of the wet barrel type.

The diameter of connection to the ring main shall be 6". Each hydrant will be equipped with at least two outlets 2W' and one pumping connection 4". The outlets will be equipped with independent gate valves.

Hydrant will be located near the following areas:

- STG Area
- Gas Turbine Generator
- HRSG
- Water Treatment & WWT Building (Indoor Hydrant)
- Fire Water Pump Area
- Boiler Feed Water Pump House
- Gate House

Gas Suppression System (Clean Agent)

Gas Suppression System shall be provided for fire protection of the following buildings:

- Central Control & Admin Building
- Switchyard Control Building

$C0_2$ Extinguishing System

CO_2 Extinguishing System shall be provided for fire protection of Electrical Building.

Semi Fixed Foam System

Semi Fixed Foam System shall be provided for fire protection of Diesel Tank.

Portable Dry Chemical Powder Fire Extinguishers

As a means of first attack, portable dry chemical powder fire extinguishers, each having a capacity of 9kg dry chemical powder of type ABC (suitable for extinguishing fires on solid, liquid, & gaseous combustibles) will be kept ready. The fire extinguishers will be equipped with weather protection cover if required.

Portable dry chemical powder fire extinguishers shall be provided for fire protection of the following areas:

- STG Area
- Gas Turbine Generator

- HRSG
- Water Treatment & WWT Building
- EDG Building
- Fire Water Pump Area
- Boiler Feed Water Pump House
- Warehouse
- Gate House

Traffic Protection Bollards

In areas of high vehicular traffic, aboveground hydrants and valves (PIV) will be protected with guards from being struck by road vehicles. Guards shall be approximately 4" pipe filled with concrete and set in a concrete foundation.

4.4.7 Fuel Supply

4.4.7.1 Liquefied Natural Gas (LNG)

Recent efforts by the responsible government agencies to procure a reliable supply of natural gas at a price that would result in lowering the price of electricity for Jamaican consumers, have been unsuccessful. Consequently, in order to move forward with their plans to implement this proposed 360 MW LNG project, SJPC has been striving to conclude arrangements for providing their own supplies of the necessary LNG. Although no firm arrangements have as yet been announced, SJPC continues to show full committment to the objective of providing a 360 MW power plant at Old Harbour, which will primarily be fuelled by natural gas. So at this stage, there are no detailed plans available for the physical facilities that will be needed for receiving and handling supplies of natural gas for the project.

The proposed plant will also be able to run on automotive diesel oil as back-up fuel for emergency situations when LNG is unavailable.

4.4.7.2 Automotive Diesel Oil (ADO)

The secondary fuel for the proposed plant will be automotive diesel oil (ADO). The source of the ADO will be from the Petrojam Limited located in Kingston. It will be transported by ships and transferred to the plant by pipeline using the existing Jamaica Energy Partners sea offloading facility and pipeline (under a commercial agreement) and construct a land based pipeline from the JEP facility to the proposed plant (Figure 4-3).

Supplies of ADO can be obtained locally from Petrojam. An 18 day ADO fuel tank storage capability will be maintained on site.

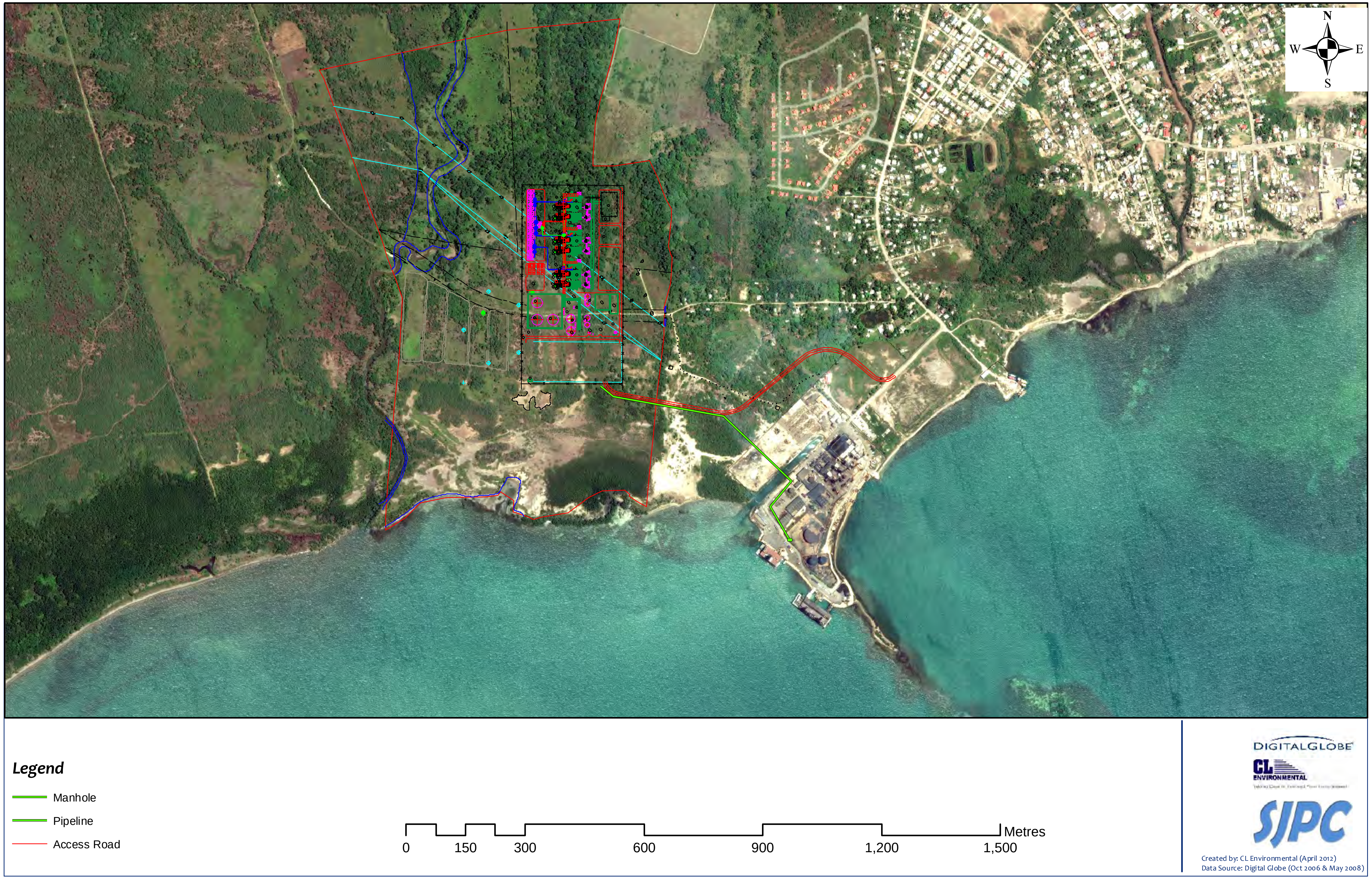


Figure 4-3 – Proposed ADO pipeline route

4.5 PROJECT OPERATIONS AND MAINTENANCE

The applicant shall develop a Best Management Practice and Mitigation Plan to prevent or minimize the potential for release of any significant amounts of toxic or hazardous pollutants to the land and waters of the local environment. This will include monitoring of the following parameters:

- Water quality (all waste water will be tested for pH and temperature)
- Noise levels
- Effluent and air emission levels
- Any other parameters identified by the World Bank, NEPA or any other Government of Jamaica Agency

Proper procedures must be developed for solid waste disposal during construction activities. In addition, SJPC will be proactive in addressing any issues raised by the neighbouring communities and local authorities.

4.5.1 Disposal of Surplus

Any surplus material resulted from construction activity will be disposed by contractor to an approved solid waste disposal site.

4.5.2 Storm Water, Oily, Chemical Drainage, Sanitary Wastewater

All wastewater from the plant will be collected in a concrete tank and pre-treated to a satisfactory level and routed through a holding pond to make it fully compliant with NEPA effluent quality standards before being discharged into Bowers Gully (Figure 4-4). The effluent quality will also be monitored by a continuous monitoring system.

The dimensions of the waste water discharge pipeline is expected to be approximately 374m long with a diameter of 450mm.

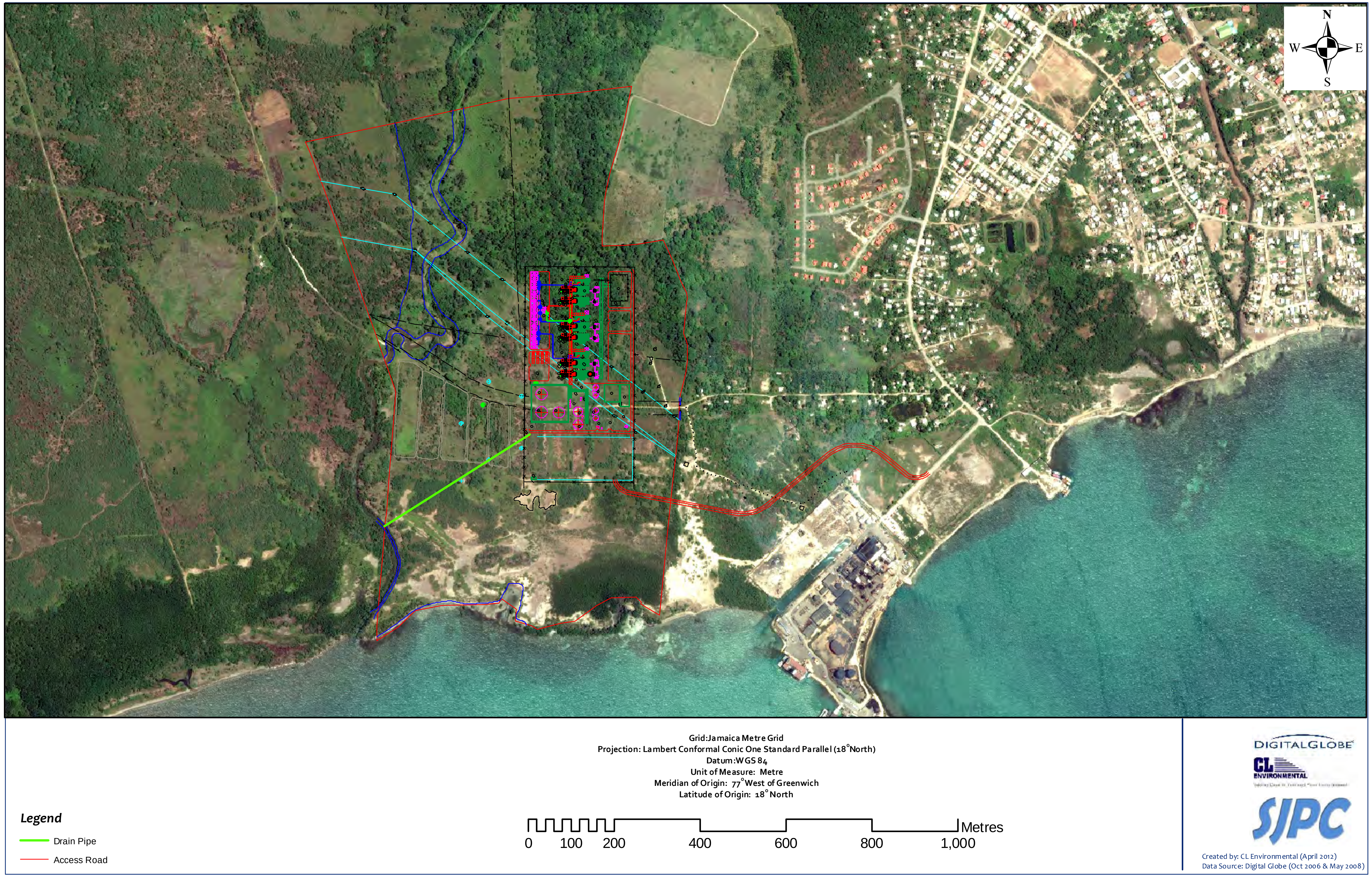


Figure 4-4 Map showing waste water drain pipe

4.5.2.1 Storm water

In order to minimize quantity of waste water, rain water from clean areas such as roads, paved areas free from contamination and buildings, etc. will be collected through open ditches (and/or) road side gutters. Collected rainwater will be routed to the holding pond before being discharged to the Bowers Gully. However, yield of rainwater from possible contaminated areas will be collected and passed through oil water separators before being discharged to the holding pond.

4.5.2.2 Oily water

The probable source of oily waste will generally be from the transformer area, STG area, etc. These areas will be isolated by; spill wall, dike, pit, and trench. Direct rainfall into the areas or floor washing water will be led to an oil separator by gravity and connected to the industrial waste piping network.

4.5.2.2.1 Oily Water Collection

Oily water will be collected at oily water sumps near to the oily water sources, such as GTG Lube Oil tank, STG Lube Oil tank, Fibre Reinforced Plastic Lube Oil tank, etc., and will be transferred to the wastewater treatment system by sump pumps.

4.5.2.2.2 Oily Water Treatment

Oily water will be treated within the oil removal system which is included in WWT (waste water treatment) system.

The Oil removal system receives oil- contaminated water from all over the plant. Oil removed from the Oil/water separator will be stored within the separator for periodic removal and off-site disposal. Treated effluent water from the oil water separator will flow to the normal waste water pond and be further treated with other chemical waste water.

4.5.2.3 Wash-down Water

The gas turbine blades periodically require water washing to remove debris thereby maintaining its efficiency.

The frequency of water washing will be decided by SJPC (generally twice per month) but will be based on the site condition and Gas Turbine Generators performance.

The expected volume of wash water would be less than 800 litres for one (1) complete washing cycle as per Siemens requirement.

This wash water will be transferred near to the Heat Recovery Steam Generators (HRSG) blow down sump pit via a drain pump. This is to facilitate transfer with the HRSG blow down sump pump and wash water to the waste water treatment system.

4.5.2.4 Chemical Wastewater

Chemically contaminated waste will be isolated by spill wall, dike, pit, trench, etc. Waste, if not biodegradable, will be treated separately and removed for disposal.

Commonly used chemicals onsite are;

1. Phosphates
2. Oxygen scavenger
3. Amine
4. Sulphuric acid

4.5.2.5 Sewage

Sewage effluent from various buildings will be piped to the central sewage treatment plant.

Waste water meeting the designated standards (Table 4-2) will be discharged into the holding pond. Those not meeting the standards will be treated to reflect the following:

Table 4-2 - Wastewater Standard targets

Property	**Treated waste water quality**
pH	6.5~8.5
Oil & Grease (mg/l)	<10
BOD5 (mg/l)	<30
COD (mg/l)	<100
TSS (mg/l)	Max. 150, Monthly Avg.: <50

4.5.3 Maintenance Frequency

The major equipment for the combined cycle dual fuel plant will be maintained according to the OEM recommendations as follows:

- **Gas Turbines** -
    - *10,000 EOH (Equivalent Operating Hours)* – Minor inspection; this includes a borescope inspection that views all the major turbine and combustion components for abnormal wear.
    - *30,000 EOH* – Hot section inspection; this includes the replacement of all turbine and combustion hardware.
    - *60,000 EOH* – Major Inspection; includes the Hot section scope as well as an inspection of the compressor and generator
- **Heat Recovery Steam Generators** - Annual inspection of all internal sections and replacing components as is necessary.
- **Steam Turbines**
    - Annual borescope inspection
    - Seven year major inspection of all internal components and replace as is necessary. This also includes a generator inspection.
- **Cooling Tower** - Annual Cleaning and inspection.
- **Balance of Plant Equipment** - The plant has been designed with redundant balance of plant equipment that will facilitate both routine and major maintenance online.

5.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

5.1 PHYSICAL

5.1.1 Physiography, Geology and Structure

5.1.1.1 Location and Physiography

The site of the proposed power station and its environs are situated on the northern section of Portland Bight. The site lies within the boundary of the Portland Bight Protected Area (Figure 5-1) but not in the RAMSAR site. It occupies a part of Kelly's Pen, bounded on the west by the seasonal Bowers Gully, and is located about 5 km west of the township of Old Harbour Bay, and northwest of the existing power plant owned by JPS.

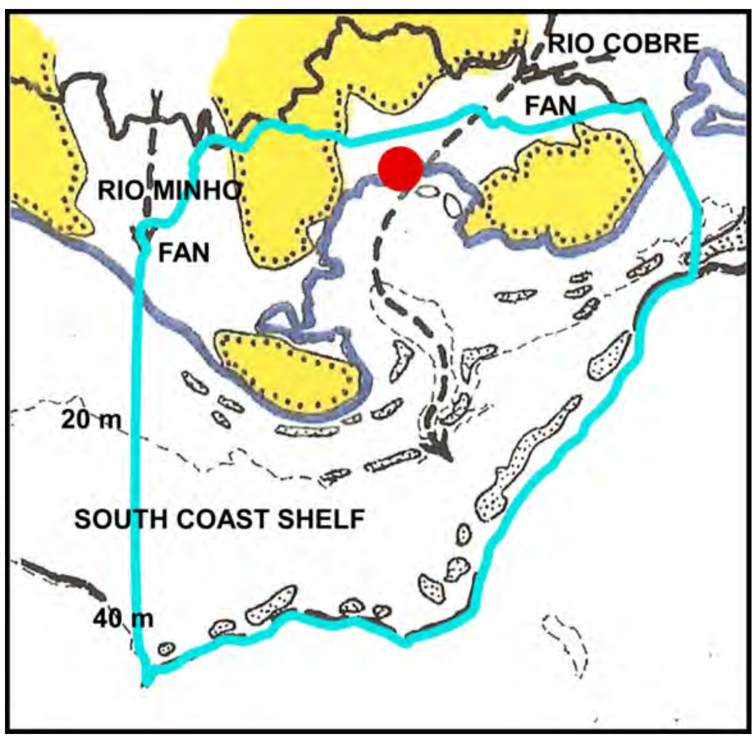


Figure 5-1 - Location of the proposed power station (red dot) within the Portland Bight Protected Area (light blue outline). Grey, Coastline; black line, boundary of the South Coast Development Area; yellow limestone areas; uncoloured, alluvium; dashed black lines, probable courses of the Rio Cobre and Rio Minho during one or more past low sea-level stands of the Pleistocene Epoch. Stippled zones, shoals inshore and along the edge of the South Coast Shelf. (Modified from Halcrow, 1998).

Physiographically, the site is at the south western margin of the Rio Cobre Alluvial Fan Complex (Figure 5-1). The coastline in this area is low-lying, characterized by sand flats, salt marsh/pans and mangrove backing the beaches. The land slopes gently up from the coastline to reach a maximum elevation of six metres at the northern edge of the site (Figure 5-2). Evidence from historical maps and air photographs indicates relatively minor changes in shoreline position over the past seventy years with the main change being early progradation of the shoreline in the vicinity of Bowers Gully (Figure 5-2). Along the south eastern edge of the site the surveyed property boundary actually lies north of a prominent stand of mangroves between the property and the sea which has developed in more recent times. In that part of the area slated for the power plant, elevations are 2 m or less (JPS OHB Topographical Survey).

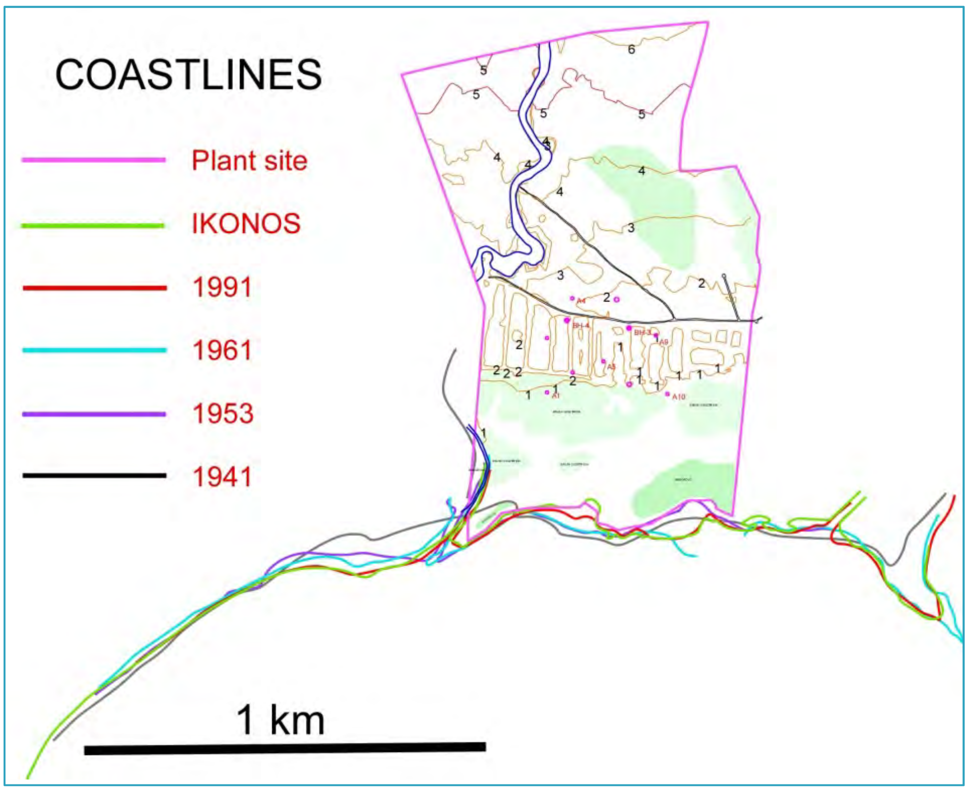


Figure 5-2 - Shoreline positions in front of the proposed power plant site for the years 1941, 1953, 1961, 1991 and 2001 (IKONOS). Site elevation contours (metres) in brown.

5.1.1.3 Geology

The geology of the area adjacent to the site consists of unconsolidated sands and sandy clays, and carbonaceous sandy clays and clays of Holocene age (last 12,000 years, marked as Qm on Figure 5-3). The present beach sediments consist mainly of non-carbonate grains (Wood, 1976). Unconsolidated or semi-consolidated deposits of Holocene age probably extend to a depth exceeding 100 metres (Figure 5-1; data from Porter and Bateson, 1974, Fernandez, 1983; Halcrow, 1998). This depression probably marks the position of an old channel of the Rio Cobre excavated during one or more low sea-level stands of the Pleistocene Epoch. Its continuation is evident through Old Harbour Bay. Regionally, the lower part of the Holocene section is probably dominated by clays, possibly older than Holocene (Fernandez, 1983; Aspinall and Shepherd, 1978), grading up into sandier deposits in the higher part of the section. All these are underlain by lithified rocks of the White Limestone Group. A low raised beach (about 1 metre in elevation) was reported at Old Harbour Bay (Porter and Bateson, 1974).

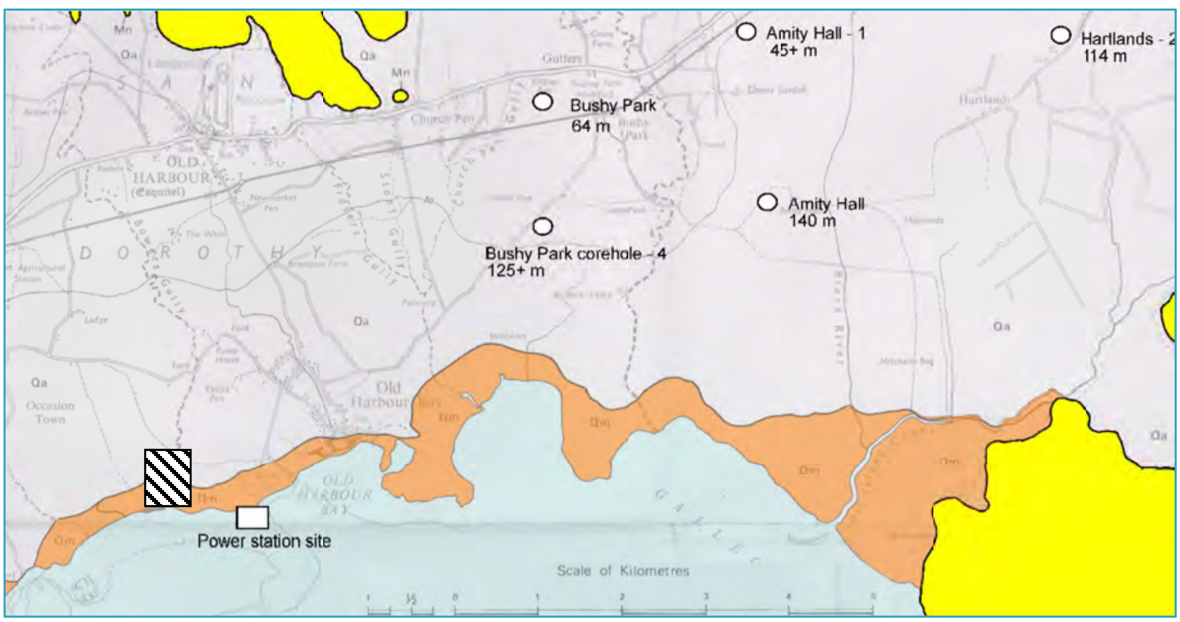


Figure 5-3. Regional geology of the site. Yellow, White Limestone Group; grey, Quaternary sediments of the Rio Cobre alluvial fan; brown, Holocene superficial sediments and soils of the coastline. Large striped rectangle is the proposed new site.

Field Investigations carried out on May 28, 2012 yielded exposures in Bowers Gully, but no geological units are visible at the surface. At the ground surface red brown clays (described below) exhibit desiccation cracks (Plate 5-1) produced during dewatering of the soils.

Plate 5-1 - Desiccation cracks in clay soils exposed at the surface of the proposed site.

Subsurface sediments are visible in river cuts on the western side of the site where nearly four metres of section are exposed. These consist of clays in the upper layers and conglomerates in the lower levels of the section. At the surface and just below, up to 3.7 m of unconsolidated sands and clays were identified (Plate 5-2 and Plate 5-3). A more detailed description is given below from the reference section measured and described in Plate 5-4.

Reference Section Log described in river cut (N17° 54.262 W 77° 06.916):

- Layer 1 - Clast supported conglomerates in a sandy matrix. Clasts are large pebbles from an igneous source. Thickness 0.60m.
- Layer 2- Clast supported conglomerates in a sandy matrix. Clasts are medium- large pebbles from an igneous source. Thickness 0.15m.

- Layer 3- Bed shows normal grading from a clast supported conglomerate with sand matrix to a sand size grains only in the upper 2”. Clasts in the lower conglomerate section of the bed consist of small pebbles in a sand matrix. Thickness 0.41m.
- Layer 4- Mud and very fine sand. Thickness 0.81m.
- Layer 5- Coarse grained sand with scattered pebbles. Thickness 0.61m.
- Layer 6- Clast supported conglomerates in a sand matrix. Clasts are small, sub angular to sub rounded, pebbles from an igneous source. Thickness 0.25m.
- Layer 7 – this is a Clay layer approximately 0.86m thick dissected by roots of vegetation above.

Plate 5-2 - Example of subsurface exposures in Bowers Gully; slumping is evident right side of photo.

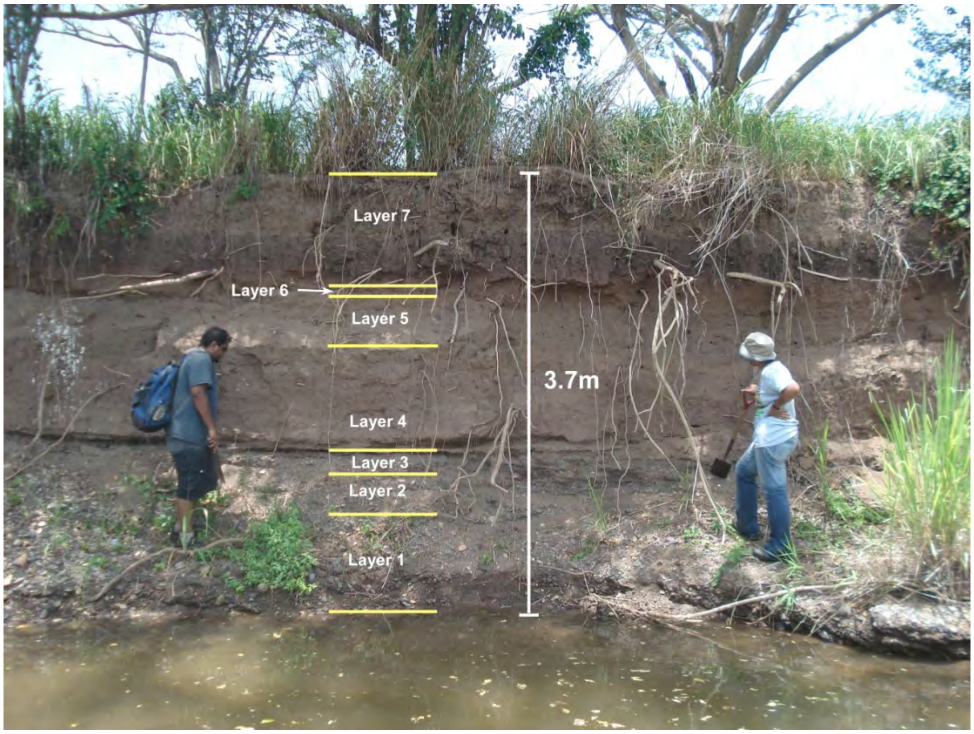


Plate 5-3 - Section in Bowers Gully described to identify subsurface units at the proposed site. Clays define the uppermost layer (layer 7). The rest of the section consists of conglomerates and sands (Layers 1-6).

Plate 5-4 - Detailed view of unconsolidated material that comprises sub-surface sediment.

5.1.1.4 Borehole Logs

Logs for boreholes BH 1 to 4 were available for inspection. Only BH 3 and BH 4 were sited on the area of interest. BH 2 was near to the south eastern corner of the site and BH 1 was located east of the existing power plant (Plate 5-3). Additional holes are sited on the area of interest, but have not been examined as finalized logs were not available.

5.1.1.5 Structure

There is no evidence of structural complications within the superficial sediments of the area. Evidence of such features as faults is difficult to obtain from unconsolidated deposits. Fernandez (1983) demonstrated the existence of faulting in the White Limestone bedrock. Examination of his borehole logs also indicates the probability of normal faulting (possibly growth faults) in the post-White Limestone sediments, which thicken towards the central axis of the St. Catherine Plains Quaternary basin.

5.1.2 Topography

The Site will be located in the southern section of Old Harbour Bay, to the Northwest of the present Power plant. The Site will be located on very gently sloping lands which falls off to the sea in the south. This area is also within the flood plain of the Bowers Gully which flows from the hills in the north.

Topographical data obtained from the Survey department 12,500 map series revealed the Bowers Gully catchment encompasses steep mountainous regions to the North which have elevation of up to 610 metres above mean sea level (msl).

The area encompassed by the SJPC site has elevations varying from 0.5m to 2.0m above msl. See Figure 5-4 and Figure 5-5 below for the topography map of the wider project area derived from the survey department' 12500 map series. The general area surrounding the site has slopes of less than two percent (2%), whereas the hills in the north are dominated by slopes between 20 and 30 percent.

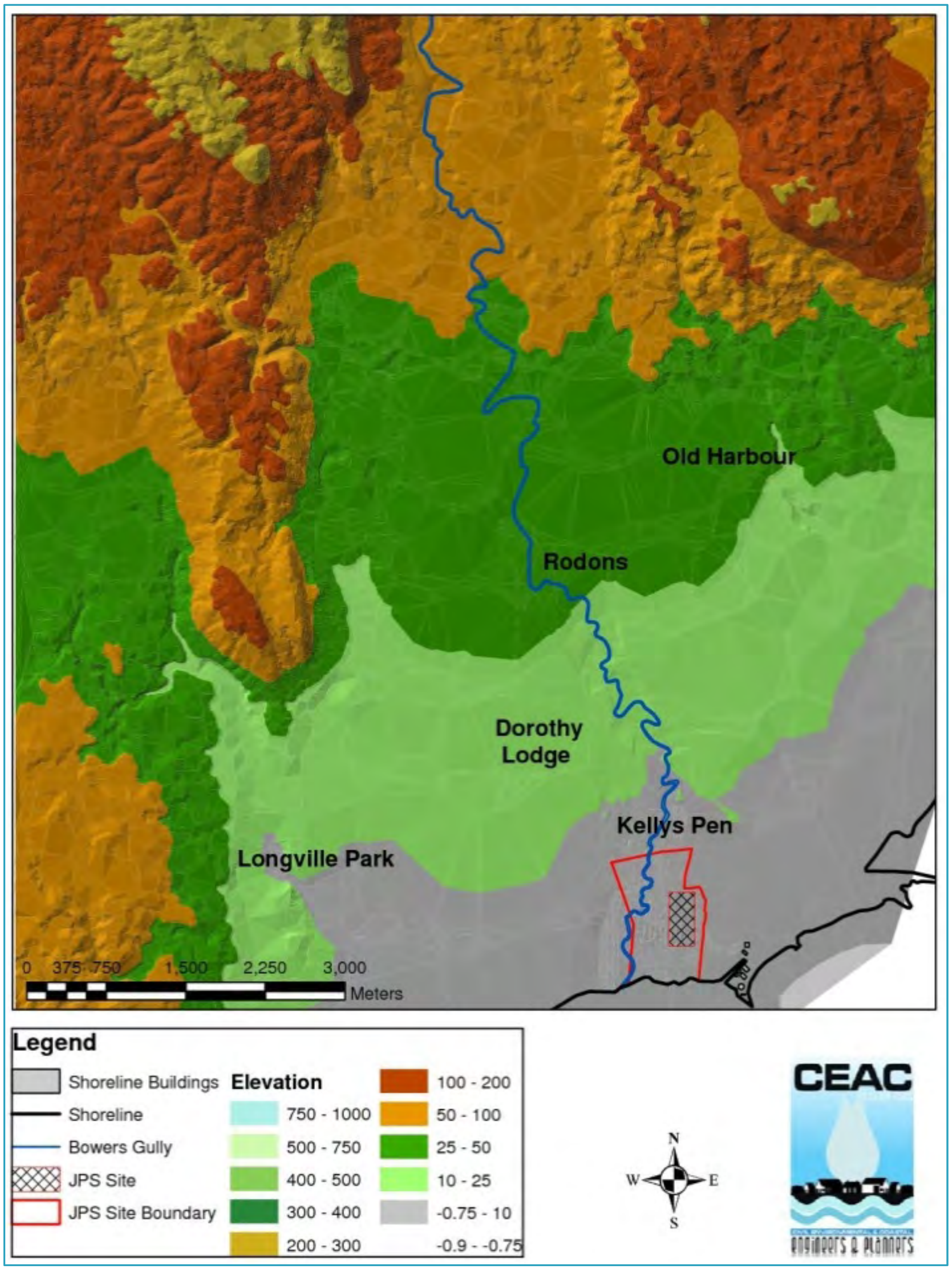


Figure 5-4 - Digital terrain map of the project area created from Survey Department 1:12,500 map series

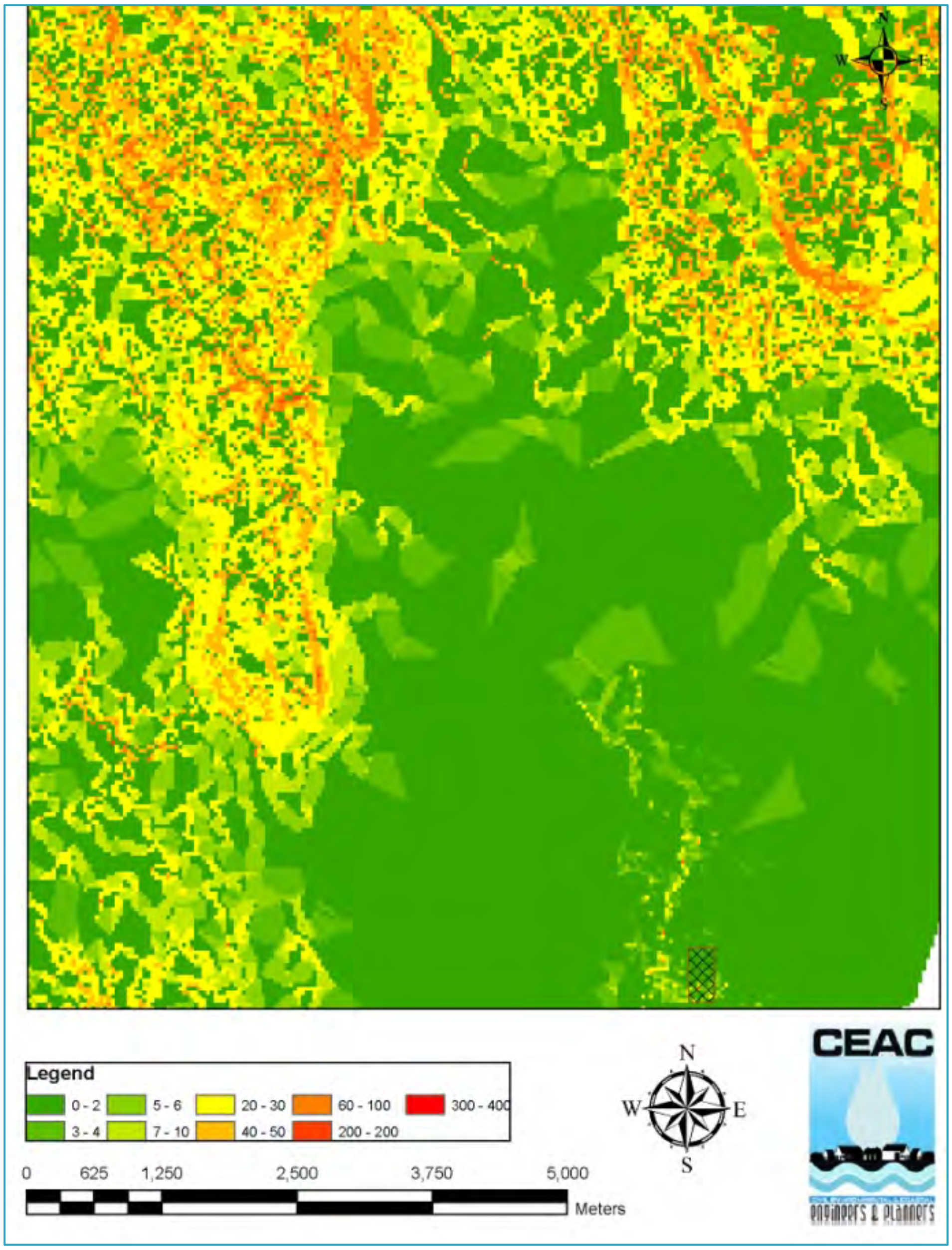


Figure 5-5 - Slope analysis of the project is showing the percent slope of the terrain

5.1.3 Soils

5.1.3.1 Soil Distribution

The spatial distribution of the soils present at the proposed site is shown in Figure 5-6 and has been modified from Campbell et al (1986) and their soil names and codes followed. Ground truthing of these were carried out during the site visit. The published soil and land use surveys

(Netherlands; Campbell et al 1986 and Vernon and Jones, 1958) identify 4 soil types (Lodge Clay; Lodge Clay, Saline- Sodic phase; Whim Clay Loam (PRb3); Salina undifferentiated (TMX1)) in the study area and we follow their classification in the descriptions below.

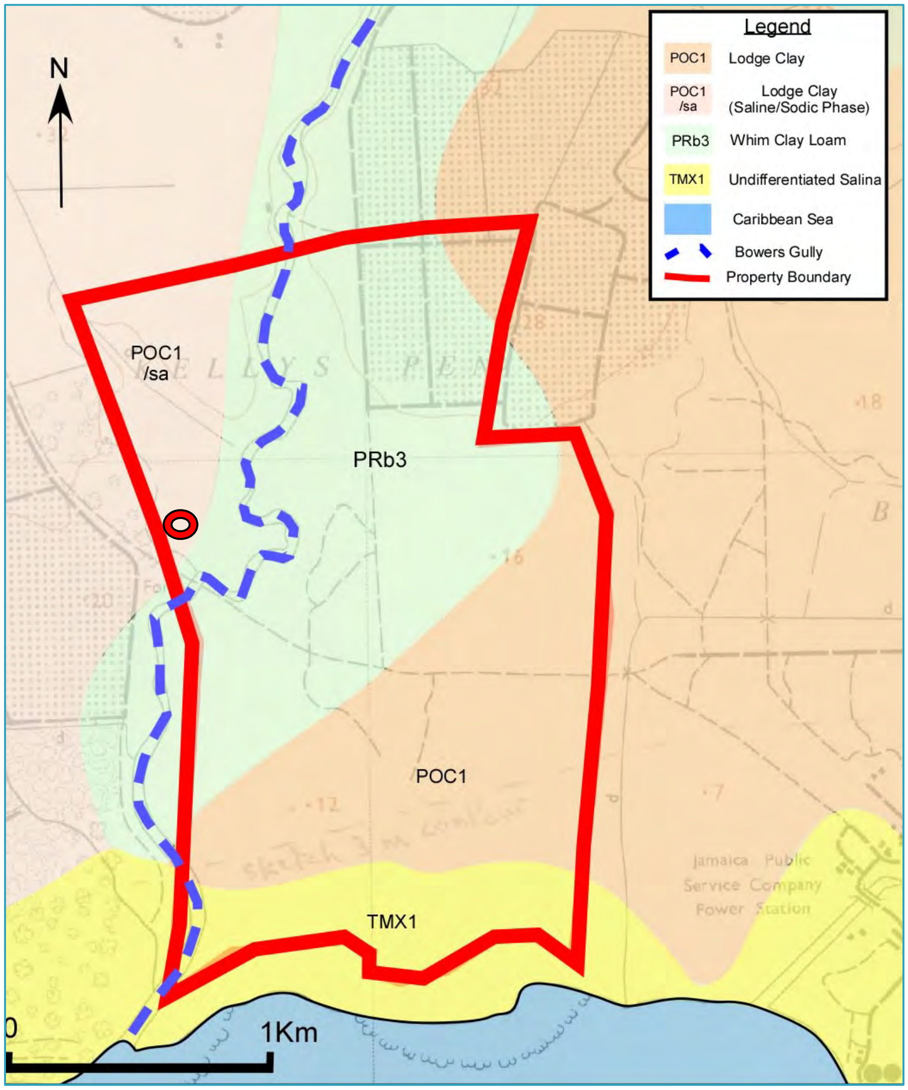


Figure 5-6 - Map showing the spatial distribution of soils associated with the area of interest (map modified from Campbell et al 1986). Red spot is location of type section in Plate 5-3.

5.1.3.1.1 Lodge Clay (POc1)

Lodge Clay (POc1) described by (Campbell et al 1986) is equivalent to the Lodge Clay loam (low salinity phase) mapped by Vernon (1958). It is formed from a very mixed gravelly and sandy old alluvium (Campbell et al 1986 and Vernon, 1958) that is from Bowers Gully source. These clays are moderately well drained deep reddish brown cracking clays occurring in primarily topographically flat areas, dominant slope range is 0-2°, but also at slightly elevated sites on the old alluvial clay plain. This soil is typically moist throughout with fair external drainage. Internal drainage is good to 11" (5 cm) and moderate below. Permeability is however low after cracks have been closed. Soils are very hard when dry and very sticky when wet (Campbell et al 1986). The surface layer is dark brown in colour, and ranges in thickness from 40-70 cm (Agricultural Chemistry Division 1964). A saline old alluvial soil, derived partly from mixed gravel is found in the Bowers Gully; depth very deep- more than 60" (1.5 m) (Agricultural Chemistry Division 1964).

5.1.3.1.2 Lodge Clay Saline- Sodic Phase (POc1/sa)

Lodge Clay Saline- Sodic phase (POc1/sa) described by (Campbell et al 1986) is equivalent to the lodge clay loam (saline) mapped by Vernon (1958). It is characteristically similar to the Lodge Clay (POc1) but saline and sodic in the subsoil. It is a moderately well (internally) drained old alluvium that occurs primarily on the lower slopes (slope range 0-2°) of the coastal (clay) plain towards the sea (Campbell et al 1986) and has erosional hazards. The soil is non-saline at the surface becoming moderately saline at depth (Campbell et al 1986; Ministry of Agriculture and Fisheries 2009).

5.1.3.1.3 Whim Clay Loam (PRb3)

Whim clay loam (PRb3) is a well-drained stratified soil developed on recent alluvium of river plains from alluvial soil derived from mixed rocks of the upper catchment of the Bowers Gully (see layer 7 in Plate 5-3). The soils occur on level smooth sites along major stream channels. Soil thicknesses may exceed 60" (1.5 m) and the Agricultural Chemistry Division report (1964) reports that soil colour and weight increases with depth. Colour varies from a dark brown sandy loam or sandy clay to a yellowish brown. It has moderate internal drainage and occurs on slopes of 0-2° (Ministry of Agriculture and Fisheries 2009).

Plate 5-5 - Loose gavel deposits on banks of Bowers Gully, include limestone, chert and igneous pebbles (N17° 54.279, W77° 06.989).

5.1.3.1.4 Salina Undifferentiated

Saline areas are located between the sea, mangrove swamps and the alluvial coastal plain swamps. They consist of poorly drained, deep, strongly saline and sodic soils of varying textures and colours and are strongly calcareous (Campbell et al 1986). They are mostly devoid of tree/shrub vegetation except for some salt tolerant plants. Soil is classified as typic halaquepts (Campbell et al 1986).

5.1.3.2 Geotechnical Survey

NHL Engineering Ltd. conducted a geotechnical survey on the proposed SJPC site located in Old Harbour, St. Catherine. The field investigation entailed the drilling and sampling of four (4) locations to a depth of 30m (90'). The testing results revealed that the soils encountered were a mixture of very soft and loose Clays and Silts. In addition, peat was discovered overlying very stiff to hard Silty Clays. Ground water was encountered in both boreholes at an average depth of 1 m below existing ground elevation.

These results indicate the foundation need specialist attention in terms of their design. Shallow foundations placed on this site will be susceptible to settlement. A Soils engineer is therefore to be consulted to design the fill and foundation that are required to mitigate against differential settlement of the power plant. Detailed results can be found in the 'Soil Investigation Report' prepared by NHL Engineering Ltd.

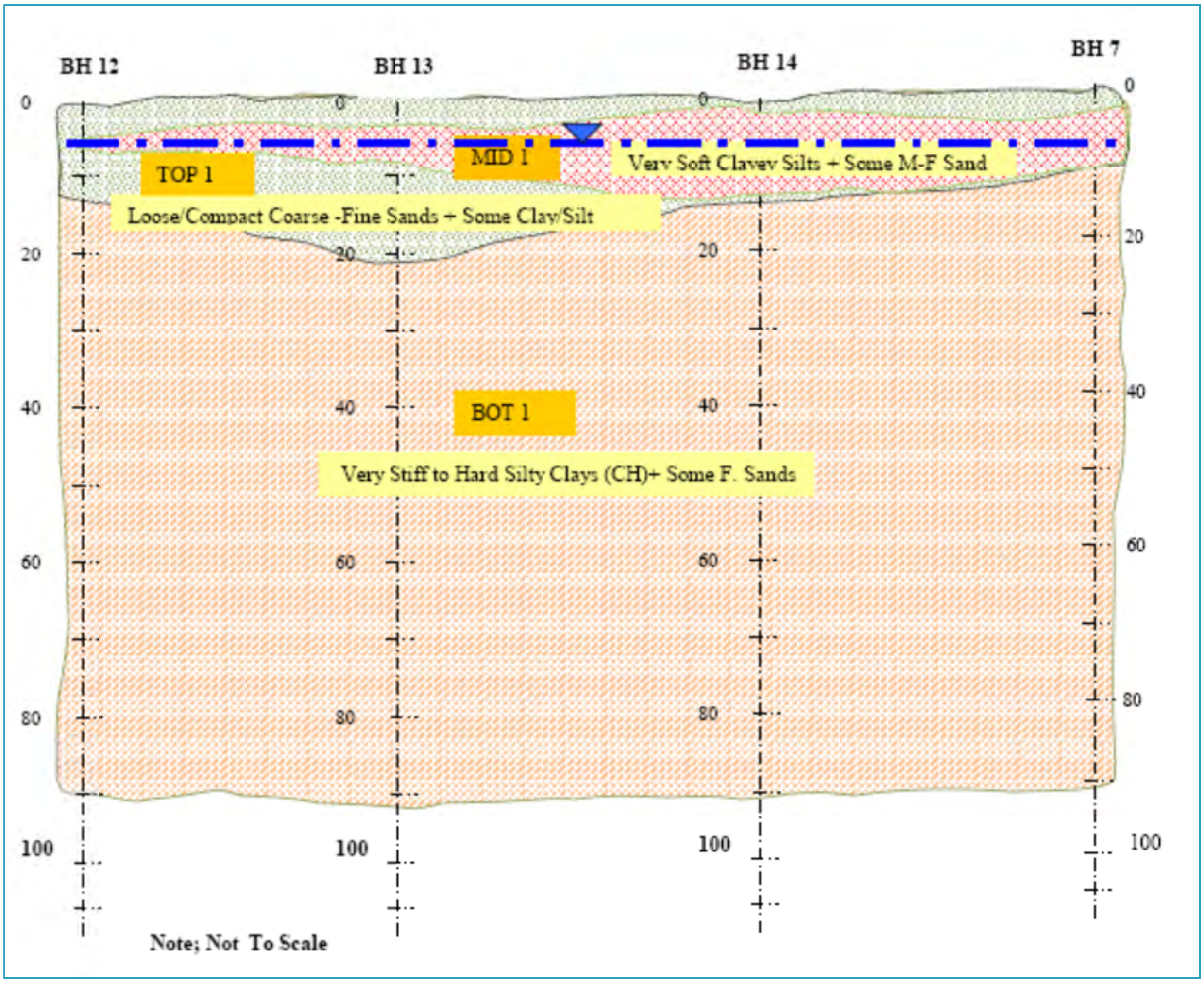


Figure 5-7 - Typical borehole profile

5.1.4 Well Analysis

The Bodles Rosehall and Experimental wells are located in the western section of the St. Catherine plains approximately 2.2 kilometres southwest of Old Harbour (Figure 5-8). Land use is characterised by scattered villages with newer housing developments and sugar cane fields interspersed. Topographically the area has a low relief with gullies and manmade water courses primarily irrigation canals.

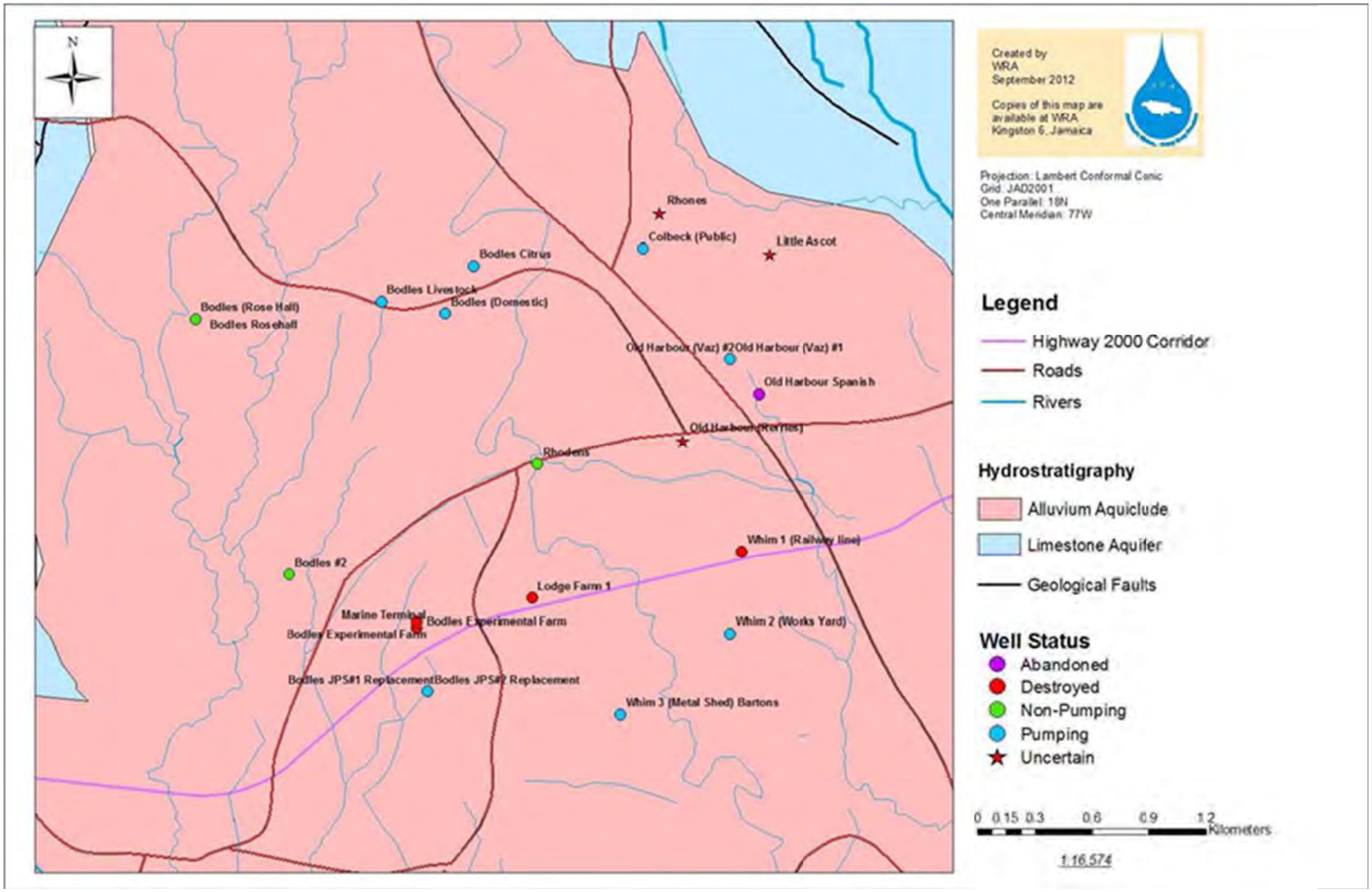


Figure 5-8 Map Showing Bodles Hydrostratigraphy (Source: WRA assessment Bodles Rosehall and Bodles Experimental Wells)

A pump test was done on the Bodles Rosehall well in 2000 and had a specific capacity of 111,741.55m^3/day/m which was calculated at its highest rate of 14,526.4m^3/day. The static water level was 29.87 metres below ground level and a measured drawdown of 0.13 metres at yield testing. This high productivity maybe as a result of the prevailing geology in the Bodles area indicating the well taps a conduit with high flows (underground river) where recharge equals discharge during testing.

Information from Well Record

Diameter: 508mm

Depth: 53.34 metres

Casing: Plain 508mm casing from 0.31m – 27.13m

Slot 508mm casing from 27.13m – 42.34m

Information from Telelog.

Diameter: 508mm (20 inches)

Depth : 53.34m (175 feet)

Casing : Plain 508mm from 0.31m -27.13m

Slot 508 mm from 27.13m -33.22m

Slots 457.2mm from 33.22m -43.89m

Open Hole from 43.89m -53.34m

The Bodles Experimental Farm well was a moderate producer at its yield testing in 2000 with a specific capacity of 769.3m^3/day/m when tested at its highest rate of 2,594.67m^3/day. The static water level was 21.52 metres below ground level and a measured drawdown of 3.37 metres at yield testing. The stabilisation of the drawdown indicated that the aquifer was continuously recharged. However, with ground elevation at 23.32 metres above sea level a licenced volume of 1,000m^3/day was assigned which would result in pumping water levels of 0.8metres above sea level. Any higher pumping would result in below sea level pumping thereby inducing seawater intrusion.

Information from Well Record

Diameter: 250mm

Depth : 35.97metres

Casing: no information

5.1.5 Seismicity

As indicated above, evidence of fault movements affecting the White Limestone bedrock (five million years and older) in the Old Harbour Bay region is provided by data from water supply wells and geophysical studies (Fernandez, 1983), confirmed from numerous surface outcrops throughout the island. Although no younger rocks outcrop in the immediate vicinity of the site, in other parts of the island rocks of the Coastal Group (130,000 to 3 million years old) are warped and/or faulted (Horsfield 1973). As noted above, faulting affecting more recent unconsolidated or semi-consolidated sediments may frequently be difficult to identify, and is not evident in the field at Old Harbour Bay. Fault displacements measured on rocks as young as 130,000 years old, together with continuing seismic events in present times indicates that Jamaica is in a seismically active part of the North Caribbean Plate boundary zone. Figure 5-9, a map showing the relative frequency of seismic events in different parts of Jamaica, indicates that between 5 and 9 events greater than intensity MM VI on the Mercalli scale occur per century.

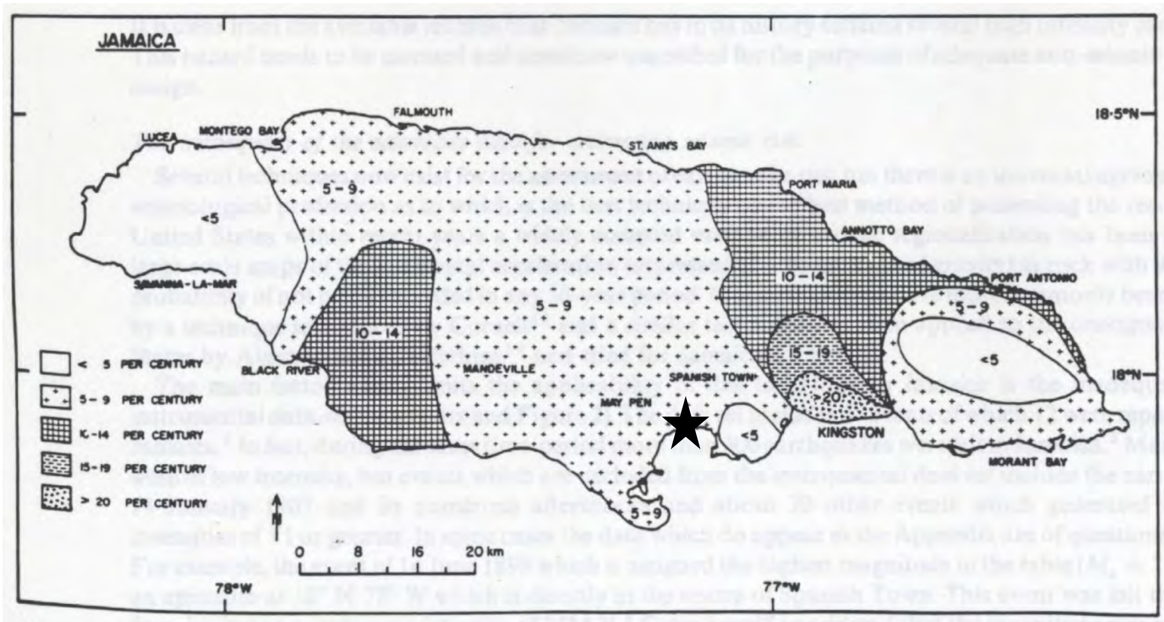


Figure 5-9 - Map showing number of times per century that intensities of MM VI or greater have been reported, 1880-1960 (from Shepherd & Aspinall, 1980). Black star is SJPC site.

Figure 5-10 shows the probability of incidence of horizontal ground accelerations with a 10% probability of exceedence in fifty years in different areas of Jamaica (Shepherd et al. 1999). The Old Harbour Bay area (starred) has a 10% probability of experiencing accelerations of about 260 gals (26% g) per fifty years. As the plant will be built on alluvial fan deposits with an estimated thickness of 200 m, accelerations experienced for the development would be

The intensity of seismic shaking depends largely on the quality and thickness of the unconsolidated or semi-consolidated sediments overlying the bedrock. Shallow (less than 50 m) thicknesses transmit short period motions to best effect. Longer period motions are transmitted most effectively by thicknesses up to about 100 m (Aspinall & Shepherd, 1978). Thicknesses of semi-consolidated sediments exceeding 100 m, such as is probably the case here, tend to suppress the periods of engineering interest (CDMP 2001 Kingston study).

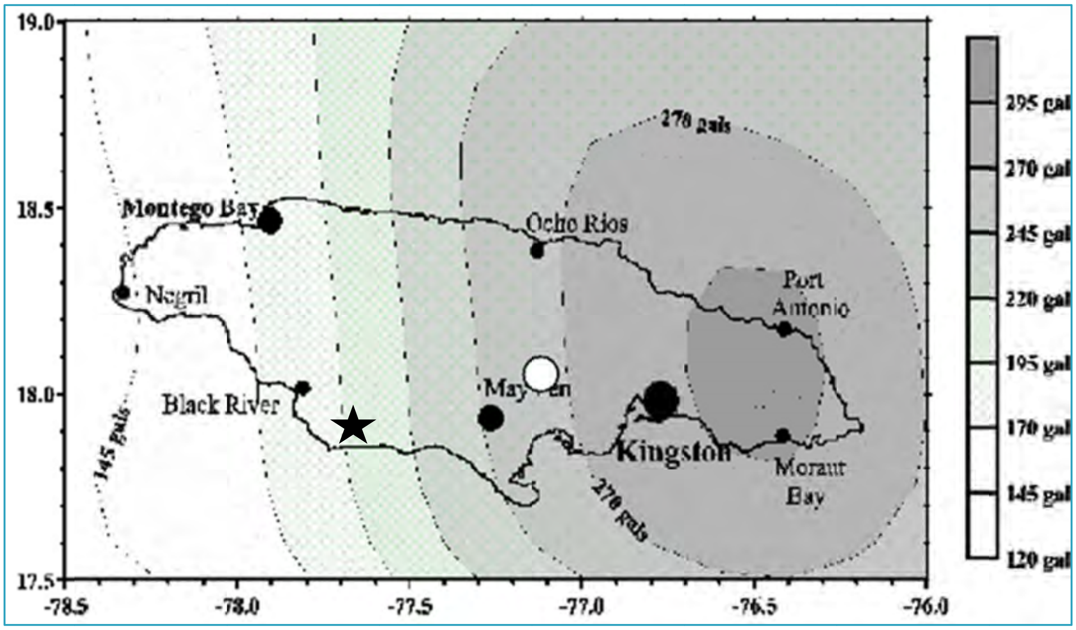


Figure 5-10 - Horizontal ground acceleration with 10% probability of exceedence in fifty years (Shepherd et al. 1999 in CDMP 2001), Contour interval is 25 gals (2.5%g). Modified from CDMP 2001. Black star is SJPC site.

5.1.6 Hazards

Both natural and anthropogenic hazards are considered in the following sections.

5.1.6.1 Hurricane Waves

Wave information on the site is crucial in order to understand the likely conditions that the shoreline will be subjected to and hence design adequate mitigating structures.

The Old Harbour Bay is part of a larger bay known as the Portland Bight. The Portland Bight is exposed to the Caribbean Sea from a southerly direction and so even though wind and current information suggests that waves from the south are uncommon, the potential is there to generate devastating waves and so must be examined.

The Portland Bight is significantly large with a fetch of approximately 15.7 km in a southerly direction from the Old Harbour Bay to the Rocky point headland. It is therefore quite possible for local waves with significant wave heights to reach the shoreline.

A rapid assessment of both local and deep water waves that could potentially reach the shoreline from deep water was done using a database of hurricanes, dating back to 1886. The database was searched for storms that passed within a 300km radius from the site and the following procedure was carried out.

1. Extraction of storms and storm parameters from the historical database: A historical database of storms was searched for all storms passing within a 300km radius of the site.
2. Application of the JONSWAP wind-wave model. A wave model was used to determine the wave conditions generated at the site due to the rotating hurricane wind field. This is a widely applied model and has been used for numerous engineering problems. The model computes the wave height from a parametric formulation of the hurricane wind field.
3. Application of extremal statistics. Here the predicted maximum wave height from each hurricane was arranged in descending order and each assigned an exceedance probability by Weibull's distribution.
4. A bathymetric profile from deep water to the site was then defined and each hurricane wave transformed along the profile. The wave height at the nearshore end of the profile was then extracted from the model and stored in a database. All the returned nearshore values were then subjected to an Extremal Statistical analysis and assigned exceedance probabilities with a Weibull distribution. Table 5-1 shows the incident wave heights and periods obtained from the JONSWAP model.

Table 5-1 - Incident wave heights and periods obtained for 1-in-50 year hurricane waves.

		SSW	S	SSE	SE	ESE
Local	**Hurricane**					
	Hs (m)	4.93	4.93	4.93	2.16	2.16
	Tp (s)	6.65	6.65	6.65	3.83	3.83
Deepwater	**Hurricane**					
	Hs (m)	5.9	5.9	5.9	7	7
	Tp (s)	12.1	12.1	12.1	13.2	13.2

Overall, these are relatively large waves with potential for wreaking severe damage on coastal infrastructure. Their potential resulting near shore climates were investigated.

Table 5-2 - Bi-variant table showing incident wave heights and periods for the specific return periods and directions.

Return Periods	Wave height (m)											
	All		SW		W		E		SE		S	
	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp
1	2.0	7.2	1.0	5.1	1.0	5.1	1.0	5.1	1.0	5.1	1.0	5.1
2	3.6	9.5	3.3	9.2	3.5	9.5	4.6	10.7	4.0	10.1	3.4	9.3
5	4.9	11.0	4.1	10.1	4.6	10.7	5.7	11.9	5.2	11.4	4.4	10.5
10	5.7	11.9	4.4	10.5	5.1	11.3	6.3	12.5	5.9	12.1	5.0	11.1
20	6.4	12.6	4.7	10.9	5.6	11.8	6.8	13.0	6.4	12.6	5.4	11.6
25	6.6	12.8	4.8	11.0	5.7	11.9	6.9	13.1	6.6	12.8	5.6	11.7
50	7.3	13.4	5.1	11.2	6.1	12.3	7.3	13.4	7.0	13.2	5.9	12.1
75	7.7	13.7	5.2	11.4	6.3	12.5	7.5	13.6	7.3	13.4	6.1	12.3
100	7.9	14.0	5.3	11.5	6.4	12.6	7.7	13.7	7.5	13.5	6.3	12.5
150	8.3	14.3	5.4	11.6	6.6	12.8	7.9	13.9	7.7	13.7	6.5	12.6
200	8.6	14.5	5.5	11.7	6.7	12.9	8.0	14.0	7.8	13.9	6.6	12.8

5.1.6.2 Hurricane Storm Surge and Wind Speeds

5.1.6.2.1 Anecdotal Information

Hurricane Ivan storm surge at the site was estimated to be 1 to 1.5 m, based on conversations with observers at the existing JPS plant. Figure 5-11 **Error! Reference source not found.**indicates the values for storm surge height and inundation distance for four localities at Old Harbour Bay during hurricane Dean, 2007. A storm surge of 3+ m was recorded at the Port Esquivel bauxite terminal just west of the site, and 3.1 m at the conch port of Old Harbour Bay, east of the site, with an inundation distance of about 180 m (Robinson & Khan, 2011). Hurricanes and tropical storms are frequently accompanied by heavy rainfall. It has also been widely suggested that the Atlantic-Caribbean region has already moved, into a cycle of more frequent and more severe tropical disturbances.

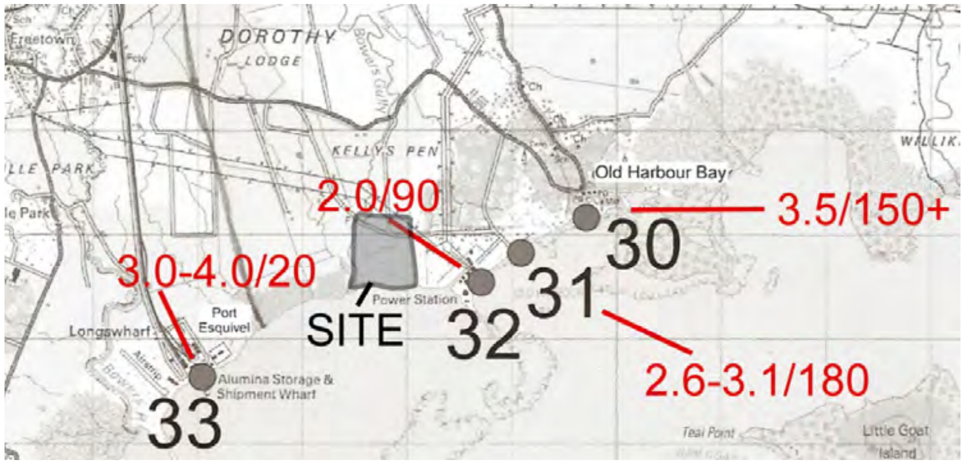


Figure 5-11 - Hurricane Dean 2007 surge heights (first red number) and inundation distances (red number after the slash) for four localities in Old Harbour Bay. Locality 30, from Mines & Geology Division data; localities 31-33 from Marine Geology Unit data. Figure modified from Robinson & Khan, 2011, fig. 15).

5.1.6.2.2 Summary

It is important to define the design water levels in the project area in order to define the appropriate crest elevations for floor levels of importance structure as well as setbacks for buildings. A rapid assessment similar to that for the hurricane waves was carried out, the results of this assessment clearly indicate the sites overall vulnerability to such systems. In summary:

- 88 hurricane systems came within 300 kilometres of the project area (Table 4)
- 8 of which were classified as catastrophic (Category 5)
- 14 were classified as extreme (Category 4)
- Wind speeds in excess of 35 metres/second are expected to impact the site for a 50 year storm
- The setup is expected to be in excess of 1.2m above MSL for a 50yr event

5.1.6.3 Earthquake

In the section above on seismicity it was suggested that, because of the depth (thickness) of sediments underlying the plant site, the problem of a close match between the natural period(s) of structures at the site with the predominant response mode of the underlying deposits is not likely to arise, due to the damping effects of response from the deepest layers.

Near the shoreline one can expect liquefaction of sediments in a severe earthquake. The borehole data should provide more data on this factor, but this has not yet been accessed.

5.1.6.4 Tsunami

Although tsunami (seismic sea waves) are rare for Jamaica, there are a number of records of their occurrence along the coast (Ahmad, 1998). A tsunami event of the magnitude already recorded for the Caribbean (A.M. Scheffers at www.sthjournal.org/shelf2.pdf), and for the 'worst case scenario' resulting from a submarine eruption of Kick 'em Jenny volcano (Smith and Shepherd, 1993) would be hazardous for the site. Historical records for Jamaica indicate that the highest inundation elevation ever reported for the Jamaican south coast was 2.2 m at Port Royal (NOAA/NGDC, 2012). A similar event at Old Harbour would immerse some two fifths of the area of interest and most of the site of the proposed power station.

5.1.6.5 Long Term Sea Level Rise

Data from the Arctic Climate Impact Assessment report, released in mid-November, 2004, and data from later studies indicate the strong probability that more than half of the Arctic sea ice and a significant part of the Greenland ice cap will melt over the next hundred years (http://news.nationalgeographic.com). This could raise sea levels by some 0.7 m to as much as 1.4 m by the end of the century (Allison et al. 2009). This rise will be gradual, but the consequences of such a rise must be taken into consideration in any construction of new plant. Figure 5-12from the Copenhagen Diagnosis indicates the possible spread of estimated rise for the rest of the century.

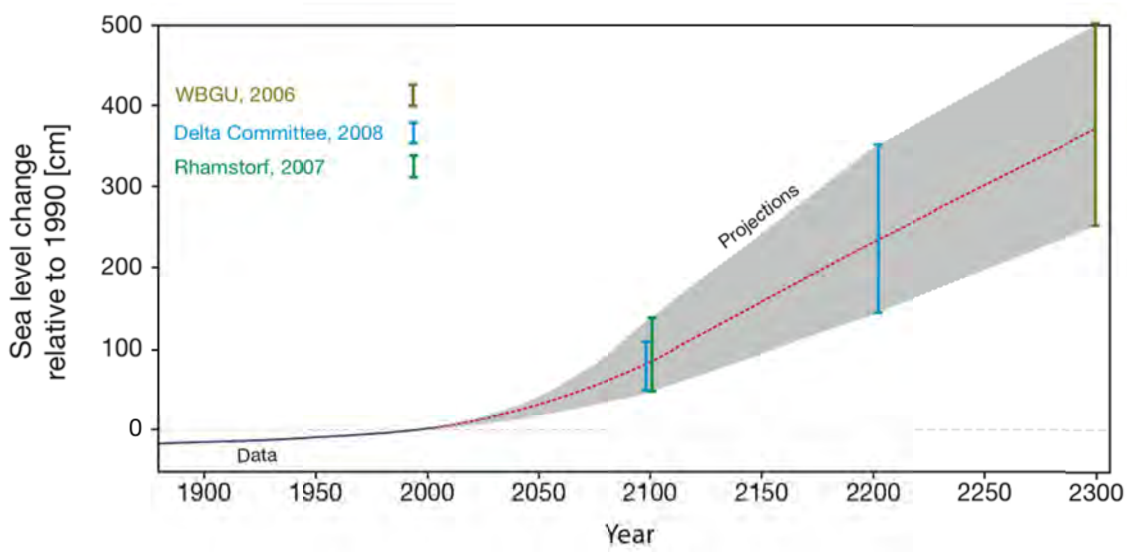


Figure 5-12 - Past and projected future rise in sea-level (Allison et al. 2009, figure 17).

5.1.6.6 Riverine Flooding

Bowers Gully forms the lower part of a relatively complex drainage system with a catchment area in excess of thirty six square kilometres (Figure 5-13) part of the Central Inlier. Here the surface drainage is perennial, collected by the Myttins River and Cedar Gully. Below the confluence of these tributaries the system, known as the Plantain River, develops seasonal flow through limestone terrain before exiting onto the St. Catherine plain near Colbeck. By the time the river exits onto the plain the system has lost most of its surface flow to the subsurface. However, Bowers Gully is susceptible to flooding under extreme precipitation conditions. As noted above the field investigations showed silt and clay overlying sand and gravel in the vicinity of the gully, indicative of flood events. The topographic survey suggests that flooding will be in the direction of the plant, as the gully course is raised slightly relative to the rest of the site. This is a typical feature of fan deposits, particularly debris fans. Although the highest layers associated with the gully are clays, the presence of gravels lower in the exposures of the gully is suggestive of debris flows as well.

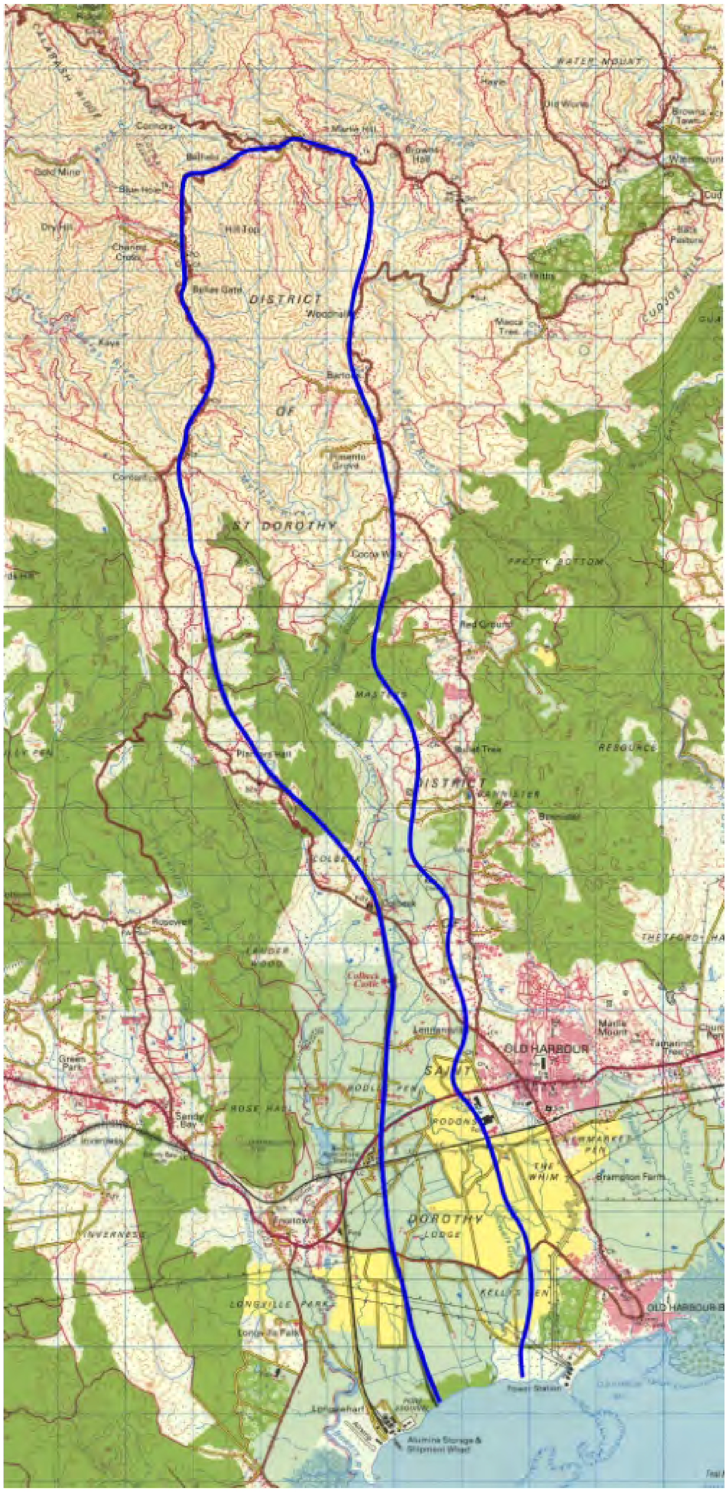


Figure 5-13 - Approximate boundary of the Bowers Gully catchment. Grid squares are 1 km each side.

5.1.7 Climate and Meteorology

5.1.7.1 Climate within Study Area

5.1.7.1.1 Methodology

Temperature, relative humidity, wind speed and direction, rainfall and barometric pressure were recorded at one (1) location adjacent to the proposed site (atop the JPS Ambient Air Quality Monitoring Station) from Wednesday April 11th – Friday July 6th, 2012 by using a Davis Instruments wireless Vantage Pro2 weather system with a data logger and a complete system shelter erected on a tripod. Data were collected every fifteen minutes and stored on the data logger. This information was downloaded using the WeatherLink 5.9.2 software.

Plate 5-6 - Photo showing location of weather station

5.1.7.1.2 Results

- Average temperature was 26.7 ^{o}C and ranged from a low of 22.6 ^{o}C to a high of 30.5 ^{o}C.
- Average relative humidity was 83.14% and ranged from a low of 55% to a high of 98%.
- Average wind speed was 2.1 m/s and ranged from a low of 0 m/s to a high of 17 m/s.

- Dominant wind direction was from the east.
- Measurable precipitation during the assessment was 274.8 mm over a total of 32 rain days.
- Mean barometric pressure was 1012.5 millibar and ranged from a low of 1008.5 millibar to a high of 1017.1 millibar.

5.1.7.2 Historical Climate Data

5.1.7.2.1 Rainfall

30 Year Climatological Data (1951-1980)

As seen below in Table 5-3 and Figure 5-14, temperatures are greatest during the months of June through September. Lowest mean minimum temperature of 15.3 ^{O}C is seen to occur in the month of February and the greatest mean maximum temperature of 31.9 occurs in between June and July. Rainfall is seen to have two yearly peaks of greater than 150 mm in September and October. January and February are seen to be the driest months of the year.

Table 5-3 - Mean Climatological data for Bodles (1951-1980) – Jamaica Meteorological Service

1951-80 MEAN CLIMATOLOGICAL DATA FOR SELECTED LOCATIONS													
Station (Altitude)	Parameter	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Bodles (Old Harbour) (St.Catherine) (alt. 37 metres)	Max Temp. (C)	29.3	29.2	29.4	30.4	30.4	31.1	31.9	31.9	31.1	30.7	30.4	30.2
	Min Temp. (C)	16.3	15.3	17.0	18.1	19.3	20.1	20.3	20.2	19.7	18.9	19.2	18.1
	Rainfall (mm)	41	42	49	56	123	91	58	97	161	198	83	53
	Rel. Hum.- 7am (%)	94	92	92	88	89	87	86	89	92	94	93	91
	Rel. Hum.- 1pm (%)	64	65	63	62	69	66	63	68	70	70	66	66

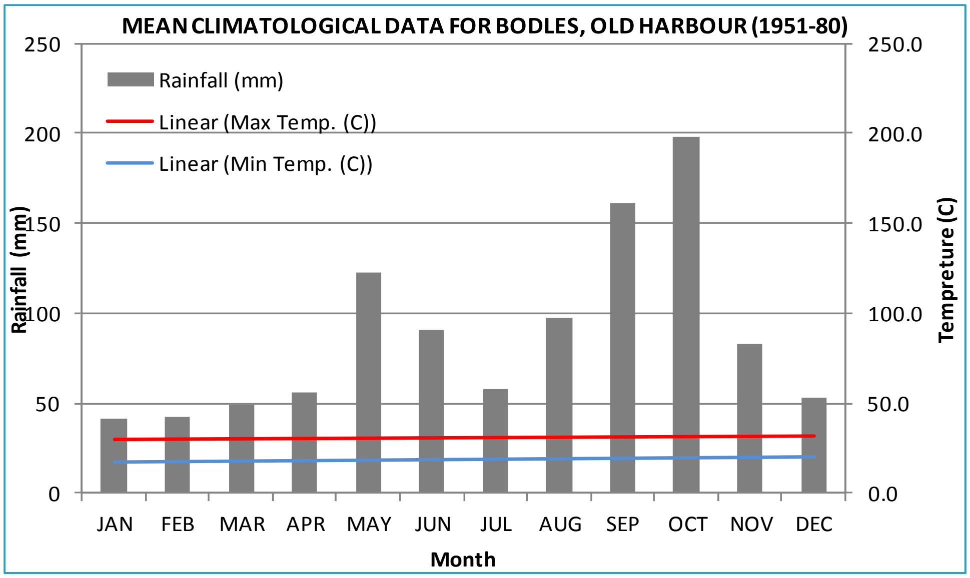


Figure 5-14 - Mean Climatological data for Bodles (1951-1980) – Jamaica Meteorological Service

Extreme Rainfall

The rainfall data for gauges in Jamaica were obtained from the Meteorological Office of Jamaica. Information for the gauges spanned 1930 to 1980 and 1992 to 2008. Both sets of data were subjected to Weibull analysis for the extreme rainfall data ranging for the 2, 5, 10, 25, 50 and 100 year. Historical rainfall extremes for stations across the island for the period 1930 to 1988 were compared with the extremes determined for the period 1992 to 2008. Rainfall depths for corresponding return periods were subjected to comparative analysis in order to determine if there was an overall increase or decrease in extreme rainfall.

The analysis has indicated that there has been an overall increase ranging from 11.7% (for the 2 year Return Period Event) to 1.5% (for the 100 year Return Period event) for all stations. This increase has occurred over a time frame of 21 years (1988 to 2009). This equates to 0.7% to 5.6% increase per decade.

Table 5-4 - Overall increase in 24-hours rainfall intensity (1988 – 2009)

	Return Period (yr)					
	2	5	10	25	50	100
Number of stations considered	117	117	117	117	117	116
Average increase (mm)	14.0	10.0	5.6	5.9	6.3	5.3
Average rainfall depth (mm) 1930 to 1988	119.8	175.0	217.7	268.2	307.8	345.7
Overall increase	11.7%	5.7%	2.6%	2.2%	2.1%	1.5%
Increase per decade	5.6%	2.7%	1.2%	1.0%	1.0%	0.7%

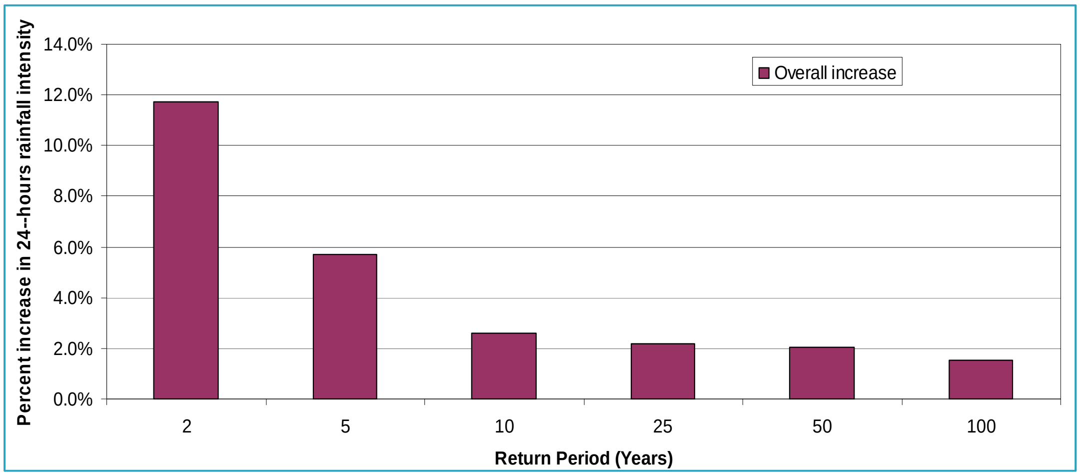


Figure 5-15 - Overall increase in 24-hours rainfall intensity for the period between 1988 and 2009

Given the design life of the project is 25 years, due consideration should be given to the changes in extreme rainfall as the old data appears to be irrelevant in light of the new data supplied by the Meteorological Office of Jamaica. See Figure 5-16 and Figure 5-17 below for the rainfall changes estimated for the 50year and 100year 24 hour extreme rainfall.

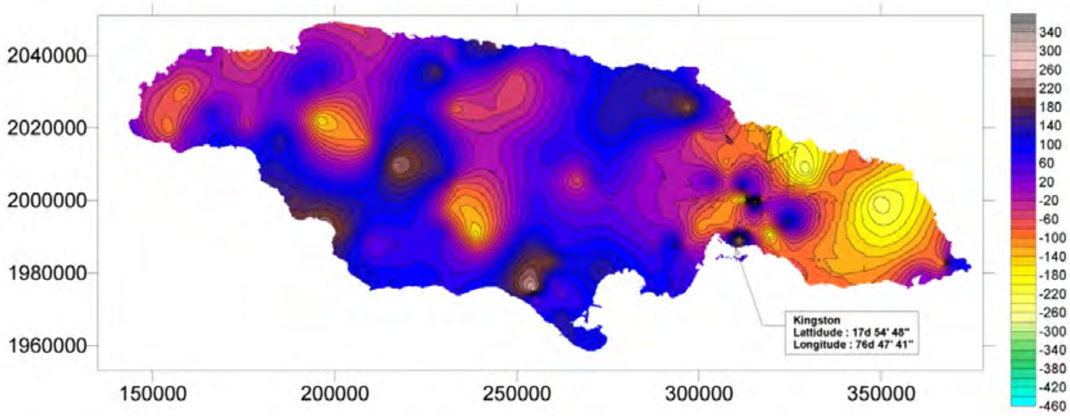


Figure 5-16 - Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 50 Year Return Period Event

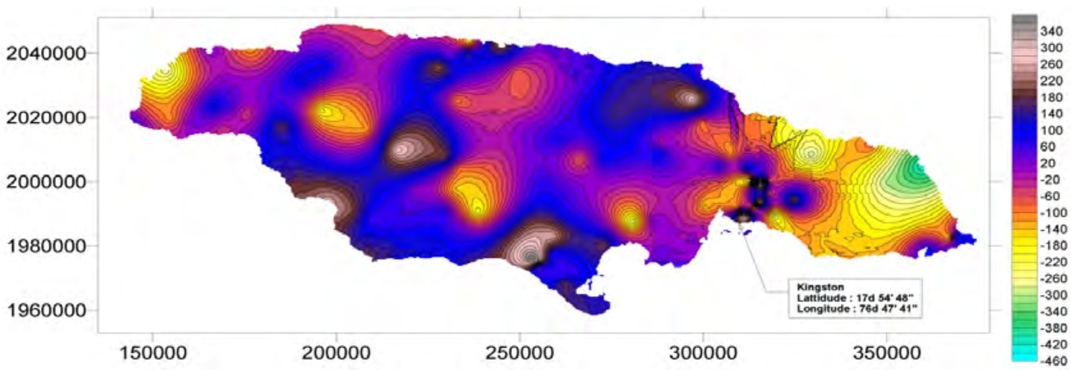


Figure 5-17 - Difference (mm) between the 1930-1988 and 1992 to 2008 24-hours Extreme rainfall intensities for the 100 Year Return Period Event

5.1.7.2.2 Wind

Historical and current wind data for the project area was obtained from two main sources:

- Offshore measurements - NOAA climate service floating stations (buoys)
- Onshore measurements – Weather station on JPS site and Norman Manley International Airport (NMIA) Meteorological Station.

NOAA Climate Service

A node was chosen in front of the bay and the wind and wave data corresponding to that node obtained. The node used was:

- Zone: 18
- Easting: 286049
- Northing: 1948299

The data spanned the years of 1999 to 2007 recorded on a daily basis at three hour intervals. The data is shown in a wind rose in Figure 5-18. The data was analysed in terms of percentage occurrence of various wind speed and direction combinations in order to characterize the wind climate for the site.

The analysis revealed that the winds have a direction of NE to ESE direction with wind speeds of 20 m/s or less approximately. Southerly and Westerly wind directions were noted to occur but rarely. Overall the average wind speed and direction is between 6 to 8m/s from the ENE to ESE.

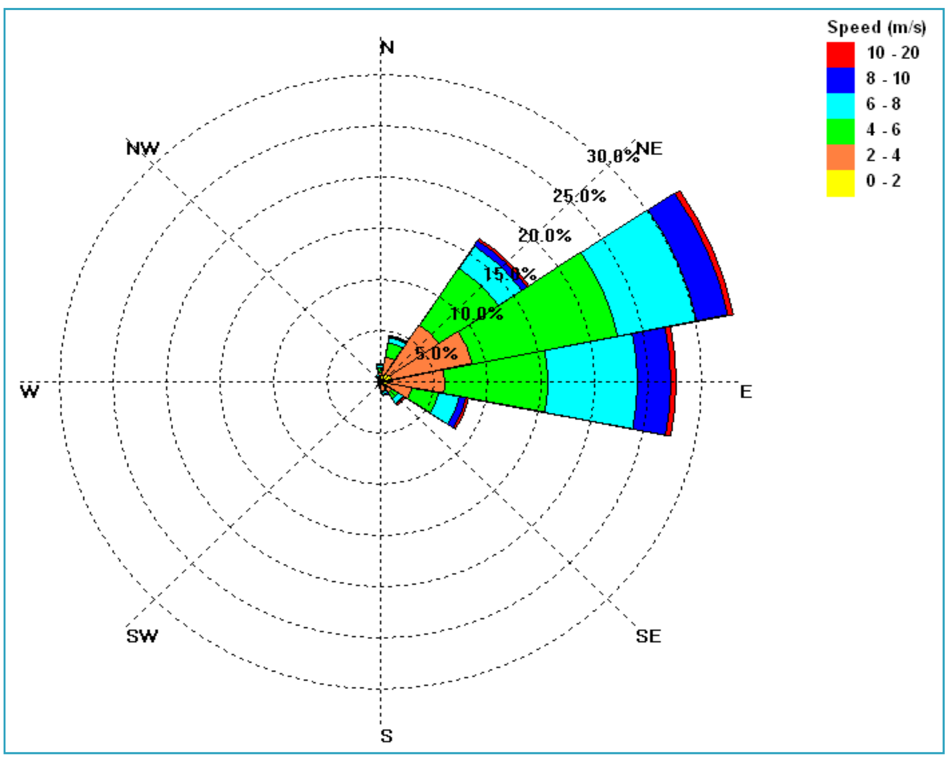


Figure 5-18 - Wind Rose of NOAA Wind Data for 1999 - 2007

NMIA Meteorological Station

The data obtained from the NMIA Meteorological station spanned the years 2004 to 2009. Analysis of this data revealed that the winds were predominantly from the ENE to ESE directions approximately with winds of 6-8m/s over 20 percent of the time.

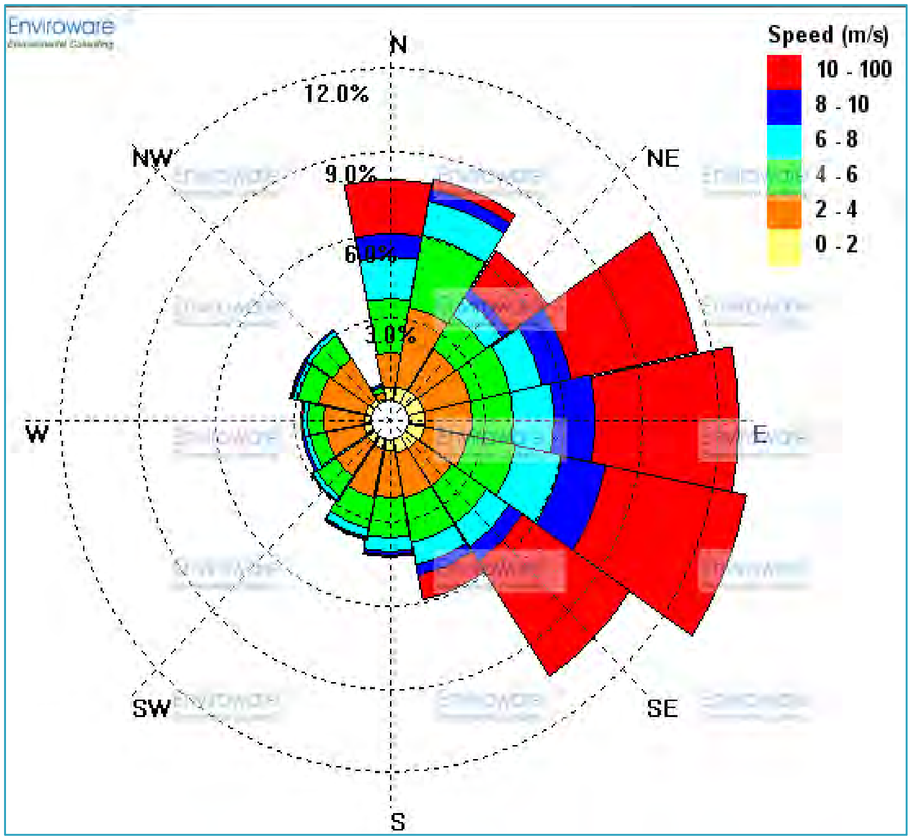


Figure 5-19 - Wind Rose of Norman Manley International Airport wind data (2004-2009)

5.1.8 Bathymetry

5.1.8.1 Existing Data

Detailed bathymetric data for the project area was essential for formulating both the hydrodynamic model (Finite Element Model, FEM) and wave model. The only available topographic survey data for Old Harbour Bay are the national 1:12,500 and 1:50,000 survey maps. There are also two existing bathymetric charts that cover the general area - 257 Salt River and 454 Portland Bight.

5.1.8.2 Bathymetric Survey

Bathymetric surveys of the bay immediately south of the project site were conducted on April 24 and 26, 2012. These were autonomous surveys using a Garmin GPSmap 178C sounder.

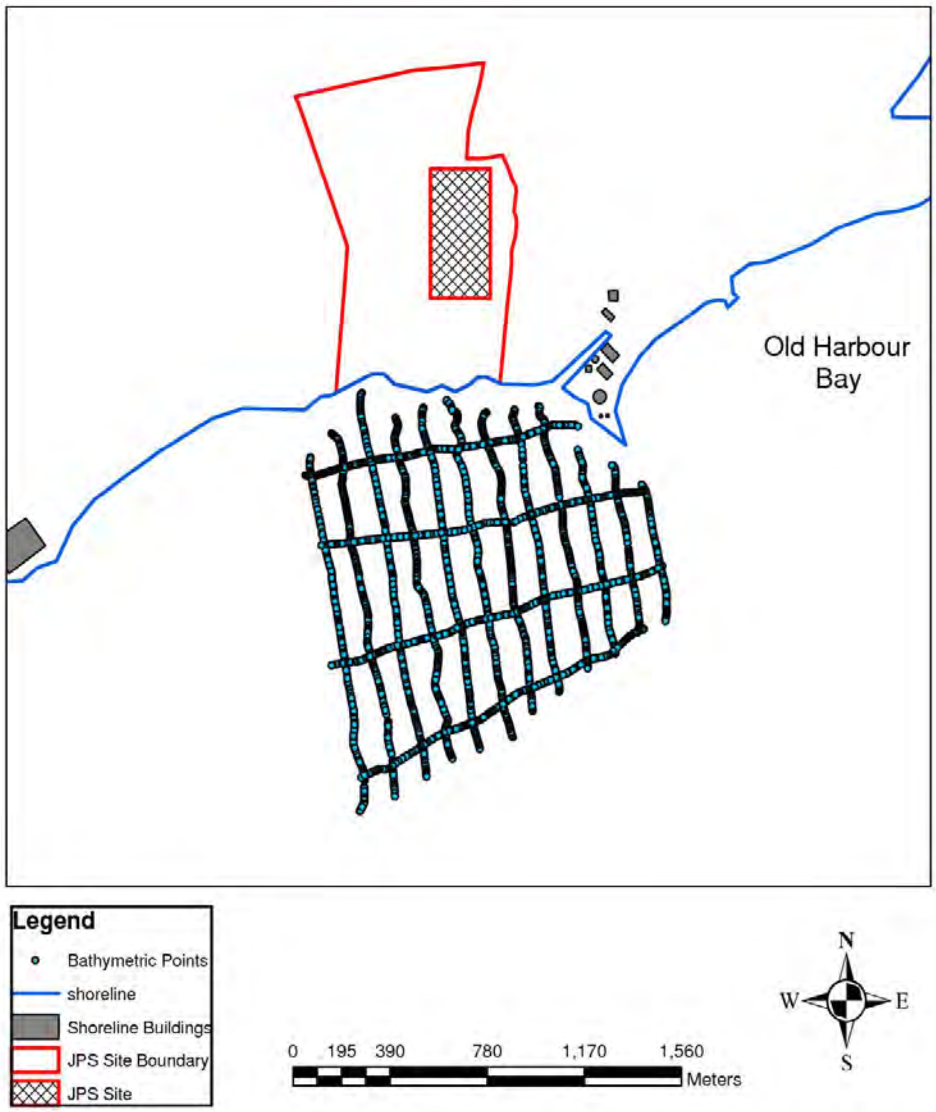


Figure 5-20 - Bathymetric survey points obtained South of the proposed 36MW plant on April 24th and 26th, 2012

The data obtained revealed that the bathymetry is relatively shallow out to the reefs which are approximately 1.6 km from the shoreline. The seafloor slopes gently at an average of 2 percent from the shoreline out to the reefs, with depths of 5 to 6 meters between the reefs and the shoreline.

These data will be combined to digitized bathymetric data from British Admiralty charts of the area to create a digital bathymetric surface of the wider area. This will be useful for running wave models, sediment models and hydrodynamic models.

5.1.9 Shoreline Sediments

5.1.9.1 Sediment Size

Surface sediment samples were recovered from the project area at two locations east of the SJPC proposed site. Two samples were collected from each location; one from the Beach front (BF) and the other from the back of the beach (BB). See Figure 5-21 below for the sediment sample location points.

Grain size analysis of these samples was conducted and the results of this analysis are summarized in Figure 5-22 and Table 5-5.

Figure 5-21 - Sediment grain size sampling locations

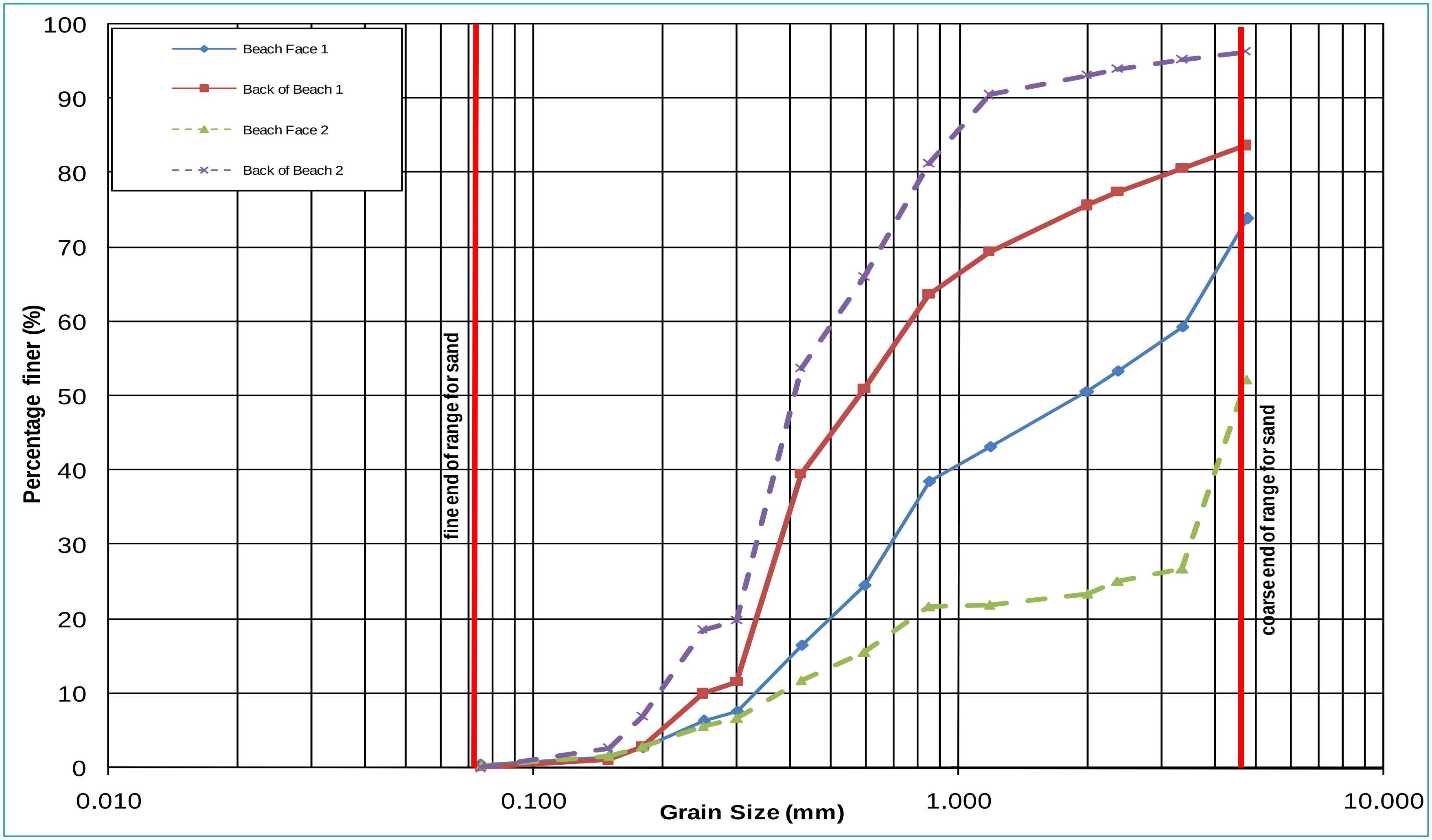


Figure 5-22 - Sieve analysis results (graph)

Table 5-5 -Sieve analysis results

Sample ID	Beach Face 1	Back of Beach 1	Beach Face 2	Back of Beach 2
Mean (mm)	1.932	0.586	4.626	0.411
Mean (phi)	-0.950	0.771	-2.210	1.283
Description	very coarse sand	coarse sand	gravel	medium sand
Percentage silt	0.38%	0.13%	0.3%	0.0%
Percentage >0.06mm and <6.0 mm	73%	84%	52%	96%
Uniformity Coefficient	10.257	2.789	17.469	2.589
Standard Deviation	1.441	1.968	1.299	1.143
	poorly sorted	poorly sorted	poorly sorted	poorly sorted
Skewness	0.608	-0.152	2.616	0.986
	strongly positive skewed	negative skewed	V. strongly positive skewed	strongly positive skewed
Kurtosis	0.264	1.095	0.204	1.412
	extremely leptokurtic	mesokurtic	extremely leptokurtic	leptokurtic

The grain size analysis was done using the unified classification which is widely used for classification of granular material. The sand sizes vary from very coarse to coarse sand moving from the front of the beach to the Back the beach at sample location one with rain sizes of 1.93mm to 0.586mm respectively. Sample location two grain sizes varied from gravel to medium sand moving from the front of the beach to the Back of the beach with medium grain size of 4.626mm and 0.411mm respectively. The levels of silt present in the sands are consistent with what was observed on the beach, with sample location one having the highest concentration/percentage of silt.

5.1.9.2 Uniformity Coefficient

The uniformity coefficient is a measure of the variation in particle sizes. It is defined as the ratio of the size of particle that has 60 percent of the material finer than itself, to the size of the particle that has 10 percent finer than itself.

The uniformity coefficient is calculated as:

Uc = D60/D10

Where :

- U_c – uniformity coefficient
- D60 - The grain size, in mm, for which 60% by weight of a soil sample is finer
- D10 - The grain size, in mm, for which 10% by weight of a soil sample is finer.

Within the unified classification system, the sand is well graded if U_c is greater than or equal to 6. The samples collected from the front of the beach at both sample locations have well graded sand as the uniformity coefficients were greater than 6. The back of the beach had uniformity coefficient values of 2.8 and 2.6 for sample locations one and two respectively. This sand in this area is considered to be poorly graded.

5.1.9.3 Standard Deviation

The Standard deviation is a measure of the degree of sorting of the particles in the sample. A standard deviation of one or less defines a sample that is well sorted while values above one are poorly sorted.

The sand samples for the respective beaches are:

- Sample Location 1 (Beach Back- Poorly sorted)
- Sample Location 1 (Beach Front - Poorly sorted)
- Sample Location 2 (Beach Back- Poorly sorted)
- Sample Location 2 (Beach Front - Poorly sorted)

5.1.9.4 Skewness

Skewness describes the shift in the distribution about the normal. The skewness is described by the equation:

$$S = \frac{\phi 84 + \phi 16 - 2(\phi 50)}{2(\phi 84 - \phi 16)} + \frac{\phi 95 + \phi 5 - 2(\phi 50)}{2(\phi 95 - \phi 5)}$$

This formula simply averages the skewness obtained using the 16 phi and 84 phi points with the skewness obtained by using the 5 phi and 95 phi points, both determined by exactly the same principle. This is the best skewness measure to use because it determines the skewness of the "tails" of the curve, not just the central portion, and the "tails" are just where the most critical differences between samples lie. Furthermore, it is geometrically independent of the sorting of the sample.

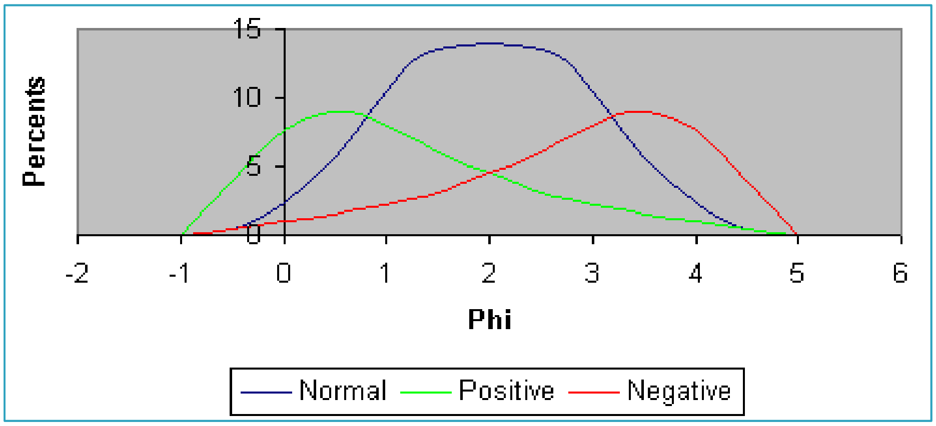


Figure 5-23 – Skewness curves

Symmetrical curves have skewness=0.00; those with excess fine material (a tail to the right) have positive skewness and those with excess coarse material (a tail to the left) have negative skewness. The more the skewness value departs from 0.00, the greater the degree of asymmetry. The limits on skewness are outlined in Table 5-6.

Table 5-6 - Descriptive limits of skewness

Values from:	Values to:	Mathematical Description	Graphical Skew
+1.00	+0.30	Strongly positive skewed	Very Negative phi values, coarse
+0.30	+0.10	Positive skewed	Negative phi values
+0.10	- 0.10	Near symmetrical	Symmetrical
- 0.10	- 0.30	Negative skewed	Positive phi values
- 0.30	- 1.00	Strongly negative skewed	Very Positive phi values, fine

The results for skewness for the stretch of shoreline can be summarized as follows:

- Sample Location one and two at the front of the beach along with sample location two back of the beach has a strong positive skewness ranging from 0.61 to 2.62. This is indicative excessive fine material and a moderated wave climate that does not wash out the fine sediment particles.

- Sample location one at the back of beach has negative skewness of -0.15. This is indicative of a long coarse tail of particles and an aggressive wave climate that washes out the fines particles.

5.1.9.5 Kurtosis

Kurtosis describes the degree of peakedness or departure from the "normal" frequency or cumulative curve

In the normal probability curve, defined by the Gaussian formula; the phi diameter interval between the 5 phi and 95 phi points should be exactly 2.44 times the phi diameter interval between the 25 phi and 75 phi points. If the sample curve plots as a straight line on probability paper (i.e., if it follows the normal curve), this ratio will be obeyed and we say it has normal kurtosis (1.00). Departure from a straight line will alter this ratio, and kurtosis is the quantitative measure used to describe this departure from normality. It measures the ratio between the sorting in the "tails" of the curve and the sorting in the central portion. If the central portion is better sorted than the tails, the curve is said to be excessively peaked or leptokurtic; if the tails are better sorted than the central portion, the curve is deficiently or flat-peaked and platykurtic.

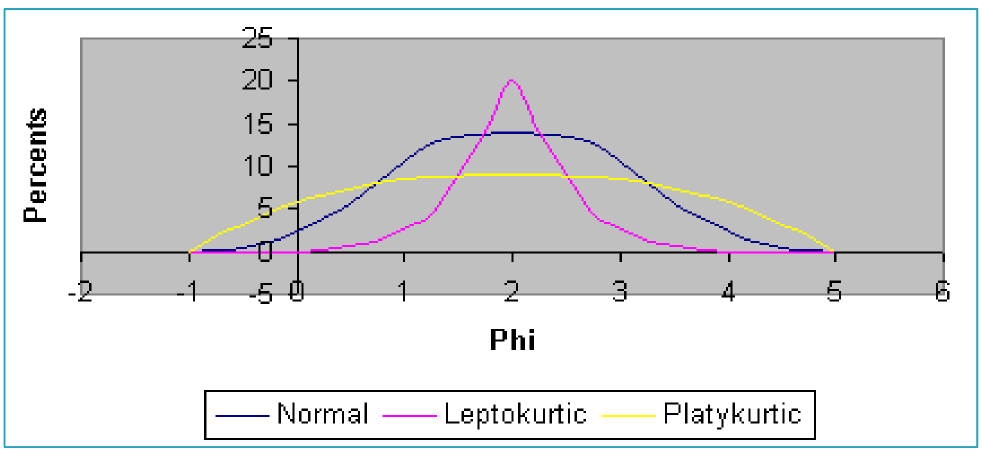


Figure 5-24 – Kurtosis curves

Strongly platykurtic curves are often bimodal with subequal amounts of the two modes; these plot out as a two-peaked frequency curve, with the sag in the middle of the two peaks accounting for its platykurtic character. For normal curves, kurtosis equals 1.00. Leptokurtic curves have a kurtosis over 1.00 (for example a curve with kurtosis=2.00 has exactly twice as large a spread in the tails as it should have, hence it is less well sorted in the tails than in the central portion); and platykurtic have kurtosis under 1.00. Kurtosis involves a ratio of spreads; hence it is a pure number and should not be written with a phi attached.

Table 5-7 – Descriptive limits of kurtosis

Values from	To	Equal
0.41	0.67	very platykurtic
0.67	0.90	platykurtic
0.90	1.11	mesokurtic
1.10	1.50	leptokurtic
1.50	3.00	very leptokurtic
3.00	∞	extremely leptokurtic

A similar trend was observed in the Kurtosis analysis as was observed in the skewness analysis. The following is a summary:

- Sample location two front and back of beach sediment is leptokurtic to extremely leptokurtic and sample location one of beach is extremely leptokurtic. This is indicative of aggressive coastal processes that sort out the particles into a discrete particle size.
- Sample location one back of beach is mesokurtic. This is indicative of mild to moderate sediment transport processes.

5.1.10 Hydrology and Flooding

5.1.10.1 Hydrology

Hydrologic analysis of the catchments associated with the bowers gully as well as the catchment bounded by the proposed plant boundary were analysed to determine runoff for the 10, 50, and 100 year return rainfall events. Hydrological modelling of the watersheds encompassed three main elements:

- Precipitation
- Rainfall abstraction model (Curve number method)
- Runoff model (Dimensionless unit hydrograph)

The SCS curve number method was used to determine the rainfall excess P_e using the following equation:

$$P_e = \frac{(P^2 - I_a^2)}{P - I_a} + S$$

Where:

- P = precipitation
- I_a = initial abstraction
- S = Potential retention which is a measure of the retention capacity of the soil.

The Maximum Potential retention, S, and the watershed characteristics are related through the Curve number CN.

$$S = \frac{25400 - (254 \times CN)}{CN}$$

Curve Numbers have been tabulated by the NRCS on the basis of soils group, soil cover or land use, and antecedent moisture conditions (initial degree of saturation).

The U.S. Army Corps of Engineers' HEC-HMS was utilized to model the precipitation-runoff processes of the Bowers Gully watershed system. A model of the watershed was constructed by separating the hydrologic cycle into manageable segments and delineating a natural watershed of interest. Watershed parameters such as infiltration losses, transforming excess precipitation and hydrologic routing methods were selected based on existing conditions. Historical meteorology data was analysed using the user-specified hyetograph method Hydrographs produced by the program are used directly or in conjunction with other software for studies of water availability, urban drainage, flow forecasting, future urbanization impact, reservoir spillway design, flood damage reduction, floodplain regulation, and systems operation.

5.1.10.2 Runoff

The peak runoffs were calculates using the type III rainfall distribution. The primary inputs into the model are as follows:

- Drainage area size (A) in square miles (square kilometres);
- Time of concentration (Tc) in hours;
- Weighted runoff curve number (RCN);
- Rainfall distribution (Figure 5-25);
- Total design rainfall (P) in inches (millimetres).

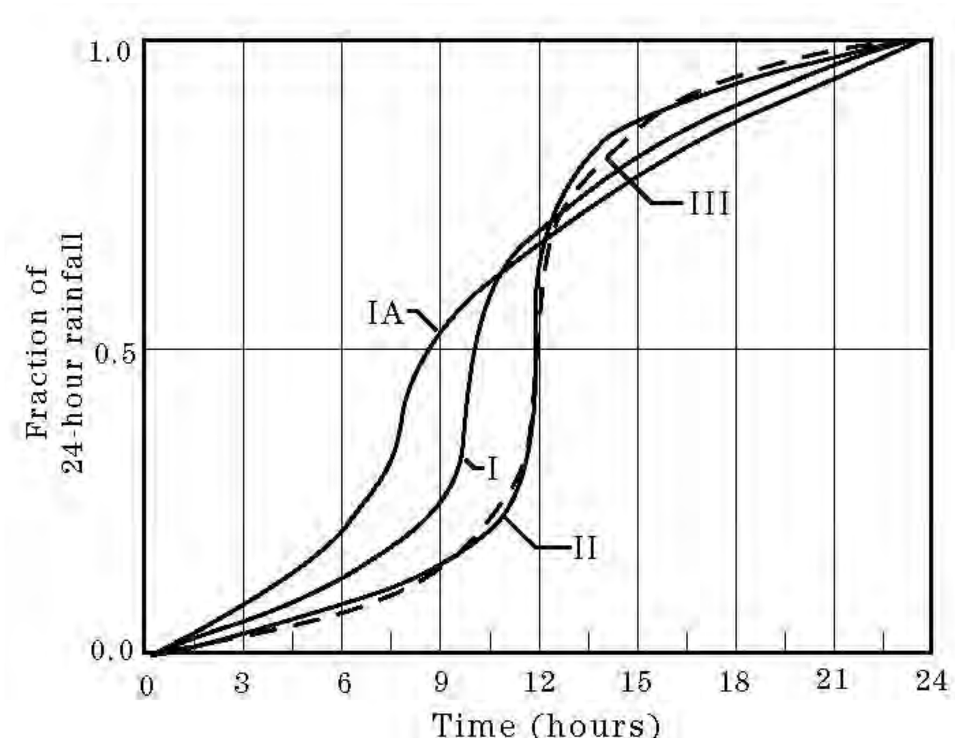


Figure 5-25 - SCS 24-hour Rainfall Distributions

Runoff was estimated for the following scenarios

- Predevelopment scenario for both Bowers Gully and the SJPC site
- Post Development Scenario for Both SJPC and the Site considering climate change impacts and future development impacts of the site and for the upper catchment of the Gully.

The overall increases in the peak flows from the Bowers Gully catchment when land use changes and climate change impacts are considered varies between 14 and 19 percent for the 10yr return to the 100yr return storm. See Table 5-8below for the summary of the flows.

Table 5-8 - Comparison of predevelopment and post development future flows in the Bowers gully

Storm	**Predevelopment runoff (m^3/s)**	**Future Flows (m^3/s)**	**Increases**
10yr	198	236	19%
50yr	406	464	14%
100yr	473	537.6	14%

The catchment delineation indicates the proposed plant area within the project site is presently not within the catchment area of Bowers Gully. It is however envisage that the designers will direct stormwater flows to the Bowers Gully. The flows from this area will increase from 77 to 49 percent for the 10 to 100 year event due to the increased impermeable areas after the construction of the power plant. The SJPC/JPSCO site flows will increase the flows in the Bowers gully at rates varying from 1.9 to 2.6 percent for the 10 year to 100 year storm event. See Table 5-9 below for a summary of the flows. The impact of this increase is however limited to the SJPC/JPSCO plant area as there are no other development downstream of the SJPC/JPSCO. See also -Table 5-10.

Table 5-9 - Comparison of predevelopment and post development future flows from the SJPC site

	Predevelopment runoff (m^3/s)	**Future Flows (m^3/s)**	**Increases**
Ivan	4.3		
Gustav	0.8		
10yr	3.5	6.2	77%
50yr	6.3	9.7	54%
100yr	7	10.4	49%

-Table 5-10 - Impacts on the Bowers Gully Flows as a result of the Proposed SJPC site development

Post-development Flows	**Bowers Gully (m^3/s)**	**Project site (m^3/s)**	**Increase**
10yr	236	6.2	2.6%
50yr	464	9.7	2.1%
100yr	537	10.4	1.9%

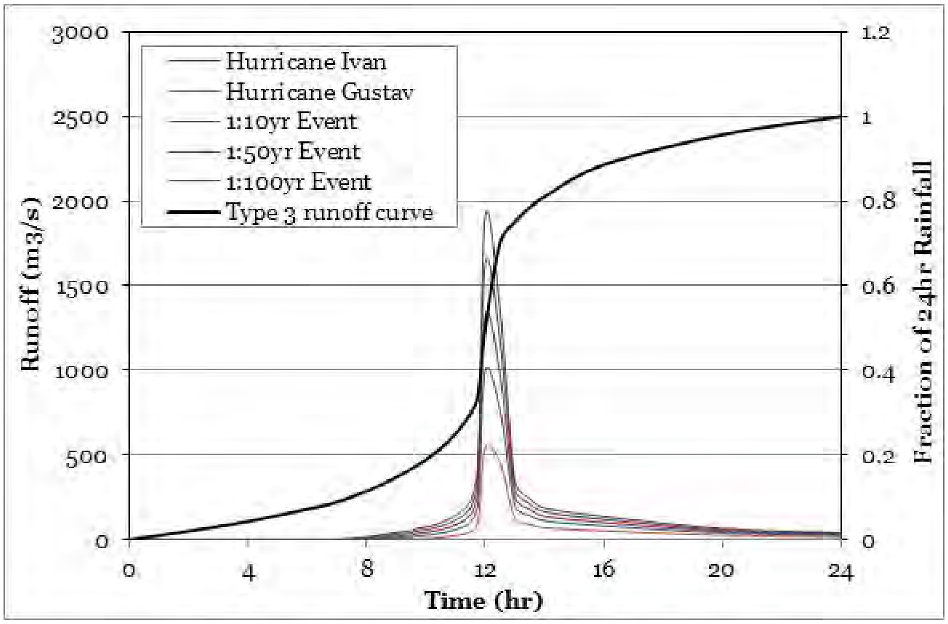


Figure 5-26 - Runoff curves for pre-development conditions based on the different return periods

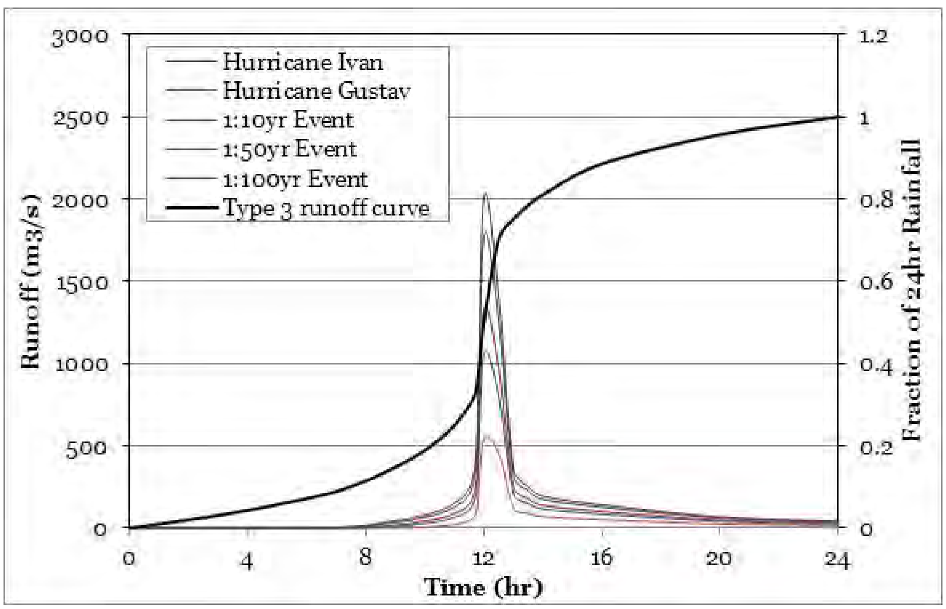


Figure 5-27 - Runoff curves for post-development conditions based on the different return periods

5.1.10.3 Storm Surge and Flooding

It is possible for storm surge to occur simultaneously with overland flooding in coastal areas such as the SJPC proposed site. It is therefore crucial that this possibility be investigated with a view to mitigating possible flooding of the site and equipment during such an event. Information regarding historical hurricane and rainfall events was obtained by conducting interviews with residents along the SJPC access road and the fishing beach in Old Harbour Bay, with living first hand memory of hurricane events in the area. This information was also compared against a Storm surge model written by CEAC Solution Company Ltd ant it was found that they had reasonable agreement.

Table 5-11 - Observed average setup (based on interviews) versus model predicted setup

Hurricane	Oberved-Average setup (m)	Predicted-Average setup (m)	Difference (m)
Dean	3.073	2.415	0.658
Ivan	3.250	4.462	-1.212
		Average	**-0.277**

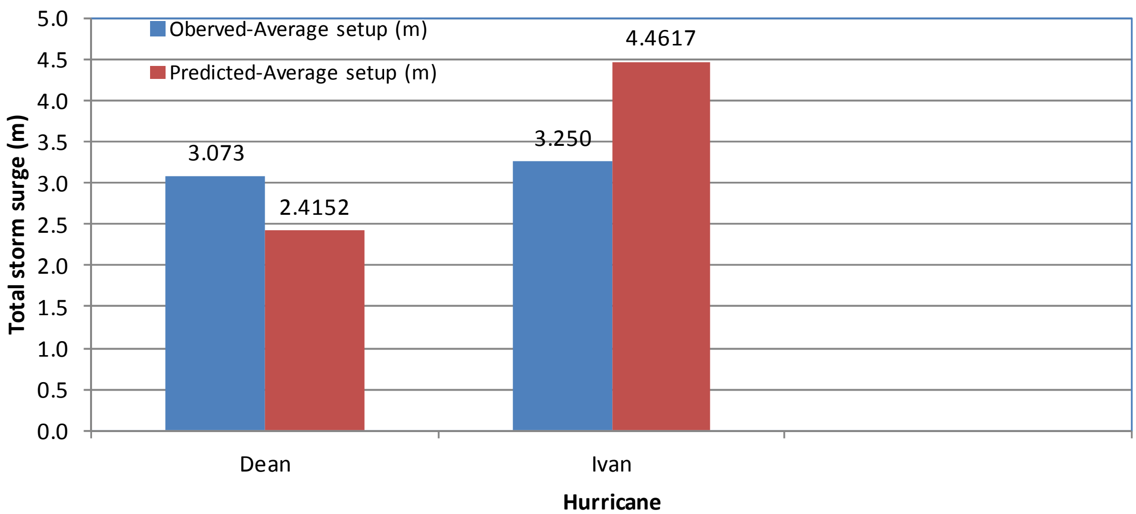


Figure 5-28 - Observed average setup (based on interviews) versus model predicted setup.

The observed setups were subjected to extremal statistical analysis to estimate the return period of the setups experienced. The statistical tool used was the Weibull function which is widely used for this type of extremal data analysis due to it having three variables which enables it to obtain a better fitted curve than others which have only two variables. The results are seen in Table 5-12.

Table 5-12 - Predicted storm surge values

Return Period	Predicted Storm Surge from Observations (m)
2	2.85
5	3.17
10	3.32
25	3.46
50	3.55
100	3.63

A storm surge inundation map of the area was plotted to highlight the areas that would be flood as a result of storm surge only. The resulting map shows the entire project site is susceptible to flooding as result of the 50 year storm surge (Figure 5-29).

5.1.10.4 Flood Plain Mapping

Flood Plain maps were generated for the current condition which showed the site is susceptible to flooding as follows:

Table 5-13 - Predicted Flood Depths

Return Period	Maximum Predicted Flood depths (m)
2	
5	
10	2.5-3.8
25	
50	2.7-5.0
100	2.7-5.3

Detailed results can be found in the 'Flood Plain Mapping Report for the Bowers Gully' prepared by CEAC Solutions Ltd.

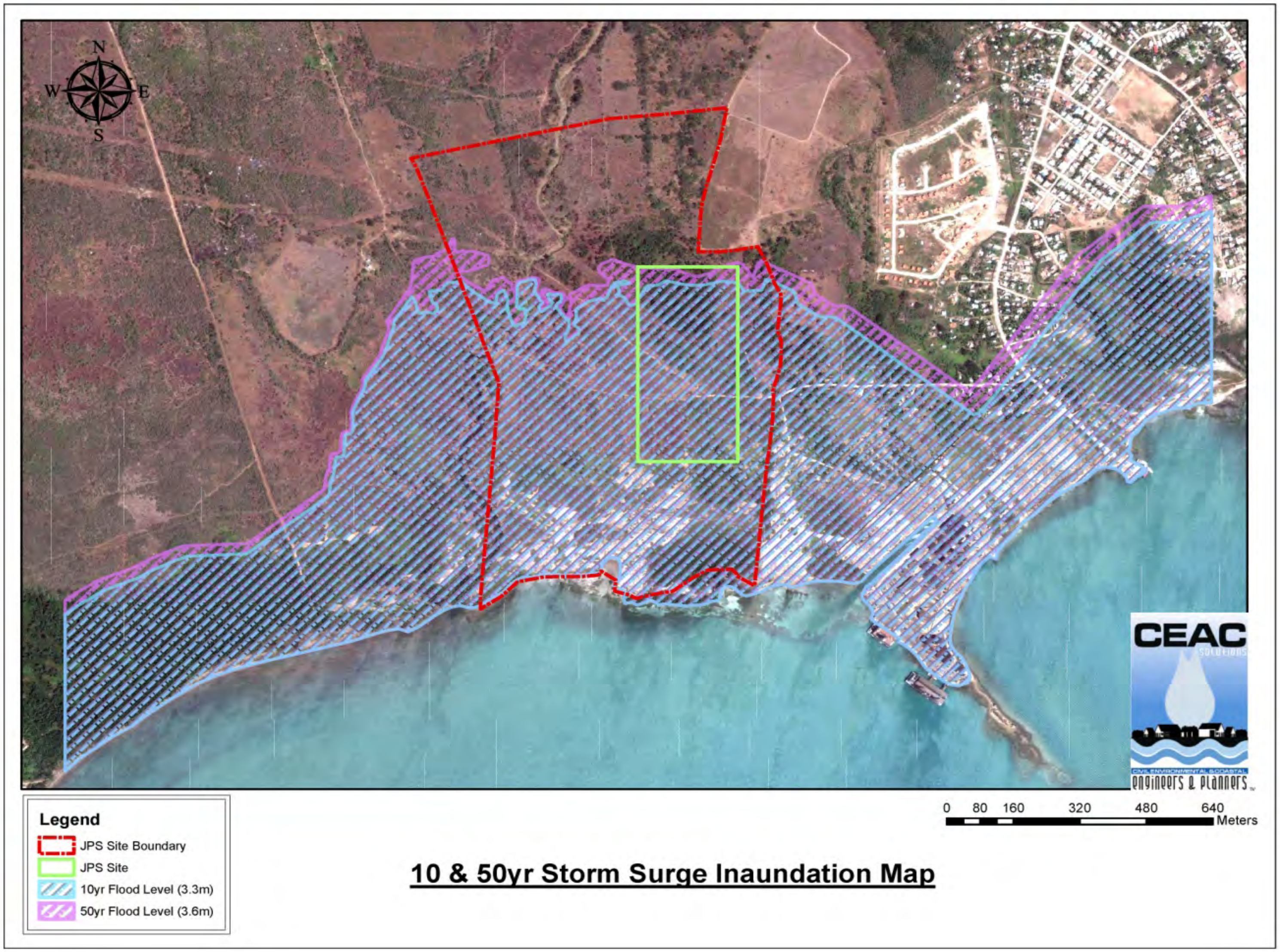


Figure 5-29 - Storm Surge inundation Map showing the extents of the 10 year and 50 year storm surge

5.1.11 Incident Wave Climate

5.1.11.1 General

Wave information on the site is crucial in order to understand the likely conditions that the shoreline will be subjected to and hence design adequate mitigating structures.

The Old Harbour Bay is part of a larger bay known as the Portland Bight. The Portland Bight is exposed to the Caribbean Sea from a southerly direction and so even though wind and current information suggests that waves from the south are uncommon, the potential is there to generate devastating waves and so must be examined.

Examination of the wave climate was done using the refraction and diffraction software known as REFDIF distributed by the US Army Corp.

The Portland Bight is significantly large with a fetch of approximately 15.7 km in a southerly direction from the Old Harbour Bay to the Rocky point headland. It is therefore quite possible for local waves with significant wave heights to reach the shoreline and add to the erosion process. It was therefore necessary for us to separate the wave analysis into two sections:

- Wave climate generated by local waves
- Wave climate generated by deep water waves

5.1.11.2 Deepwater Operational and Swell Wave Data

Historical wave climate data for the period 1999 to 2007 at a 3 hour interval was obtained from the NOAA weather service database for the node offshore mentioned earlier (Easting: 286049, Northing: 1948299). This data was tabulated into a bi-variant table and the mean wave heights and corresponding periods extracted to be used as the incident wave height and period for the operational deepwater analysis. The incident swell waves were defined as the highest 5 percent waves. Table 5-14 which shows the incident operational and swell wave data deduced.

Table 5-14 - Deepwater Operational and swell waves estimated from 1999 to 2007 NOAA Data for offshore node south of Portland Bight.

	Operational		Swell	
Direction	**Hs (m)**	**Tp (s)**	**Hs (m)**	**Tp (s)**
ESE	0.29	2.07		
SE	0.60	7.00	1.70	9.75
SSE	0.60	7.00	1.70	9.75
S	0.60	7.00	1.70	9.75
SSW	0.29	2.07		

5.1.11.3 Locally Generated Hurricane and Operational Waves

The incident wave height and period to be used in the model corresponding to the locally generated waves was calculated using the JONSWAP equation as summarized in Figure 5-30. This equation takes into account the duration of the wind associated with a storm or other weather system well as the fetch or distance in which the wave will have to travel before reaching the shoreline. The estimation of the significant wave heights and period that may be generated in Portland Bight is summarized in Table 5-15.

$$F^* = \frac{g \cdot F}{U^2},$$

$$H^*_{mo} = 0.0016\left(F^*\right)^{\frac{1}{2}} = \frac{g \cdot H_{mo}}{U^2},$$

$$T^*_p = 0.286\left(F^*\right)^{\frac{1}{3}} = \frac{g \cdot T_p}{U},$$

$$t^* = \frac{g \cdot t}{U},$$

$$d^* = \frac{g \cdot d}{U^2},$$

$$F_{eff}{}^* = \left(\frac{t^*}{68.8}\right)^{\frac{3}{2}}$$

Figure 5-30 - JONSWAP Equations

Table 5-15 - Summary of locally generated Hurricane waves using the Jonswap model

	Units	**S**	**SE**	**S**	**S**
Return Period	year	50	50	100	100
Wind Speed	m/s	65.6	65.6	70.8	70.8
Fetch	km	13	14	13	14
Duration	hours	5	5	5	5
F*		30	32	25	27
t*		2695	2695	2497	2497
Feff*		245	245	219	219
		Fetch limited	Fetch limited	Fetch limited	Fetch limited
Feff*		30	32	25	27
Hmo*		0.01	0.01	0.01	0.01
Tp*		1.79	1.79	1.72	1.72
Hmo	m	3.82	3.96	4.12	4.28
Tp	seconds	5.91	6.06	6.07	6.22

Table 5-16 - Summary of locally generated Hurricane waves using the Jonswap model

	Units	**SE**	**ESE**	**South**
Wind Speed	(m/s)	9.1	9.1	9.1
Fetch	(km)	14	4	13
Duration	(hours)	5	5	5
Comments				
F*		1660	474	1542
t*		19424	19424	19424
Feff*		4744	4744	4744
		Fetch limited	Fetch limited	Fetch limited
Feff*		1660	474	1542
Hmo*		0.07	0.03	0.06
Tp*		4.81	4.81	4.81
Hmo	m	0.55	0.29	0.53
Tp	seconds	3.14	2.07	3.06

5.1.11.4 Deepwater Hurricane Wave Climate

It was necessary to define the deepwater hurricane wave climate at the site as a part of defining the wave climate that the shoreline is subject to. Hurricane wave track data in the Caribbean Sea was available which enabled us to carry out a thorough statistical analysis to determine the hurricane wind and wave conditions at a deep-water location offshore the site.

A database of hurricanes, dating back to 1886, was searched for storms that passed within a 300km radius from the site. The following procedure was carried out:

1) Extraction of storms and storm parameters from the NOAA historical database: A historical database of storms was searched for all storms passing within a 300km radius of the site.
2) Application of the JONSWAP wind-wave model - A wave model was used to determine the wave conditions generated at the site due to the rotating hurricane wind field. This is a widely applied model and has been used for numerous engineering problems. The model computes the wave height from a parametric formulation of the hurricane wind field.
3) Application of extremal statistics - Here the predicted maximum wave height from each hurricane was arranged in descending order and each assigned an exceedance probability by Weibull's distribution.
4) A bathymetric profile from deepwater to the site was then defined and each hurricane wave transformed along the profile. The wave height at the nearshore end of the profile was then extracted from the model and stored in a database. All the returned nearshore values were then subjected to an Extremal Statistical analysis and assigned exceedance probabilities with a Weibull distribution

The search of the database indicated that 96 hurricane systems came within 300 kilometres of the site between the start of records in 1852 until the year 2008. This relatively large number speaks to the site's overall vulnerability to such systems and the likelihood of events occurring relatively frequently.

The waves generated by these events were estimated to be in the order of 5 to 9 metres in height. The bi-variant chart in shown in Figure 5-31 below indicates the most vulnerable directions are from the East to the South. The Extremal analysis results indicate that the most intense waves are generated from the SE as is evident in the summarised results in Table. The wave heights and periods for the for the 50yr storm event are in the order of 7.2m and 13.3s and 7.7m and 13.7s for the 100 year event. Overall, these are relatively large waves with potential for wreaking severe damage on coastal infrastructure. Their potential resulting nearshore climates should be investigated through wave transformation modelling.

Wind direction- NW

Tp(s) <value	Wave height(m) 2	4	6	8	10	12	14	16	18	20	Total
2											
4											
6											
8											
10											
12											
14											
16											
18											
20											
Total											

Wind direction- N

Tp(s) <value	Wave height(m) 2	4	6	8	10	12	14	16	18	20	Total
2											
4											
6											
8											
10											
12											
14											
16											
18											
20											
Total											

Wind direction- NE

Tp(s) <value	Wave height(m) 2	4	6	8	10	12	14	16	18	20	Total
2											
4											
6		1									1
8											
10											
12											
14											
16											
18											
20											
Total		1									1

Wind direction- W

Tp(s) <value	Wave height(m) 2	4	6	8	10	12	14	16	18	20	Total
2											
4											
6		3									3
8		7	1								8
10			3								3
12											
14											
16											
18											
20											
Total		10	4								14

All directions

Tp(s) <value	Wave height(m) 2	4	6	8	10	12	14	16	18	20	Total
2											
4											
6		29									29
8		92	24	1							117
10			47	12							59
12				2							2
14											
16											
18											
20											
Total		121	71	15							207

Wind direction- E

Tp(s) <value	Wave height(m) 2	4	6	8	10	12	14	16	18	20	Total
2											
4											
6		2									2
8		11	6								17
10			16	3							19
12											
14											
16											
18											
20											
Total		13	22	3							38

Wind direction- SW

Tp(s) <value	Wave height(m) 2	4	6	8	10	12	14	16	18	20	Total
2											
4											
6		12									12
8		26	4								30
10			9								9
12											
14											
16											
18											
20											
Total		38	13								51

Wind direction- S

Tp(s) <value	Wave height(m) 2	4	6	8	10	12	14	16	18	20	Total
2											
4											
6		6									6
8		28	3								31
10			8	3							11
12											
14											
16											
18											
20											
Total		34	11	3							48

Wind direction- SE

Tp(s) <value	Wave height(m) 2	4	6	8	10	12	14	16	18	20	Total
2											
4											
6		5									5
8		20	10	1							31
10			11	6							17
12				2							2
14											
16											
18											
20											
Total		25	21	9							55

Figure 5-31 - Bi-variant table showing incident wave heights and periods for the directions.

Table 5-17 - Bi-variant table showing incident wave heights and periods for the specific return periods and directions

Return Periods	Wave height (m)																	
	All		SW		W		NW		N		NE		E		SE		S	
	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp	Hs	Tp
1	2.5	8.0	1.5	6.2	1.5	6.2	0.0	0.0	0.0	0.0	0.0	0.0	1.5	6.2	1.5	6.2	1.5	6.2
2	3.7	9.6	3.5	9.4	3.5	9.4	0.0	0.0	0.0	0.0	0.0	0.0	4.6	10.7	4.2	10.2	3.5	9.4
5	5.0	11.2	4.2	10.3	4.8	10.9	0.0	0.0	0.0	0.0	0.0	0.0	5.7	11.9	5.4	11.6	4.4	10.5
10	6.0	12.2	4.6	10.8	5.5	11.7	0.0	0.0	0.0	0.0	0.0	0.0	6.3	12.5	6.0	12.2	4.8	11.0
20	7.0	13.1	5.0	11.2	6.2	12.4	0.0	0.0	0.0	0.0	0.0	0.0	6.8	13.0	6.6	12.8	5.3	11.4
25	7.3	13.4	5.1	11.3	6.4	12.5	0.0	0.0	0.0	0.0	0.0	0.0	6.9	13.1	6.8	12.9	5.4	11.6
50	8.3	14.2	5.4	11.6	7.0	13.1	0.0	0.0	0.0	0.0	0.0	0.0	7.3	13.4	7.2	13.3	5.7	11.9
75	8.8	14.7	5.5	11.7	7.3	13.4	0.0	0.0	0.0	0.0	0.0	0.0	7.6	13.6	7.5	13.6	5.9	12.1
100	9.2	15.0	5.6	11.8	7.5	13.6	0.0	0.0	0.0	0.0	0.0	0.0	7.7	13.7	7.7	13.7	6.0	12.2
150	9.7	15.4	5.8	12.0	7.8	13.8	0.0	0.0	0.0	0.0	0.0	0.0	7.9	13.9	7.9	13.9	6.2	12.4
200	10.1	15.7	5.9	12.0	8.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	14.0	8.1	14.1	6.3	12.5

5.1.11.5 Nearshore Wave Climate Analysis

5.1.11.5.1 Objectives and Approach

It was necessary to estimate what the wave climate is like in the bay in order to:

1. Allow for the estimation of wave forces on the existing shoreline and the proposed protective structures to be implemented.
2. Determine operational, swell and hurricane environments in bay.

Deepwater water wave data forms the input for such analysis and by itself offers limited information on how waves reach the shoreline. The objective of this exercise is to derive a nearshore wave climate in order to better understand the environment and processes involved. The approach adopted in order to achieve these objectives was as follows:

1. Prepare a bathymetric database of the project domain for extremal analysis.
2. Determine the nearshore wave climate for the Bay.
3. Conduct spatial wave transformation analysis around the proposed structures in the model.

5.1.11.5.2 Wave Climate Model: REFDIF

The weakly nonlinear combined refraction and diffraction model described here denoted REFDIF simulates the behaviour of a random sea over irregular bottom bathymetry incorporating the effects of shoaling, refraction, energy dissipation and diffraction. Although the model is developed to simulate a random sea state it can also be used to model the behaviour of monochromatic waves. REFDIF was developed by Kirby and Dalrymple. The model REFDIF is constructed in parabolic form and thus there is a restriction of the model to cases where the propagation direction is within the assumed mean wave direction

5.1.11.5.3 Modelling Approach and Summary of Incident Wave Conditions Modelled

The output from the storm surge model used for hurricane impact analysis provided us with the incident wave height and period as well as the water setup for the deepwater extremal analysis. Locally generated waves i.e. waves generated by wind action within the bay were predicted using the JONSWAP equations. These incident wave heights and periods were then used in the REFDIF model to generate the nearshore wave climate. The spatial patterns of wave breaking and shoaling were noted in relation to the proposed site. Should intense wave focusing be noted, then it would probably be advisable that this be considered in the design of adequate structural engineering provisions. See Table 5-18 and Table 5-19 or a summary of the incident wave conditions used for the analysis.

Table 5-18 - Incident Wave heights and Periods obtained for hurricane waves (Local)

Return Period	Dp	Hs (m)	Tp (s)
50yr	S	3.82	5.91
	SE	3.96	6.06
100yr	S	4.12	6.07
	SE	4.28	6.22

Table 5-19 - Incident Wave heights and Periods obtained for hurricane waves (Deep water)

Return Period	Dp	Hs (m)	Tp (s)	Setup
50yr	S	7.20	13.30	2.15
	SE	7.20	13.30	2.15
100yr	S	7.70	13.70	2.44
	SE	7.70	13.70	2.44

5.1.11.5.4 Operational Waves

The model was calibrated to run operational waves from the SSW, S, SSE, SE and ESE directions. The existing shoreline was modelled first to better understand the areas which are most vulnerable as well as to estimate based on the wave predictions, what wave heights are reaching the shoreline.

The model showed that the shoreline under operational conditions could possibly experience wave heights of up to 0.3 m at the shoreline from the south and south easterly directions. Waves from these directions are however not very frequent (less than 5%).

The most frequent wave directions, east south east, and south south east showed that wave heights of up to 0.2 m reaches the shoreline. The SJPC Shoreline is most vulnerable to waves from the south, south south east and south easterly directions, however the SJPC shoreline is sheltered by the reefs located south east of the shoreline resulting in a reduction in the size of the waves reaching the shoreline. See Figure 5-32 below for the operational wave plots.

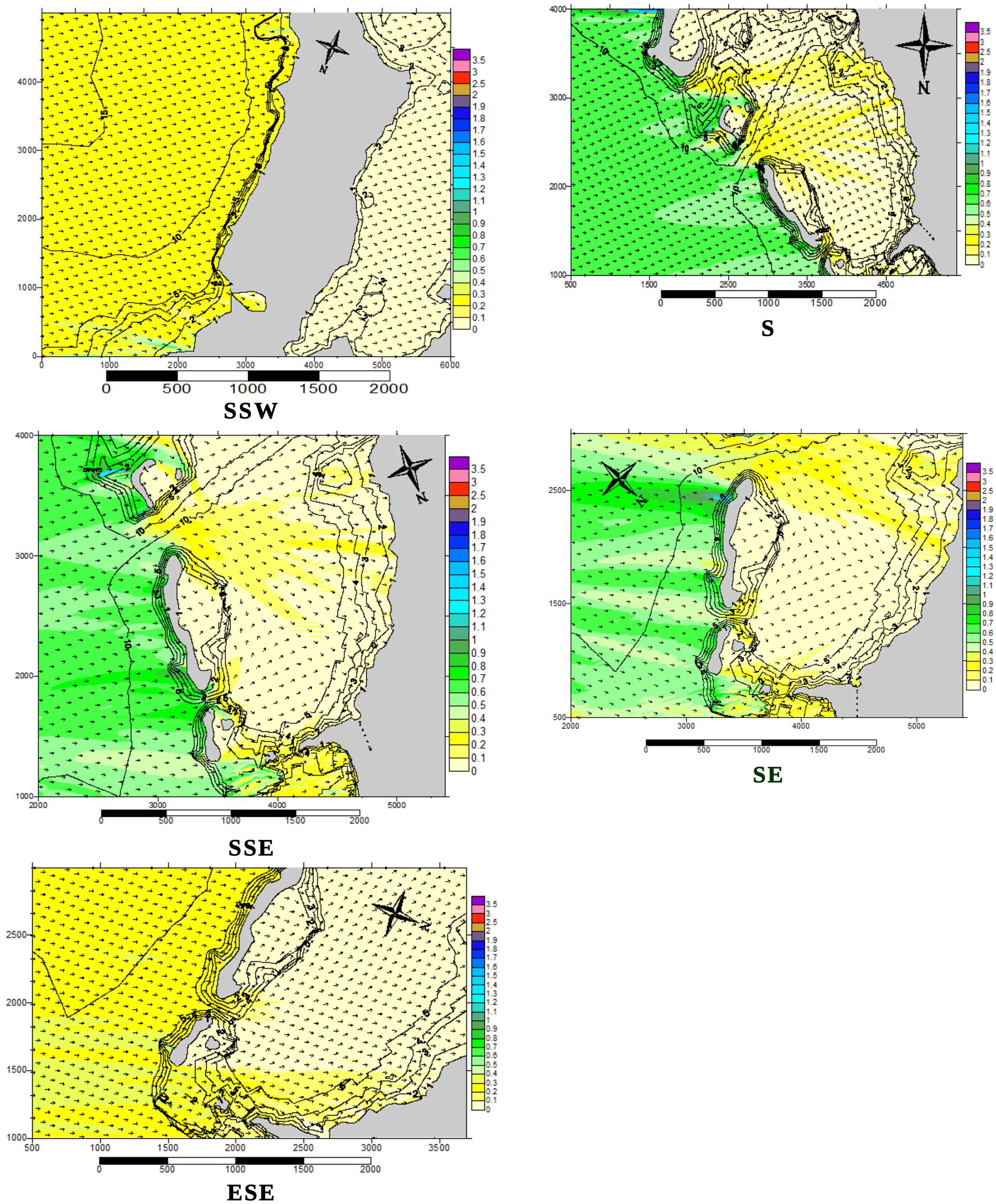


Figure 5-32 - Operational Wave Plots

5.1.11.5.5 Swell Waves

It was also important to look at the swell wave climate so as understand the impact on the existing shoreline and to design shoreline protective structures which would handle these scenarios. The model was manipulated to run swell waves from the SSE, S, and SE directions.

The model showed that the shoreline under swell wave conditions could possibly experience wave heights of up to 0.7 m at the shoreline from the south, south east and south south easterly directions. However wave heights of 0.4m from these directions generally affect the site area on a frequent basis.

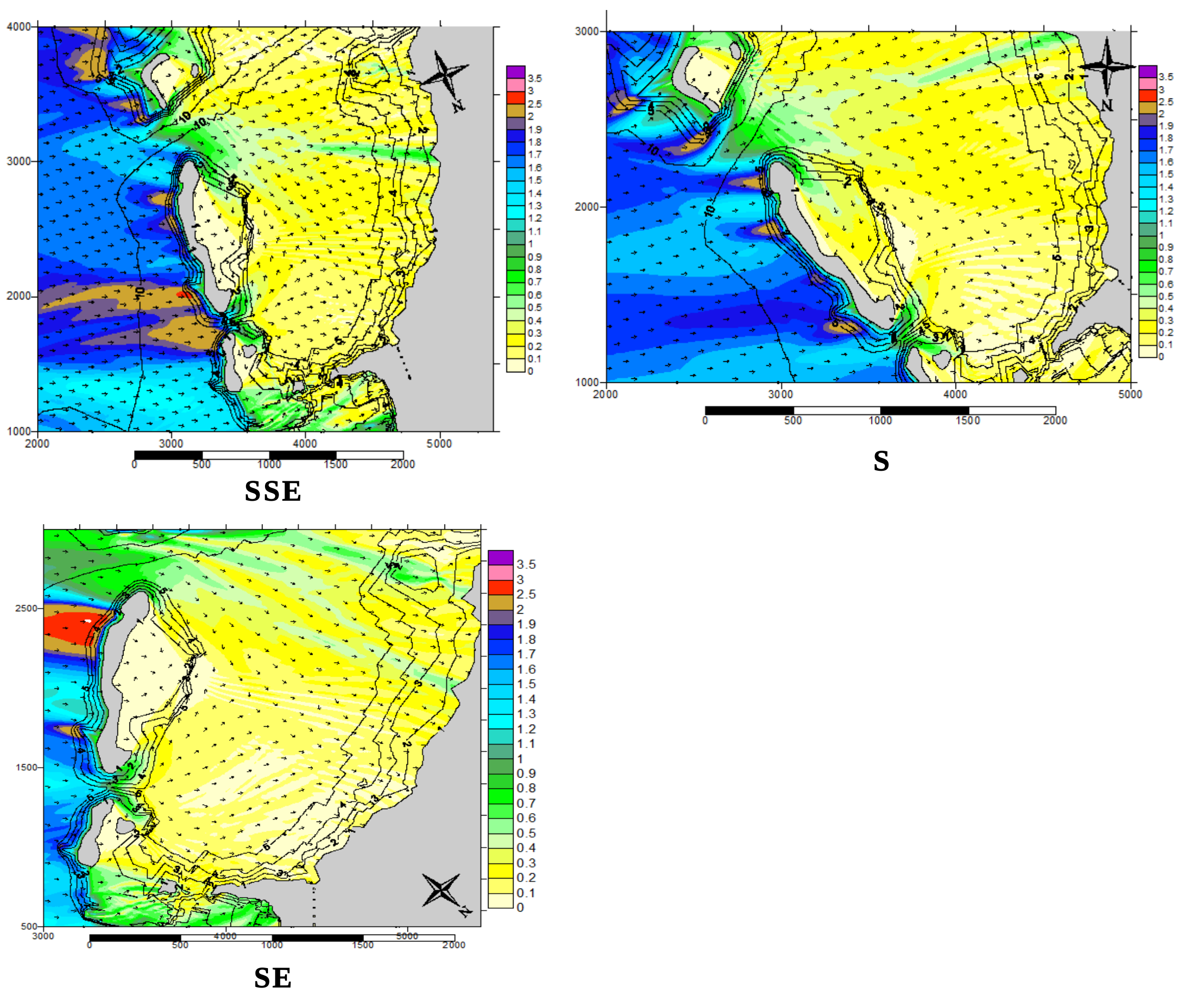


Figure 5-33 - Swell Wave Plots

5.1.11.5.6 Hurricane Waves (Locally Generated)

Considering the size of the bay, it was important that we model hurricane wind generated waves which could form within the bay. Given that wind generated waves originating nearshore in relatively shallow water need a long fetch to generate significant wave heights, we modelled two directions, S, and SE for both 50 and 100 years return periods. These directions show that a wave would have a fetch of approximately 14 km and so show great potential for significant wave generation.

The wave plots generated from the model showed that during hurricane conditions, wave heights of up 1.5 m reaching the shoreline each direction, with the waves from the southern direction affecting the SJPC shoreline more severely.

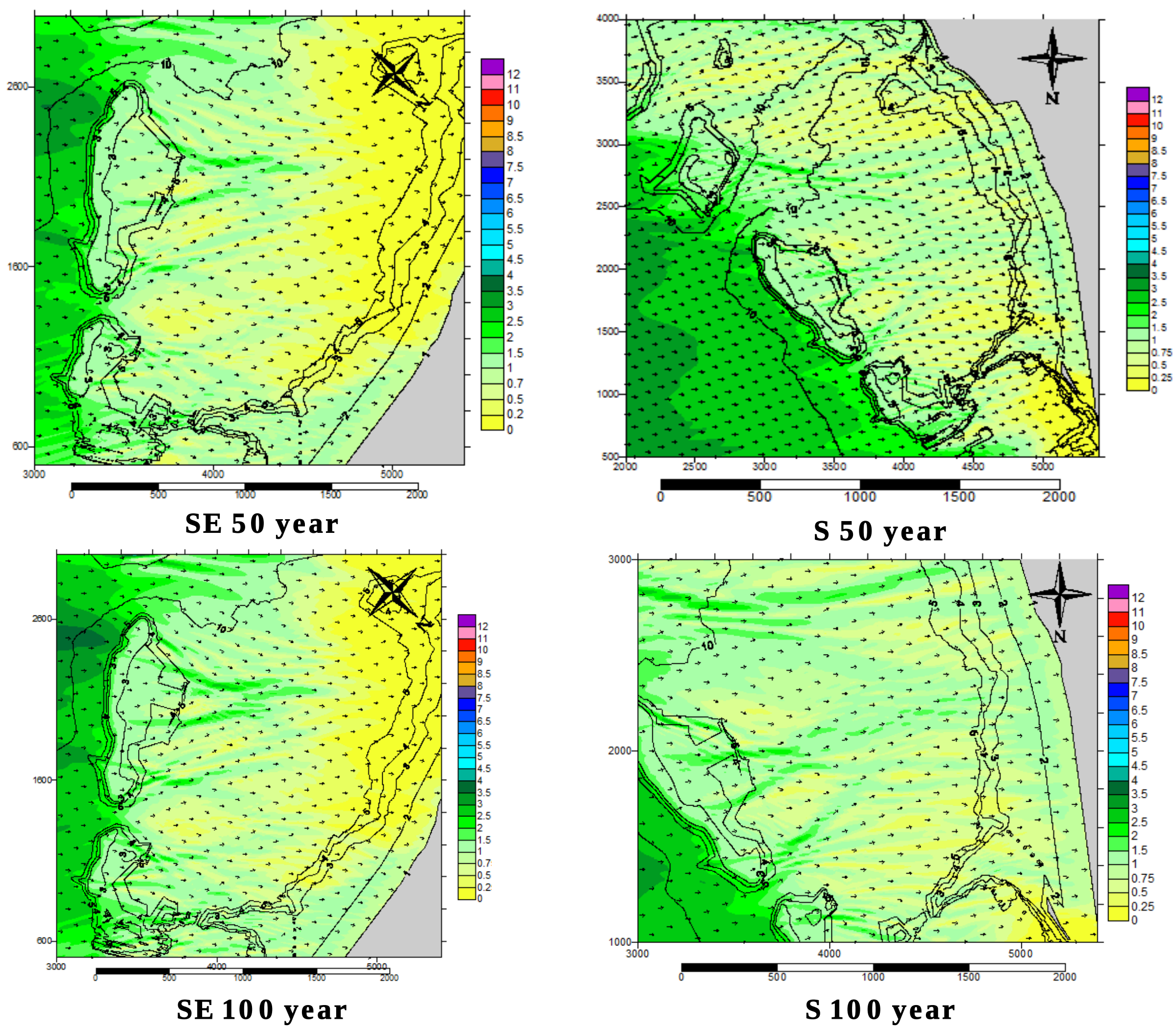


Figure 5-34 - Locally Generated Wave Plots

5.1.11.5.7 Hurricane Waves (Deepwater)

It was very important to model hurricane wind generated waves from deepwater. We modelled two directions, S, and SE for both 50 and 100 years return periods. These directions show that a wave would have a fetch of approximately 14 km and so show great potential for significant wave generation.

The largest predicted wave heights to reach the shoreline were generated from the SE and S directions ranging from 1.5 to 2 m for the 100 year return period. While for the 50 year return period wave heights of up to 1.5m was noticed reaching the shoreline. The SJPC shoreline is sheltered by the reefs located south east of the shoreline resulting in a reduction in the size of the waves reaching the shoreline.

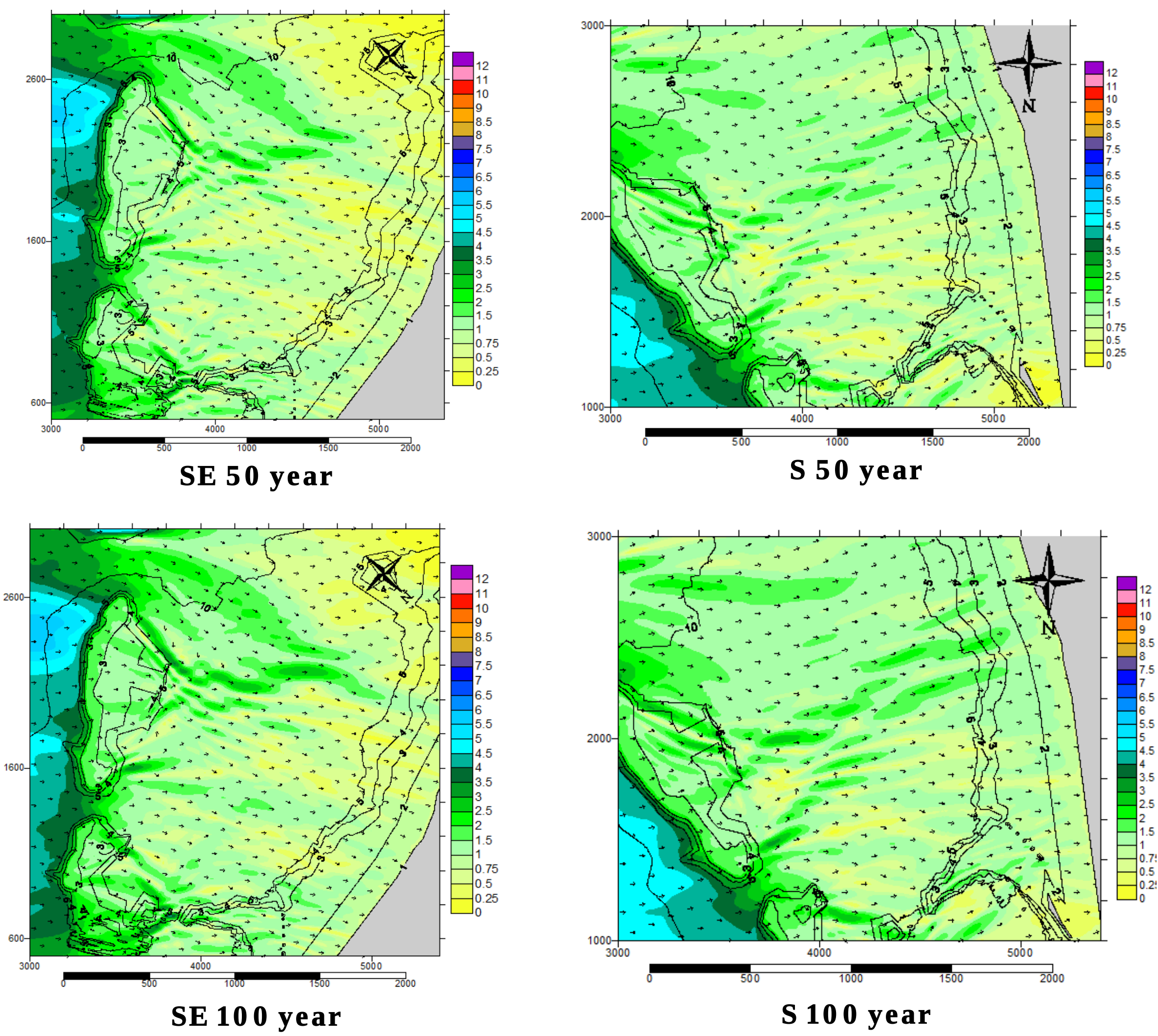


Figure 5-35 - Locally Generated Wave Plots (deepwater)

5.1.11.5.8 Cross-shore Sediment Transport

Cross-shore transport is the seaward or landward movement of sediments due to wave breaking and the resulting cross shore currents which are set up. This results in changes in the beach profile due to accretion or erosion of sediments. Coarse suspended sediments settle faster and deposit on the back of beach whilst finer sediments are kept suspended and washed offshore. This process therefore implies that there is a relationship between the fall velocity of the sediment particles (Wf) and the wave climate that can be used to predict whether there will be accretion or erosion.

The fall velocity ratio:

$$\frac{Ho}{w_f T} \cong 1$$

Where

- H_o = deepwater wave height
- w_f = fall velocity and
- T = wave period

If the ratio exceeds one (1), sediment moves offshore; if it is less than 1, sediment moves onshore. The grain sizes used for this analysis were the mean grain sizes for each sample. The fall velocity was estimated from the grain sizes after which the stable wave height was estimated from the period and the falling velocity.

The results are summarized in Table 5-20 and summarized as follows:

- The cross-shore analysis revealed the stable wave height for operational waves is in the order of 1.3 to 4.5m, whereas the operational waves predicted to reach the shoreline is less than 0.4m for all scenarios considered. The shoreline is therefore stable for all operational waves.
- The cross-shore analysis revealed the stable wave height for swell waves is in the order of 6.29 m, whereas the swell waves predicted to reach the shoreline is less than 1.0m for all scenarios considered. The shoreline is therefore stable for all swell waves.
- The cross-shore analysis revealed the stable wave height for hurricane waves is in the order of 3.9 to 23m, whereas the operational waves predicted to reach the shoreline is less than 3m

for all scenarios considered. The shoreline is therefore stable for all operational waves.

Overall the shoreline is predicted to be stable in all conditions considered due to the shallow offshore bathymetry south of the shoreline.

Table 5-20 - Cross-shore sediment stability

CROSS SHORE GRAIN SIZE STABILITY				
Sample ID	**Beach Face 1**	**Back of Beach 1**	**Beach Face 2**	**Back of Beach 2**
Location	**JPS Old Harbour**	**JPS Old Harbour**	**JPS Old Harbour**	**JPS Old Harbour**
Water and sediment characteristics				
Mean (D50) mm	1.932	0.586	4.626	0.411
Specific density	2.65	2.65	2.65	2.65
Density of water	1.025	1.025	1.025	1.025
Gravity	9.82	9.82	9.82	9.82
Kinematic viscosity	8.01E-07	8.01E-07	8.01E-07	8.01E-07
Fall velocity (Wf/m/s)	0.65	0.17	1.69	0.12
Wave period (seconds)				
Operational-Local waves	2.07	2.07	2.07	2.07
Operational-Deepwater waves	7.00	7.00	7.00	7.00
Swell	9.75	9.75	9.75	9.75
50yr local	6.06	6.06	6.06	6.06
100yr local	6.22	6.22	6.22	6.22
50yr deepwater	13.30	13.30	13.30	13.30
100yr deepwater	13.70	13.70	13.70	13.70
Stable Wave Height				
Operational-Local waves	1.34	0.36	3.49	0.24
Operational-Deepwater waves	4.52	1.22	11.80	0.82
Swell	6.29	1.69	16.43	1.15
50yr local	3.91	1.05	10.21	0.71
100yr local	4.01	1.08	10.48	0.73
50yr deepwater	8.58	2.31	22.41	1.56
100yr deepwater	8.84	2.38	23.09	1.61

5.1.12 Erosion Hazard and Vulnerability

5.1.12.1 Long Term Coastal Erosion Trends

The shoreline positions over a number of years were plotted and compared in order to determine the long-term spatial and temporal erosion trends across the bay. This was important in order to identify the actual erosion hotspots that might require stabilization and in order to verify wave transformation modelling.

5.1.12.1.1 Methodology

The overall long-term erosion trend was estimated by:

1) Firstly, observation of actual long-term shoreline positions from dated aerial photography.
2) Secondly, the global sea level rise component was estimated to determine the erosion that was due to chronic global trends versus event based erosion events (i.e. hurricanes and swell events).

5.1.12.1.2 Results

Historical Shoreline

Figure 5-36 shows the most recently available satellite imagery (March 2010) over which the observed shorelines from Aerial photos of the area obtained from the Survey department for the years 1968, 1991, and 2000. The SJPC 360MW proposed site is located North west of the JPS power plant and extends in a northern direction parallel to the Bowers Gully.

Close examination of the image in Figure 5-36 reveals a general trend of erosion occurring along the shoreline of the proposed site from 1968 to 2010. The central section of the shoreline between chainage 0+450 and 0+700 shows a general pattern of accretion.

Table 5-21 summarizes the results of measuring and noting the displacements of the shoreline at intervals of 50m along the shoreline. The rates of accretion and or erosion between the time intervals and the overall time interval were determined using the following relationship:

$$E_y^1 = \frac{D}{N},$$

Where:

- E = the rate of erosion or accretion between two successive intervals (metres per year)
- D = the displacement between two intervals (metres)
- N = the number of years between two successive intervals (years)

and

$$E_y^0 = \frac{D_T}{N_T},$$

Where

- E_y^0 = the rate of erosion or accretion from the datum year to the final interval
- D_T = the displacement from the datum to the final interval
- N_T = the number of years from datum year to final interval

The long term erosion trend are summarised as follows:

- The SJPC shoreline is eroding at a rate of 0.4 to 1.7 meters per year, with a small section chainage 0+350 that showed a massive erosion of 2.7 meters per year.
- Accretion is occurring in the central section of the shoreline at a rate of 0.2 to 0.6 meters per year.

Table 5-21 - Summary of shoreline changes

	Shoreline Intervals											
Year	1968	1991			2000			2010			Overall	
Chainage	Datum	Process	Accretion/Erosion Rate (m/year)	distance from datum (m)	Process	Accretion/Erosion Rate (m/year)	distance from datum (m)	Process	Accretion/Erosion Rate (m/year)	distance from datum (m)	Process	Rate
0+000	0	erosion	-1.366	-31.41	accretion	0.803	-24.18	erosion	-0.448	-28.21	erosion	-0.672
0+050	0	erosion	-0.727	-16.71	accretion	0.752	-9.94	erosion	-1.743	-25.63	erosion	-0.610
0+100	0	erosion	-0.664	-15.27	accretion	0.298	-12.59	erosion	-1.458	-25.71	erosion	-0.612
0+150	0	erosion	-0.815	-18.74	accretion	0.550	-13.79	erosion	-1.032	-23.08	erosion	-0.550
0+200	0	erosion	-0.654	-15.04	accretion	0.501	-10.53	erosion	-0.812	-17.84	erosion	-0.425
0+250	0	erosion	-1.657	-38.1	accretion	0.420	-34.32	erosion	-0.359	-37.55	erosion	-0.894
0+300	0	erosion	-1.833	-42.15	erosion	-1.564	-56.23	erosion	-0.851	-63.89	erosion	-1.521
0+350	0	erosion	-1.967	-45.23	erosion	-3.820	-79.61	erosion	-3.803	-113.84	erosion	-2.710
0+400	0	erosion	-0.606	-13.94	accretion	0.924	-5.62	accretion	0.403	-1.99	erosion	-0.047
0+450	0	erosion	-0.618	-14.21	accretion	1.704	1.13	accretion	0.598	6.51	accretion	0.155
0+500	0	accretion	0.189	4.34	accretion	1.211	15.24	erosion	-0.047	14.82	accretion	0.353
0+550	0	accretion	0.041	0.95	accretion	1.278	12.45	erosion	-0.076	11.77	accretion	0.280
0+600	0	accretion	0.022	0.5	accretion	1.903	17.63	erosion	-0.286	15.06	accretion	0.359
0+650	0	accretion	0.451	10.37	accretion	0.669	16.39	accretion	0.910	24.58	accretion	0.585
0+700	0	accretion	0.903	20.77	erosion	-0.061	20.22	erosion	-0.700	13.92	accretion	0.331
0+750	0	accretion	0.205	4.72	erosion	-2.490	-17.69	accretion	0.034	-17.38	erosion	-0.414
0+800	0	accretion	0.454	10.44	erosion	-1.808	-5.83	erosion	-1.467	-19.03	erosion	-0.453
0+850	0	erosion	-0.489	-11.25	erosion	-0.603	-16.68	erosion	-1.618	-31.24	erosion	-0.744
0+900	0	erosion	-0.610	-14.04	erosion	-0.006	-14.09	erosion	-1.380	-26.51	erosion	-0.631
0+950	0	erosion	-0.447	-10.29	accretion	0.354	-7.1	erosion	-0.667	-13.1	erosion	-0.312

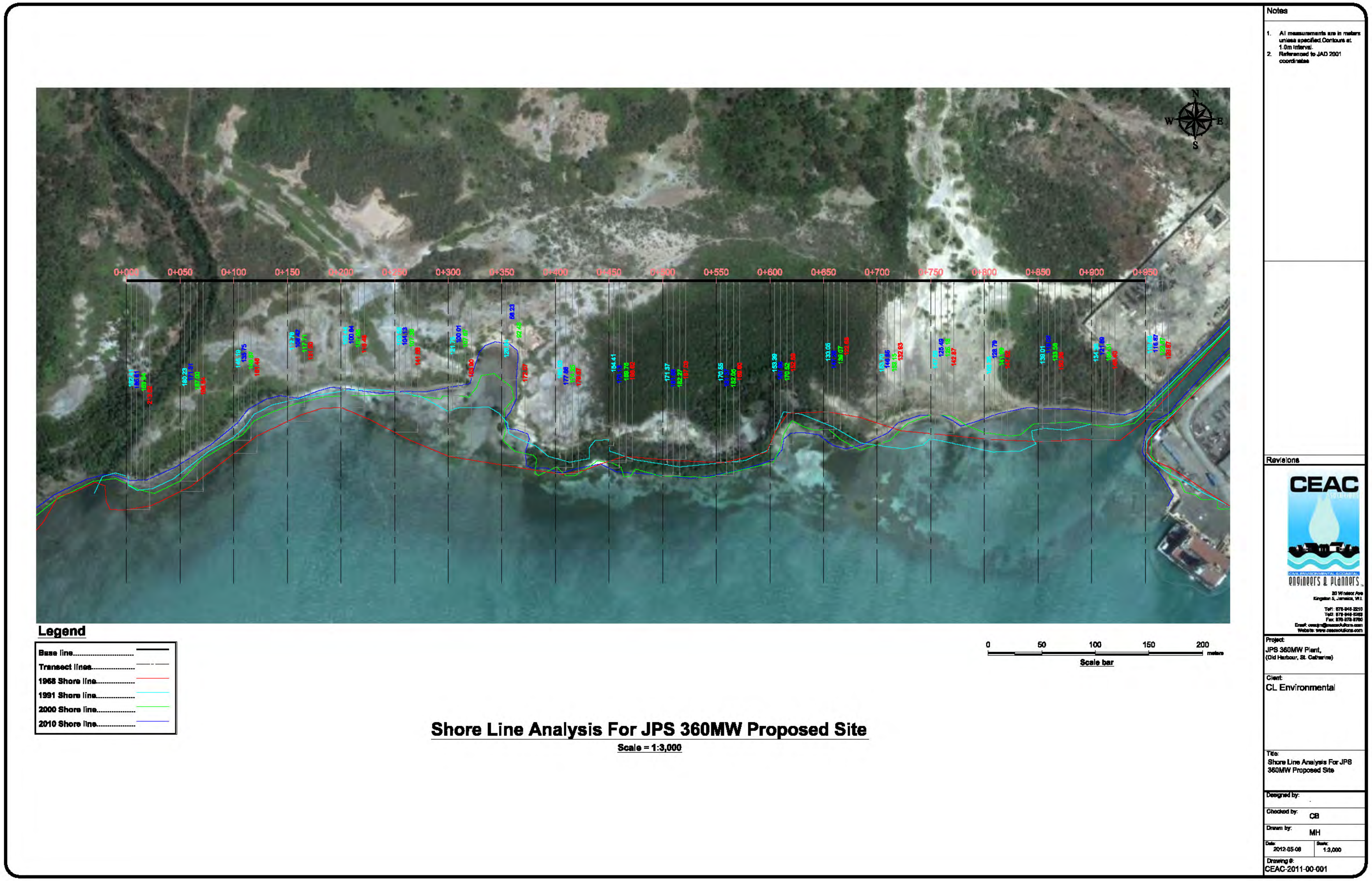


Figure 5-36 - Historical Shoreline changes

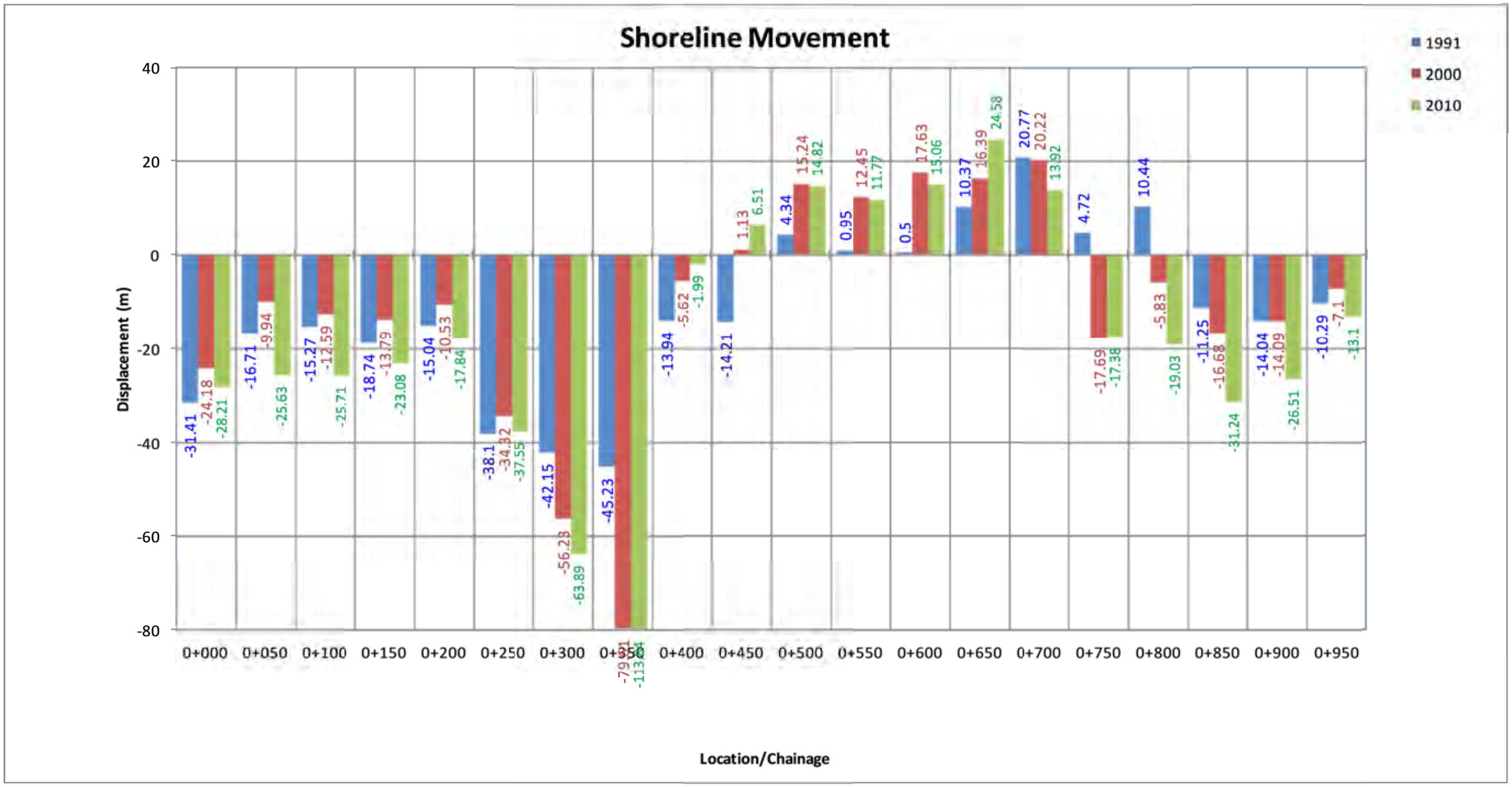


Figure 5-37 - Graph showing the displacements of the shoreline for different years about the 1968 shoreline for Old Harbour Bay (1964 to 20010)

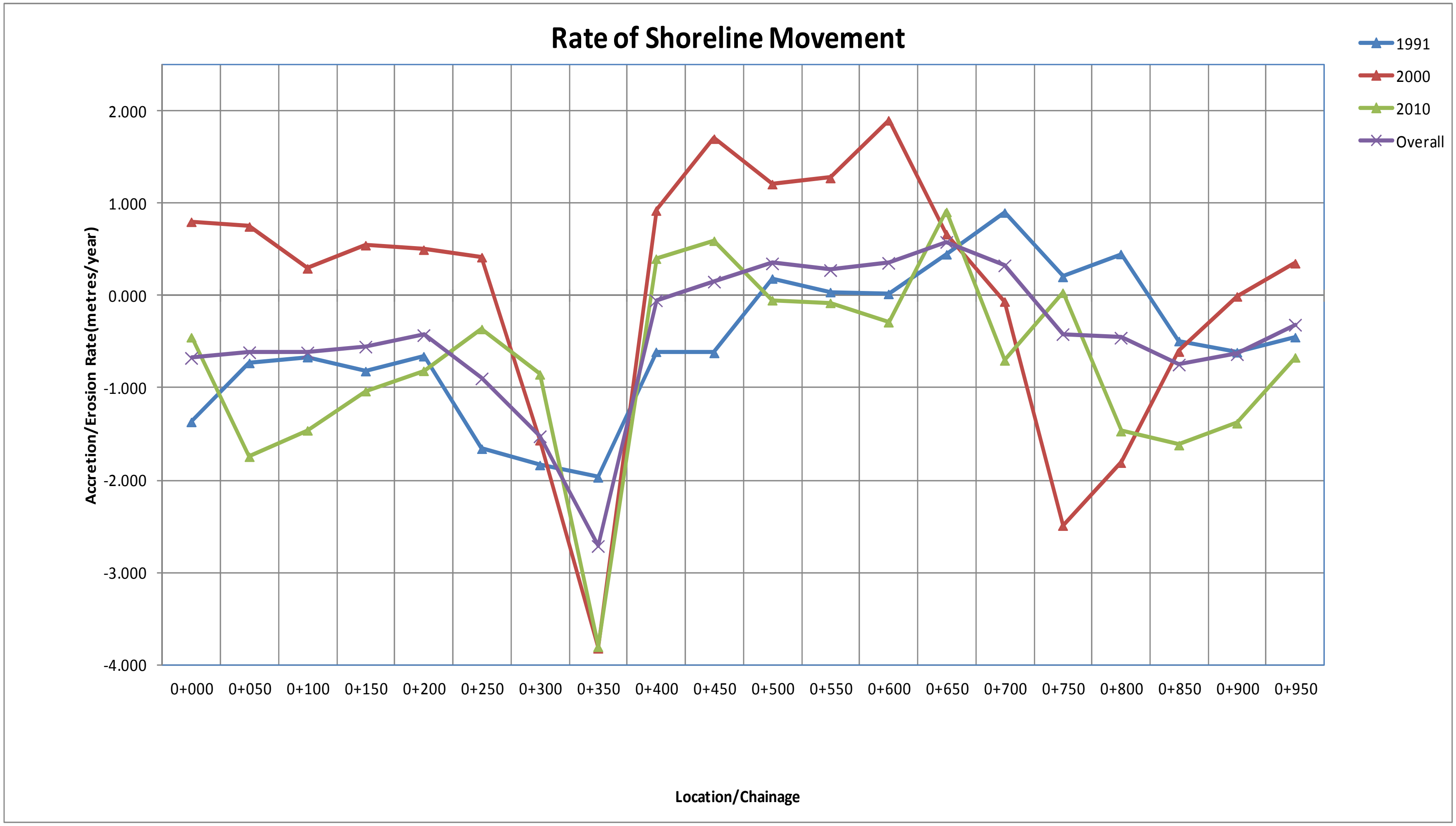


Figure 5-38 - Graph showing the rates of erosion/accretion for the shoreline about the 1968 shoreline for different time intervals for Old Harbour Bay (1964 to 2010)

Bruun Model

The Bruun model is perhaps the best-known and most commonly used of the models that relate shoreline retreat to sea level rise. This two-dimensional model assumes an equilibrium profile. Thus, it inherently assumes that the volume of sediment deposited is equal to that eroded from the dunes and that the rise in the nearshore bottom as a result of the deposited sediment is equal to the rise in sea level.

The original Bruun model is expressed below, and this mathematical relationship was the basis for estimating shoreline retreat within the study area.

$$\Delta y = \frac{\Delta s \cdot l^*}{h^*}$$

Where:

Parameter	**Description**	**Units**
Δy	Dune line erosion	m
Δs	Rate of sea level rise	m
l^*	Length of the offshore profile out to a supposed depth, h*, of the limit of material exchange from the beach and the offshore	m
h^*	Depth at offshore limit of l*, to which nearshore sediments exist (as opposed to finer- grained continental shelf sediments)	m

Rate of Sea Level Rise, Δs

Inspection of research in this area revealed that global sea level may rise as a result of greenhouse gas-induced global warming at a rate of 5 mm/year over the next 100 years. Indeed, there will be regional variation in the sea level rise signal, and for this reason regions may undertake sea-level rise scenario modelling, which takes into account various factors such as land movement and region-specific oceanographic data.

For the purposes of this project, a simple scenario, based on one estimate of sea level rise will be utilized (not taking into account any vertical tectonic movements of the shoreline nor any discernible change in the ocean geodynamic surface). Typically, a mid-range or upper estimate is chosen for such types of scenarios. The Intergovernmental Panel on Climate Change's (IPCC) Special Report on Emissions Scenarios (SRES) estimate global sea-level to rise 9-88 cm in the next 100 years (McCarthy et al, 2001) was considered for the calculations, and specially the upper limit of this range, 8.9 cm by 2025 (0.00445 m/yr) was utilized.

Sea-level rise is projected to the year 2025, as the shelf life of the project was chosen to be 20 years. Using the upper limit value of 8.9 cm by 2025 allowed this analysis to test whether the coastal region of Old Harbour Bay is vulnerable to a plausible upper limit of climate change and simultaneous storm-induced short-term erosion for the 100-year return period.

Depth to which Nearshore Sediments exist, h*

A beach profile has a practical seaward limiting depth, where the wave conditions can no longer change the profile. Sand may move back and forth along this equilibrium profile, but there is no perceptible change in depth. This seaward limiting depth is equivalent to the depth at which nearshore sediments exist (h^*). Hallermeier (Hallermeier,1981 in Kamphuis, 2000) refers to this depth as the critical or closure depth (d_c), and approximates it using the following equation.

$$d_c = 1.6 H_{s,12}$$

Where:

$H_{s,12}$ = significant wave height which occurs 12 hrs/yr on average

It was therefore necessary to determine the operational wave climate within the study area between the shoreline and the reefs in order to estimate the critical depth. Long term wave data available for the south of Portland Bight was analysed to determine the 12 hour wave ($H_{s,12}$). The $H_{s,12}$ was determined to be a 11.5 second, 2.5 metre swell wave.

Length of Offshore Profile, l*

The calculated critical depth (or h^*) was used to estimate the length of the offshore profile. This was done by inspecting each of the three (3) profiles cut for the REFDIF modelling and obtaining profile lengths for the corresponding critical depth. These profile lengths obtained were incorporated into the Brunn Model equation.

Calculations

Table 5-22 shows the calculation of the long term trends expected in 25 years along the Old Harbour bay beaches. As seen in this table, the following input values were incorporated into the Bruun Model to arrive at an estimate for the long-term erosion trend at each of the six (6) profile shoreline positions:

- Rate of sea-level rise = 0.0047 m/yr (IPCC 2007)
- Depth to which nearshore sediment exists (h^*, d_c) = 2.5 m

It should be emphasized here that the results of these calculations are an estimate of the projected shoreline retreat using a simplistic approach with an upper limit of global sea level rise. Indeed, the changes in beach profile over the years may have been impacted by the annual sea level rise as well as operational and storm-induced erosion estimated. This estimation of the sea level rise will assist in the determination of the true impacts that are due to operational a storm induces erosion.

The shoreline along the study area was estimated to retreat at varying rates between 0.4 and 0.6 metres per year as a result of global sea level rise. Profiles 1 and 3 are seen to have the longest distances of 317 and 271 metres, whilst profile 2 was seen to have the shortest distance of 208 metres.

Table 5-22 - Estimation of long-term erosion trends for Old Harbour Bay beaches using Bruun Model.

Parameter	**Profile**			
	1	**2**	**3**	**4**
	0+250	**0+550**	**0+750**	**1+600**
Rate of sea level rise, Δs *(mm/yr)*	0.0047	0.0047	0.0047	0.0047
Offshore profile, l (m)*	317	208	271	549
depth of offshore limit, h (m)*	2.5	2.5	2.5	2.5
Dune line Erosion, Δy (m)	0.60	0.39	0.51	1.03
Estimated change in 42 years (m)	25.03	16.42	21.40	42.32
Projected change in 25 years (m)	14.90	9.78	12.74	51.61

5.1.12.1.3 Summary

The long term erosion trend are summarised as follows:

- The eastern and western ends of the SJPC shoreline are eroding at a rate of 0.4 to 1.5 meters per year. There was however one section of the shoreline chainage 0+350 that showed a massive erosion of 2.7 meters per year.
- The central section of the SJPC shoreline is growing at a rate of 0.2 to 0.6 meters per year.
- GSLR is estimated responsible for approximately 66% to 100% of observed erosion.

5.1.12.1.4 Limitations

Estimating long-term erosion trends as result of global sea level rise was not the main focus of this section. Given the anecdotal information in the area, it was important to know how the area is affected by long term and short term weather/climate events.

The two most applicable approaches were chosen in order to arrive at a shoreline retreat rate which may be useful in determining how much of the observed erosion as actually due to events and short term erosion.

The maps obtained were only snapshots at a moment in time that cannot be manipulated to show years or times of interest. Therefore some of the maps may be displaying short term shoreline configurations while others long term. The accuracy of the rates is therefore subjected to the use of more Arial photos at strategic times which cannot be sourced.

Bruun model gives an estimate of the dune line erosion rate, however does not implicitly explore the possible changes in the profile owing to this retreat. These profile changes would have undoubtedly had an effect on any predicted storm-induced erosion on the shoreline and may certainly have explained why there is accretion at profile #2 and erosion for profiles 1 and 2.

5.1.12.2 Event Based Short Term Coastal Erosion

5.1.12.2.1 Model Description

SBEACH is an empirically based numerical model for estimating beach and dune erosion due to storm waves and water levels. The magnitude of cross-shore sand transport is related to wave energy dissipation per unit water volume in the main portion of the surf zone. The direction of transport is dependent on deep water wave steepness and sediment fall speed. SBEACH is a short-term storm processes model and is intended for the estimation of beach profile response to storm events. Typical simulation durations are limited to hours to days (1 week maximum).

5.1.12.2.2 Model Input

Profiles were cut from deep water to land up to a maximum elevation of approximately 10 metres from four Profiles spanning the entire shoreline. The wave data from the deep water hurricane model were utilized for this analysis. The wave characteristics used in this model are the same as those used for the wave transformation modelling (Table 5-23).

Table 5-23 - Input parameters for 50 year return storm

Return Period	Direction	Hs (s)	Tp (s)	Setup (m)	Storm Duration (days)
50	S	7.2	13.3	2.15	2
	SE	7.2	13.3	2.15	2
100	S	7.7	13.7	2.44	2
	SE	7.7	13.7	2.44	2

5.1.12.2.3 Results

No erosion was shown for the 50 and 100 year storm at the four locations analysed along the SJPC shoreline. These results are consistent with the previous cross shore sediment transport model and wave transformation results that indicate the shoreline is stable for the 50year and 100 year wave conditions.

5.1.12.3 Terrestrial Erosion

5.1.12.3.1 Methodology

One of the most widely used and accepted equations for estimating soil erosion is the Universal Soil Loss Equation (USLE), an empirical equation developed by the U.S. Department of Agriculture. The USLE estimates the annual tonnage of soil eroded from the site attributed only to a sheet and rill erosion. However, not all eroded soil qualifies as soil loss due to the fact that eroded soil may be redeposited before it leaves a slope and therefore does not factor into soil loss quantity. The formula for USLE is:

$$A = R \times K \times LS \times C \times P$$

Where A is the average annual soil loss measured in tons/acre, R is the rainfall erosion index, K is the soil erodibility factor, LS is the length-slope factor, C is the cover factor and P is the erosion control practice factor.

The rainfall erosion index (R) is a measure of the rainfall and runoff by geographic location. Rainfall data throughout the island was extracted from the rainfall stations database and the average annual precipitation was determined; the monthly precipitations were used to determine the respective annual precipitations. The greater the intensity and duration of the rain storm, the higher the erosion potential.

$$R = 0.0483 \times p^{1.61}$$

Where p is the average annual precipitation measured in mm.

The *K factor* is an empirical value representing both susceptibility of soil to erosion and the amount and rate of runoff (i.e.) the erodibility per rainfall erosion unit. The soil texture, organic matter, structure, and permeability determine the erodibility of a particular soil. Generally, soils with $K < 0.23$ are low-erodibility soils and soils with $K > 0.41$ are considered highly erodible. The factors implemented within the GIS model ranged from 0.01 for almost no erosion to 0.65 for soils which are highly vulnerable to soil erosion. These values are summarized in Table 5-24 below:

Table 5-24 -K Factors associated with respective erosive soil properties

Erosion Number	K Factor
0	0.01
1	0.1
2	0.125
3	0.35
4	0.5
5	0.65

The combined topographic effects of length and steepness of a slope are accounted for in the *LS factor*. The *S factor* is related the slope gradient factor while the *L factor* is the length of that slope; both factors being closely related with each other. The slope was calculated from a 30 meter DEM. In order to fit into the equation in terms of units, the slope was calculated using percent rise (s). This percent was then plugged into the formula to compute the *S factor*:

$$S = \frac{0.43 + 0.30s + 0.043s^2}{6.613}$$

Where s = percent rise of the calculated slope. The USLE was created to predict soil erosion delivered to the base of a 22-meter agricultural plot. As applied in this study, the cell's flow length was calculated as 30 meters and plugged into the following formula to compute the *L factor*:

$$L = \left(\frac{30}{22}\right)^m$$

Where m = 0.5 for slopes ≥ 5%, m = 0.4 for slopes 3.5% and 4.5% and m = 0.3 for slopes ≤ 3%. The *S factors* and *L factors* were then combined to form the *LS factors* using the following formula:

$$LS = L \times S\left(\frac{10000}{10000 + s^2}\right)$$

LS values range from less than 1 for short, flat slopes to nearly 50 for long, steep slopes, as demonstrated by the equation:

The *C factor* represents the effect of plants, soil cover, below-ground biomass, and soil-disturbing activities on soil erosion. It is essentially a ratio of the soil loss from a specific cover condition to the soil loss from a clean, tilled, fallow condition for the same soil, slope and rainfall conditions. It is an index of the type of ground cover and the condition of the soil over the area. Table 5-25 below summarizes the *C factors* implemented in the GIS model:

Table 5-25 - C factors associated with specific land uses

Land Use	C Factor
Agriculture	0.07
Less cultivated lands	0.3
Bauxite Extraction	0.5

The *P* factor is defined as the ratio of soil loss with a given surface condition (contouring, control structures, roughening the soil) to soil loss with up-and-down hill ploughing. This factor accounts for ground surface conditions that affect the runoff velocity. This was assigned a constant value of 1.

The parameters used in the above equation were then manipulated in order to simulate a higher level of urban development within the project area. This analysis will determine how soil erosion will be affected by the introduction of further development. The Universal Soil Loss Equation (USLE) was utilized and the factors R, K, L, S and P remained the same. The limiting factor was C as it relates to land use properties. This factor ranges greatly, the lower the value, the greater the vegetative biomass. The land use within the project area changed to a more developed environ, directly increasing the value of the *C factor*. The revised *C factors* are shown in Table 5-26 below.

Table 5-26 - C factors revised based on a change in land use

Land Use	C Factor
Agriculture	0.1
Less cultivated lands	0.3
Bauxite Extraction	0.5

5.1.12.3.2 Results

The parameters in both scenarios were plugged into the Universal Soil Loss Equation (USLE) and the average annual soil loss measured in tons/acre was determined using a GIS calculator. The results are discussed in the following sections.

A soil erosion hazard map was first created using the Universal Soil Loss Equation (USLE) described in the previous section based on the existing conditions such as land use and level of development within the Blue Hole area. The SJPC site is predicted to experience erosion rates of up to 0.4Tones/acre/year whereas the experience upper catchments of the Bowers gully are predicted to experience rates of up to 3,000 tonnes per acre/year.

The post construction option was also created to reflect the change of use for the project site. It was noted that the soils loss was increased up to a maximum of 5 Tonnes per acre per year.

In light of the increased soils loss predicted from the site, the designers should consider installing sediment traps to prevent excess sediments leaving the site and entering the gully. All storm water flows leaving the site should pass through sediment traps or sediment basins within the property limits.

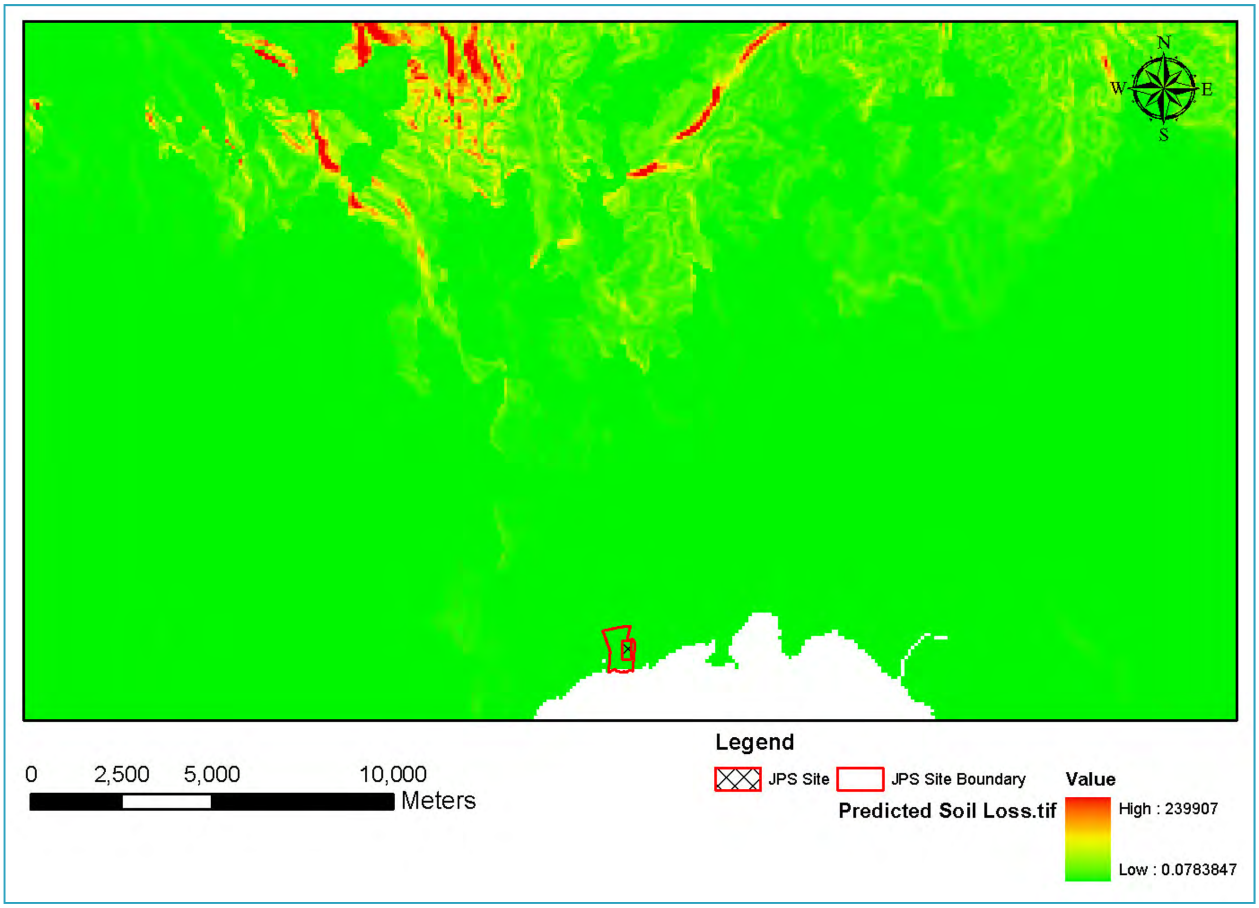


Figure 5-39 - Soil loss hazard map showing the magnitude of soils loss within the SJPC site and the wider Bowers Gully catchment

5.1.13 Hydrodynamic Modelling

The current regime (i.e. patterns and speeds) in the coastal setting determines the ability of an area to flush and maintain sufficiently good water quality. Currents are generated by winds, tides and waves:

- **Tides -** Rising tides will cause water to enter the marina/harbour area and a portion will leave on falling tide that follows. This will result in some exchange of water between the outside and inside of the project area. This result is dependent on the ratio of the water entering to the water leaving; this ratio is dependent on the tide range, hydraulic efficiency of the entrance, and the water internal depths.

- **Wind -** Wind action over the water surface will generate a surface current that will essentially be in the direction of the wind. The wind generated current will be a few degrees to the right of the wind, (in the northern hemisphere), owing to the Coriolis effect, (Bowden, 1983)[3]. If the fetch and duration are sufficient, the surface current speeds may approach 2-3% of the wind speeds.

Flushing Rates and circulation patterns can be predicted by numerical, physical models or by field studies. Numerical models are most often used as is simply requires collection of field data to calibrate and verify the model for use in a predictive mode.

5.1.13.1 Objective and Approach

The objective of this analysis is to characterise the existing hydrodynamic regime in the area and to identify the impacts if any of the development on the water quality, by using a numerical model.

The approach adopted or this exercise involved:

1. Collecting field data for model calibration
2. Creating Finite Element Hydrodynamic Model (FEM) mesh for the existing or pre-project bathymetric configuration and for the proposed configuration.
3. Calibrating the model with the available current speed and direction data.
4. Interpreting the surface current predictions for the existing and proposed changes

5.1.13.2 Data Collection

5.1.13.2.1 Wind

It was necessary to collect wind data, specifically wind speed and direction on the days when drogues were done. This parameter is vital in

[3] Bowden, KF . 1983. ***Physical Oceanography of Coastal Waters***, John Wiley, NY

calibrating the hydrodynamic model before it can be used to predict the circulation patterns in the bay.

On-site anemometer – Weather Station

This data was collected from the weather station set up adjacent to the proposed Project site. The anemometer readings over the two field days, April 24 to April 26 2012, were used to plot a graph of the wind speeds and directions as shown in Figure 5-40.

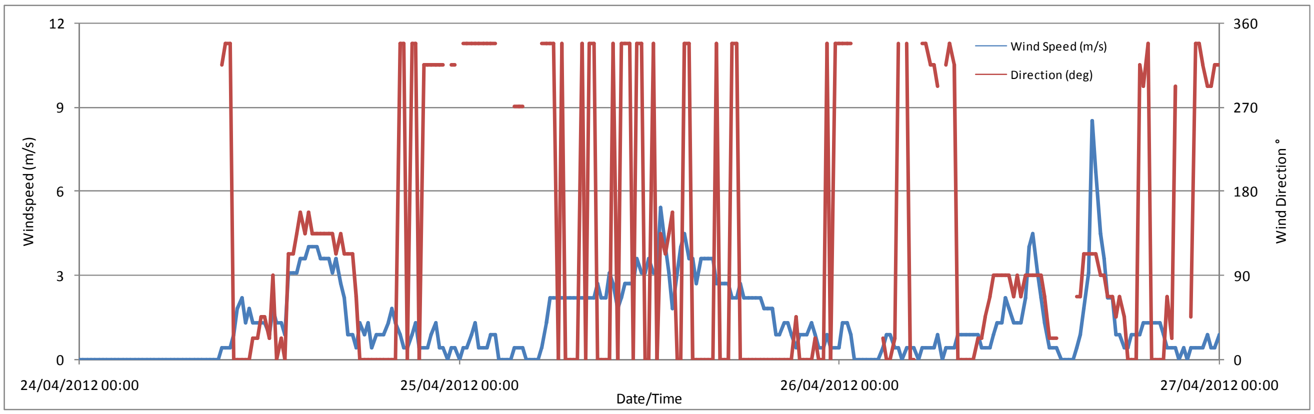


Figure 5-40 - Wind Data collected from the weather station setup adjacent to proposed site

NOAA Buoy Data

The online database of NOAA was consulted for the deep water/offshore winds which occurred during the drogue tracking sessions on April 24th and 26th. The Data obtained shows that the wind speeds varied between 6m/s and 8m/s during the day on the 24th and 4 to 10m/s on the 26th. The wind directions changed frequently on the 24th while they were fairly stable between 0 to 120 degrees on the 26th.

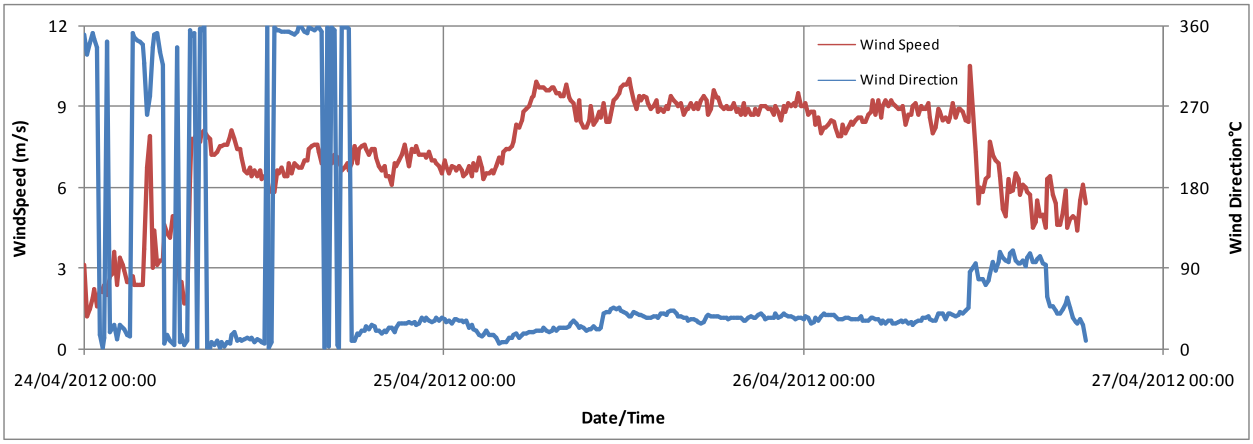


Figure 5-41 - Variation of the wind speeds and directions on the measured by the NOAA Buoy to the SW of Jamaica between April 24th and 26th 2012

Wind Summary for Drogue Sessions

The average wind speeds and directions during the drogue tracking exercises are seen in Table 5-27 below.

Table 5-27 - Average wind speeds and directions during drogue tracking sessions

	Time			Wind (Onshore)		Wind (NOAA Buoy)	
				Avg. Dir	Avg. speed (cm/s)	Avg. Dir	Avg. speed (cm/s)
Session 1	12:50	-	15:21	SE	3.10	NW	6.8
Session 2	16:45	-	17:45	E	1.14	N	6.8
Session 3	08:36	-	10:11	NE	1.09	NE	8.70

The two wind stations have shown marked differences in the wind speeds and directions recorded. The onshore met station whilst being closer to the site is less likely to have captured the wind speed that was experienced on the sea. This is due to the fact that the wind speeds are normally changed at the coast as a result of the change in surface friction characteristics. The directions however are normally correct. These factors were taken into consideration when calibrating the hydrodynamic model.

5.1.13.2.2 Tides

Tidal information was important in order to drive the FEM and also to set up the water level in the wave model. More importantly, it was necessary to determine the tide range in order to determine the minimum crest height for the breakwater structures so as to minimize overtopping during swell events.

Information on tides was generated by undertaking a harmonic analysis of data from Rocky Point for October 2007 to January 2009. Table 5-28 shows a list of tidal constituents for Rocky Point, and as is evident from this table, M2 (semi-diurnal moon tide) and K1 (diurnal sun tide) are the dominant tidal constituents. Harmonics were then used in a forward prediction model in order to estimate the tidal elevations on the dates the drogues were done.

The tide range was determined to be 598mm or +/- 299mm relative to Mean Sea Level.

Table 5-28 - Tidal components for Portland Bight, Jamaica

Start time	1/1/07 12:00 AM							
H0	0.25 m							
Tide Range	598 mm							
				Constituents				
Tide constitutent	M2	S2	O1	K1	N2	P1	L2	
Speed	12.42	12.00	25.82	23.93	12.66	24.07	12.19	Hours
Phase lag	1.96	1.50	-1.68	2.97	2.35	-2.26	-1.27	Radians
Amplitude	0.05	0.05	0.05	0.06	0.05	0.05	0.05	Metres

Figure 5-42 shows a plot of the typical signal after synthesizing of the components, and estimation for April 24 to 26 2012. These tides were found to be comparable to the British admiralty tidal Predictions for Port Esquivel.

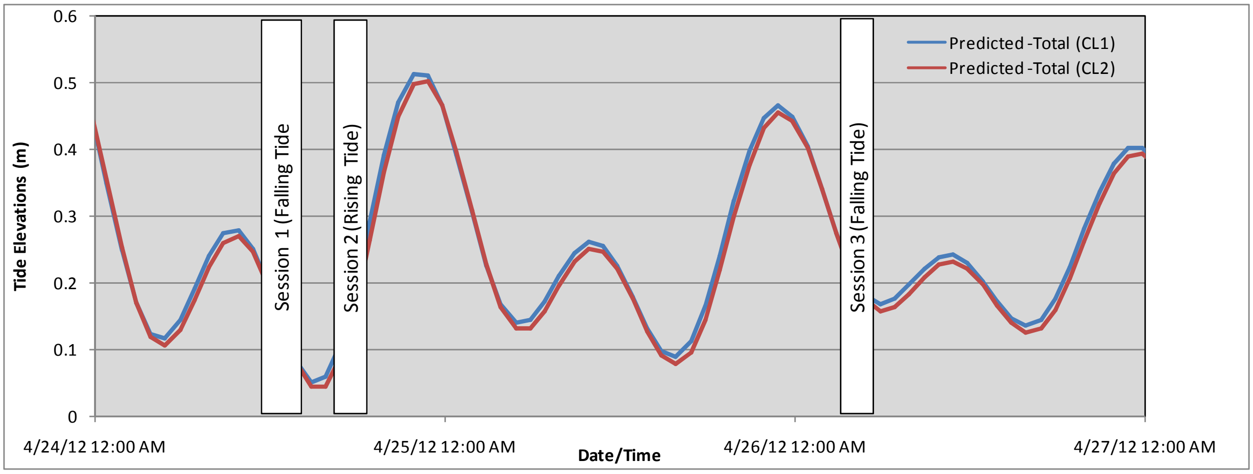


Figure 5-42 - Tidal signal for April 24 to 26 2012.

5.1.13.2.3 Currents

In order to facilitate the development of the hydrodynamic model for the area and to fully understand the relationship amongst tides, winds and currents, current speed and direction information was required. This information was acquired by carrying out drogue tracking missions.

Drogue Tracking Missions

A two-day drogue tracking programme was executed by the CEAC team on April 24th, 2012 and April 26th, 2012. Six (6) drogues were placed within the Old Harbour Bay; three (3) surface and three (3) sub-surface drogues (with sail depths ranging from 2 to 10 metres) were placed near shore, between the two reef structures and further offshore.

The drogues were tracked during two separate sessions over the two days, one in the morning and the other in the evening, in order to capture the rising and falling tides on each day. The sessions tracked were the morning falling tide and the evening rising tide.

The GPS and drogue log sheet results from the drogue tracking missions were reduced and incorporated in a database. The data was then analysed in order to determine current speed and directions, and current speed vectors were produced for the rising and falling tides.

Plate 5-7 - Photo of drogue offshore Old Harbour bay

Results – Falling Tide

Sessions 1 and 3 were conducted during falling tide conditions. The periods for falling tide conditions were as follows: session 1 was observed from 12:50 pm to 3:21 pm and session 3 from 8:36am to 10:11am in the morning. The average wind speed recorded for session 1 was 3.10 m/s onshore and 6.8m/s offshore. The average directions were SE and NW respectively. Session 3 had wind speeds of 1.09m/s onshore and 8.70m/s offshore, while the average direction were NE for both locations.

Near Shore

During sessions 1 and 3, the surface drogues near shore were tracked moving in general westerly directions at speeds of 9.25 cm/s and 9.52 cm/s respectively. The deeper sub-surface drogues (2m) deployed near shore travelled in westerly directions at average speeds of 52.55 cm/s and 3.04 cm/s for sessions 1 and 3 respectively. The directions of the drogues for the first session correspond to the wind directions measured by the onshore wind station. The third session had the drogue movements aligned with the wind direction also indicating the nearshore currents are predominantly wind driven.

Offshore (North of the reefs)

The surface drogues placed in close proximity to the reefs in the bay were observed to move in a north westerly direction at a speed of 12.63 cm/s for session 1 and south westerly direction at speeds of 7.46 cm/s during session 3. The sub-surface drogues (5m) travelled north westerly with average speeds of 2.86 to and southerly at 0.31 cm/s for session 1 and 3 respectively.

The directions of the offshore drogues correspond to the wind directions measured by the onshore wind station. The third session had the drogue movements being aligned with the average wind direction indicating the currents are being driven by the wind.

Deep Off Shore

The surface drogues were tracked moving at average speeds of between 14.72 cm/s and 1.93 cm/s in westerly and south westerly directions. The deeper sub-surface drogues (10m) travelled in directions of north westerly and south westerly directions at average speeds between 4.28 cm/s and 1.66 cm/s.

The directions of the deep offshore drogues for the first session correspond to the wind directions measured by the onshore wind station. The third session had the drogue movements misaligned with the wind direction also indicating the deep offshore are indirectly wind driven since they are moving into the bay and are not aligned with the direction that would correspond with falling tide.

Table 5-29 - Summarized drogue tracking session #1 - Falling tide conducted on April 24, 2012

Falling Tide Drogue Session - Conducted April 24th, 2012										
Drogue #	Depth of Sail	Notes	Location	Distance Travelled (m)	Time (s)	Speed (cm/s)	Direction of Motion	Average Speed (cm/s)	Average Direction of Motion	
7	2m	deploy	Near Shore	59.540	360	16.539	330.852	52.548	260.068	Westerly
7	2m	measurement	Near Shore	162.604	120	135.503	148.069	52.548	260.068	Westerly
7	2m	measurement	Near Shore	184.878	3300	5.602	301.283	52.548	260.068	Westerly
7	2m	remove	Near Shore					52.548	260.068	Westerly
8A	surface	deploy	Near Shore	333.014	3600	9.250	280.905	9.250	280.905	Westerly
8A	surface	remove	Near Shore					9.250	280.905	Westerly
5	5m	deploy	Outside Reefs	134.462	4560	2.949	337.249	2.858	343.421	North Westerly
5	5m	measurement	Outside Reefs	49.820	1800	2.768	349.592	2.858	343.421	North Westerly
5	5m	remove	Outside Reefs					2.858	343.421	North Westerly
2	surface	deploy	Outside Reefs	656.804	4860	13.514	307.079	12.634	318.894	North Westerly
2	surface	measurement	Outside Reefs	141.032	1200	11.753	330.709	12.634	318.894	North Westerly
2	surface	remove	Outside Reefs					12.634	318.894	North Westerly
6A	10m	deploy	Deep Off Shore	109.481	3060	3.578	320.932	4.279	331.198	North Westerly
6A	10m	measurement	Deep Off Shore	179.301	3600	4.981	341.464	4.279	331.198	North Westerly
6A	10m	remove	Deep Off Shore					4.279	331.198	North Westerly
6	surface	deploy	Deep Off Shore	515.656	3180	16.216	267.110	14.715	276.284	Westerly
6	surface	measurement	Deep Off Shore	420.201	3180	13.214	285.458	14.715	276.284	Westerly
6	surface	remove	Deep Off Shore					14.715	276.284	Westerly

Table 5-30 - Summarized drogue tracking session #3 - Falling tide conducted on April 26, 2012

Falling Tide Drogue Session - Conducted April 26th, 2011										
Drogue #	Depth of Sail	Notes	Location	Distance Travelled (m)	Time (s)	Speed (cm/s)	Direction of Motion	Average Speed (cm/s)	Average Direction of Motion	
8A	2m	deploy	Near Shore	40.311	1620	2.488	262.875	3.039	271.914	Westerly
8A	2m	measurement	Near Shore	26.173	1020	2.566	263.418	3.039	271.914	Westerly
8A	2m	measurement	Near Shore	29.069	900	3.230	273.945	3.039	271.914	Westerly
8A	2m	measurement	Near Shore	53.451	1380	3.873	287.418	3.039	271.914	Westerly
8A	2m	remove	Near Shore					3.039	271.914	Westerly
6	surface	deploy	Near Shore	99.930	1680	5.948	251.928	9.520	260.642	Westerly
6	surface	measurement	Near Shore	82.280	1080	7.619	249.362	9.520	260.642	Westerly
6	surface	measurement	Near Shore	103.392	840	12.309	265.006	9.520	260.642	Westerly
6	surface	measurement	Near Shore	183.096	1500	12.206	276.271	9.520	260.642	Westerly
6	surface	remove	Near Shore					9.520	260.642	Westerly
5	5m	deploy	Outside Reefs	8.485	1200	0.707	315.000	0.307	169.679	Southerly
5	5m	measurement	Outside Reefs	4.123	1980	0.208	104.036	0.307	169.679	Southerly
5	5m	measurement	Outside Reefs	0.100	1920	0.005	90.000	0.307	169.679	Southerly
5	5m	remove	Outside Reefs					0.307	169.679	Southerly
6A	surface	deploy	Outside Reefs	89.275	1260	7.085	221.367	7.463	244.280	South Westerly
6A	surface	measurement	Outside Reefs	147.231	1980	7.436	245.524	7.463	244.280	South Westerly
6A	surface	measurement	Outside Reefs	113.283	1440	7.867	265.950	7.463	244.280	South Westerly
6A	surface	remove	Outside Reefs					7.463	244.280	South Westerly
3	10m	deploy	Deep Off Shore	6.708	1140	0.588	153.435	1.655	241.060	South Westerly
3	10m	measurement	Deep Off Shore	12.042	840	1.434	265.236	1.655	241.060	South Westerly
3	10m	measurement	Deep Off Shore	38.833	1320	2.942	304.509	1.655	241.060	South Westerly
3	10m	remove	Deep Off Shore					1.655	241.060	South Westerly
2	surface	deploy	Deep Off Shore	31.385	1080	2.906	149.349	1.932	242.670	South Westerly
2	surface	measurement	Deep Off Shore	2.000	900	0.222	270.000	1.932	242.670	South Westerly
2	surface	measurement	Deep Off Shore	32.016	1200	2.668	308.660	1.932	242.670	South Westerly
2	surface	remove	Deep Off Shore					1.932	242.670	South Westerly

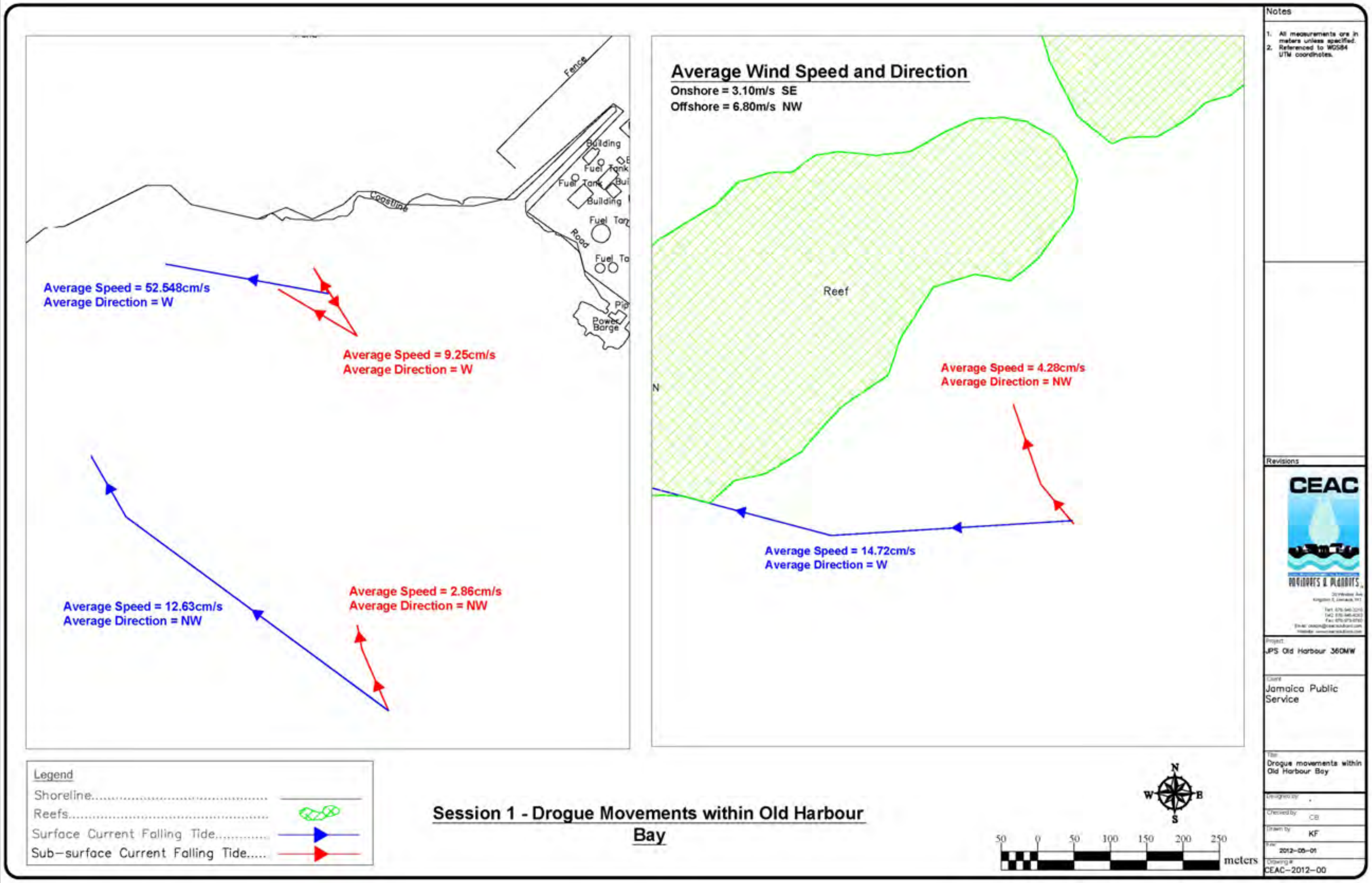


Figure 5-43 - Approximate path and direction of the drogues during drogue session #1

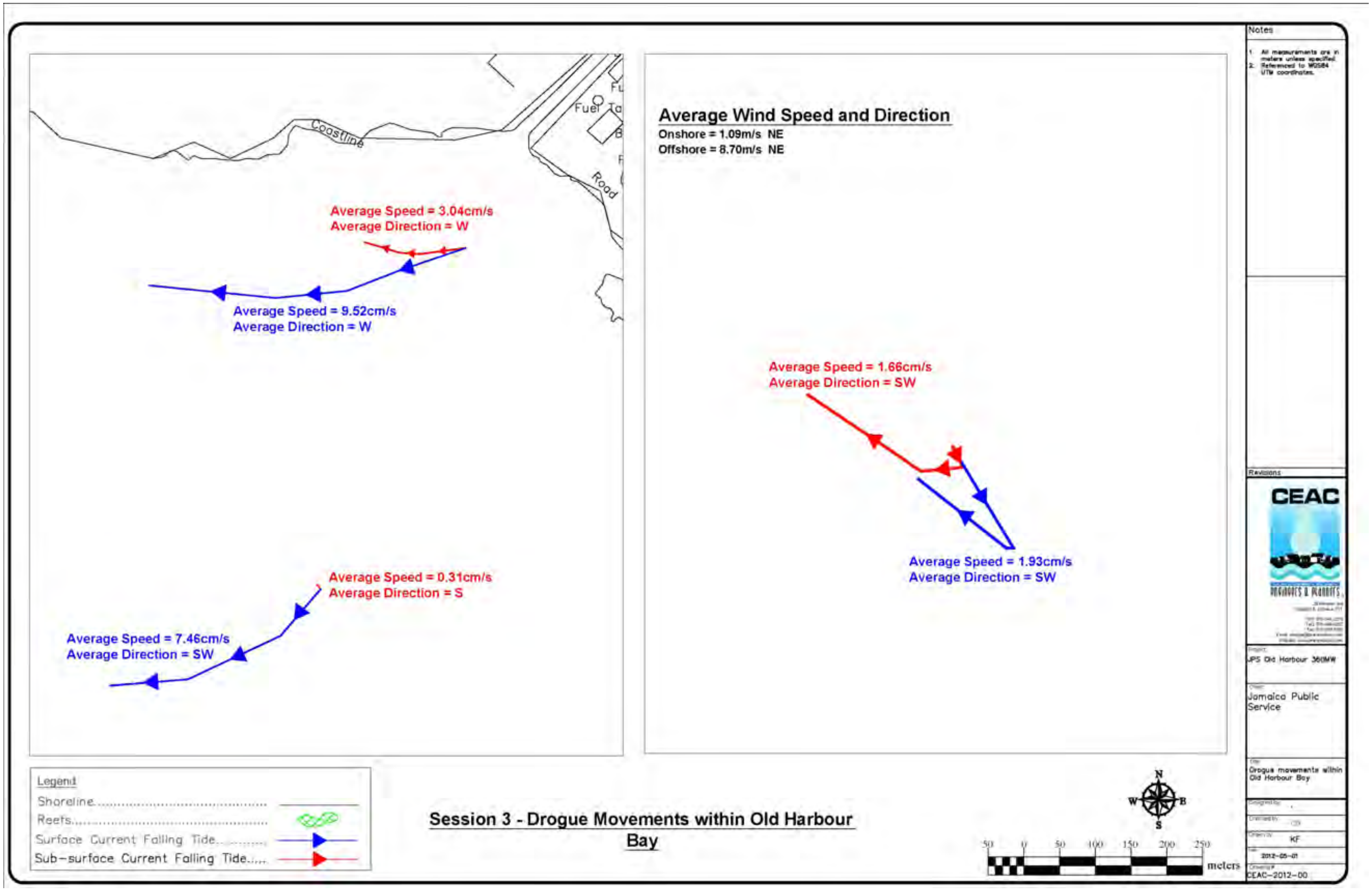


Figure 5-44 - Approximate path and direction of the drogues during Drogue session #3.

Results – Rising Tide

Near Shore

During session 2, the surface drogue near shore was observed moving in a westerly direction at a velocity of 13.34 cm/s. The deeper sub-surface drogue (2m) set up near shore travelled in a southerly direction at an average speed of 62.11 cm/s.

The directions of the nearshore drogues correspond to the wind directions measured by the onshore both the onshore and offshore wind stations, indicating the nearshore currents are predominantly wind driven.

Offshore (before the reefs)

The surface drogues placed outside the reefs in the bay were observed to be moving in a north westerly direction at a speed of 6.61 cm/s during this session. The sub-surface drogue (5m) travelled southerly at an average velocity of 1.16 cm/s.

The directions of the offshore drogues correspond to the wind directions measured by the onshore wind station, indicating the nearshore currents are predominantly wind driven.

Deep Off Shore

The surface drogues were tracked moving at an average speed of 4.64 cm/s in a general northerly direction. The deeper sub-surface drogue (10m) travelled north westerly at 2.36 cm/s.

Table 5-31 - Summarized drogue tracking session #2 – Rising tide conducted on April 24, 2012

Rising Tide Drogue Session - Conducted April 24th, 2012										
Drogue #	Depth of Sail	Notes	Location	Distance Travelled (m)	Time (s)	Speed (cm/s)	Direction of Motion	Average Speed (cm/s)	Average Direction of Motion	
7	2m	deploy	Near Shore	8.062	1740	0.463	60.255	62.106	191.865	Southerly
7	2m	measurement		216.227	120	180.189	234.031			
7	2m	measurement		10.198	180	5.666	281.310			
7	2m	remove								
6	surface	deploy		172.792	1560	11.076	257.975	13.337	257.818	Westerly
6	surface	measurement		65.513	420	15.598	257.661			
6	surface	remove								
5	5m	deploy	Outside Reefs	13.892	540	2.573	329.744	1.158	174.091	Southerly
5	5m	measurement		4.123	1020	0.404	165.964			
5	5m	measurement		4.472	900	0.497	26.565			
5	5m	remove								
8A	surface	deploy		46.840	540	8.674	343.887	6.606	334.891	North Westerly
8A	surface	measurement		70.774	1080	6.553	336.695			
8A	surface	measurement		35.805	780	4.590	324.090			
8A	surface	remove								
6A	10m	deploy	Deep Off Shore	43.829	1860	2.356	325.222	2.356	325.222	North Westerly
6A	10m	remove								
2	surface	deploy		89.006	1920	4.636	0.644	4.636	0.644	Northerly
2	surface	remove								

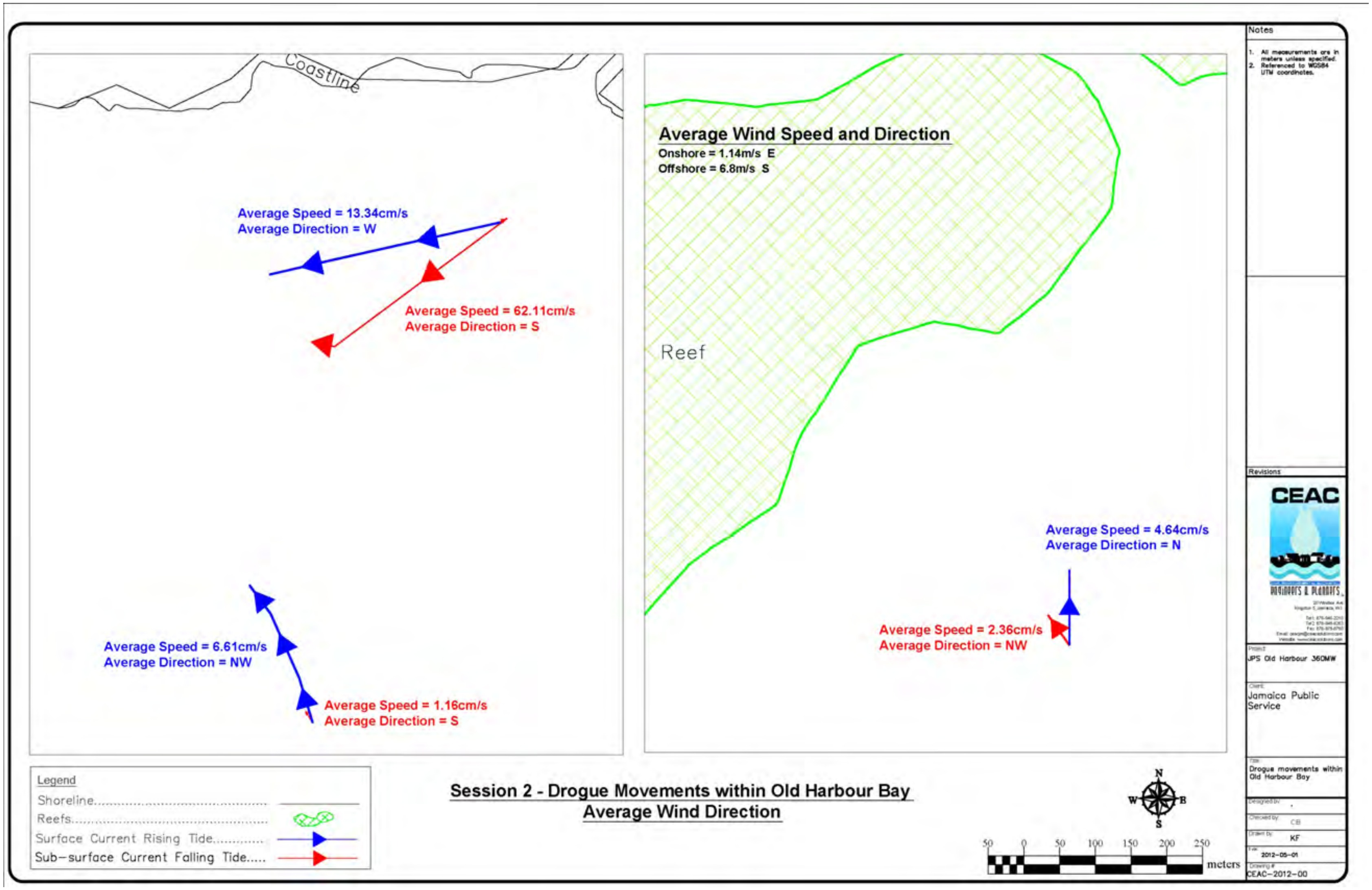


Figure 5-45 - Approximate path and direction of the drogues during Drogue session #2

5.1.13.2.4 Summary Data Collected

The two days of drogue tracking involved three sessions total; two falling tides and one rising tide. The currents in this area appear to be mostly wind driven during the rising and falling tides session. These current speeds varied from 12.63 cm/s to 62.11 cm/s and 0.31 cm/s to 14.72 cm/s for the surface and sub-surface drogues respectively. The speeds during the rising tide varied from 4.64 cm/s to 13.34 cm/s and 1.16 cm/s to 62.11 cm/s for the surface and sub-surface currents.

Knowledge of the prevailing wind conditions allowed for the determination of the effect of wind speed and direction. The current speeds are generally higher for the falling tides than for the rising tide session. It is evident that the deeper waters in the bay area tidally dominated (as expected) and the shallower waters are wind driven/dominated.

5.1.13.2.5 Model Development and Calibration

Description of RMA 10 Model

RMA-10 is a three-dimensional finite element model for stratified flow by King (1993). The primary features of RMA-10 are:

- The solution of the Navier-Stokes equations in three-dimensions;
- The use of the shallow-water and hydrostatic assumptions;
- Coupling of advection and diffusion of temperature, salinity and sediment to the hydrodynamics;
- The inclusion of turbulence in Reynolds stress form;
- Horizontal components of the non-linear terms are included;
- A capacity to include one-dimensional, depth-averaged, laterally-averaged and three-dimensional elements within a single mesh as appropriate;
- No-, partial- and full-slip conditions can be applied at both lateral boundaries;
- Partial or no-slip conditions can be applied at the bed;
- Depth-averaged elements can be made wet and dry during a simulation; and
- Vertical turbulence quantities are estimated by either a quadratic parameterisation of turbulent exchange or a Mellor-Yamada Level 2 turbulence sub-model.

Finite Element Mesh Development

The process of mesh developments entails the following steps:

- Input of bathymetric data for the wider area and in detail for the project area
- Specifying of nodes in the mesh
- Element construction in the mesh
- Interpolation for depth at nodes
- Specifying of open boundaries

The mesh constructed for the calibration and existing configuration extended some 34 kilometres in a southerly direction. The outer deep water areas were gridded with large mesh which gradually decreases on approach to the project area (Figure 5.).

The eastern and western boundaries were used as the open boundaries on which tides were applied.

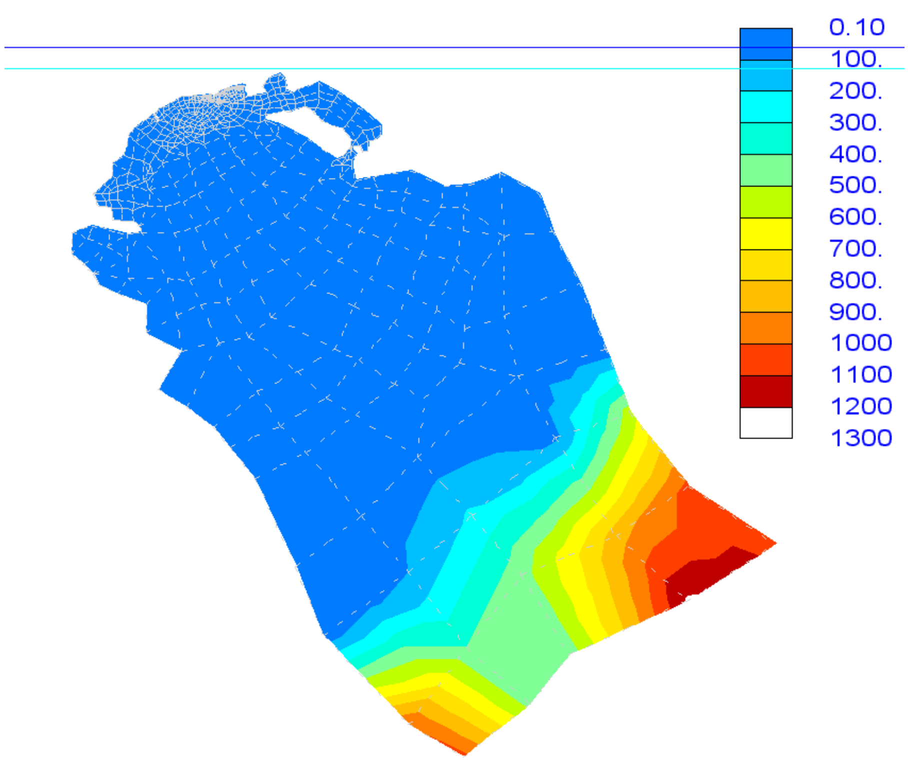


Figure 5. - Overview of entire Finite Element Mesh used for this project showing depth in metres

Calibration

The model was calibrated by adjusting the tide elevation signal on the model boundaries, turbulence and viscosity parameters, until there was reasonable agreement between the observed currents and model predictions. See Figure 5-46, Figure 5-47 and Figure 5-48 for the predicted currents.

The predicted current speeds and directions, versus the data from the drogue tracking sessions are summarized in Table 5-32. The model predictions were within the data ranges for the observed occurrences in most instances. The calibration data essentially indicates that there is reasonable agreement between the model and the data.

Table 5-32 - Calibration data for FEM for the existing bathymetric configuration based on drogue and wind data for the 2006/06/20

		Observations		**Model Predictions**	
Session	**Location**	**Speed (cm/sec)**	**Direction**	**Speed**	**Direction**
1	Nearshore	9.25	W	9-10	W
	Offshore	12.63	NW	8-9	W
	Deep offshore	14.72	W	6 - 9	SW - NW
2	Nearshore	13.34	W	8-9	W-SW
	Offshore	6.61	NW	6-8	W-SW
	Deep offshore	4.64	N	4-6	W-NW
3	Nearshore	9.52	W	9-11	W-SW
	Offshore	7.46	SW	6-8	SW
	Deep offshore	1.65	SW	9-10	SW

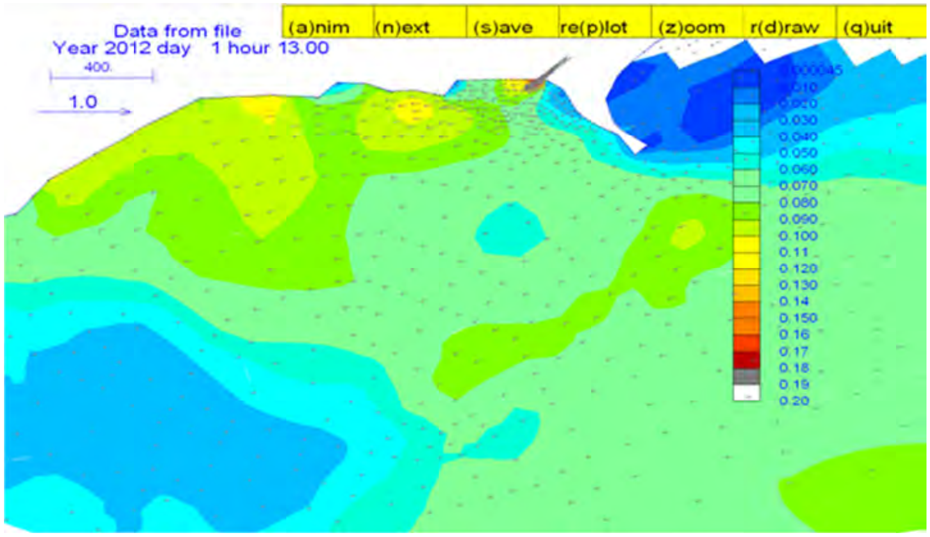


Figure 5-46 Calibration plot of currents (in m/s) for day one corresponding to drogue session 1

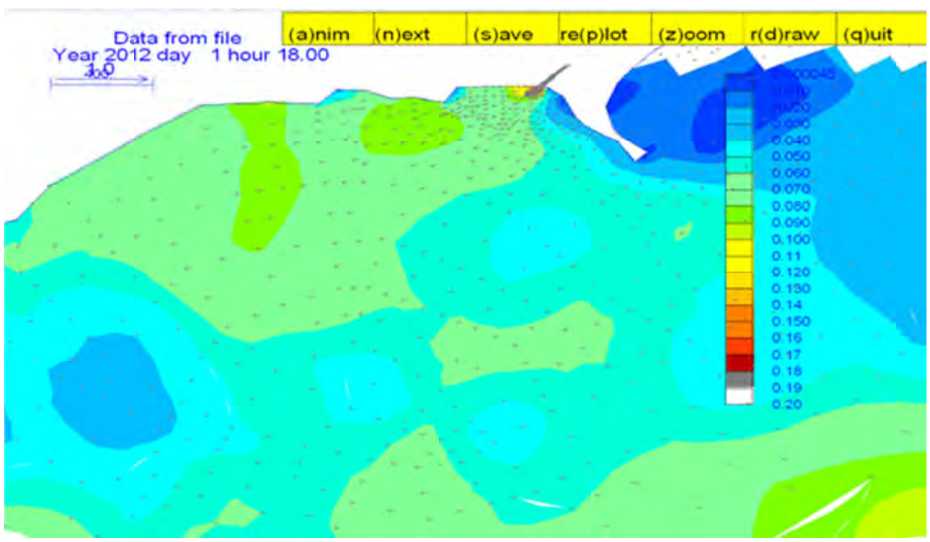


Figure 5-47 - Calibration plot of currents (in m/s) for day one corresponding to drogue session 2

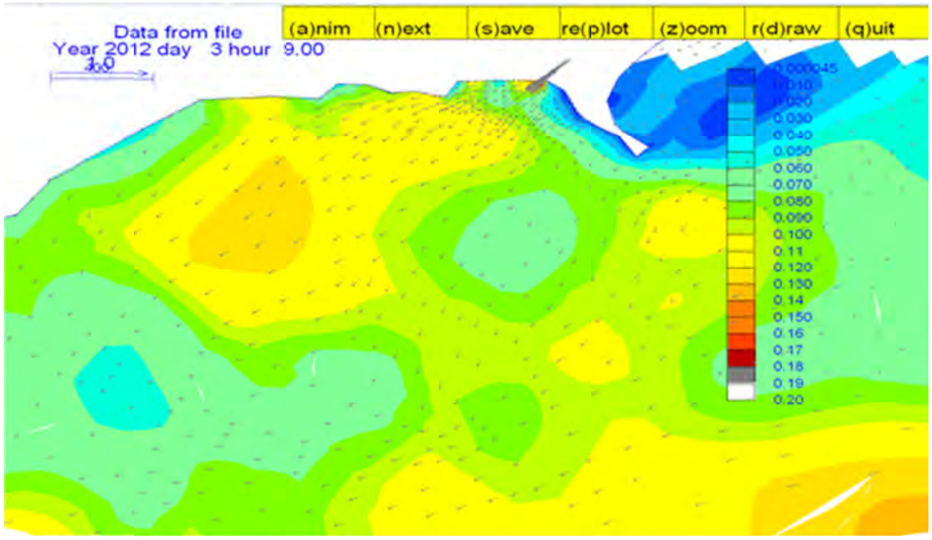


Figure 5-48 - Calibration plot of currents (in m/s) for day one corresponding to drogue session 3

Operational Wind Speed and Direction Scenarios

Table 5-33 - Summary of wind speeds and directions investigated

Conditions	**Speed (m/s)**	**Direction**
Slow	2.0	Easterly
Average	5.5	Easterly
Fast	15.5	Easterly

5.1.13.2.6 Results

Slow Wind Conditions

Surface current predictions for the slow wind speed meteorological conditions for the existing shoreline configuration indicate that current velocities below 6 cm/sec can be expected within the bay. The current directions are predominantly towards the west which indicates the surface currents are predominantly wind driven.

Falling Tide	**Rising Tide**

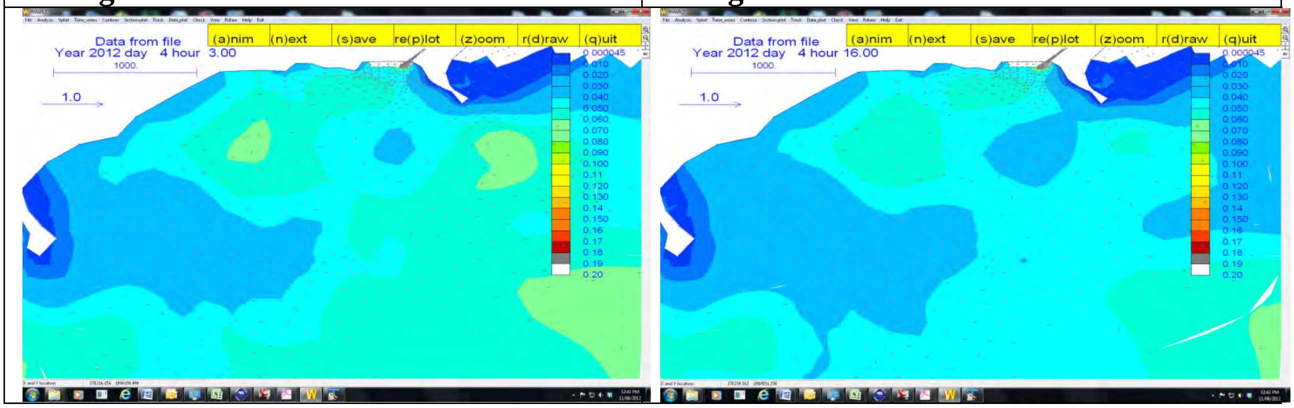


Figure 5-49 - Falling Tide and Rising Tide – Slow Wind Conditions

Average Wind Conditions

Surface current predictions for the average wind speed meteorological conditions for the existing shoreline configuration indicate that current velocities below 13 cm/sec for falling tides and 10cn/sec for rising tides can be expected within the bay. The current directions are predominantly towards the west which indicates the surface currents are predominantly wind driven.

Falling Tide	**Rising Tide**

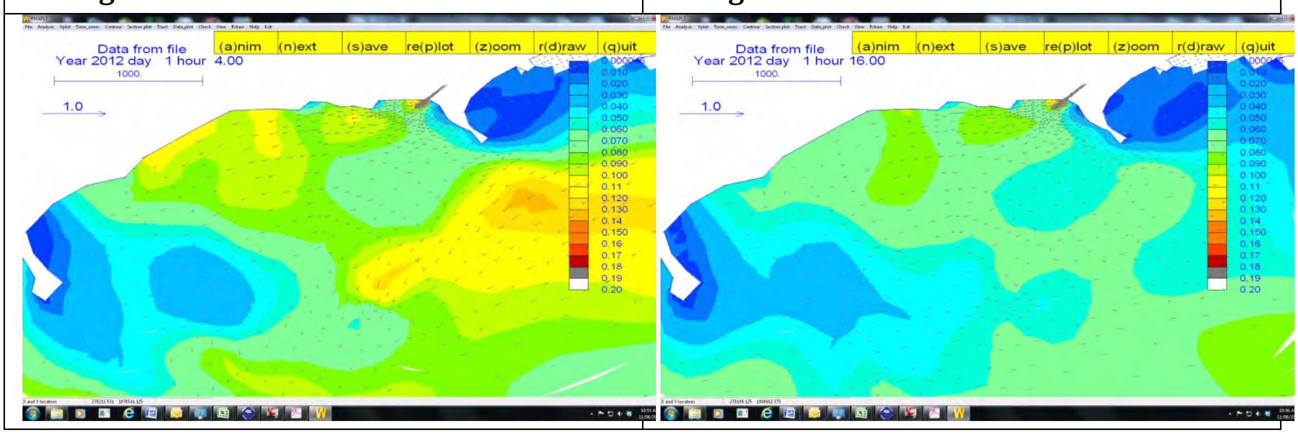


Figure 5-50 - Falling Tide and Rising Tide – Average Wind Conditions

Fast Wind Conditions

Surface current predictions for the average wind speed meteorological conditions for the existing shoreline configuration indicate that current velocities below 13 cm/sec for falling and rising tides can be expected within the bay. The Currents are driven by the winds and tides.

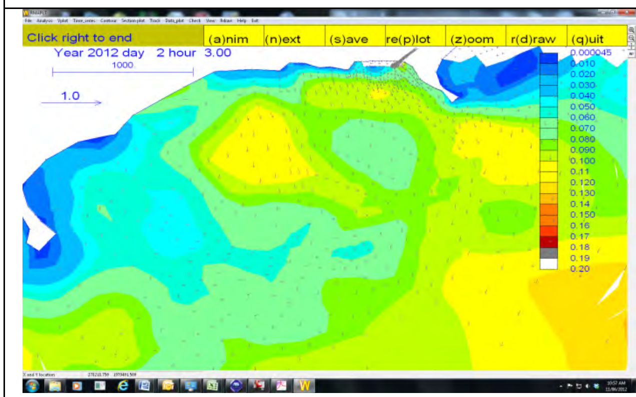
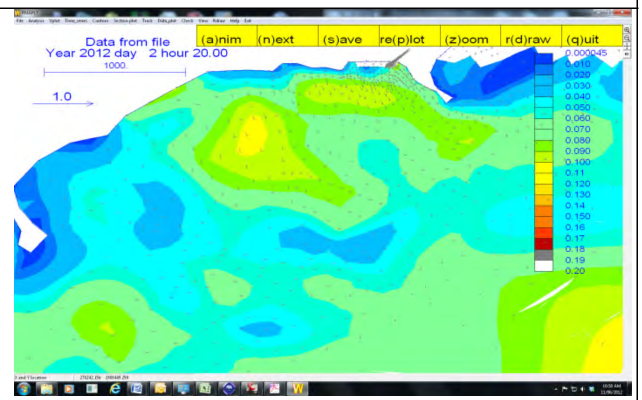
<table>
<tr><th>Falling Tide</th><th>Rising Tide</th></tr>
<tr><td>
</td><td>
</td></tr>
</table>

Figure 5-51 - Falling Tide and Rising Tide – Fast Wind Conditions

5.1.14 Water Quality

5.1.14.1 Introduction

Three water quality sampling exercises were conducted on the following dates:

- April 26, 2012
- May 10, 2012
- May 24, 2012

Weather conditions were fair and sunny on the first two sampling runs, while slightly windy conditions and intermittent rainfall occurred on the May 24 sampling event.

5.1.14.2 Methodology

5.1.14.2.1 Aquatic and Potable

Physical data (Temperature, conductivity, salinity, dissolved oxygen, pH, turbidity, and total dissolved solids - TDS) was collected *in situ* at identified aquatic locations within the project environs and potable water location, using a Hydrolab DataSonde DS-5 meter (See Appendix 7 for Calibration Certificate). Measurements were taken at intervals throughout the water column. Chemical and biological data were obtained from whole water samples collected at a depth of approximately 0.5 m. The samples were collected in pre-cleaned 1L plastic bottles. Bacterial samples were collected in sterilised 100 ml bottles at above mentioned depth. Fats Oil and Grease samples were collected in glass bottles. The samples were stored on ice in a cooler and transported to Caribbean Environmental Testing and Monitoring Services, and Test America Pensacola Laboratory for laboratory analyses. Eleven (11) aquatic and one (1) potable water quality sampling stations were sampled. The potable water sample was taken from the JPS Old Harbour Bay power station bathroom faucet (station JPS12).

Three (3) sampling events were conducted.

The parameters analysed for the aquatic (marine and freshwater) water samples were: BOD, Total Suspended Solids, Nitrates, Phosphates, Oil and Grease, Faecal Coliform, Total Hardness, Iron, Zinc and Total Petroleum Hydrocarbons (TPH).

The parameters analysed for the potable water sample were: barium, boron, fluoride, manganese, nitrates, faecal coliform, residual chlorine, arsenic, cadmium, chromium, copper, cyanide, lead, mercury, nickel and selenium.

The water quality stations were accurately mapped using a Trimble® Geo XT GPS unit(s). This will facilitate spatial comparison of the data and determining any possible source(s) of pollutants by putting it into a GIS. Figure 5-52 shows a map of the sampling locations and Table 5-34 gives the GPS locations.

The results from these sampling runs were compared to National Environment and Planning Agency (NEPA), World Health Organization Standards and World Bank Standards.

Table 5-34 – Water quality sampling locations

STATION NUMBER	JAD 2001	
	NORTHINGS	EASTINGS
1	639438.343	737654.465
2	638597.429	737507.143
3	638357.524	738155.675
4	637987.383	738937.267
5	638813.095	738832.651
6	637216.854	738447.687
7	636661.153	739006.650
8	636051.270	737552.652
9	636842.198	736505.603
10	637635.129	737550.379
11	637982.890	736600.345

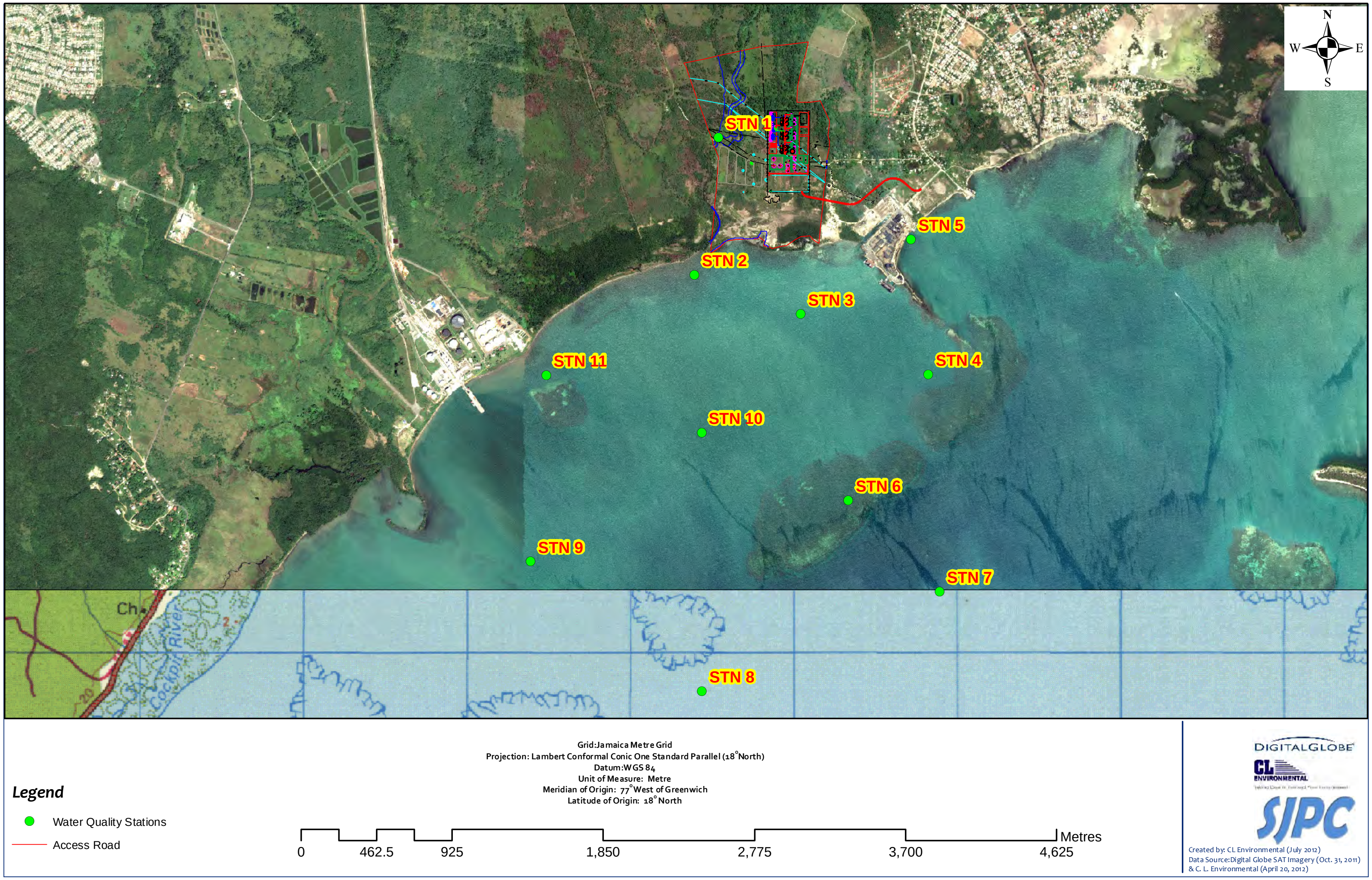


Figure 5-52 - Map showing water quality sampling locations

5.1.14.2.2 Statistical Analysis

The analysis of variance test (ANOVA) was applied using the statistical program STATISTICA 7 (Statsoft Inc., 2004). This test analysed the effect of one independent variable (station) on a dependant variable (physical and biological parameter) and tested whether there were significant differences between samples at each station. The 95% confidence interval was used and differences were considered significant if the significance value was greater than 0.05 ($p > 0.05$). The post-hoc test, Tukey's, was applied to show if a relation exists between the different sites and parameters analysed and grouped most similar stations based on the 95 % confidence limit.

5.1.14.3 Results and Discussion

The physicochemical data represent the average values through the water column at each station. Stations were sampled up to a depth of nine (9) metres.

Table 5-35 shows the mean water quality values at each location. Table 5-37 shows the minimum and maximum values for the water quality parameters. Table 5-37 shows ANOVA results for the various water quality parameters and Figure 5-53 shows the grouping of the various water quality stations according to the parameters sampled. These tables and figures are discussed in subsequent sections.

Detailed water quality values can be found in Appendix 8.

Table 5-35 - Average values for chemical parameters for the water quality stations

Stn	BOD (mg/l)	TSS (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	FOG (mg/l)	Faecal Coliform (mpn/100ml)	Total Hardness (% CaCO3)	Iron (mg/l)	Zinc (mg/l)	DRO (mg/l)	GRO (mg/l)
JPS1	11.33	44.67	0.30	0.13	21.24	196.67	0.59	0.92	0.02	ND	ND
JPS2	11.00	19.67	0.80	0.10	26.57	11.00	0.66	0.28	0.03	ND	ND
JPS3	11.67	6.67	0.67	0.04	10.48	1305.00	0.65	0.50	0.03	1.5	ND
JPS4	18.00	7.00	0.70	0.06	11.14	11.00	0.67	0.56	0.02	ND	ND
JPS5	12.33	17.67	0.67	0.02	3.29	69.00	0.66	0.70	0.03	ND	ND
JPS6	11.67	6.00	0.77	0.10	4.38	22.00	0.67	0.37	0.02	ND	ND
JPS7	14.33	8.33	0.77	0.08	11.14	11.00	0.67	0.67	0.03	ND	ND
JPS8	11.00	5.33	0.80	0.13	7.43	11.00	0.67	0.16	0.02	ND	ND
JPS9	11.33	8.67	0.63	0.02	49.24	11.00	0.67	0.22	0.02	ND	ND
JPS10	9.00	6.67	0.73	0.03	7.90	11.00	0.66	0.26	0.03	ND	ND
JPS11	12.00	8.67	0.67	0.02	36.00	566.00	0.67	0.27	0.03	ND	ND

Table 5-36 - Range of values (minimum and maximum) for chemical parameters for the water quality stations

Stn	BOD (mg/l)	TSS (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	FOG (mg/l)	Faecal Coliform (mpn/100ml)	Total Hardness (% CaCO3)	Iron (mg/l)	Zinc (mg/l)
JPS1	7-12	27-61	0.1-0.6	0.09-0.23	7.43-42.57	100-250	0.5-0.7	0.86-1.01	0.023-0.025
JPS2	5-17	3-53	0.7-0.9	0.01-0.24	5.71-63.71	11	0.66-0.69	0.21-1.2	0.016-0.036
JPS3	8-17	5-10	0.6-0.7	0.01-0.05	4.29-15.14	11-2400	0.65-0.67	0.22-1.53	0.024-0.039
JPS4	13-23	2-20	0.7	0.02-0.09	2.29-20.57	11	0.64-0.72	0.18-0.54	0.02-0.027
JPS5	8-21	3-43	0.5-0.7	0.01-0.02	2-4.43	11-69	0.65-0.69	0.2-1.12	0.019-0.033
JPS6	7-19	1-11	0.6-0.9	0.01-0.15	2.29-5.71	11-69	0.65-0.69	0.1-0.19	0.022-0.029
JPS7	8-27	2-20	0.7-0.8	0.01-0.23	9.14-15.14	11-22	0.66-0.68	0.21-0.24	0.021-0.028
JPS8	7-17	1-10	0.6-1	0.06-0.26	6.29-8	11	0.65-0.66	0.19-0.33	0.026-0.34
JPS9	8-18	5-16	0.3-0.9	0.01-0.02	4.57-130.29	11	0.65-0.68	0.16-0.41	0.017-0.029
JPS10	8-10	3-13	0.7-0.8	0.01-0.06	4.86-13.71	11	0.63-0.67	0.24-0.36	0.026-0.041
JPS11	8-18	3-19	0.5-0.9	0.01-0.02	3.14-72.86	78-1500		0.28-0.63	0.025-0.03

Table 5-37 - ANOVA Results

Parameter	d.f	ANOVA ($p<0.05$)
Temperature	161	0.000
Conductivity	161	0.000
Salinity	161	0.000
pH	161	0.000
ORP	161	0.016
PAR	159	0.090
Dissolved Oxygen	161	0.000
Turbidity	161	0.000
Total Dissolved Solids	161	0.754
Total Suspended Solids	22	0.051
Nitrates	22	0.079
Phosphates	22	0.345
FOG	22	0.536
F. coliform	22	0.370
Total Hardness	22	0.313
Iron	22	0.141
Zinc	22	0.439

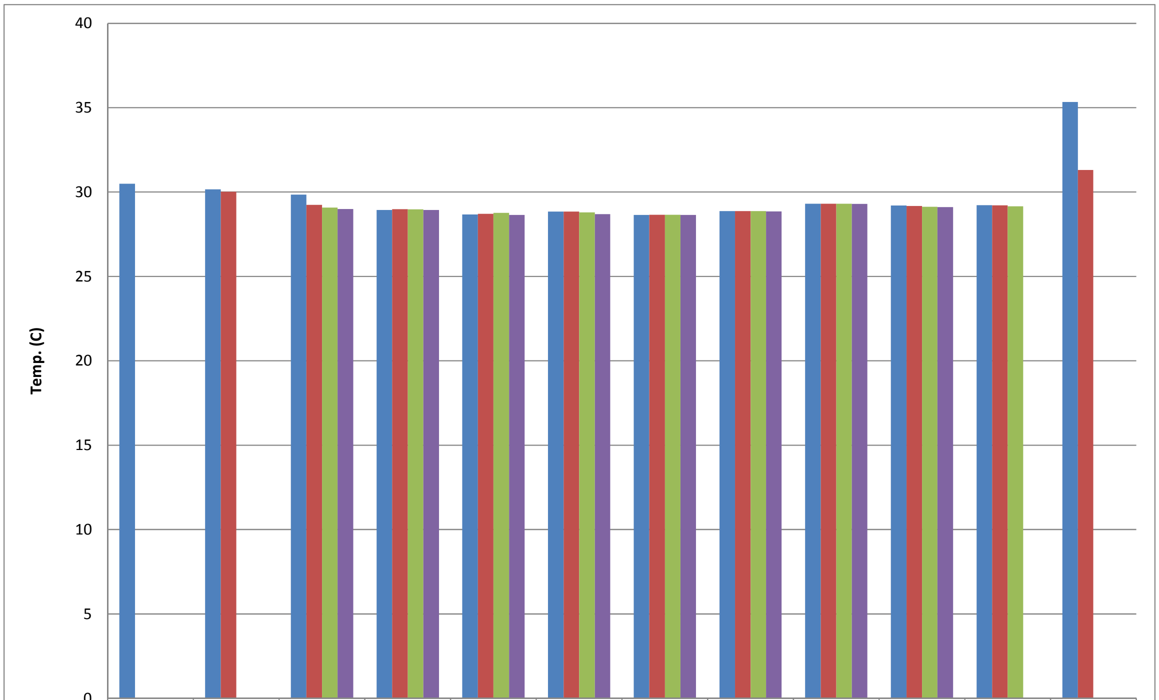
Values in red are significant.

Parameter	D.F	Station Grouping
Temperature	161	13-1-2-9-3- 11-10-4-8-6-5- 7
Conductivity	161	10-3-13-8-7-6-2-4-9-5-11-1
Salinity	161	10-3-8-7-6-2-4-9-5-13-11-1
pH	161	4-9-7-6-10-5-8-11-3-2-13-1
ORP	161	1-5-7-8-9-11-6-13-3-4-10-2
Dissolved Oxygen	161	1-9-7-10-13-4-3-8-2-5-11-6
Turbidity	161	9-2-1-5-13-11-10-3-8-7-4-6

Figure 5-53 - Grouping of stations according to the various parameters sampled.

5.1.14.3.1 Temperature

Temperature levels varied across the stations with the lowest values at station JPS7 (28.63C). Station JPS13, (the existing JPS power plant cooling water outlet), had a surface temperature of 35.33C. The temperature values were significantly different across the stations with an ANOVA value of $p<0.000$. Based on the post-hoc Tukey's, five different groups were formed. The overlying groups indicate that some mixing is occurring in the area; however station JPS13 was in a separate group because of the high temperatures of the water coming from the JPS plant.

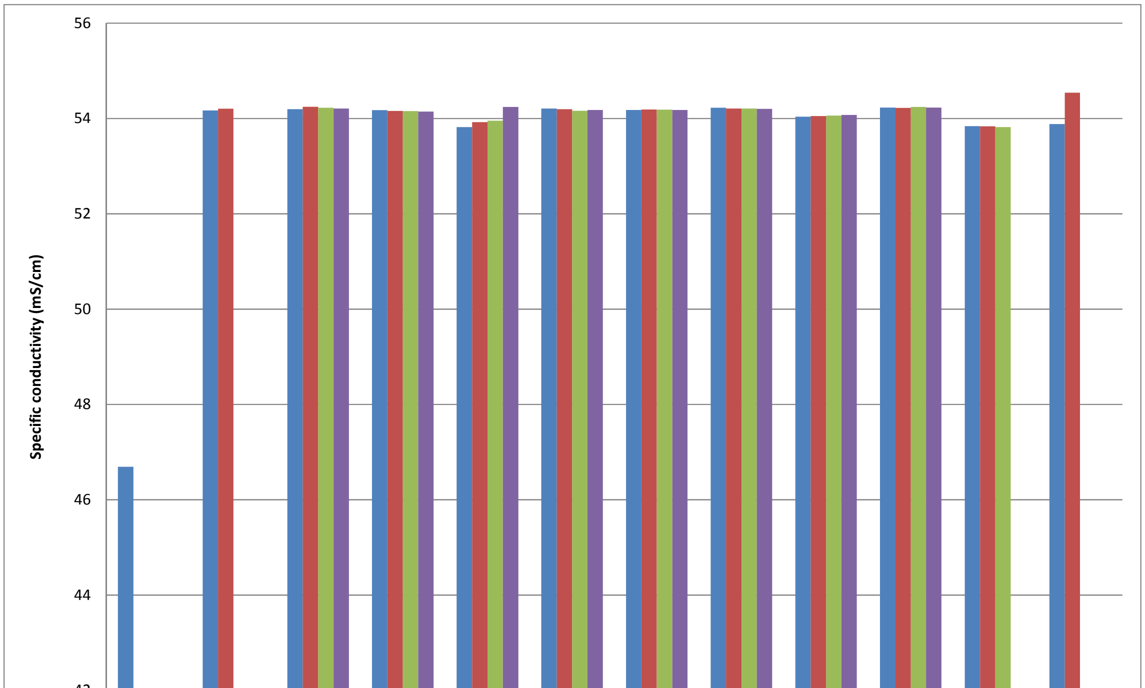


	1	2	3	4	5	6	7	8	9	10	11	13
Surface	30.49	30.16	29.85	28.94	28.67	28.84	28.64	28.87	29.31	29.21	29.23	35.33
1m		30.02	29.24	28.99	28.71	28.85	28.65	28.87	29.31	29.18	29.22	31.31
2m			29.08	28.98	28.77	28.79	28.65	28.87	29.31	29.13	29.16	
3m			29.00	28.94	28.64	28.69	28.64	28.86	29.30	29.10		

Figure 5-54 - Mean temperature values for the various water sampling locations

5.1.14.3.2 Conductivity

The conductivity values varied across the stations ranging from 46.69 – 54.54mS/cm (Figure 5-55). Lowest conductivity value was obtained at station JPS1, whereas station JPS13 had the highest value (54.54mS/cm). The mean values across the stations were significantly different using ANOVA ($p<0.000$) with three groupings formed using Tukey's post hoc test. Most stations were similar; however station JPS1 was grouped by itself because of the brackish water nature of the Bowers Gully.

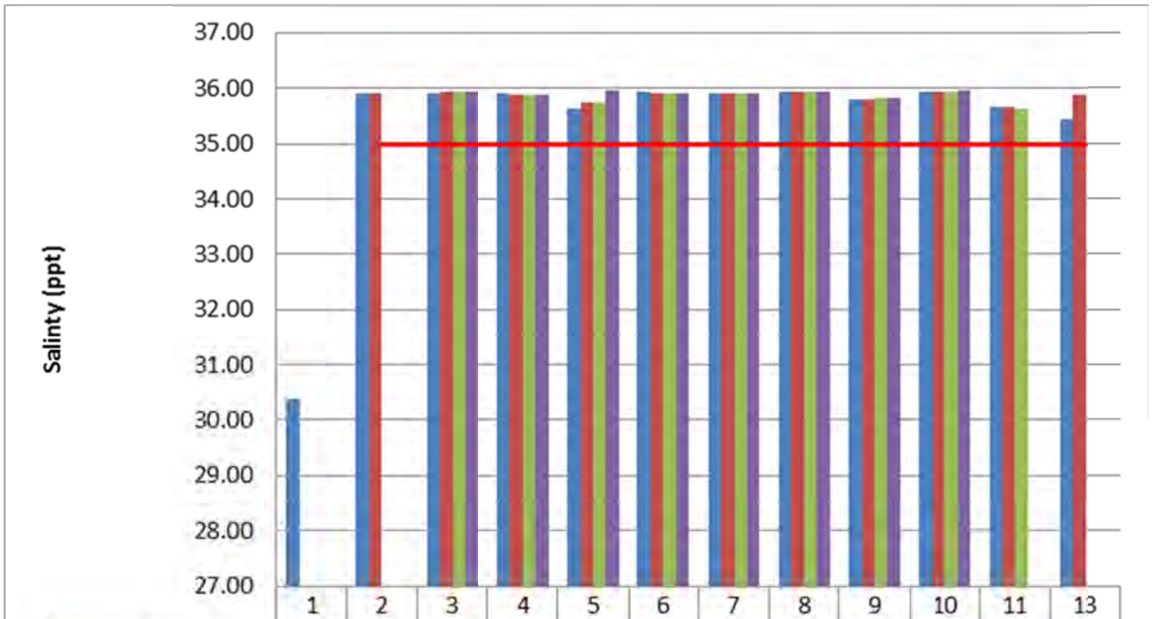


	1	2	3	4	5	6	7	8	9	10	11	13
Surface	46.69	54.17	54.20	54.17	53.82	54.21	54.18	54.23	54.04	54.23	53.84	53.88
1m		54.20	54.25	54.16	53.92	54.20	54.19	54.21	54.05	54.22	53.84	54.54
2m			54.22	54.15	53.95	54.16	54.18	54.21	54.06	54.24	53.82	
3m			54.21	54.15	54.24	54.18	54.18	54.20	54.07	54.23		

Figure 5-55 - Mean conductivity values for the various water sampling locations

5.1.14.3.3 Salinity

Salinity values varied across the stations ranging from 30.39 – 35.96ppt. The salinities varied little with depth across the stations, with stations JPS5 and JPS13 showing a slight increase. Highest salinity value was obtained at station JPS10 (35.96ppt) whereas lowest salinity was obtained at station JPS1 (30.96ppt). The salinity values were significantly different across stations with an ANOVA value of $p<0.000$. Five groups were formed using Tukey's post hoc test. The groupings suggest that mixing occurs within the Bay except for station JPS1 which was in its own group because of the brackish water nature of the Bowers Gully.

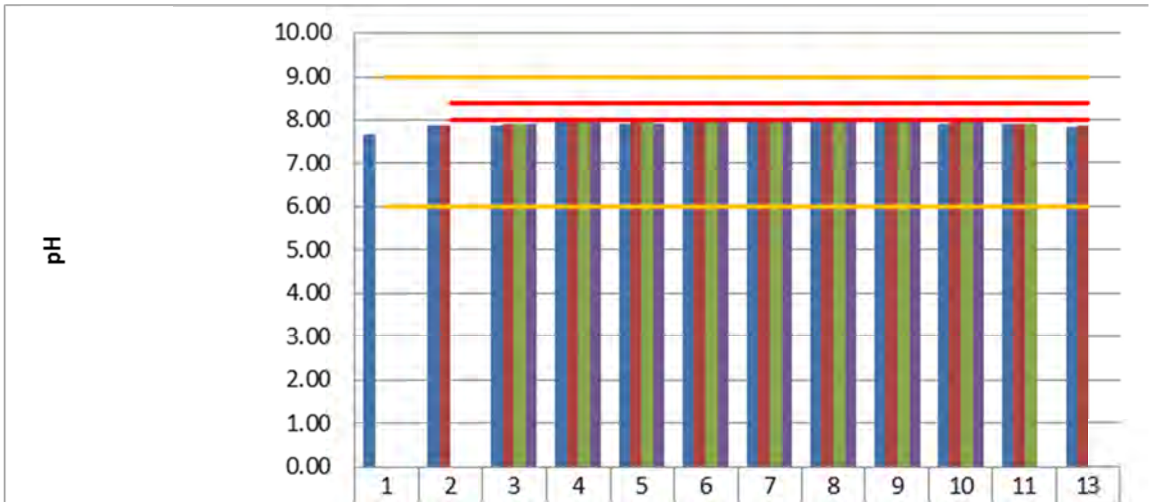


	1	2	3	4	5	6	7	8	9	10	11	13
Surface	30.39	35.90	35.93	35.90	35.64	35.93	35.91	35.94	35.81	35.95	35.65	35.45
1m		35.92	35.95	35.89	35.74	35.92	35.91	35.93	35.81	35.95	35.65	35.88
2m			35.94	35.89	35.74	35.90	35.91	35.93	35.82	35.95	35.65	
3m			35.93	35.88	35.96	35.91	35.91	35.93	35.83	35.96		
Draft NEPA Std.		35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00

Figure 5-56 - Mean salinity values for the various water sampling locations

5.1.14.3.4 pH

pH values varied across the stations ranging from 7.68 – 7.98, and the variation with depth was slight. Lowest pH value was obtained at station JPS1 (7.68), whereas the highest pH was obtained at station JPS4 (7.98). All the stations within the Bay were below the Draft NEPA Standard for Marine Water of 8 – 8.4, whereas station 1 was located in Bowers' Gully. All stations were compared to the World Bank Guideline for Effluent Discharge of 6 -9 and they were within the range. pH varied significantly between the stations with an ANOVA value of $p<0.000$. Four different groups were formed using the post hoc Tukey's. These groupings suggest mixing within the Bay area except for station JPS1 which was grouped by itself, due to the gully's brackish water nature.

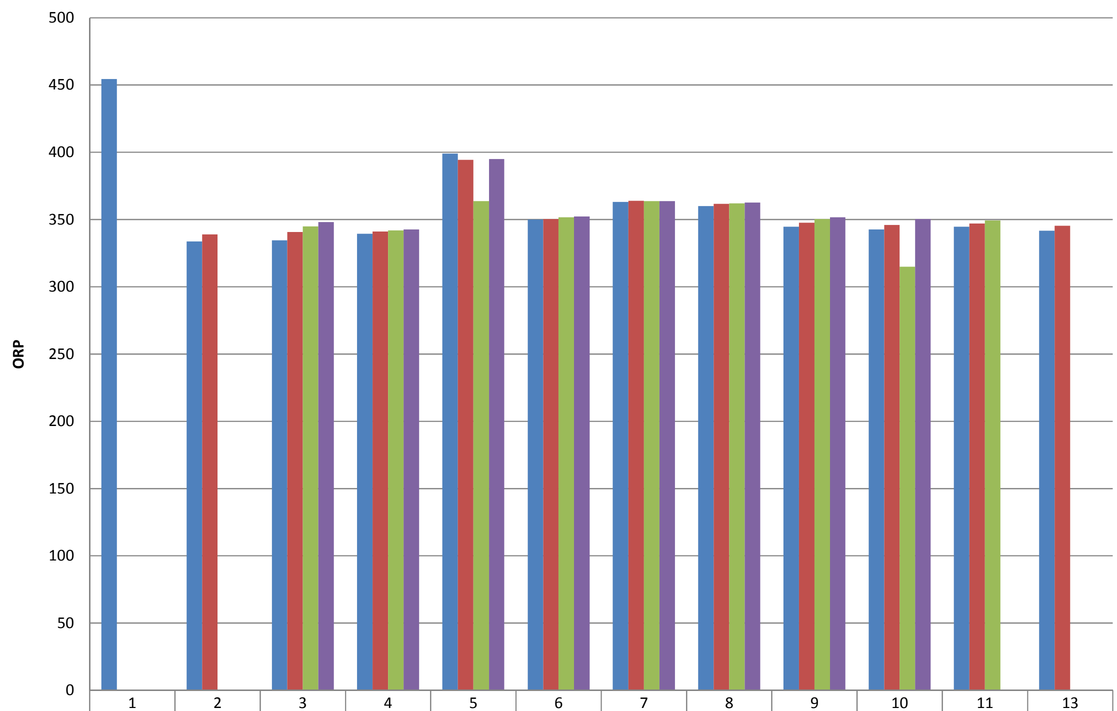


	1	2	3	4	5	6	7	8	9	10	11	13
Surface	7.68	7.88	7.89	7.98	7.92	7.96	7.95	7.94	7.95	7.92	7.92	7.84
1m		7.88	7.92	7.97	7.93	7.96	7.96	7.94	7.96	7.94	7.92	7.86
2m			7.92	7.97	7.94	7.94	7.96	7.94	7.96	7.94	7.92	
3m			7.92	7.97	7.92	7.93	7.96	7.94	7.96	7.95		
Draft NEPA std. (lower)		8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Draft NEPA std.(upper)		8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40	8.40
IFC std.(lower)	6	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
IFC std. (upper)	9	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00

Figure 5-57 - Mean pH values for the various water sampling locations

5.1.14.3.5 Oxidative Reductive Potential (ORP)

ORP varied across the stations ranging from 315 – 454.33. The highest value was obtained at station JPS1 (454.33), whereas the lowest value was obtained at station JPS10 (315). The ORP values were significantly different across the stations with an ANOVA value of $p<0.016$. Two groups were formed using the post hoc Tukey's with the extreme stations being JPS1 and JPS2. The groupings suggest that the area has similar ORP levels except for station JPS1, which was in a separate group.

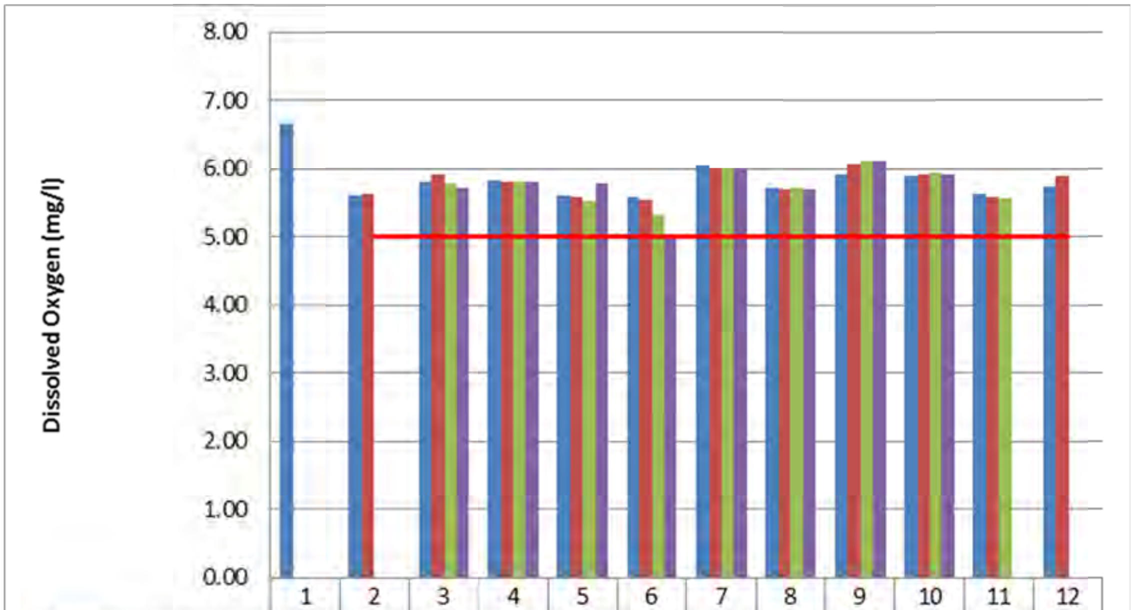


	1	2	3	4	5	6	7	8	9	10	11	13
Surface	454.33	333.67	334.67	339.33	399.00	350.00	363.00	360.00	344.67	342.67	344.67	341.67
1m		339.00	340.67	341.00	394.33	350.33	364.00	361.67	347.67	346.00	347.00	345.33
2m			345.00	342.00	363.67	351.67	363.67	362.00	350.33	315.00	349.33	
3m			348.00	342.67	395.00	352.33	363.67	362.67	351.67	350.33		

Figure 5-58 - Mean ORP values for the various water sampling locations

5.1.14.3.6 Dissolved Oxygen (DO)

Dissolved oxygen values varied across stations and with depth ranging from 5.04 – 6.67mg/l (Figure 5-59). All stations were within the NEPA standard for marine water of 5mg/l. Highest dissolved oxygen value was obtained at station JPS1, whereas the lowest value was at station JPS6. The values were significantly different across stations with an ANOVA value of $p<0.000$. Four groups were formed using the post hoc Tukey's. Stations JPS1 and JPS6 were at the extremes with station JPS1 grouped individually.



	1	2	3	4	5	6	7	8	9	10	11	12
Surface	6.67	5.61	5.82	5.83	5.62	5.58	6.04	5.73	5.93	5.90	5.63	5.74
1m		5.64	5.92	5.82	5.58	5.55	6.01	5.71	6.07	5.92	5.58	5.90
2m			5.79	5.82	5.53	5.33	6.02	5.72	6.11	5.94	5.56	
3m			5.72	5.80	5.80	5.04	6.00	5.70	6.12	5.93		
Draft NEPA std.		5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00

Figure 5-59 - Mean D.O. values for the various water sampling locations

5.1.14.3.7 Photosynthetically Active Radiation (PAR)

The PAR for all stations within the Bay decreased with depth (Figure 5-60). The rate of loss of light, extinction coefficient, showed that all stations had at least a 30% loss. The highest extinction coefficient was obtained at station JPS3 (0.85) whereas the lowest was obtained at station JPS6 (0.32). Station JPS6, located further out on the reef had better water quality in terms of turbidity than that of JPS3 which is located closer to the shoreline in the vicinity of the Dr Bird Barge and JPS cooling water outlet.

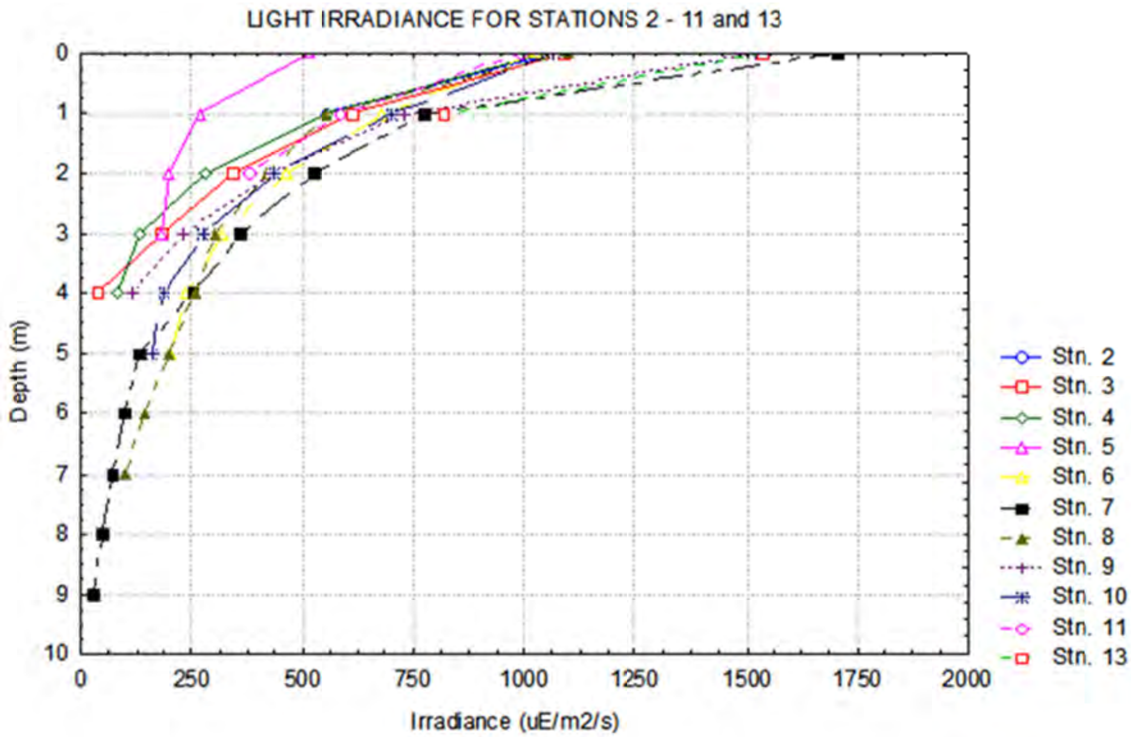


Figure 5-60 - Mean PAR values for the various water sampling locations

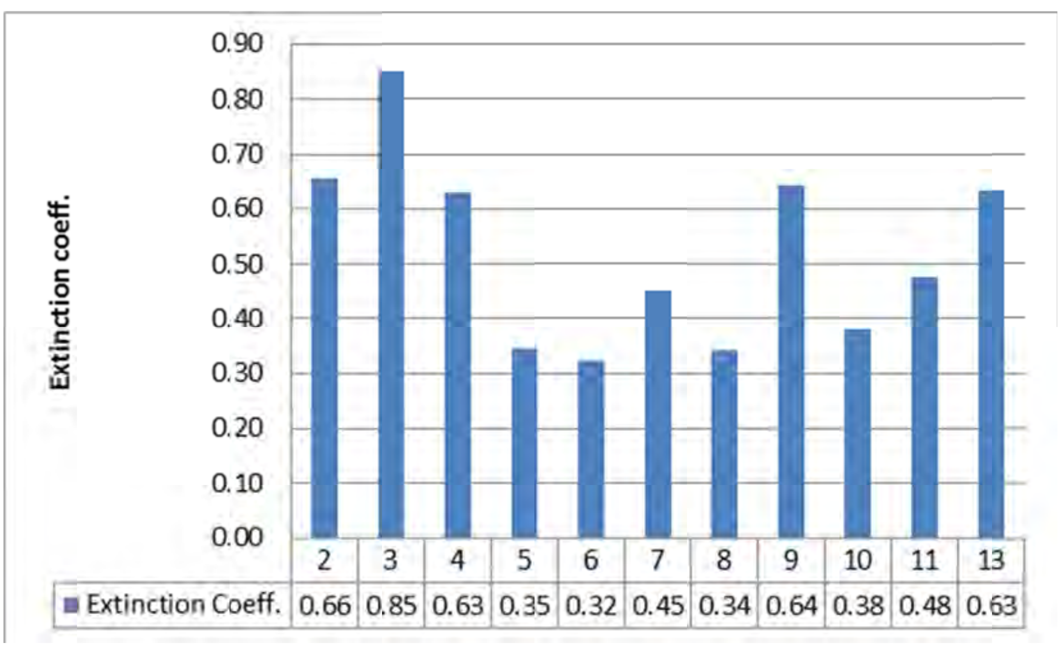
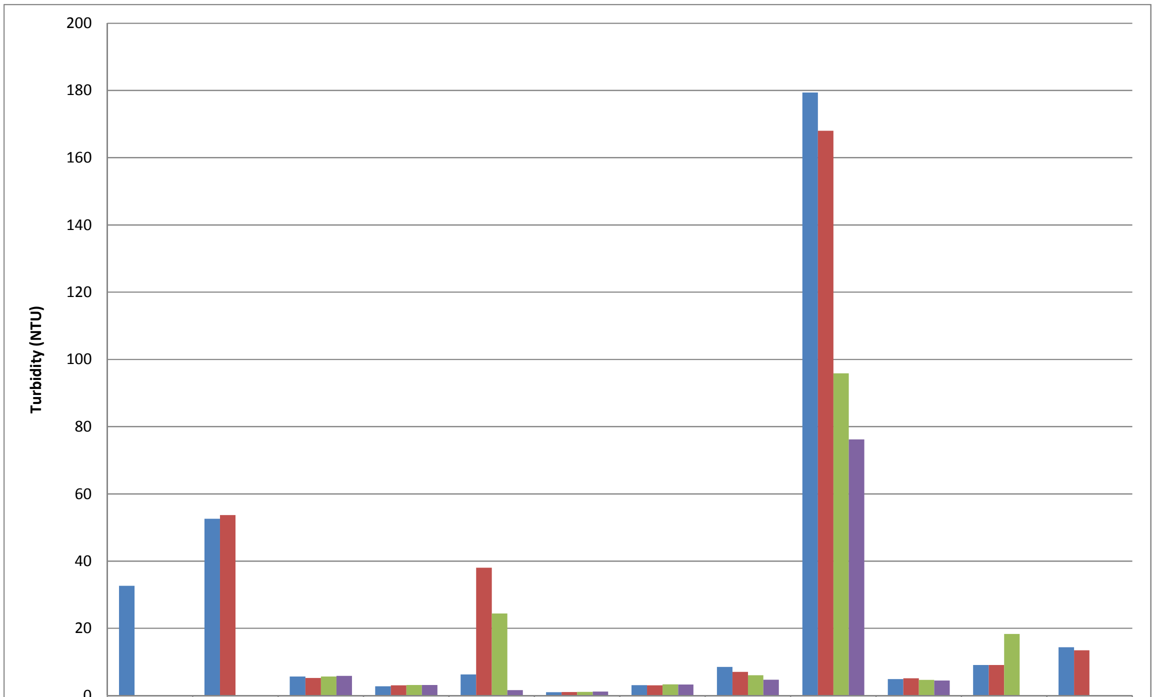


Figure 5-61 - Mean extinction coefficient values for the various water sampling locations

5.1.14.3.8 Turbidity

The Turbidity values varied greatly across stations ranging from 1.03 – 179.4 NTU. Highest turbidity value (179.4 NTU) was obtained at station JPS9, whereas the lowest value was obtained at station JPS6 (1.03 NTU). The values were significantly different across stations with an ANOVA value of $p<0.000$. Two groups were formed using the post hoc Tukey's with stations JPS9 and JPS6 at the extremes. The groupings suggest that mixing occurs within the area.



	1	2	3	4	5	6	7	8	9	10	11	13
Surface	32.67	52.60	5.67	2.73	6.30	1.03	3.13	8.53	179.40	4.93	9.10	14.40
1m		53.67	5.30	3.03	38.03	1.07	3.07	7.07	168.00	5.17	9.13	13.50
2m			5.70	3.20	24.43	1.13	3.33	6.07	95.87	4.70	18.37	
3m			5.90	3.20	1.60	1.20	3.30	4.73	76.23	4.47		

Figure 5-62 - Mean turbidity values for the various water sampling locations

5.1.14.3.9 Biological Oxygen Demand (BOD)

BOD values varied across the stations ranging from 9 – 18mg/l. The highest average value was obtained at station JPS4 whereas the lowest average value was obtained at station JPS10 (Figure 5-63). All stations were above the Draft NEPA standard for marine water of 1.16mg/l, however station JPS1 was located in Bowers' Gully.

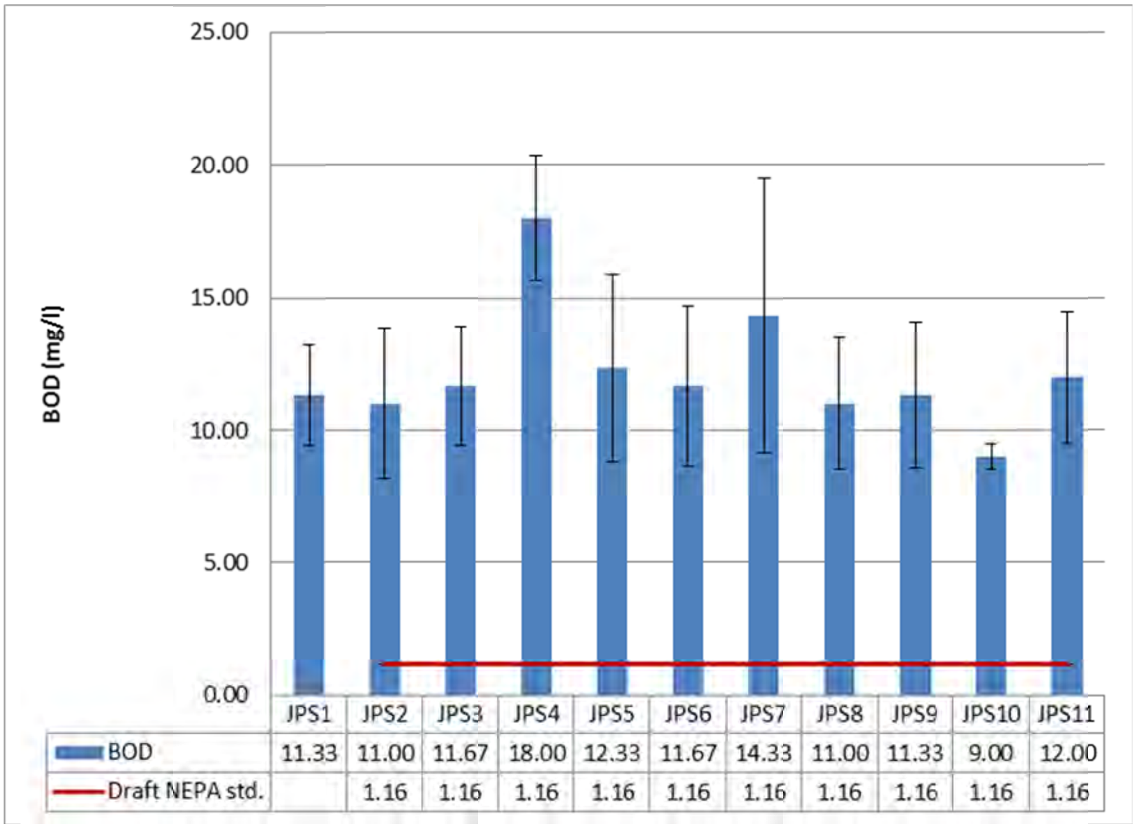
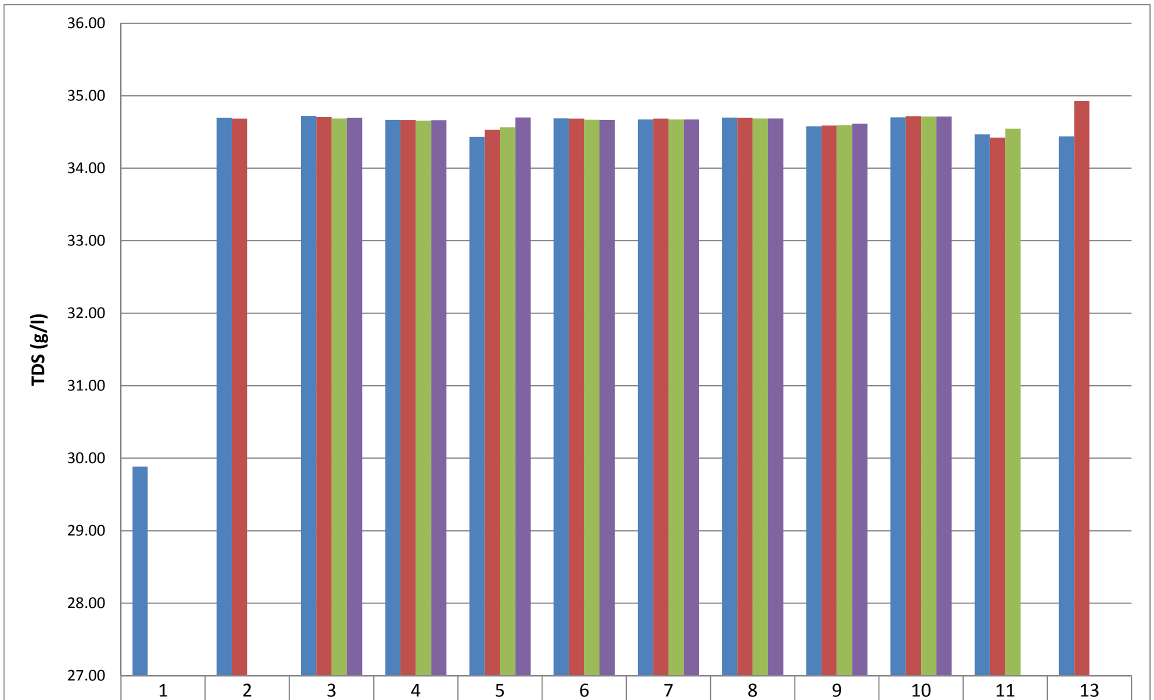


Figure 5-63 - Mean BOD values for the various water sampling locations

5.1.14.3.10 Total Dissolved Solids (TDS)

The TDS values varied across the stations ranging from 29.88 – 34.93 g/l (Figure 5-64). Depth profiles at the stations showed little variation with station JPS13 showing the greatest change. The values were not significantly different according to ANOVA with $p<0.754$.

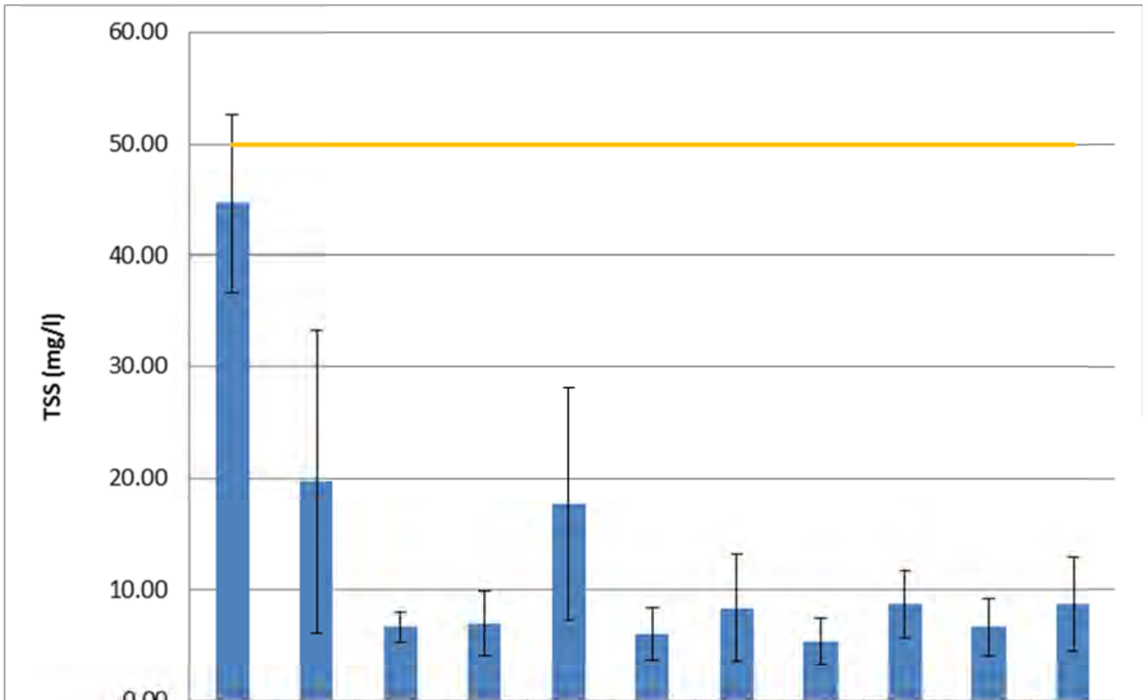


	1	2	3	4	5	6	7	8	9	10	11	13
Surface	29.88	34.69	34.72	34.67	34.43	34.69	34.67	34.70	34.58	34.70	34.47	34.44
1m		34.68	34.71	34.66	34.53	34.68	34.68	34.69	34.59	34.72	34.42	34.93
2m			34.69	34.66	34.56	34.67	34.67	34.69	34.59	34.71	34.54	
3m			34.69	34.66	34.70	34.67	34.67	34.69	34.61	34.71		

Figure 5-64 - Mean TDS values for the various water sampling locations

5.1.14.3.11 Total Suspended Solids (TSS)

The TSS values varied across the stations ranging from 5.33 – 44.67mg/l (Figure 5-65). Highest TSS value was obtained at station JPS1 (44.67mg/l), whereas the lowest value was obtained at station JPS9 (5.33mg/l). The average TSS values were below the limit of the World Bank Guidelines for Effluents of 50mg/l. However, the values were not significantly different between stations with an ANOVA value of 0.051.



	JPS1	JPS2	JPS3	JPS4	JPS5	JPS6	JPS7	JPS8	JPS9	JPS10	JPS11
TSS	44.67	19.67	6.67	7.00	17.67	6.00	8.33	5.33	8.67	6.67	8.67
IFC std.	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00

Figure 5-65 - Mean TSS values for the various water sampling locations

5.1.14.3.12 Nitrate

The nitrate values varied slightly across the stations ranging from 0.3 – 0.77mg/l. Station JPS1 had the lowest nitrate value (0.3mg/l), whereas stations JPS2 and JPS8 had the highest value (0.8mg/l). All stations were above the NEPA standard for marine water of 0.01mg/l. The values were not significantly different between stations with an ANOVA value of 0.079.

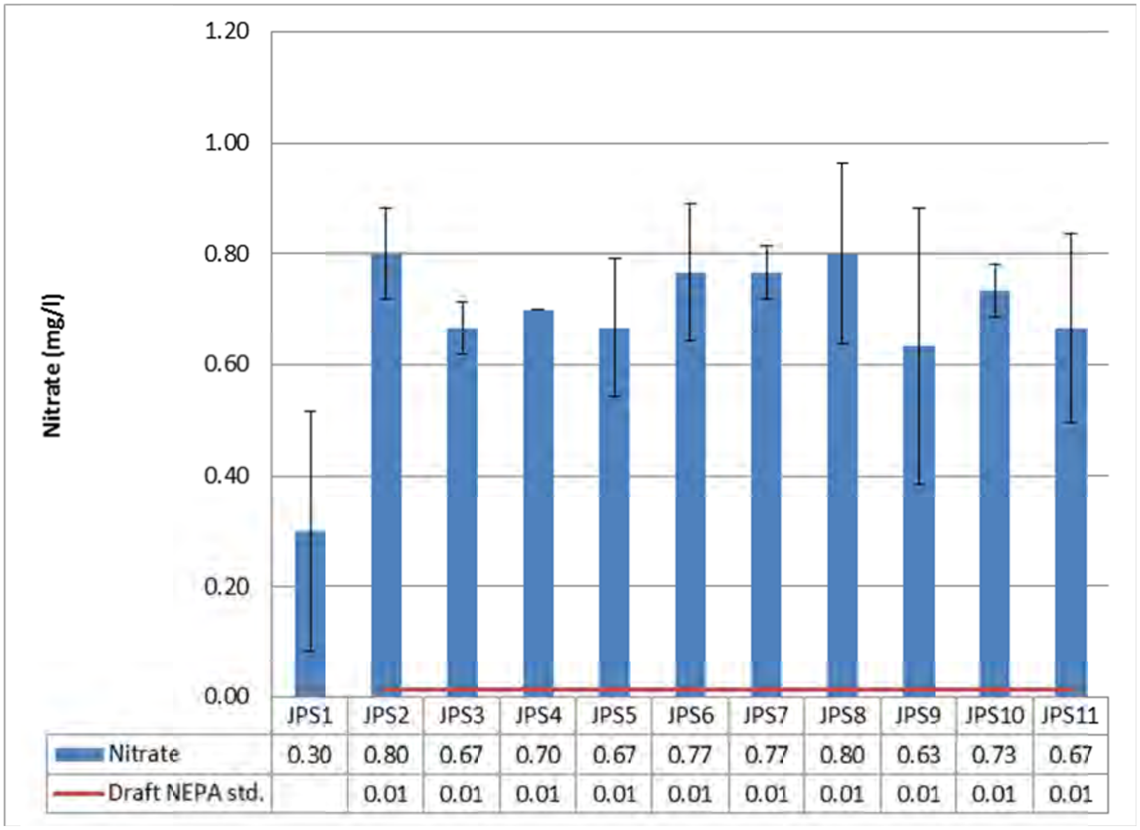
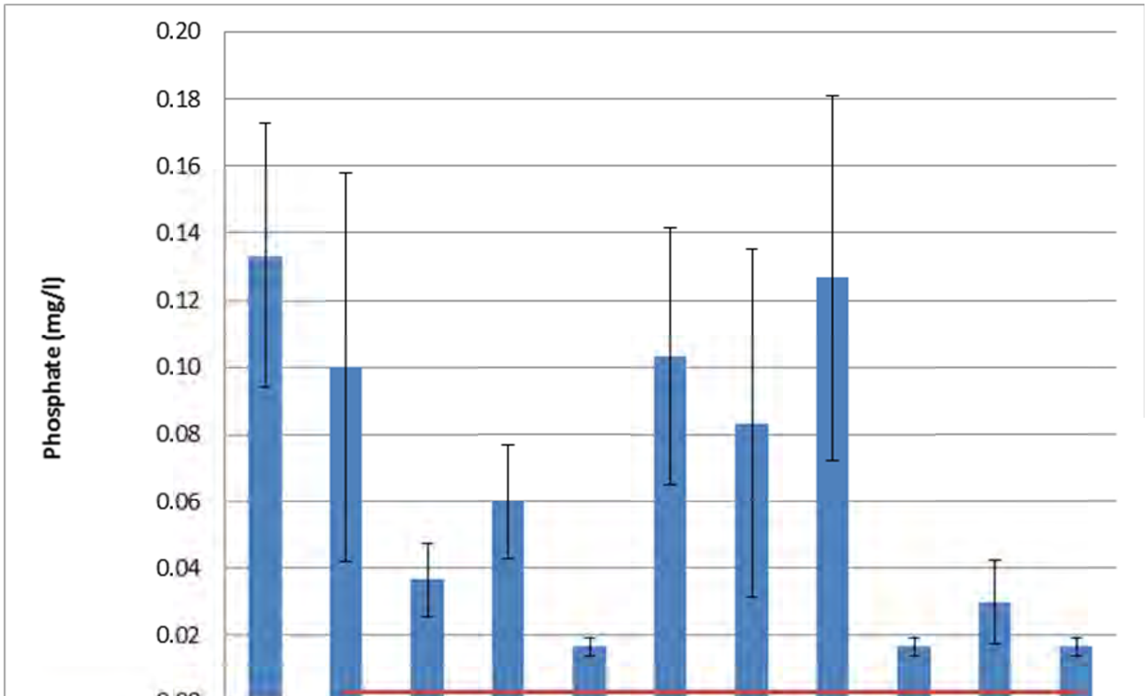


Figure 5-66 - Mean nitrate values for the various water sampling locations

5.1.14.3.13 Phosphate

The phosphate values varied across the stations ranging from 0.02 – 0.13mg/l. Highest values were obtained at stations JPS1 and JPS8 (0.13mg/l) whereas the lowest values were obtained at stations JPS5, JPS9 and JPS11 (0.02mg/l). Stations JPS2 – 11 were above the NEPA Standards for Marine Water of 0.03mg/l. The ANOVA result was not significantly different between stations with a p value of 0.345.



	JPS1	JPS2	JPS3	JPS4	JPS5	JPS6	JPS7	JPS8	JPS9	JPS10	JPS11
Phosphate	0.13	0.10	0.04	0.06	0.02	0.10	0.08	0.13	0.02	0.03	0.02
Nepa std.		0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003

Figure 5-67 - Mean phosphate values for the various water sampling locations

5.1.14.3.14 Fats, Oils and Grease (FOG)

The FOG values varied greatly across the stations ranging from 3.29 – 49.24mg/l. The highest mean value was obtained at station JPS9 whereas the lowest mean value was at station JPS5. Compared to the World Bank Guidelines for Effluent (10mg/l), stations JPS1 -4, 7, 9 and 11 were above this level. Station JPS1 was located in Bowers' Gully whereas the other stations were in Old Harbour Bay. The ANOVA result was not significantly different between stations with a p value of 0.536.

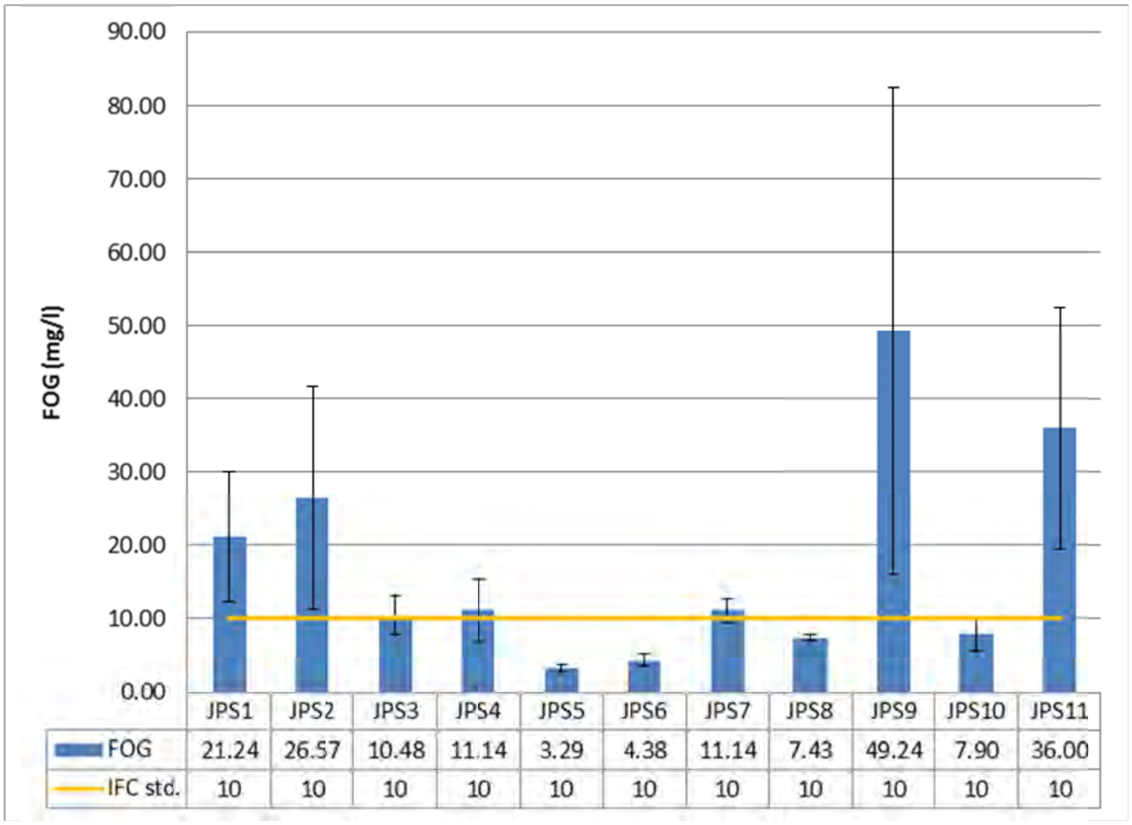


Figure 5-68 - Mean FOG values for the various water sampling locations

5.1.14.3.15 Faecal Coliform

The faecal coliform values varied across the stations ranging from <11 – 1305 MPN/100ml. The highest mean value was obtained at station JPS3 (1305 MPN/100ml). The stations within the Bay were compared to the Draft NEPA Marine Water Quality Standard of 13 MPN/100ml which showed four stations above ambient standard. The mean values were not significantly different between stations using ANOVA with a p value of 0.305.

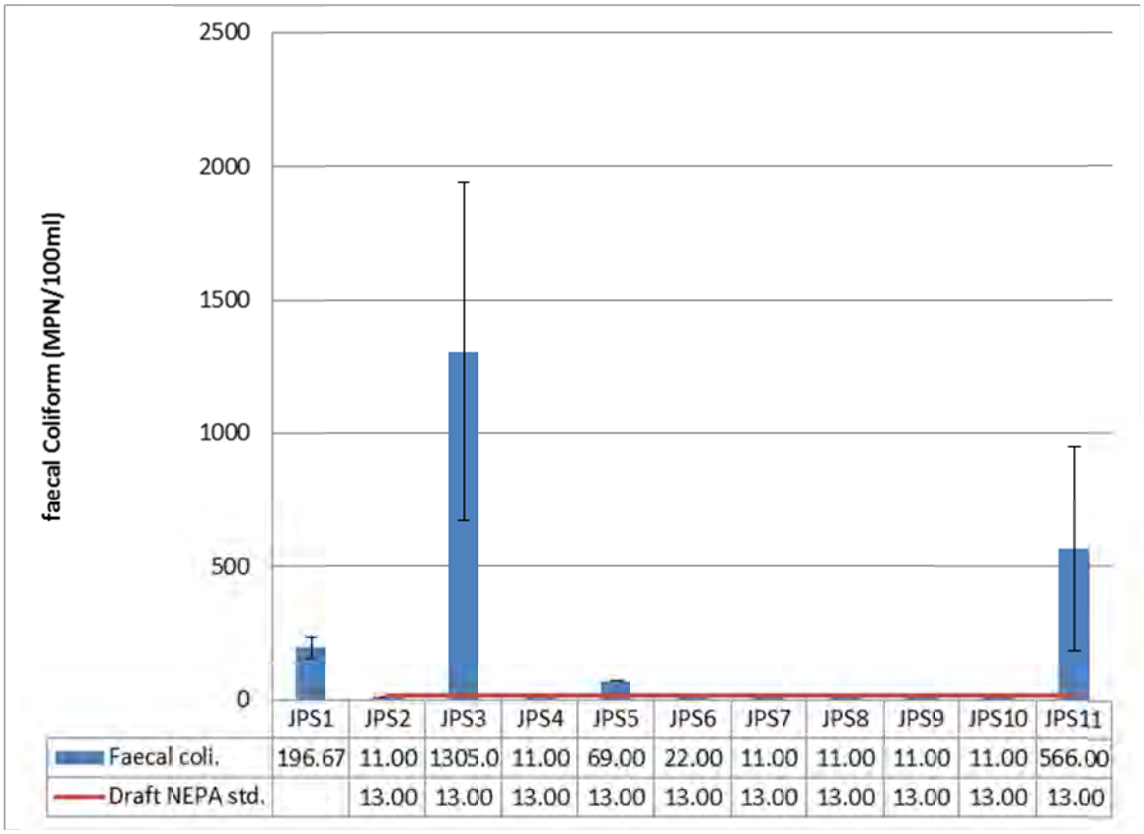


Figure 5-69 - Mean faecal coliform values for the various water sampling locations

5.1.14.3.16 Total Hardness

Total Hardness varied little across the stations ranging from 0.59 – 0.67 %$CaCO_3$. The lowest value was obtained at station JPS1 (0.59 %$CaCO_3$) which was located in Bowers' Gully. The mean values were not significantly different between stations as established by the ANOVA test with a p value of 0.313.

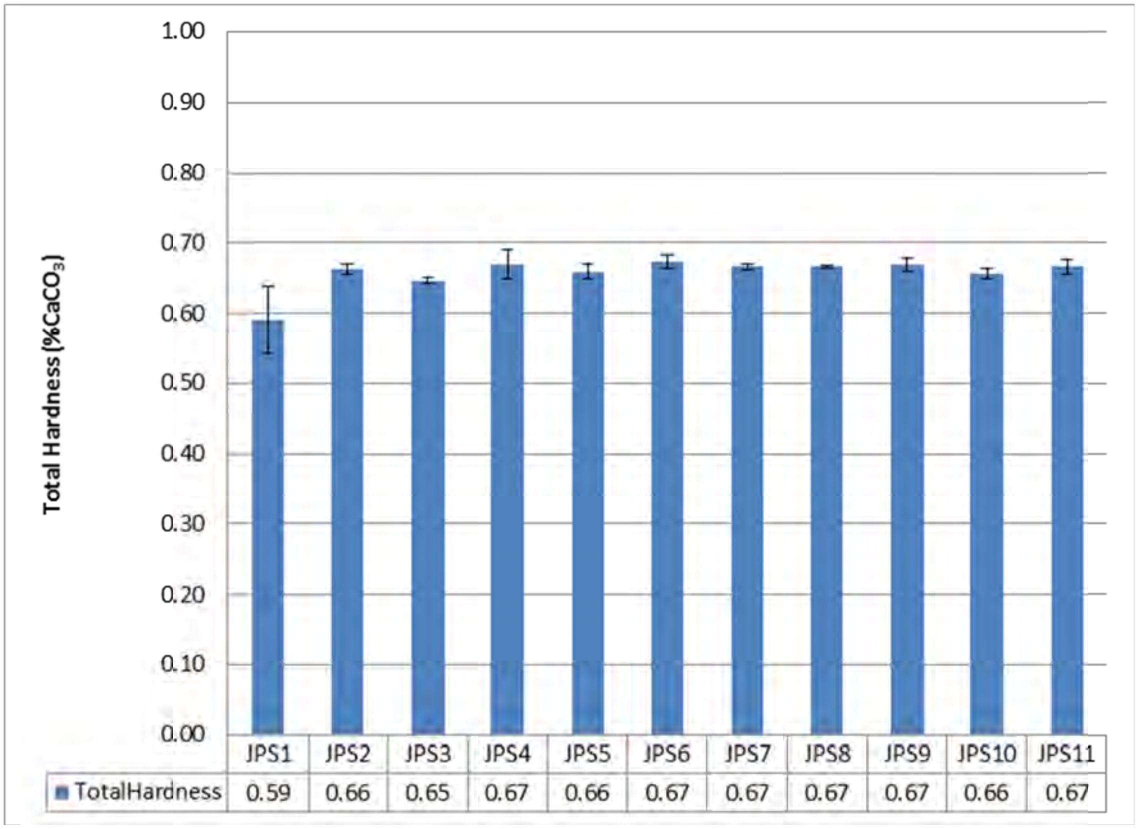
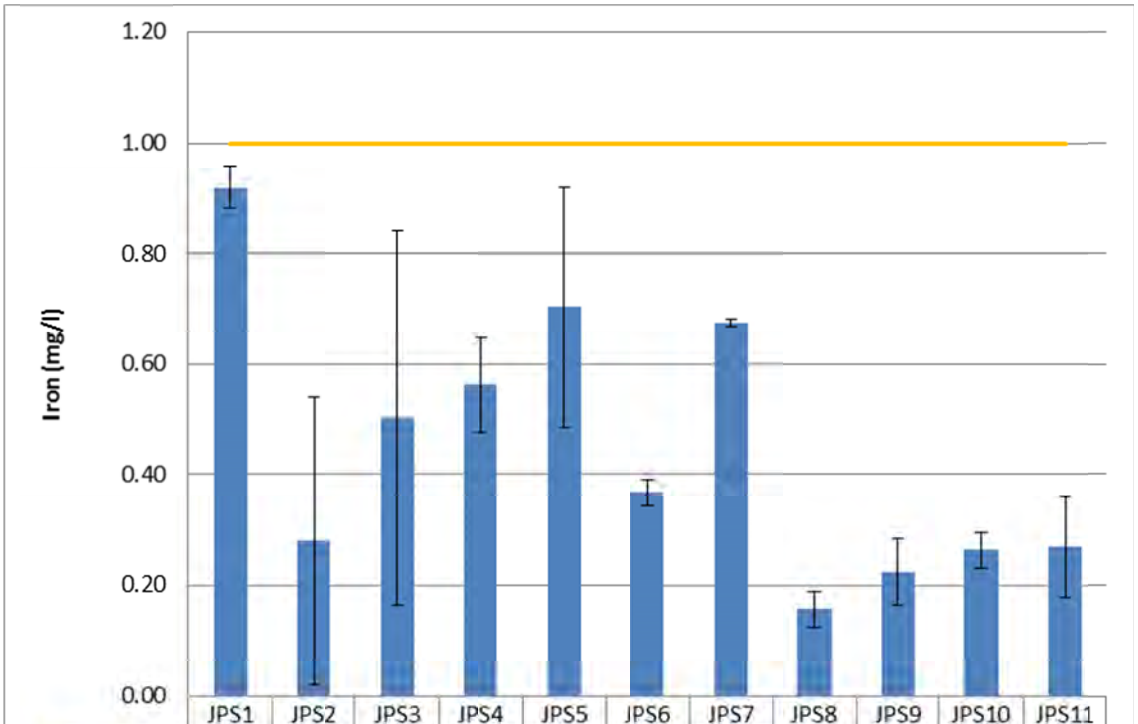


Figure 5-70 - Mean Total Hardness values for the various water sampling locations

5.1.14.3.17 Iron

Iron values varied across the stations ranging from 0.16 – 0.92mg/l (Figure 5-71). Highest mean value was obtained at station JPS1 (0.92mg/l) whereas the lowest mean value was obtained at station JPS8 (0.16mg/l). All stations were below the World Bank Guidelines for Effluent of 1mg/l. These values were not significantly different between stations as established by the ANOVA test with a p value of 0.141.



	JPS1	JPS2	JPS3	JPS4	JPS5	JPS6	JPS7	JPS8	JPS9	JPS10	JPS11
Iron	0.92	0.28	0.50	0.56	0.70	0.37	0.67	0.16	0.22	0.26	0.27
IFC std.	1	1	1	1	1	1	1	1	1	1	1

Figure 5-71 - Mean iron values for the various water sampling locations

5.1.14.3.18 Zinc

Zinc levels varied little across stations ranging from 0.02 – 0.03mg/l (Figure 5-72). When compared to the World Bank Guidelines for Effluent of 1mg/l all stations were within limits. These values were not significantly different using ANOVA with a p value of 0.439.

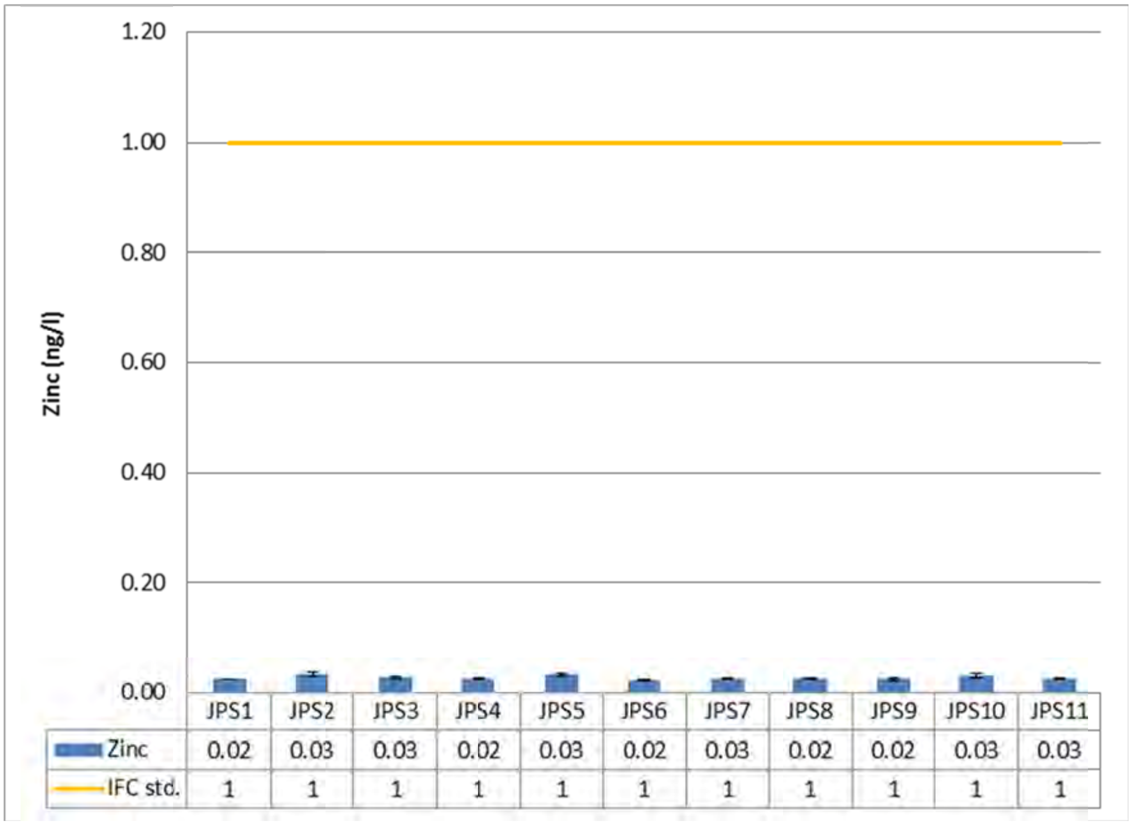


Figure 5-72 - Mean zinc values for the various water sampling locations

5.1.14.3.19 Total Petroleum Hydrocarbons (Diesel Range Organics)

TPH-DRO values (1.5 mg/l) were only detected at Station JPS3 (located close to the Dr. Bird Barges) on May 10, 2012. No DRO values were detected at any other station on any sampling run.

5.1.14.3.20 Total Petroleum Hydrocarbons (Gasolene Range Organics)

No TPH-GRO was detected at any station on any of the sampling runs.

5.1.14.3.21 Potable Water (Station JPS12)

Table 5-38 below shows the potable water quality values for Station JPS12. The results for JPS12 indicate that the water is of good quality.

Table 5-38 - Potable water quality values (JPS12)

Run	Stn	Arsenic (mg/l)	Barium (mg/l)	Boron (mg/l)	Cadmium (mg/l)	Chromium (mg/l)	Copper (mg/l)	Lead (mg/l)	Manganese (mg/l)
Apr-26	JPS12	ND	0.073	ND	ND	ND	ND	ND	ND
May-10	JPS12	ND	0.082	ND	ND	ND	ND	ND	ND
May-24	JPS12	ND	0.12	0.17	ND	ND	ND	ND	ND
Run	Stn	Nickel (mg/l)	Selenium (mg/l)	Mercury (mg/l)	Tot. Cyanide (mg/l)	Fluoride (mg/l)	Nitrate (mg/l)	Residual Chlorine (mg/l)	F. coliform (mpn/100ml)
Apr-26	JPS12	ND	ND	ND	ND	0.18	0.6	0.57	<11
May-10	JPS12	ND	ND	ND	ND	0.16	1.6	0.21	<11
May-24	JPS12	ND	ND	ND	ND	0.13	2.5	0.19	<11

5.1.15 Marine Sediments

5.1.15.1 Introduction

Three sediment sampling exercises were conducted on the following dates:

- April 26, 2012
- May 10, 2012
- May 24, 2012

Weather conditions were fair and sunny on the first two sampling runs, while slightly windy conditions and intermittent rainfall occurred on the May 24 sampling event.

5.1.15.2 Methodology

Five (5) sediment samples were taken using a sediment grab sampler, and analysed for the heavy metals (Pb - lead, As - Arsenic, Cd - Cadmium, Hg-Mercury) and Total Petroleum Hydrocarbons.

The sediment sampling locations correspond to specific water quality sampling locations as shown in Table 5-39. The samples were stored on ice in a cooler and transported to Test America Pensacola Laboratory for analyses.

Table 5-39 - Soil sampling stations and corresponding water quality stations

Water quality Station	Sediment Sampling Station
JPS 5	JPSoil 1
JPS 11	JPSoil 2
JPS 10	JPSoil 3
JPS 2	JPSoil 4
JPS 3	JPSoil 5

5.1.15.3 Results and Discussion

Table 5-40 displays the sediment sampling results for various parameters at the various sampling locations.

Table 5-40 - Average marine sediment values

Stn	Arsenic (mg/kg)	Cadmium (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	GRO (mg/kg)	DRO (mg/kg)
JPSoil 1	7.23	ND	12.33	0.04	ND	68.67
JPSoil 2	8.63	ND	11.00	0.04	ND	11
JPSoil 3	7.07	ND	11.67	0.05	ND	13
JPSoil 4	6.50	ND	9.77	0.04	ND	0
JPSoil 5	8.67	ND	13.33	0.05	ND	0

5.1.15.3.1 Arsenic

Average arsenic values varied across the stations ranging from 6.5 – 8.67mg/kg (Figure 5-73). The highest value was obtained at station JPSoil5, whereas the lowest value was obtained at station JPSoil4.

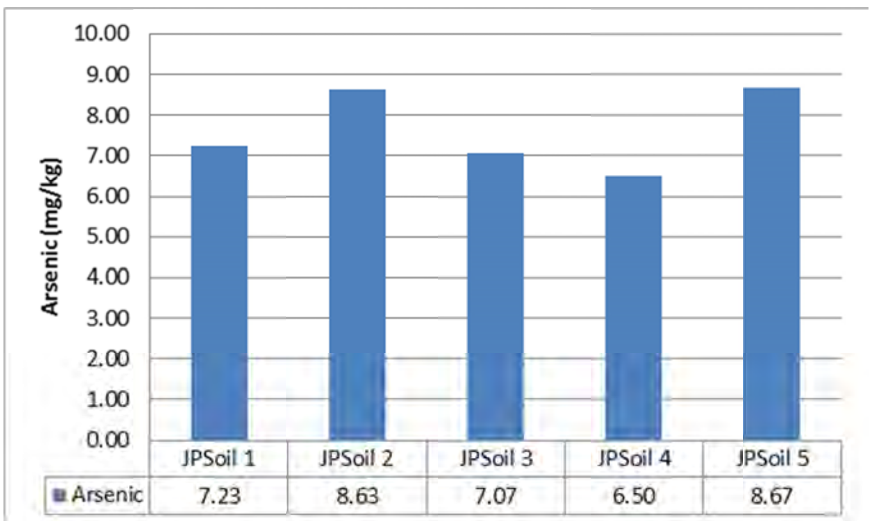


Figure 5-73 - Mean arsenic values for the various soil sampling locations

5.1.15.3.2 Lead

Average lead values varied across the stations ranging from 9.77 – 13.33mg/kg (Figure 5-74). The highest value was obtained at station JPSoil 5, whereas the lowest value was obtained at station JPSoil.

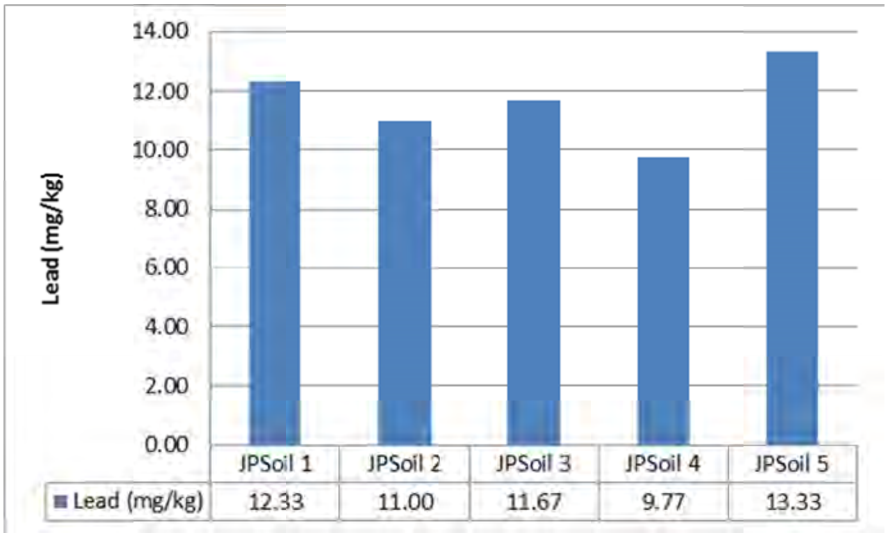


Figure 5-74 - Mean lead values for the various soil sampling locations

5.1.15.3.3 Mercury

Average mercury values varied slightly across the stations ranging from 0.04 – 0.05mg/kg (Figure 5-75). Stations JPSoil 1, 2 and 4 had average values of 0.04mg/kg, whereas stations JPSoil 3 and 5 had values of 0.05mg/kg.

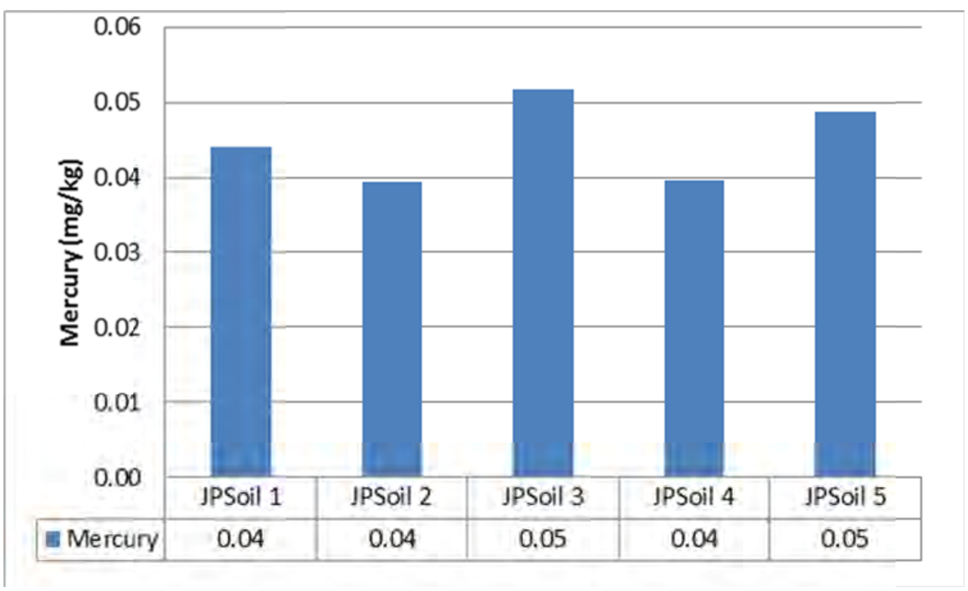


Figure 5-75 - Mean mercury values for the various soil sampling locations

5.1.15.3.4 Diesel Range Organics (DRO)

Average DRO values varied across the stations ranging from 0 – 68.67mg/kg (Figure 5-76). The highest value was obtained at JPSoil 1 which is the cooling water intake point.

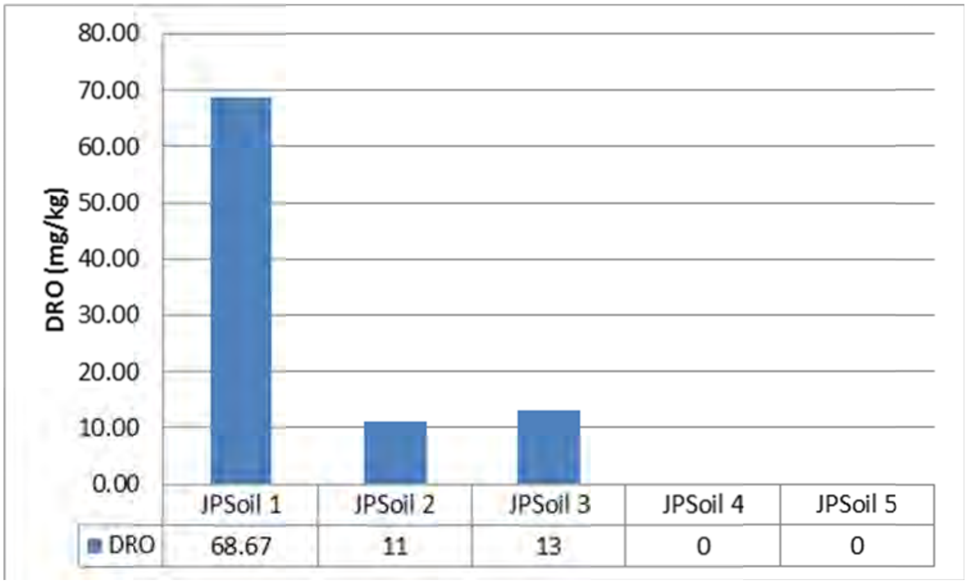


Figure 5-76 - Mean DRO values for the various soil sampling locations

5.1.15.3.5 Gasoline Range Organics (GRO)

None were detected at the stations during the sample period.

5.1.15.3.6 Cadmium

None were detected at the stations during the sample period.

5.1.16 Air Quality (PM10 and PM2.5)

5.1.16.1 Methodology

PM2.5 and PM10 particulate sampling was conducted for 24 hours using both Tisch Environmental High Volume Ambient Samplers and Airmetrics Mini-Volume Tactical Air Samplers. A total of three (3) PM2.5 sampling events and three (3) PM10 sampling events were conducted, each on separate occasions for both high volume and mini volume samplers.

The first PM10 sampling exercise was conducted from 12:00am on June 11th, 2012 until 12:00am June 12th, 2012. The second PM10 sampling exercise was conducted from 12:00am on June 13th, 2012 until 12:00am June 14th, 2012. The third PM10 sampling exercise was conducted from 12:00am on June 15th, 2012 until 12:00am June 16th, 2012.

The first PM2.5 sampling exercise was conducted from 12:00am on June 21st, 2012 until 12:00am June 22nd, 2012. The second PM2.5 sampling exercise was conducted from 12:00am on June 25th, 2012 until 12:00am June 26th, 2012. The third PM2.5 sampling exercise was conducted from 12:00am on June 27th, 2012 until 12:00am June 28th, 2012.

PM10 and PM2.5 ambient particulate measurements were conducted at three (3) locations using the high volume samplers, and at six (6) locations using the mini volume samplers (Table 5-41, Table 5-42 and Figure 5-77).

Table 5-41 - Sampling locations using High Volume Samplers

STATION	LOCATION	JAD 2001	
		Northing (m)	**Easting (m)**
P7	Blackwood Gardens Housing Scheme	639881.159	739192.250
P8	Bannister	647364.690	737793.276
P9	Colbeck	646766.871	734924.108

Table 5-42 - Sampling locations using Mini Volume Samplers

STATION	LOCATION	JAD 2001	
		Northing (m)	**Easting (m)**
P1	Proposed Site- Southern Boundary	639074.52	738044.21
P2	Proposed Site- Western Boundary	639362.02	737948.38
P3	Proposed Site- Eastern Boundary	639427.19	738126.63
P4	Proposed Site- Northern Boundary	639611.19	738019.29
P5	Esquivel Road	639772.19	737461.54
P6	Sandy Bay	643272.05	733434.60

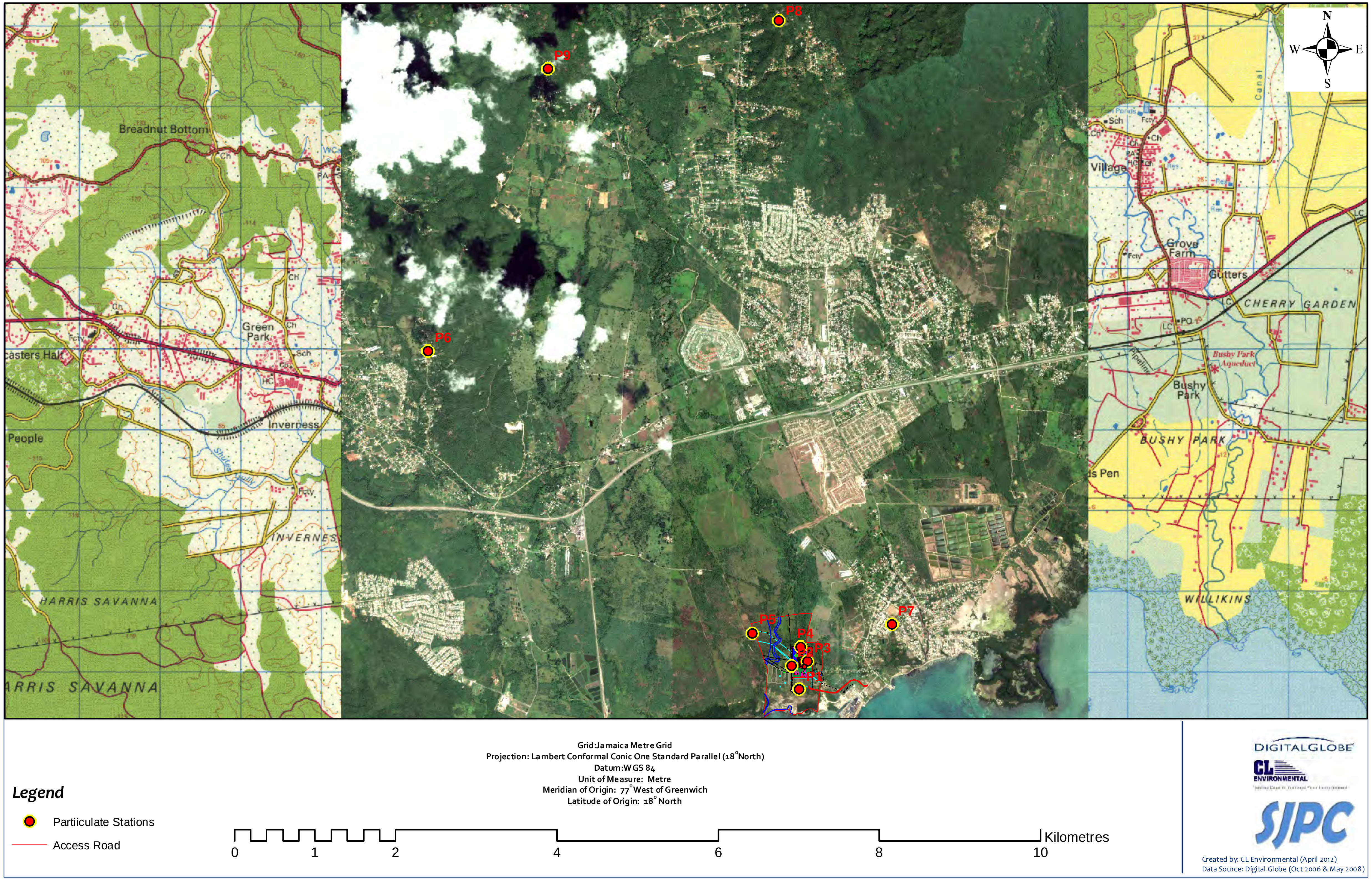


Figure 5-77 - Map depicting the particulate sampling stations

Plate 5-8 - Photo showing Hi Volume sampler at Colbeck

Plate 5-9 - Photo showing Hi Volume sampler at Bannister

Plate 5-10 - Photo showing Mini Volume sampler at boundary of proposed site

Plate 5-11 - Photo showing Mini Volume sampler at boundary of proposed site

5.1.16.2 PM10 Results

The PM10 results indicate that all locations had particulate values compliant with the 24-hour US EPA standard of 150 µg/m3. Results were similar for the locations at the boundaries of the proposed site, with the southern boundary having the highest value and the western boundary having the lowest. Sandy Bay had the highest overall PM10 value of 60.51 µg/m3 while Colbeck had the lowest PM10 value of 45.06 µg/m3. Sandy Bay is potentially affected by particulates from vehicular traffic and commercial activities along the roadway. There is a truck garage across the road from the Sandy Bay particulate sampling location and this perhaps contributed to higher levels of particulates. The stations on the proposed site and at Colbeck and Bannister are prone to minor dust nuisance. Blackwood Gardens Housing Scheme, located close to the JPS Old Harbour Bay power station, also had relatively high PM10 value of 58.28 µg/m3, possibly due to its close proximity to the plant or from areas with low vegetation cover.

The results of the high and low volume PM10 sampling runs are shown inTable 5-43.

Table 5-43 - PM10 Results using high and mini volume samplers

STATION	LOCATION	Range Result (µg/m^3)	Mean Result (µg/m^3)	US EPA Std. (µg/m^3)
Mini Volume				
P1	Proposed Site-Southern Boundary	31.53 – 60.97	48.65	**150**
P2	Proposed Site-Western Boundary	32.78 – 57.22	45.69	**150**
P3	Proposed Site-Eastern Boundary	32.22 – 57.78	46.71	**150**
P4	Proposed Site-Northern Boundary	34.86 – 55.69	45.97	**150**
P5	Esquivel Road	38.06 – 59.31	49.91	**150**
P6	Sandy Bay	58.06 – 62.5	60.51	**150**
High Volume				
P7	Blackwood Gardens Housing Scheme	47.62 – 64.34	58.28	**150**
P8	Bannister	28.13 – 54	45.37	**150**
P9	Colbeck	27.65 – 54.71	45.06	**150**

5.1.16.3 PM2.5 Results

The PM2.5 results indicate that all locations had particulate values compliant with the 24-hour US EPA standard of 35 μg/m^3. Results were somewhat similar for the locations at the boundaries of the proposed site. The southern and western boundaries had the highest value on the proposed site, while the northern and eastern boundaries had the lowest. Blackwood Gardens Housing Scheme had the highest overall PM2.5 value of 16.5 μg/m^3 while the northern boundary of the proposed site had the lowest PM2.5 value of 7.68 μg/m^3. Because of the close proximity of Blackwood Gardens Housing Scheme to the JPS Old Harbour Bay power station, this may have resulted in the highest PM2.5 values as this area may be affected from soot from combustion.

The results of the high and low volume PM2.5 sampling runs are shown in Table 5-44.

Table 5-44 - PM2.5 Results using high and mini volume samplers

STATION	LOCATION	Range Result (μg/m^3)	Mean Result (μg/m^3)	US EPA Std. (μg/m^3)
Mini Volume				
P1	Proposed Site- Southern Boundary	13.06 – 16.53	14.4	**35**
P2	Proposed Site- Western Boundary	7.5 – 16.11	11.34	**35**
P3	Proposed Site- Eastern Boundary	7.92 – 11.53	9.96	**35**
P4	Proposed Site- Northern Boundary	6.11 – 10.69	7.68	**35**
P5	Esquivel Road	8.06 – 14.72	10.28	**35**
P6	Sandy Bay	6.25 – 10.14	7.73	**35**
High Volume				
P7	Blackwood Gardens Housing Scheme	12.03 – 23.73	16.5	**35**
P8	Bannister	5.48 – 36.35	16.16	**35**
P9	Colbeck	6.3 – 16.25	10.82	**35**

5.1.17 Noise

5.1.17.1 Methodology

A data logging noise survey exercise was conducted to establish baseline conditions along the proposed boundaries of the SJPC 360 MW LNG power plant and its environs.

The data logging exercise was conducted for seventy two (72) hours between 7:00 hrs Friday 27th, to 7:00 hrs Monday 30th, April 2012. The readings were taken at eleven (11) locations (Stations N1 – N11) depicted in Table 5-45.

Noise level readings were taken by using Quest Technologies SoundPro DL Type 1 hand held sound level meters with real time frequency analyser setup in outdoor monitoring kits. The octave band analysis was conducted concurrently with the noise level measurements. Measurements were taken in the third octave which provided thirty three (33) octave bands from 12.5 Hz to 20 kHz (low, medium and high frequency bands).

The noise meters were calibrated pre and post noise assessment by using a Quest QC - 10 sound calibrator (Appendix 9). The meters were programmed using the Quest suite Professional II (QSP II) software to collect third octave, average sound level (Leq) over the period, Lmin (The lowest level measured during the assessment) and Lmax (The highest level measured during the assessment) every ten (10) seconds.

Average noise levels over the period were calculated within the QSP II software using the formula:

$$\textit{Average dBA} = 20 \log 1/N \sum_{j=1}^{N} 10^{(L_j/20)}$$

Where N = number of measurements, Lj = the jth sound level and j = 1, 2, 3 .... N.

A windscreen (sponge) was placed over the microphone to prevent measurement errors due to noise caused by wind blowing across the microphone.

The descriptions, GPS locations in (JAD2001 coordinate system) of these noise stations are listed in Table 5-45 and depicted in Figure 5-78.

Table 5-45 - Station numbers and locations in JAD2001

STATIONS	LOCATIONS	JAD 2001 (m)	
		E	N
N1	Northern Property Boundary	738107.646	639615.054
N2	Eastern Property Boundary	738230.127	639360.186
N3	Southern Property Boundary	738104.944	639109.821
N4	Western Property Boundary	737985.165	639362.888
N5	JPS Guard House	738788.007	639001.909
N6	Informal Settlement	738918.492	639429.031
N7	Old Harbour Bay Police Station	739748.645	639704.502
N8	New Harbour Village – Phase 1	738671.956	642070.095
N9	Church Pen	740726.535	643518.684
N10	Bodles	735978.556	642313.288
N11	Longville Park	733215.355	639733.868

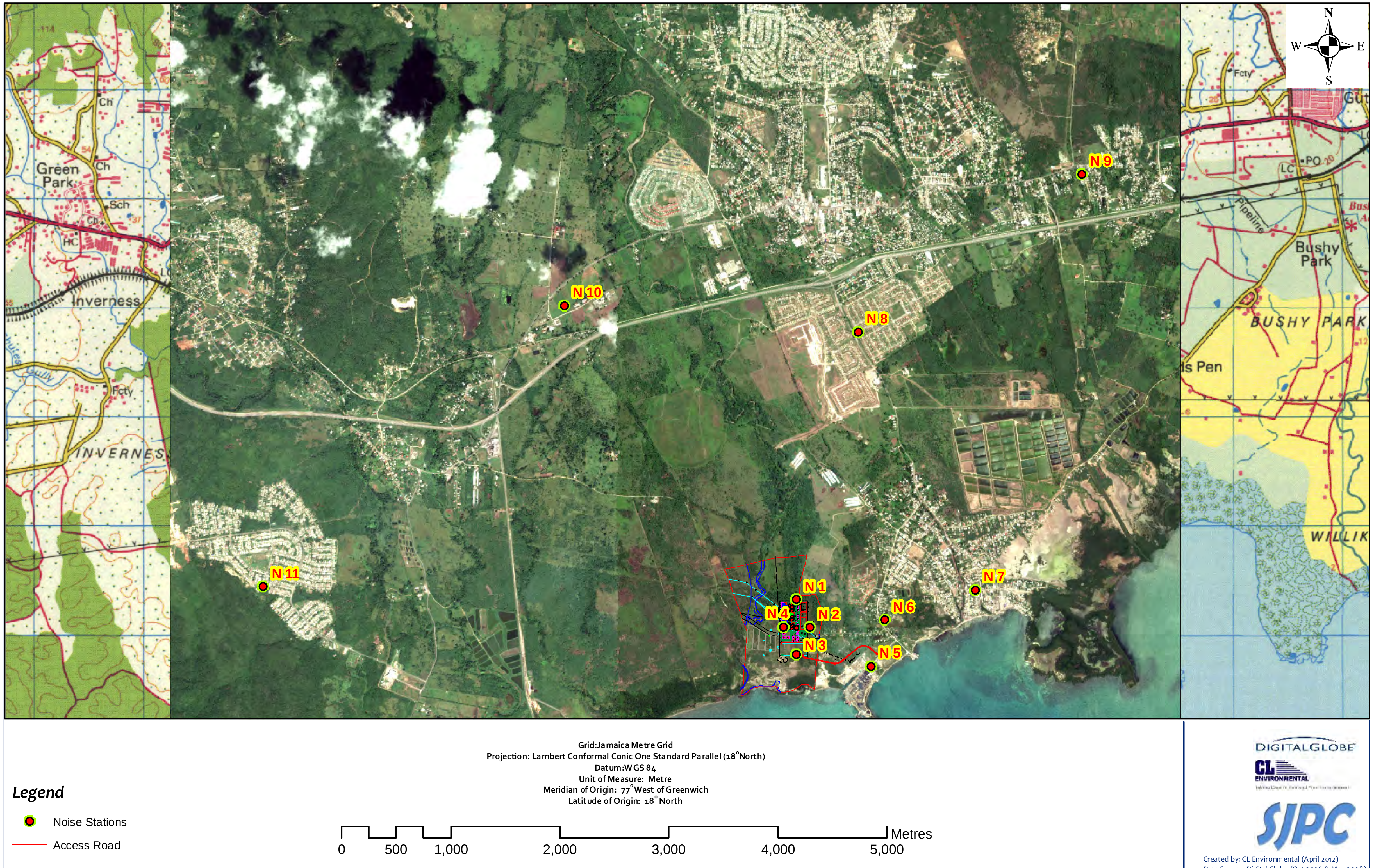


Figure 5-78 - Locations of noise survey stations

5.1.17.2 Results

This section outlines the results of the forty eight (72) hour noise monitoring exercise at the eleven (11) monitoring stations.

5.1.17.2.1 Station 1 – Northern Property Boundary

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 30.8 dBA which occurred at 5:02:50 pm on April 29, 2012 to a high (Lmax) of 78.0 dBA which occurred at 1:50:00 pm on April 29, 2012. Average noise level for this period was 49.8L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 5-79.

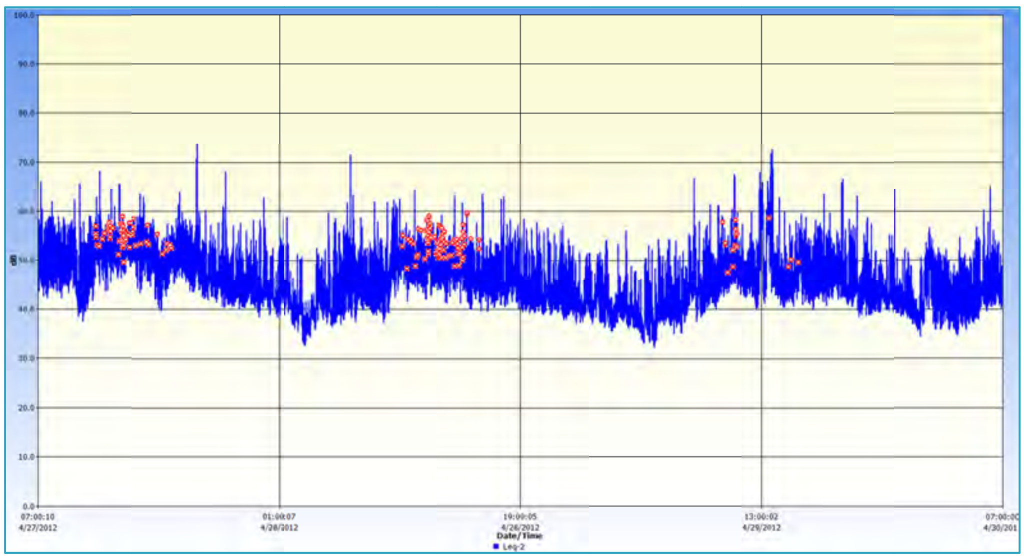


Figure 5-79 - Noise fluctuation (Leq) over 72 hours at Station 1

Octave Band Analysis at Station 1

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 12.5 Hz (octave frequency range is 11 - 14 Hz) (Figure 5-80).

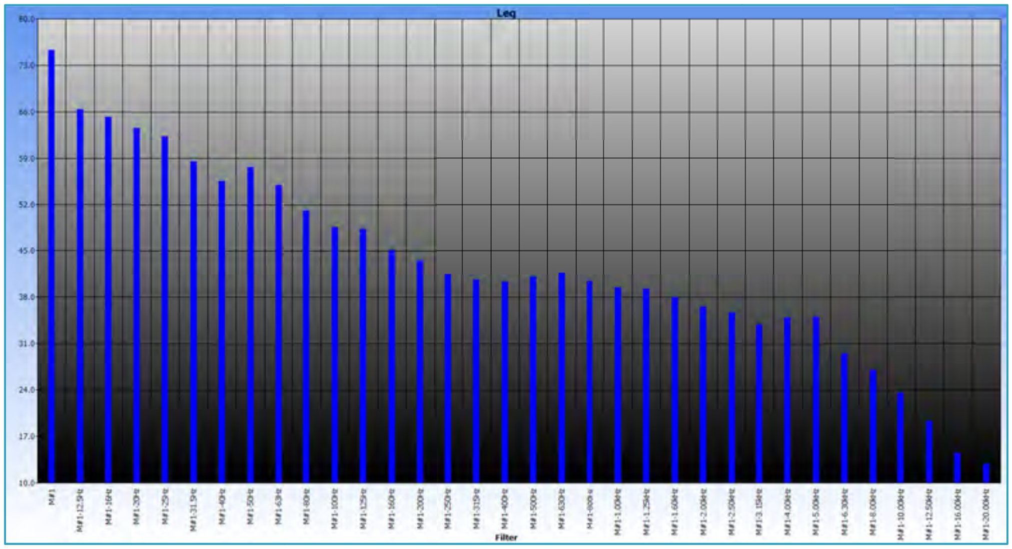


Figure 5-80 - Octave band spectrum of noise at Station 1

L10 and L90 – Northern Property Boundary

The two most common **L_n** values used are **L_{10}** and **L_{90}** and these are sometimes called the 'annoyance level' and 'background level' respectively. **L_{10}** is almost the only statistical value used for the descriptor of the higher levels, but **L_{90}**, is widely used to describe the ambient or background level. L10-L90 is often used to give a quantitative measure as to the spread or "how choppy" the sound was.

L10 is the noise level exceeded for 10% of the time of the measurement duration. This is often used to give an indication of the upper limit of fluctuating noise, such as that from road traffic. L90 is the noise level exceeded for 90% of the time of the measurement duration.

The difference between L10 and L90 gives an indication of the noise climate. When the difference is < 5 dBA then it is considered that there are no significant fluctuations in the noise climate, moderate fluctuations 5-15 dBA and large fluctuations >15 dBA.

Figure 5-81 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows no significant fluctuations (L10 – L90) ≈ 94.4%, moderate fluctuations (L10 – L90) ≈2.8% of the time and large fluctuations (L10 – L90) ≈2.8% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 52.8 dBA and 39.3 dBA respectively.

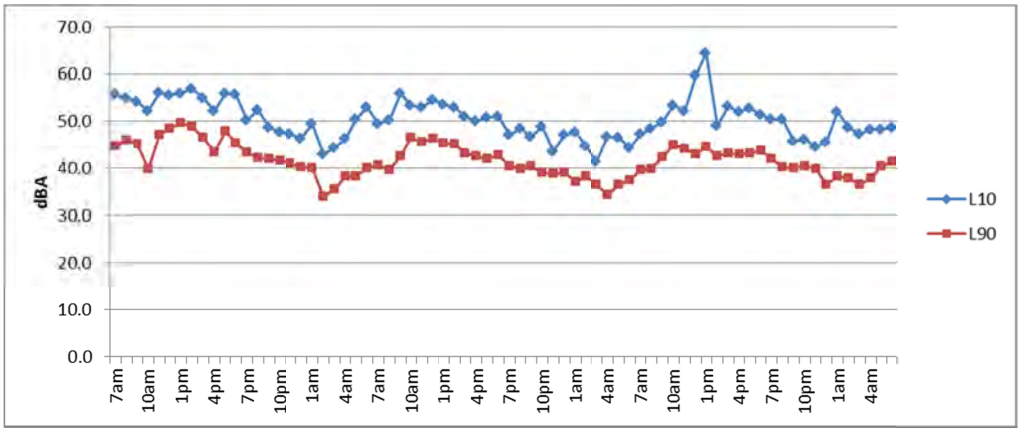


Figure 5-81 - L10 and L90 for Station 1

5.1.17.2.2 Station 3 – Eastern Property Boundary

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 37.8 dBA which occurred at 7:03:50 am on April 28, 2012 to a high (Lmax) of 75.1 dBA which occurred at 7:30:40 am and 7:36:20 am on April 27, 2012. Average noise level for this period was 52.4 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 5-82.

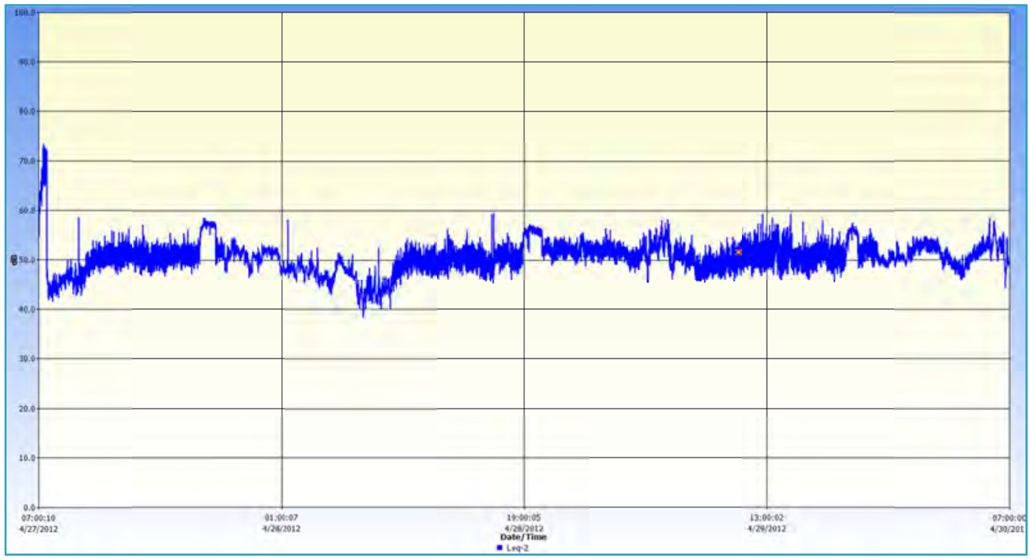


Figure 5-82 - Noise fluctuation (Leq) over 72 hours at Station 2

Octave Band Analysis at Station 2

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 25 Hz (octave frequency range is 22 - 28Hz) (Figure 5-83).

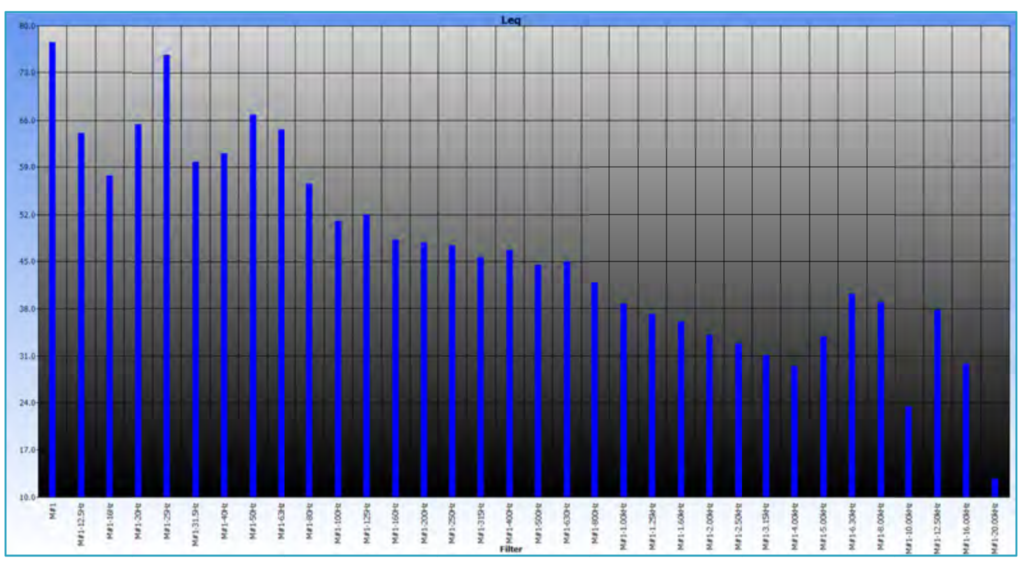


Figure 5-83 - Octave band spectrum of noise at Station 2

L10 and L90 – Eastern Property Boundary

Figure 5-84depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows no significant fluctuations in the noise climate (L10 – L90) ≈83.3% of the time, moderate fluctuations (L10 – L90) ≈15.3% and large fluctuations (L10 – L90) ≈1.4% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 53.5 dBA and 46.7 dBA respectively.

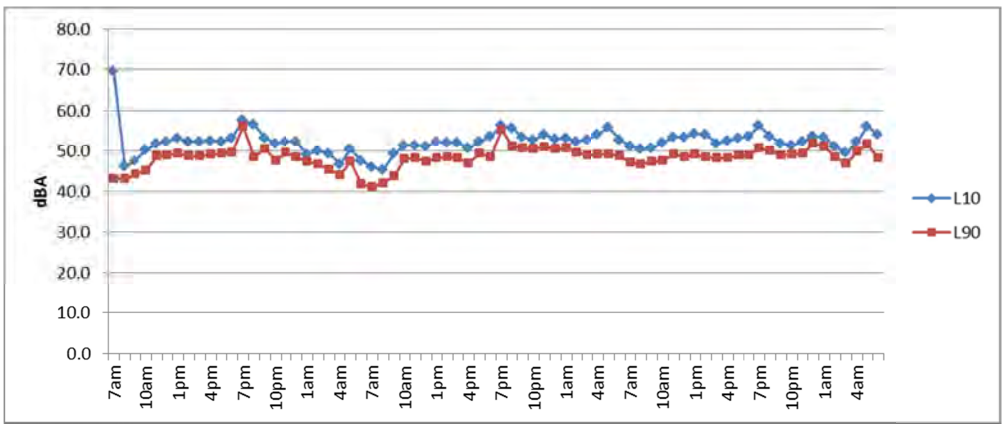


Figure 5-84 - L10 and L90 for Station 2

5.1.17.2.3 Station 3 – South Property Boundary

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 46.0 dBA which occurred at 10:41:30 pm and 10:41:30 pm on April 27, 2012 to a high (Lmax) of 84.6 dBA which occurred at 7:35:30 am on April 27, 2012. Average noise level for this period was 57.9 LAeq (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 5-85.

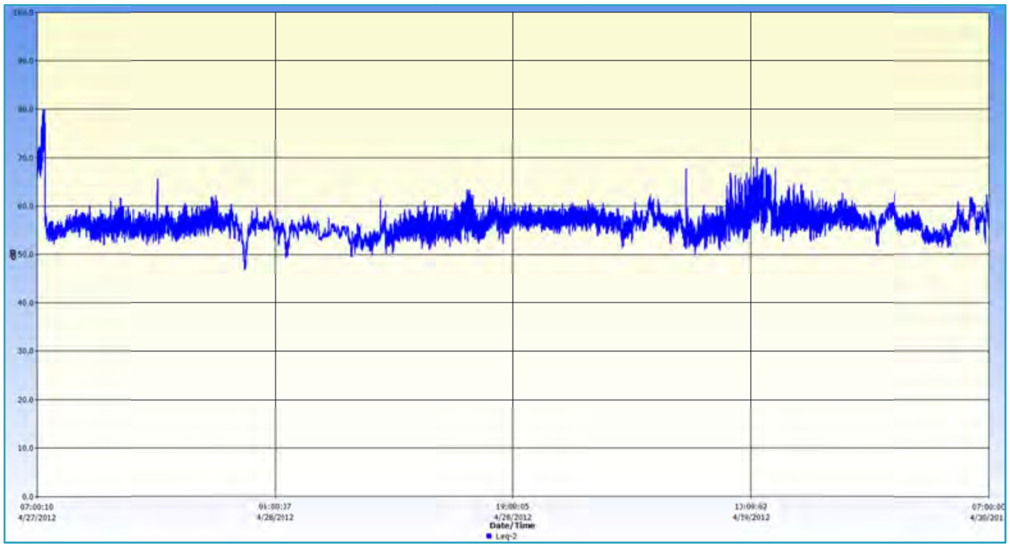


Figure 5-85 - Noise fluctuation (Leq) over 72 hours at Station 3

Octave Band Analysis at Station 3

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 25 Hz (octave frequency range is 22 - 28 Hz) (Figure 5-86).

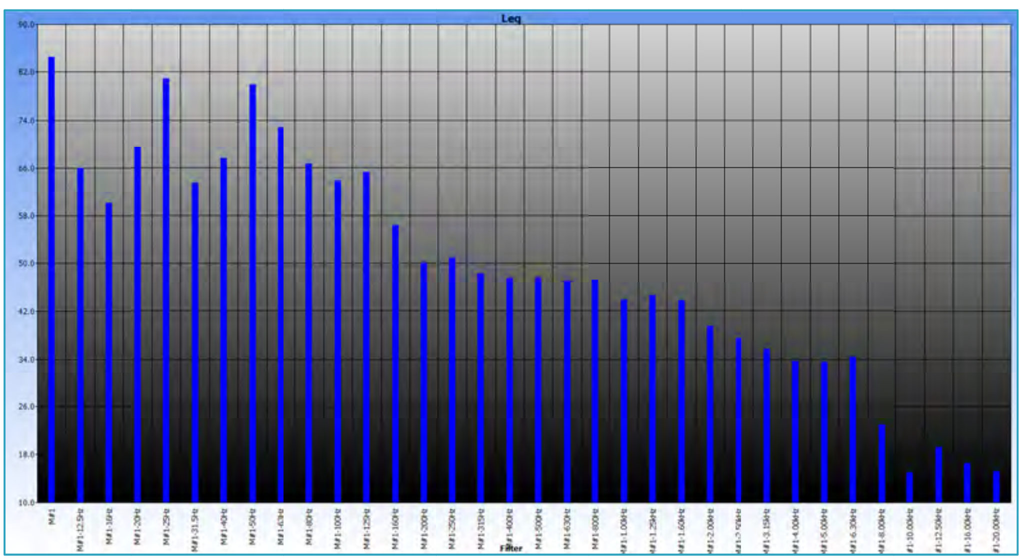


Figure 5-86 - Octave band spectrum of noise at Station 3

L10 and L90 – Southern Property Boundary

Figure 5-87 the noise assessment period. The data shows moderate fluctuations in the noise climate (L10 – L90) ≈87.5% of the time, no significant fluctuations in the noise climate (L10 – L90) ≈11.1% of the time and large fluctuations (L10 – L90) ≈1.4% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 58.8 dBA and 53.6 dBA respectively.

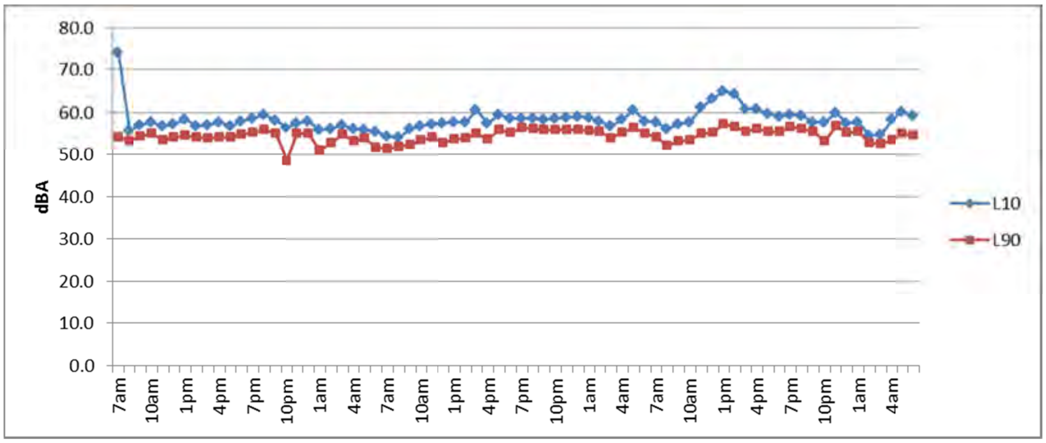


Figure 5-87 - L10 and L90 for Station 3

5.1.17.2.4 Station 4 – Western Property Boundary

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 33.8 dBA which occurred at 7:05:20 am on April 28, 2012 to a high (Lmax) of 71.1 dBA which occurred at 7:25:20 am on April 27, 2012. Average noise level for this period was 51.9 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 5-88.

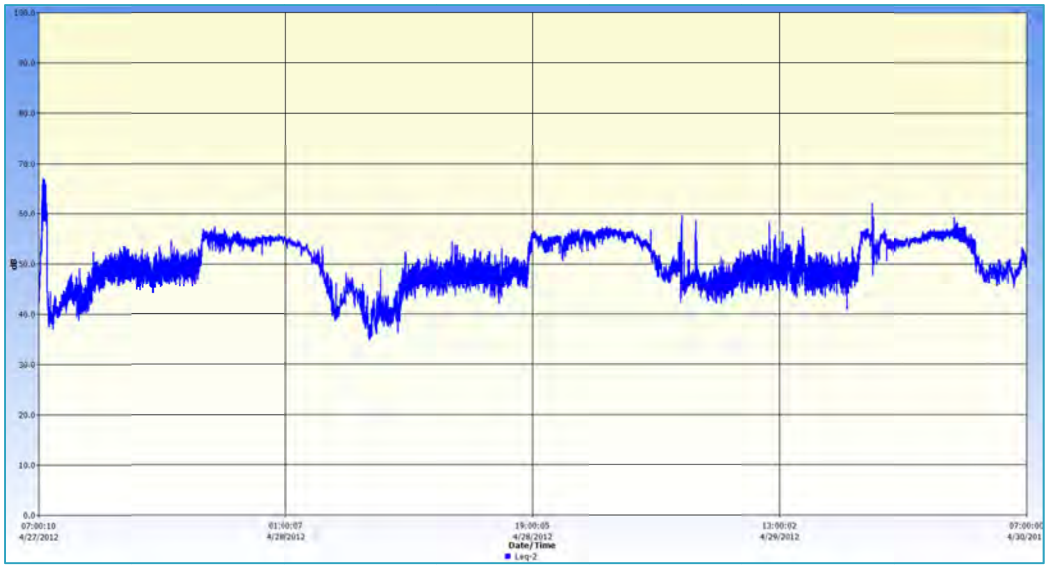


Figure 5-88 - Noise fluctuation (Leq) over 72 hours at Station 4

Octave Band Analysis at Station 4

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 25 Hz (octave frequency range is 22 - 28 Hz) (Figure 5-89).

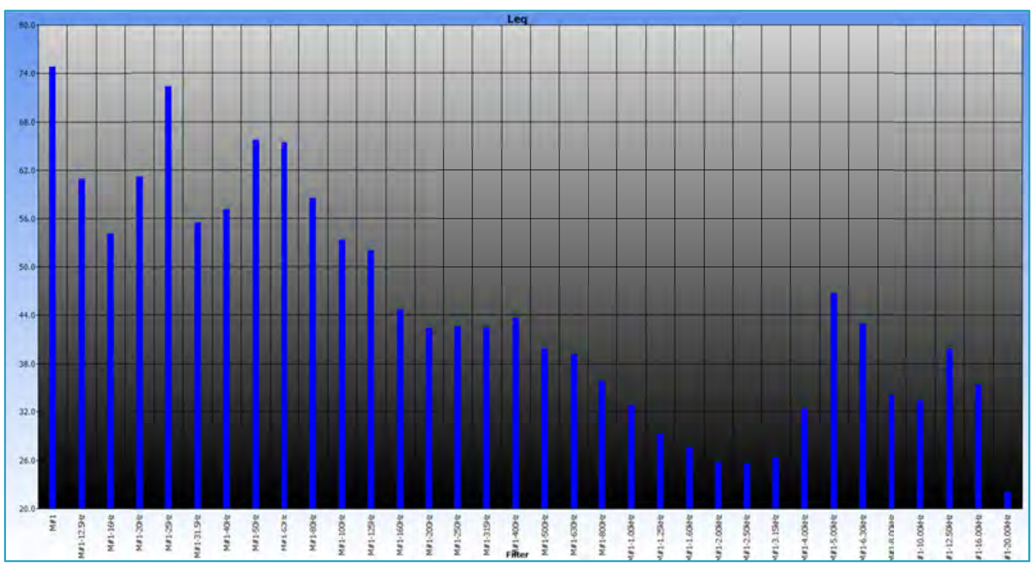


Figure 5-89 - Octave band spectrum of noise at Station 4

L10 and L90 – Western Property Boundary

Figure 5-90 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows no significant fluctuations in the noise climate (L10 – L90) ≈84.7% of the time, moderate fluctuations in the noise climate (L10 – L90) ≈13.9% of the time and large fluctuations (L10 – L90) ≈1.4% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 55.5 dBA and 43.9 dBA respectively.

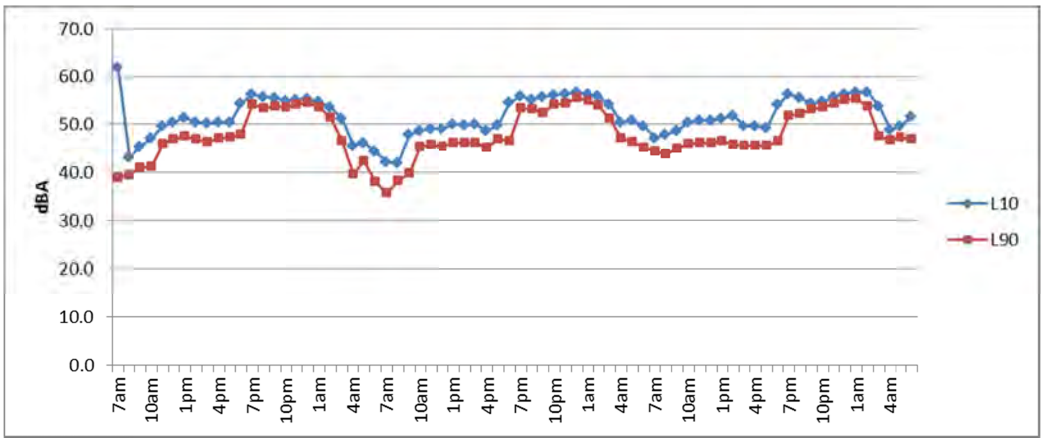


Figure 5-90 - L10 and L90 for Station 4

5.1.17.2.5 Station 5 - JPS Guard House

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 49.9 dBA which occurred at 3:31:50 am on April 30, 2012 to a high (Lmax) of 81.5 dBA which occurred at 2:36:50 pm on April 27, 2012. Average noise level for this period was 59.9 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 5-91.

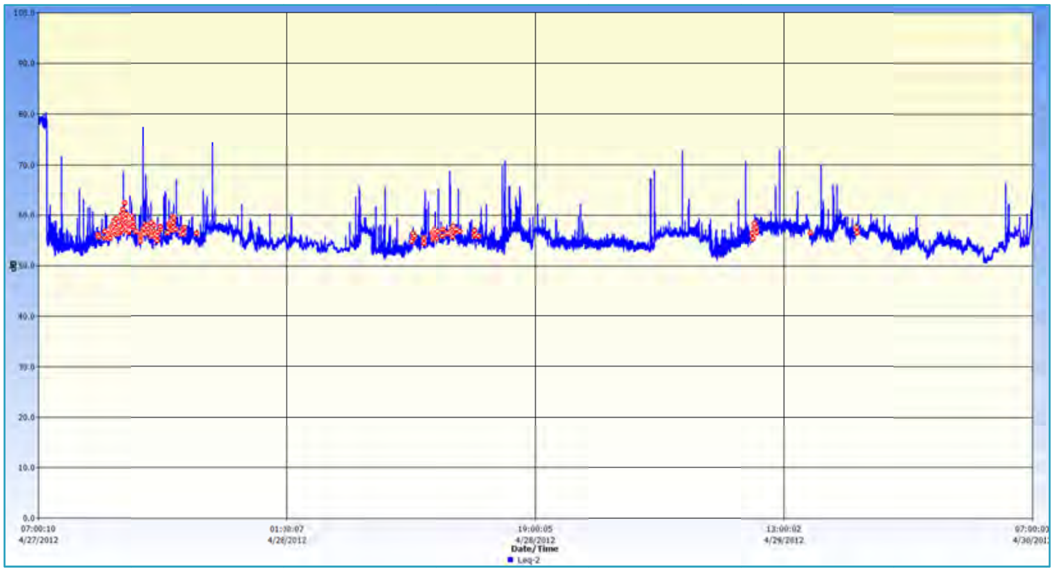


Figure 5-91 - Noise fluctuation (Leq) over 72 hours at Station 5

Octave Band Analysis at Station 5

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 50 Hz (octave frequency range is 45 - 56 Hz) (Figure 5-92).

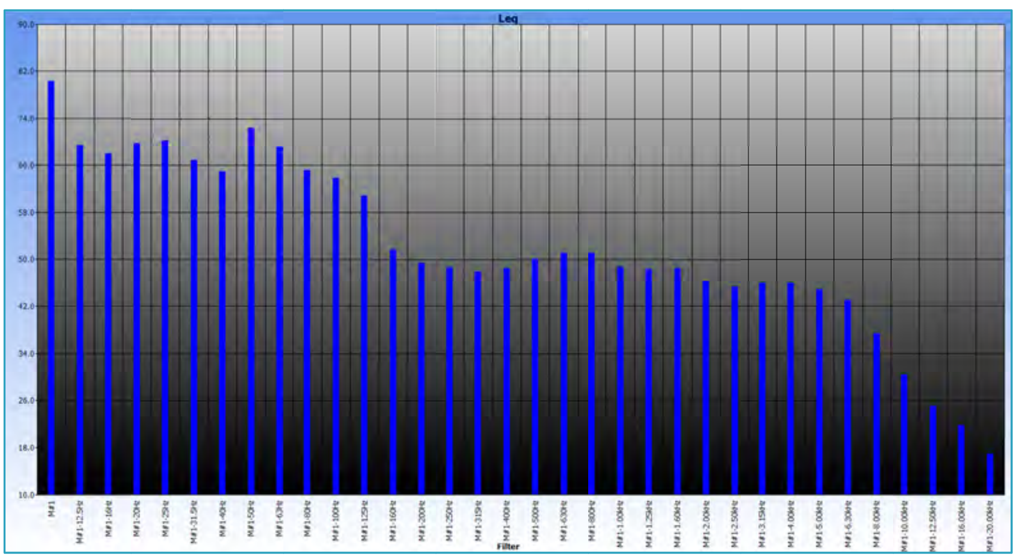


Figure 5-92 - Octave band spectrum of noise at Station 5

L10 and L90 – JPS Guard House

Figure 5-93 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows no significant fluctuations in the noise climate (L10 – L90) ≈98.6% of the time and large fluctuations (L10 – L90) ≈1.4% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 57.6 dBA and 53.3 dBA respectively.

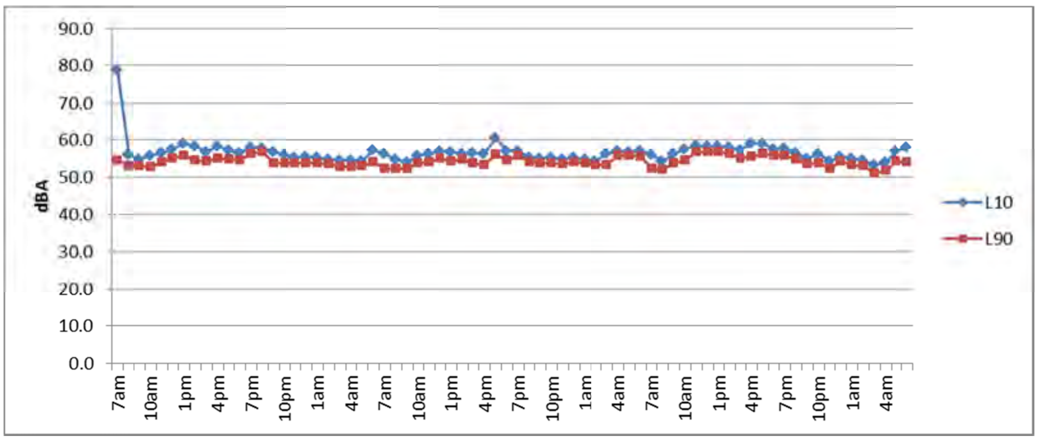


Figure 5-93 - L10 and L90 for Station 5

5.1.17.2.6 Station 6 – Informal Settlement

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 36.4 dBA which occurred at 3:47:40 am on April 28, 2012 to a high (Lmax) of 84.1 dBA which occurred at 10:14:30 am on April 28, 2012. Average noise level for this period was 51.3 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 5-94.

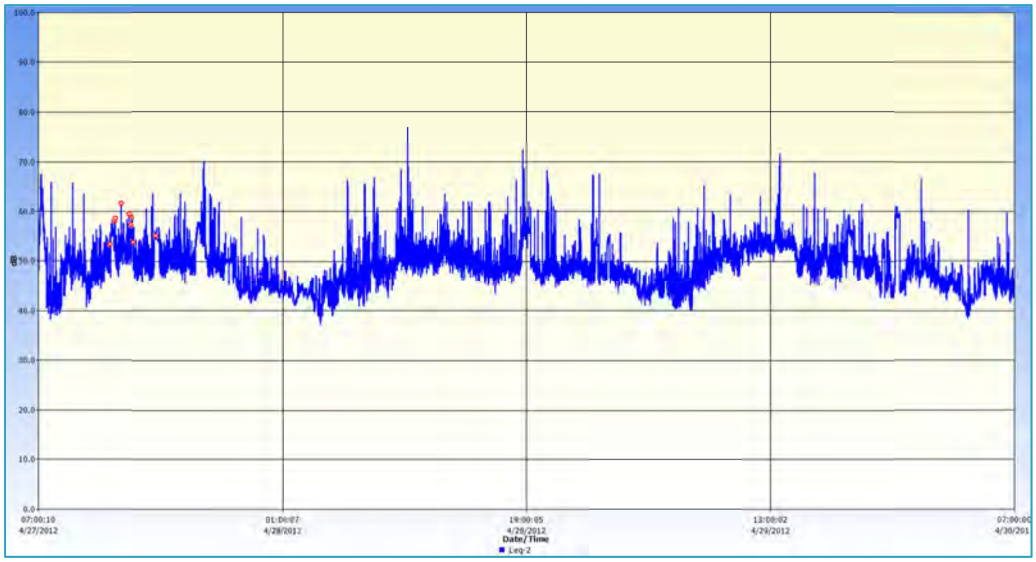


Figure 5-94 - Noise fluctuation (Leq) over 72 hours at Station 6

Octave Band Analysis at Station 6

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 25 Hz (octave frequency range is 22 - 28 Hz) (Figure 5-95).

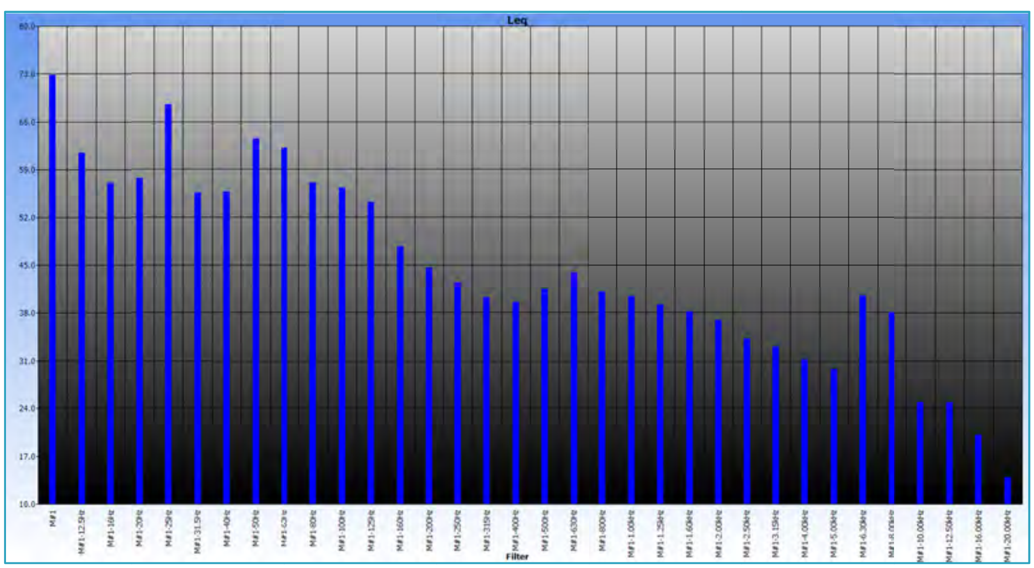


Figure 5-95- Octave band spectrum of noise at Station 6

L10 and L90 – Informal Settlement

Figure 5-96 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) ≈55.6% of the time, no significant fluctuations in the noise climate (L10 – L90) ≈41.6% of the time and large fluctuations in the noise climate (L10 – L90) ≈2.8% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 54.0 dBA and 43.6 dBA respectively.

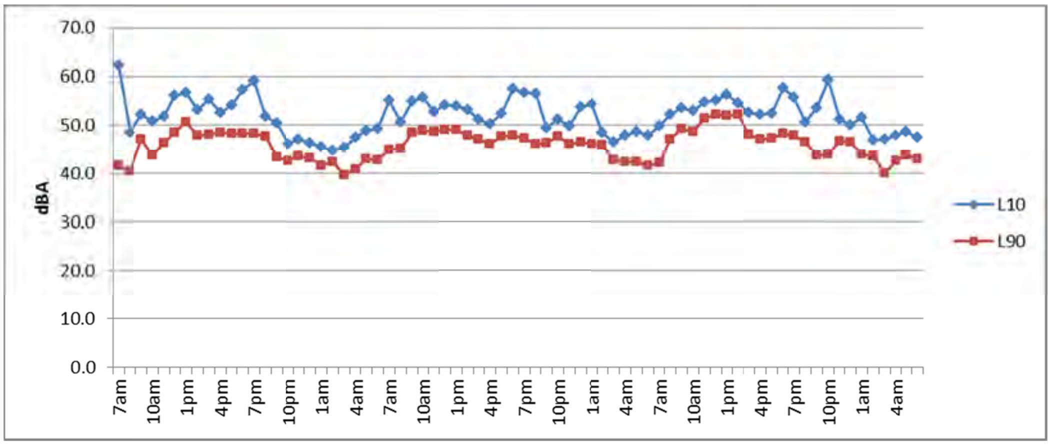


Figure 5-96 - L10 and L90 for Station 6

5.1.17.2.7 Station 7 – Old Harbour Bay Police Station

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 30.2 dBA which occurred at 3:36:50 am on April 30, 2011 to a high (Lmax) of 90.3 dBA which occurred at 2:20:40 pm on April 27, 2012. Average noise level for this period was 57.3 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 5-97.

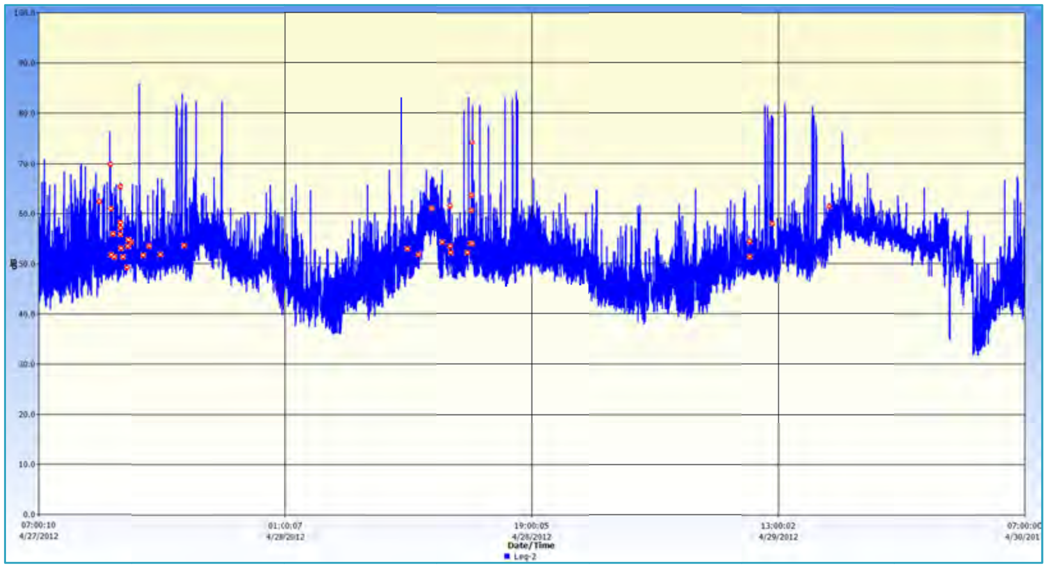


Figure 5-97 - Noise fluctuation (Leq) over 72 hours at Station 7

Octave Band Analysis at Station 7

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 25 Hz (octave frequency range is 22 - 28 Hz) (Figure 5-98).

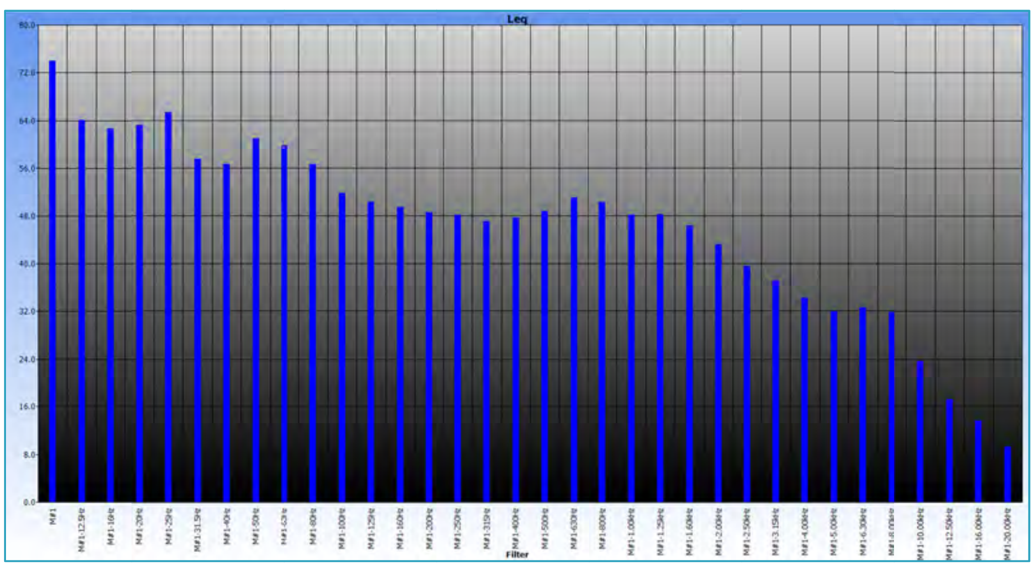


Figure 5-98 - Octave band spectrum of noise at Station 7

L10 and L90 – Old Harbour Bay Police Station

Figure 5-99 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations in the noise climate (L10 – L90) ≈87.5% of the time, no significant fluctuations in the noise climate (L10 – L90) ≈9.7% of the time and large fluctuations (L10 – L90) ≈2.8% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 57.2 dBA and 43.1 dBA respectively.

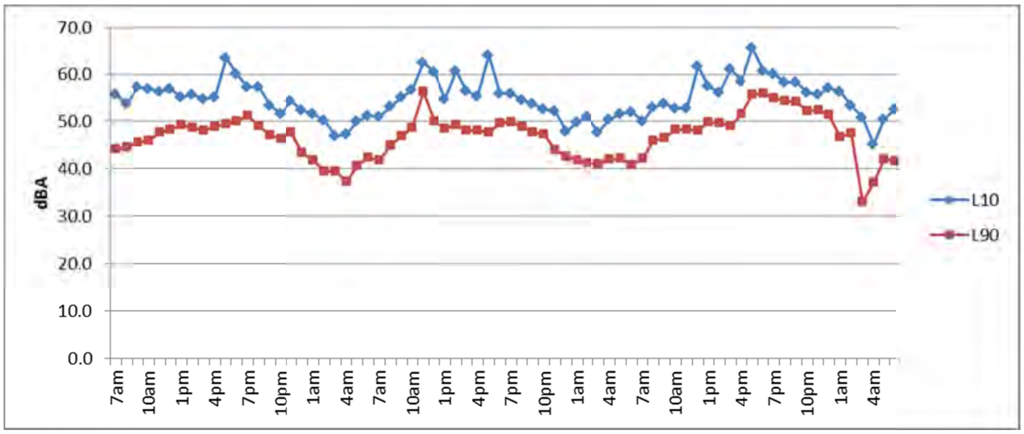


Figure 5-99 - L10 and L90 for Station 7

5.1.17.2.8 Station 8 – New Harbour Village Phase 1

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 30.9 dBA which occurred at 3:17:10 am on April 30, 2012 to a high (Lmax) of 93.7 dBA which occurred at 8:07:20 pm on April 29, 2012. Average noise level for this period was 58.7 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 5-100.

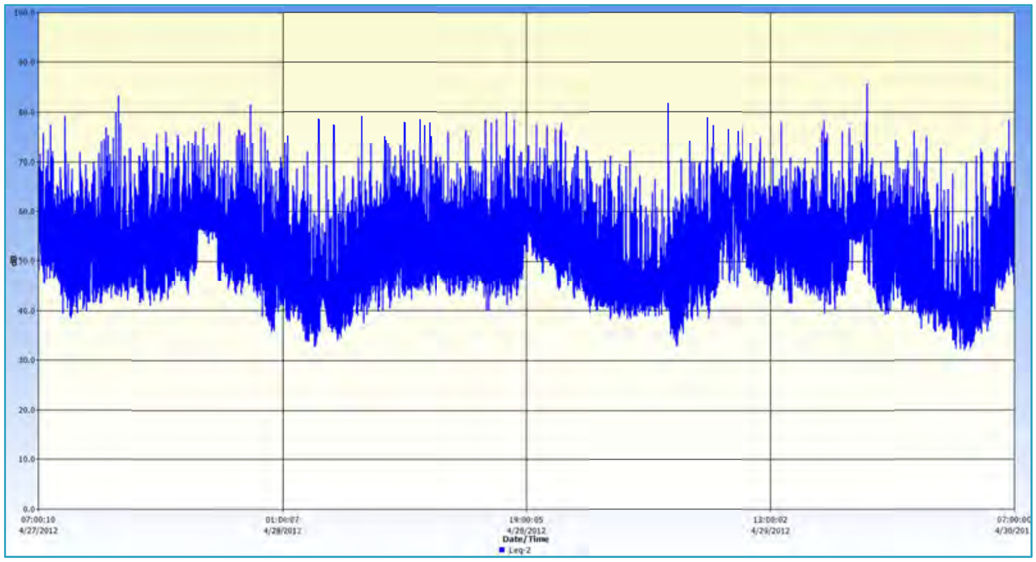


Figure 5-100 - Noise fluctuation (Leq) over 72 hours at Station 8

Octave Band Analysis at Station 8

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 80 Hz (octave frequency range is 71 - 90 Hz) (Figure 5-101).

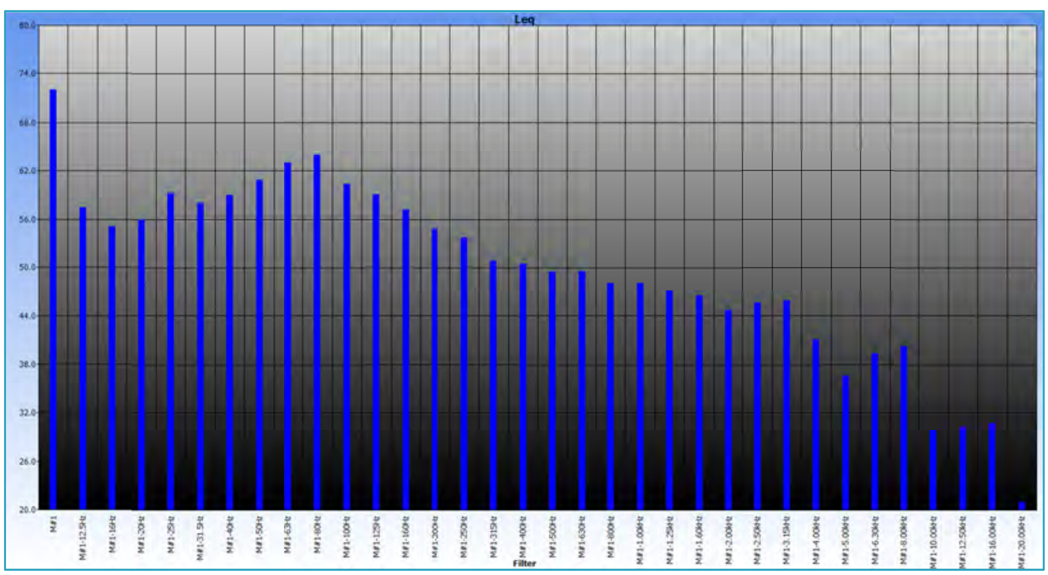


Figure 5-101 - Octave band spectrum of noise at Station 8

L10 and L90 – New Harbour Village Phase 1

Figure 5-102 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations in the noise climate (L10 – L90) ≈55.6% of the time and large fluctuations (L10 – L90) ≈44.4% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 60.9 dBA and 41.2 dBA respectively.

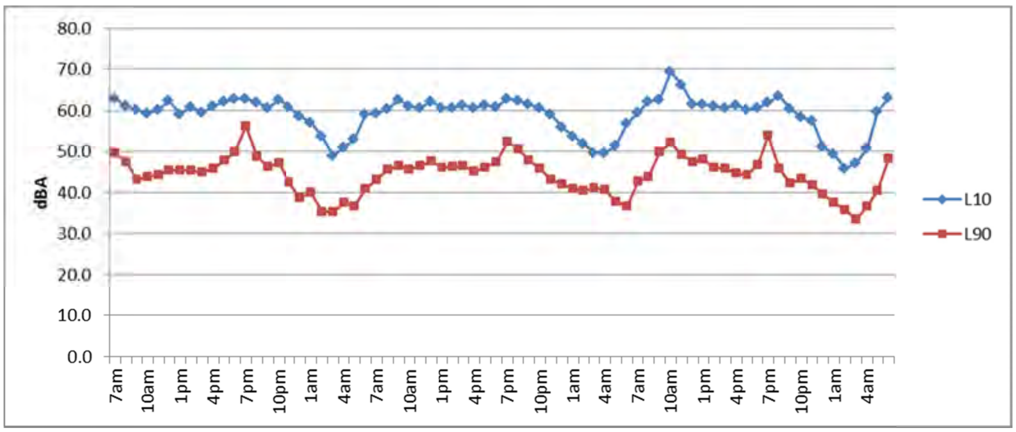


Figure 5-102 - L10 and L90 for Station 8

5.1.17.2.9 Station 9 – Church Pen

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 32.8 dBA which occurred at 3:30:40, 3:53:30 and 3:56:50 am on April 30, 2012 to a high (Lmax) of 90.0 dBA which occurred at 6:17:20 pm on April 27, 2012. Average noise level for this period was 57.9 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 5-103.

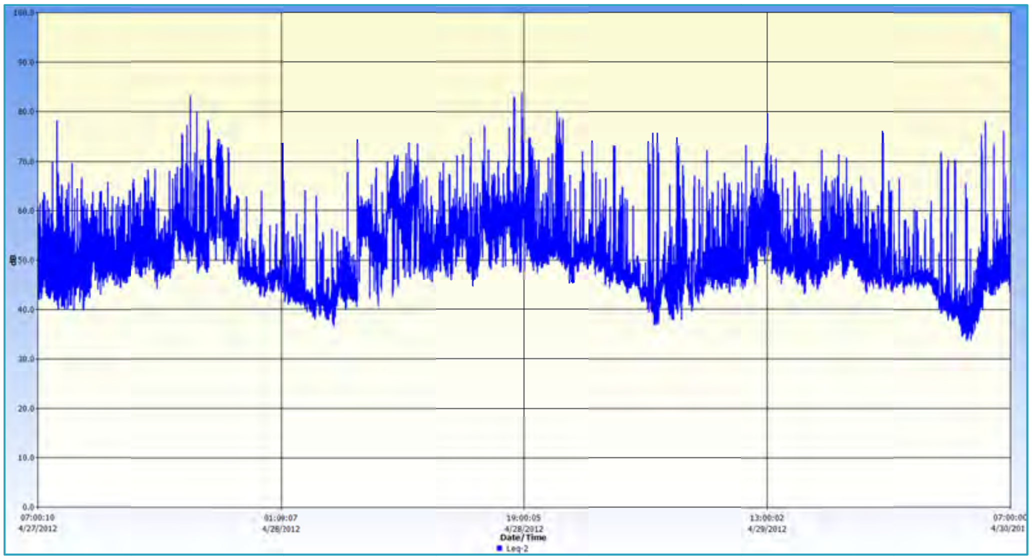


Figure 5-103 - Noise fluctuation (Leq) over 72 hours at Station 9

Octave Band Analysis at Station 9

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz (octave frequency range is 56 - 71 Hz) (Figure 5-104).

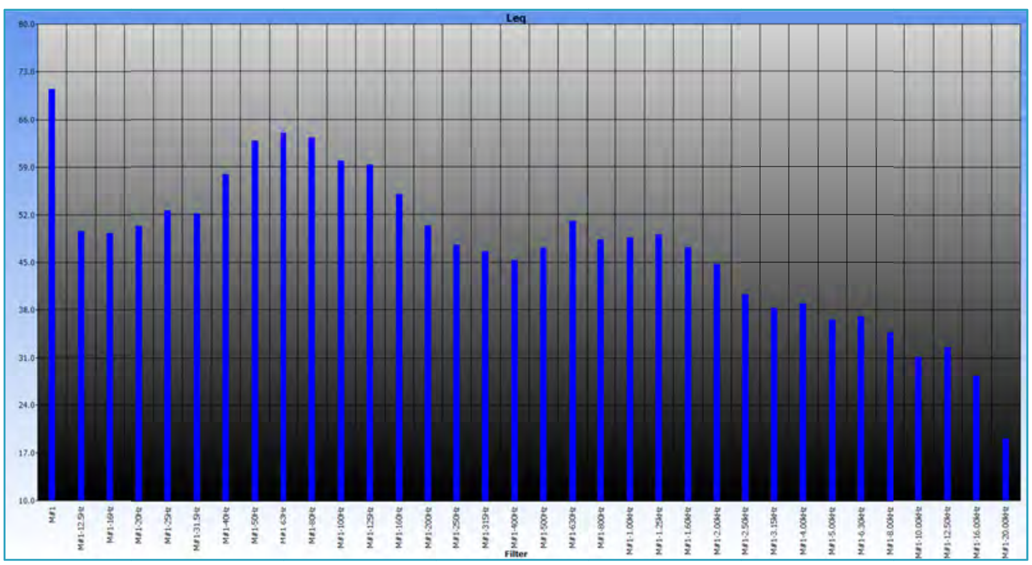


Figure 5-104 - Octave band spectrum of noise at Station 9

L10 and L90 – Church Pen

Figure 5-105 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) ≈72.2% of the time, no significant fluctuations in the noise climate (L10 – L90) ≈15.3% of the time and large fluctuations in the noise climate (L10 – L90) ≈12.5% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 59.6 dBA and 43.0 dBA respectively.

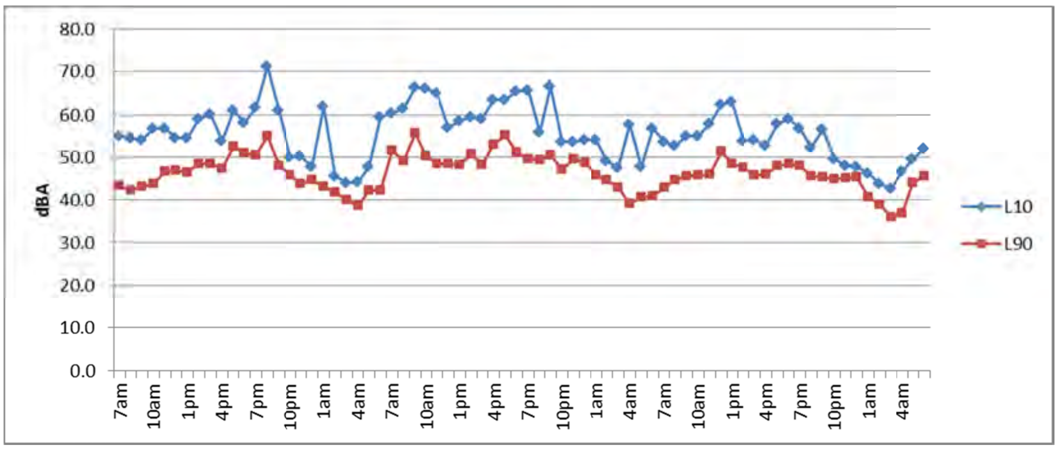


Figure 5-105 - L10 and L90 for Station 9

5.1.17.2.10 Station 10 - Bodles

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 32.5 dBA which occurred at 4:13:10 am on April 30, 2012 to a high (Lmax) of 89.0 dBA which occurred at 1:23:00 pm on April 27, 2012. Average noise level for this period was 52.6 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 5-106.

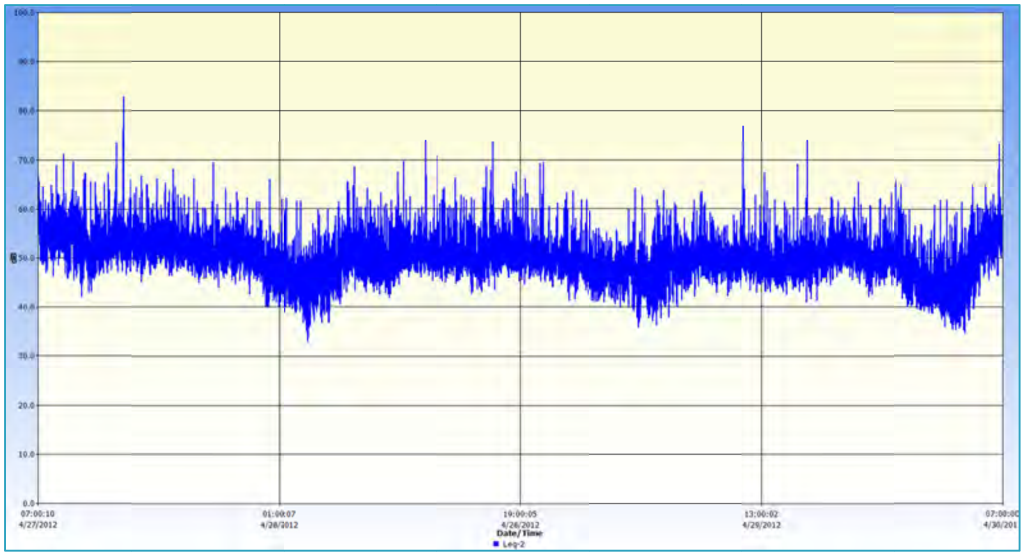


Figure 5-106 - Noise fluctuation (Leq) over 72 hours at Station 10

Octave Band Analysis at Station 10

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz (octave frequency range is 56 - 71 Hz) (Figure 5-107).

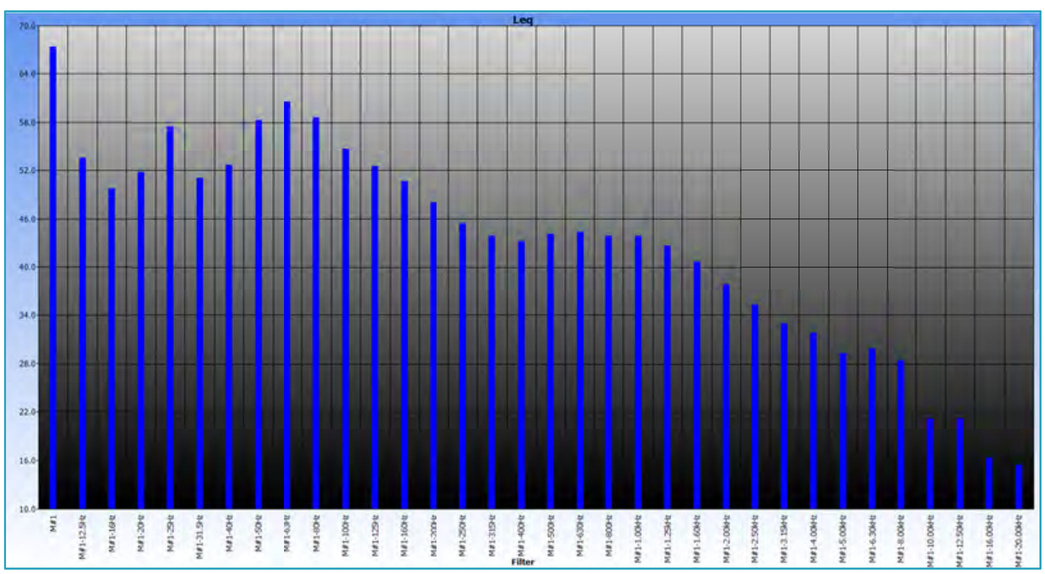


Figure 5-107 - Octave band spectrum of noise at Station 10

L10 and L90 – Bodles

Figure 5-108 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows moderate fluctuations (L10 – L90) ≈98.6% of the time and large fluctuations in the noise climate (L10 – L90) ≈1.4% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 54.9 dBA and 44.4 dBA respectively.

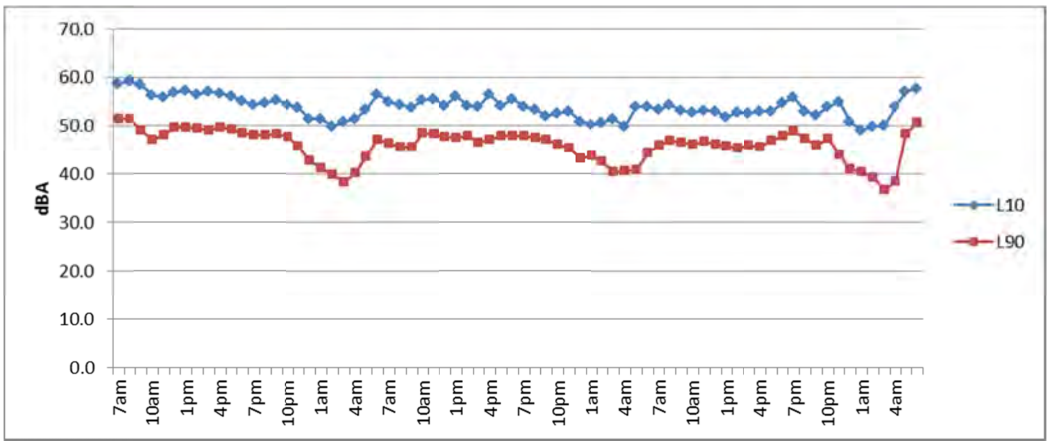


Figure 5-108 - L10 and L90 for Station 10

5.1.17.2.11 Station 11 – Longville Park

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 37.1 dBA which occurred at 7:04:20, 7:04:40 and 7:04:50 am on April 28, 2012 to a high (Lmax) of 76.0 dBA which occurred at 9:35:10 am on April 28, 2012. Average noise level for this period was 51.1 L_{Aeq} (72h). The fluctuation in noise levels over the 72 hour period is depicted in Figure 5-109.

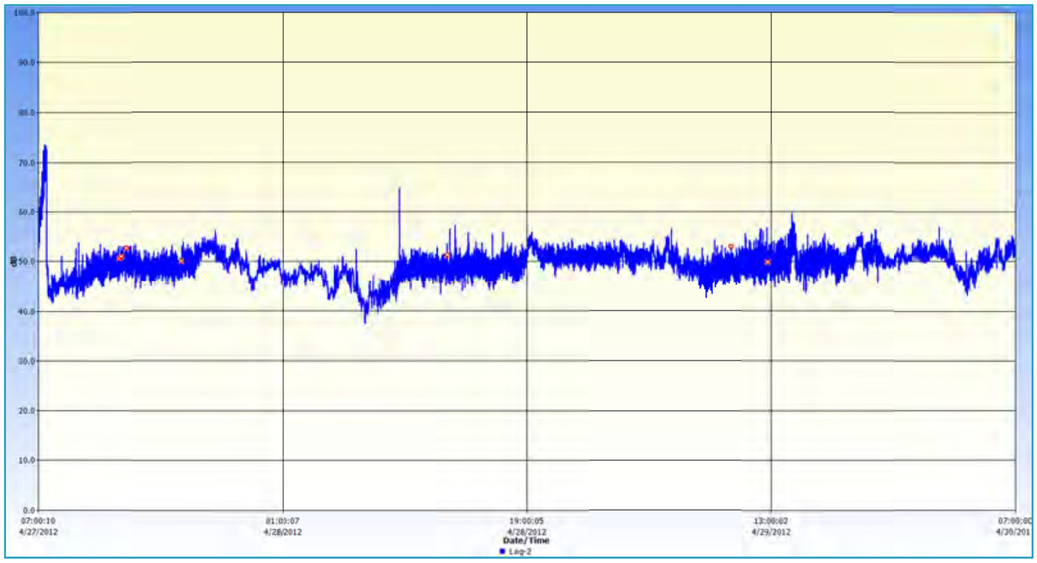


Figure 5-109 - Noise fluctuation (Leq) over 72 hours at Station11

Octave Band Analysis at Station 11

The noise at this station during the 72 hour period was in the low frequency band centred around the geometric mean frequency of 25Hz (octave frequency range is 22 - 28 Hz) (Figure 5-110).

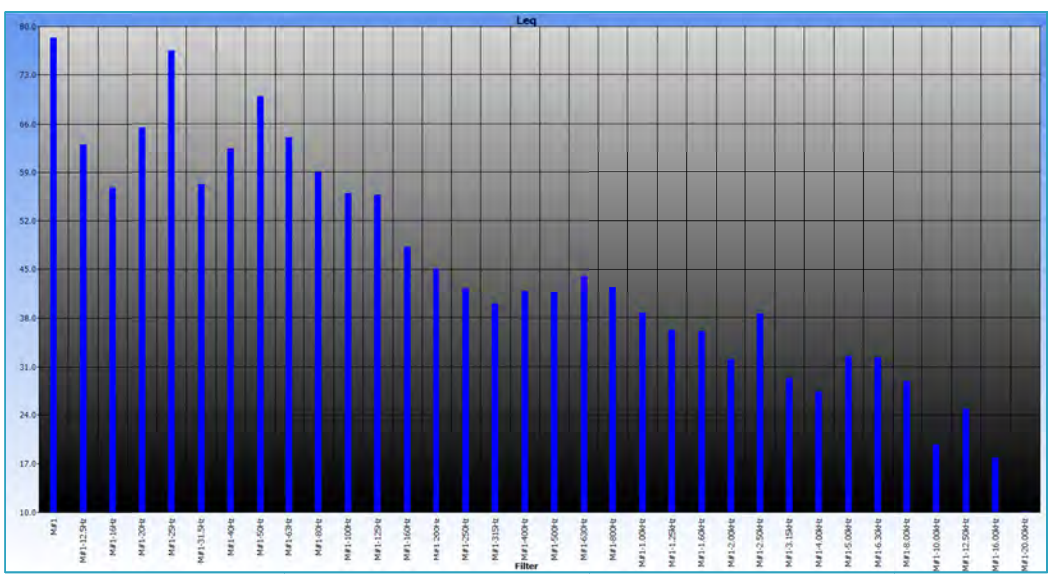


Figure 5-110 - Octave band spectrum of noise at Station 11

L10 and L90 – Longville Park

Figure 5-111 depicts the hourly L10 and L 90 statistics for this station over the noise assessment period. The data shows no significant fluctuations in the noise climate (L10 – L90) ≈91.7% of the time, moderate fluctuations (L10 – L90) ≈6.9% of the time and large fluctuations in the noise climate (L10 – L90) ≈1.4% of the time in the noise climate at this station.

The overall L10 and L 90 at this station for the time assessed were 52.2 dBA and 45.8 dBA respectively.

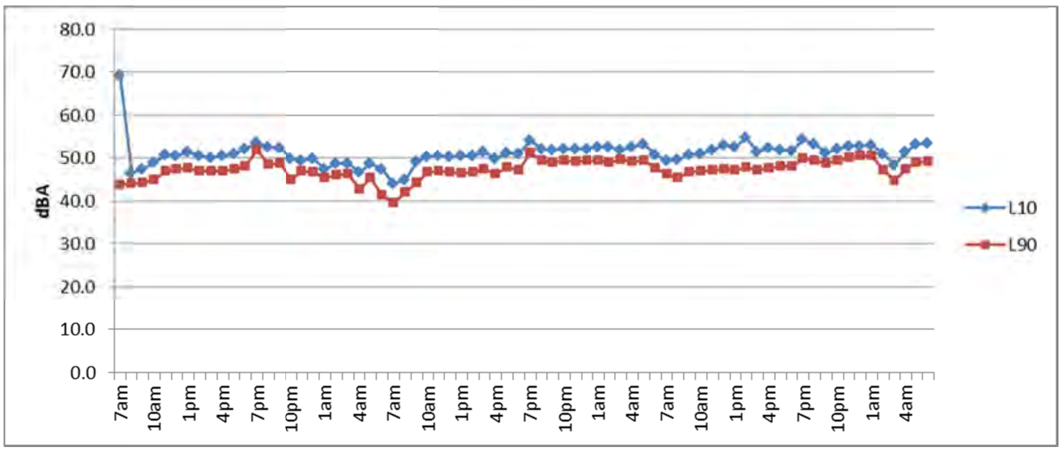


Figure 5-111 - L10 and L90 for Station 11

5.1.17.3 Comparisons of Ambient Noise Levels with NEPA Guidelines

Comparison of the ambient noise levels in the study area with the National Environmental and Planning Agency (NEPA) guidelines are shown in Table 5-46. Three stations (7, 8 and 9) were non-compliant with the NEPA noise guidelines during the daytime (7am – 10 pm). During the night the same three stations that were non-compliant during the day with the NEPA guidelines were non-compliant during the night.

Table 5-46 - Comparison of noise levels at the stations with the NEPA guidelines

STN #	ZONE	7 am. - 10 pm. (dBA)	NEPA Guideline (dBA)	10 pm. - 7 am. (dBA)	NEPA Guideline (dBA)

1	Commercial	51.3	65	45.1	60
2	Commercial	53.1	65	51.1	60
3	Commercial	58.7	65	56.4	60
4	Commercial	50.9	65	53.4	60
5	Industrial	61.4	75	54.9	70
6	Residential	52.6	55	48.1	50
7	Residential	**59.1**	55	**50.1**	50
8	Residential	**59.9**	55	**55.8**	50
9	Residential	**59.4**	55	**53.6**	50
10	Commercial	53.5	65	50.6	60
11	Residential	51.7	55	49.9	50

NB. Numbers in red are non-compliant with the standard/guideline

5.1.18 Vibration

Vibrations consist of rapidly fluctuating motions in which there is no "net" movement. When an object vibrates, any point on the object is displaced from its initial "static" position equally in both directions so that the average of all its motion is zero. Any object can vibrate differently in three mutually independent directions; vertical, horizontal, and lateral. It is common to describe vibration levels in terms of velocity, which represents the instantaneous speed at a point on the object that is displaced.

Vibrations are transmitted from the source to the ground, and propagate through the ground to the receiver. Soil conditions have a strong influence on the levels of ground-borne vibration.

Stiff soils, such as some clay and rock, can transmit vibrations over substantial distances. Sandy soils, wetlands, and groundwater tend to absorb movement and thus reduce vibration transmission.

5.1.18.1 Ground Borne Vibration Measurement Units

Ground borne vibration is caused when the individual particles making up the strata are caused to oscillate by the passage of a pressure wave. The resulting vibration can be summarized in terms of 4 main parameters:

a) **Velocity** – how fast the particles move when they are oscillating. Since the velocity of these particles continually change as the pressure wave passes the most useful value that is often reported is the maximum or peak particle velocity (PPV). PPVs are usually expressed in terms of ms-1 or mms-1.

b) **Acceleration** – is the rate at which the particle velocity changes during oscillation. It is usually measured in ms-2 mms-2 or “g’s”. 1g is that acceleration imparted to an object by the earth’s gravitational pull and is approximately 9.81 ms-2.
c) **Displacement** – is the distance moved by oscillating particles. This is usually very small and measured in mm or even µm.
d) **Frequency** – is the number of oscillations per second which a particle undergoes due to the passage of a vibration wave. It is measured in cycles per second or Hertz (Hz).

The movement of particles induced to oscillate by vibration waves are usually measured in three mutually perpendicular directions to fully describe the vibration intensity, as particles will be oscillating in three dimensions. These are:

a) **Longitudinal/Radial** – back and forth particle movement in the same direction that the vibration wave is travelling.
b) **Vertical** – up and down movement perpendicular to the direction the vibration wave is travelling.
c) **Transverse** – left and right particle movement perpendicular to the direction the vibration wave is travelling.

5.1.18.2 Vibration Criteria

Various governmental agencies have criteria regarding architectural and structural damage, as well as annoyance and acceptability of vibration.

In general, most of the criteria specify that for a PPV less than approximately 3.048 mms^{-1} (0.12 inches per second) the potential for architectural damage due to vibration is unlikely, for a PPV from approximately 3.048 mms^{-1} (0.12 inches per second) to 12.7 mms^{-1} (0.50 inches per second) there is potential for architectural damage due to vibration, and for a PPV greater than approximately mms^{-1} (0.50 inches per second) the potential for architectural damage due to vibration is very likely.

Human beings are known to be very sensitive to vibration, the threshold of perception being typically in the PPV range of 0.14 mms^{-1} to 0.3 mms^{-1} (British Standard BS 5228-2:2009). Table 5-47 provides an indication of the effects of ground vibration on humans.

Table 5-47 - Guidance on the effects of vibration

VIBRATION LEVEL	EFFECT
0.14 mms^{-1}	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mms^{-1}	Vibration might be just perceptible in residential environments.
1.0 mms^{-1}	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10 mms^{-1}	Vibration is likely to be intolerable for any more than a brief exposure to this level.

Source: (British Standard BS 5228-2:2009)

5.1.18.3 Methodology

Measurements were performed using Nomis Seismometer Type Mini Supergraph. The Mini Supergraph consisted of a 3-axis velocity transducer, an air over-pressure transducer, and a data acquisition and storage device. The transducer measures velocities on three mutually

perpendicular axes (Vx, Vy, Vz) corresponding to a radial, vertical, and transverse component at a linear frequency response range from 2 Hz to 400 Hz. The Mini Supergraph was calibrated to meet ISO-9000 requirements on April 13, 2012.

The seismometer was set to summarize every hour at a sampling rate 1024/sec. Two locations were monitored over a twenty four hour period. These were located at the current JPSCo Old Harbour Power Plant. Location 1 was located approximately 30 m west and Location 2 was approximately 85 m east of the power house.

The readings were taken from 12:01 pm June 27 – 11:53 am June 28, 2012 at Location 1 and 11:53 am June 28 – June 29, 2012 at Location 2.

Plate 5-12 - Photo showing vibration meter at JPS Old Harbour Bay Plant

5.1.18.4 Results

The results indicate that the vibration events recorded over the two days at the JPSCo Old Harbour Bay plant that generally the vibration levels begin to annoy and become unacceptable to persons if exposed to continuous exposure. There will be no effect on buildings to minimal potential for damage to weak or sensitive structures.

Only event #22 had a maximum peak particle velocity (PPV) (67.564 mm/sec) which would have been considered unpleasant for most persons. This must be viewed in light of the fact that construction work (trenching etc. with heavy equipment took place in close proximity to the location).

Table 5-48 - Effects of Construction Vibration

PEAK PARTICLE VELOCITY (mm/sec)	EFFECTS ON HUMANS	EFFECTS ON BUILDINGS
< 0.127	Imperceptible	No effect on buildings
0.127 – 0.381	Barely perceptible	No effect on buildings
0.508 – 1.27	Level at which continuous vibrations begin to annoy in	No effect on buildings

	buildings	
2.54 – 12.7	Vibrations considered unacceptable for people exposed to continuous or long-term vibration	Minimal potential for damage to weak or sensitive structures
12.7 – 25.4	Vibrations considered bothersome by most people, however tolerable if short-term in length	Threshold at which there is a risk of architectural damage to buildings with plastered ceilings and walls. Some risk to ancient monuments and ruins.
25.4 – 50.8	Vibrations considered unpleasant by most people	U.S. Bureau of Mines data indicates that blasting vibration in this range will not harm most buildings. Most construction vibration limits are in this range.
>76.2	Vibration is unpleasant	Potential for architectural damage and possible minor structural damage

Version 3.2.1
Executable Date: 23Apr2012

File: C:\Consultancy\JPS 360MW\Vibration\New folder\20.NSZ

Nomis Seismographs, Inc.

C. L. Environmental Co. Ltd. - Report

Company: CL ENVIRONMENTAL CO LTD

Telephone: (876) 756-0338

Unit #: 12485

27/Jun/2012 at 12:01:44 Event # 20

Location: JPS

Operator:

Notes:

Distance-Source: N

End Time: 00:00:03
Sample Rate: 1024/sec
Last Calibration: 13Apr12

Seismic

Gain: 2

Vector Sum: .82 mm/s

Channel	Radial	Transverse	Vertical
Velocity (mm/s)	0.635	0.445	0.699
Frequency (Hz)	33.00	60.20	68.30
Time	13:30:56	17:11:41	13:30:56
Displacement (mm)	0.0031	0.0012	0.0016
Acceleration (g's)	0.013	0.017	0.031

Air

Gain: 1

Measurement	Value		
kPa	.0072		
dBL	**111.2**		
Hz	341.3		
Time	23:16:52		

BarGraph

Seismic Scale: 2.03 mm/s/div. Bar Samples total/shown: 718/143 Summary Interval (min): 60 Bar Interval (sec): 60

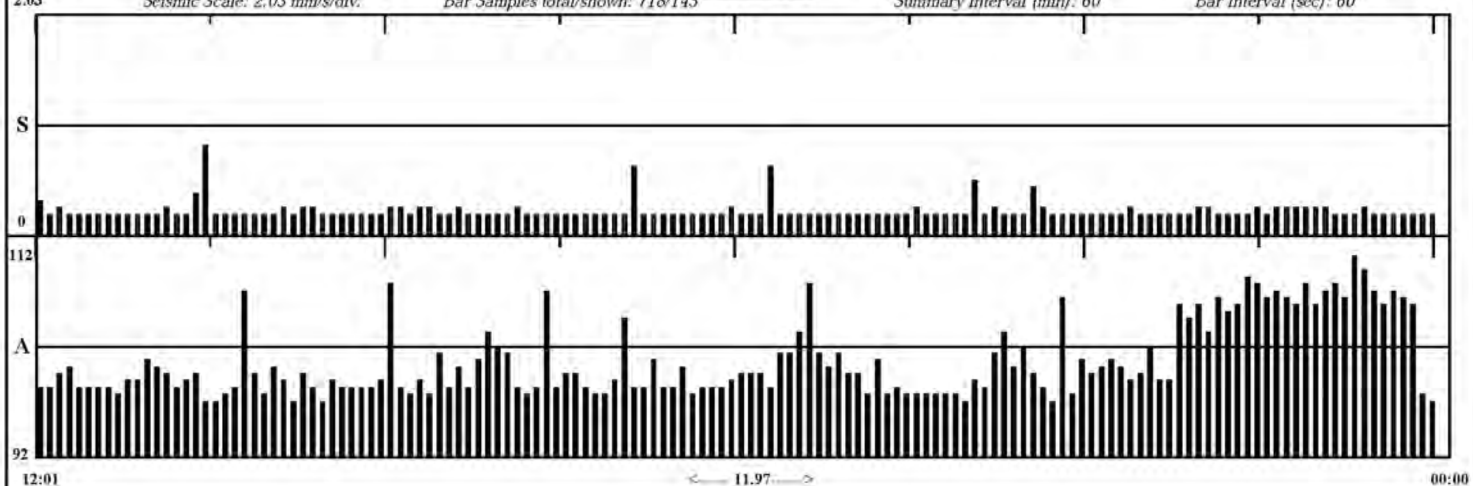


Figure 5-112 - Results for event #20 at 30m west of the existing JPSCo Old Harbour occurring at 12:01:44 pm on June 27, 2012

Version 3.2.1
Executable Date: 23Apr2012

File: C:\Consultancy\JPS 360MW\Vibration\New folder\22.NSZ

Nomis Seismographs, Inc.

C. L. Environmental Co. Ltd. - Report

Company: CL ENVIRONMENTAL CO LTD

Telephone: (876) 756-0338

Unit #: 12485

28/Jun/2012 at 00:00:17 Event # 22

Location: JPS

Operator:

Notes:

End Time: 11:53:06
Sample Rate: 1024/sec
Last Calibration: 13Apr12

Distance-Source: N

Seismic

Gain: 2

Vector Sum: 84.79 mm/s

Channel	Radial	Transverse	Vertical
Velocity (mm/s)	46.165	67.564	29.972
Frequency (Hz)	113.80	341.30	341.30
Time	11:52:55	11:52:55	11:52:54
Displacement (mm)	0.0646	0.0315	0.0140
Acceleration (g's)	3.363	14.763	6.549

Air

Gain: 1

Measurement	Value		
kPa	.0087		
dBL	**112.8**		
Hz	3.1		
Time	07:39:14		

BarGraph

Seismic Scale: 130.05 mm/s/div. Bar Samples total/shown: 712/142 Summary Interval (min): 60 Bar Interval (sec): 60

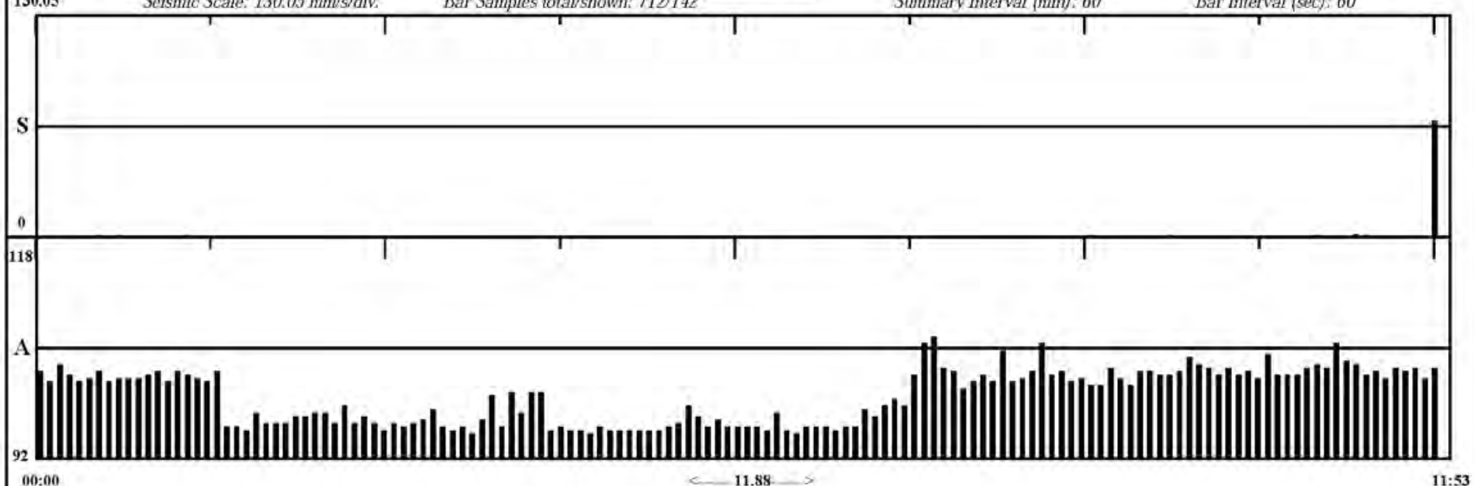


Figure 5-113 - Results for event #22 at 30m west of the existing JPSCo Old Harbour occurring at 00:00:17 am on June 28, 2012

Version 3.2.1
Executable Date: 23Apr2012

File: C:\Consultancy\JPS 360MW\Vibration\New folder\24.NSZ

Nomis Seismographs, Inc.

C. L. Environmental Co. Ltd. - Report

Telephone: (876) 756-0338

Company: CL ENVIRONMENTAL CO LTD

Unit #: 12485

28/Jun/2012 at 12:06:44 Event # 24

Location: JPS

Operator:

Notes:

End Time: 00:00:03
Sample Rate: 1024/sec
Last Calibration: 13Apr12

Distance-Source: N

Seismic

Gain: 2

Vector Sum: .55 mm/s

Channel	Radial	Transverse	Vertical
Velocity (mm/s)	**0.191**	**0.445**	**0.381**
Frequency (Hz)	**16.80**	**41.00**	**26.30**
Time	16:01:46	12:07:07	12:07:07
Displacement (mm)	0.0018	0.0017	0.0023
Acceleration (g's)	0.002	0.012	0.006

Air

Gain: 1

Measurement	Value		
kPa	.0125		
dBL	**115.9**		
Hz	2.4		
Time	14:40:49		

BarGraph

Seismic Scale: 2.03 mm/s/div. *Bar Samples total/shown: 713/142* *Summary Interval (min): 60* *Bar Interval (sec): 60*

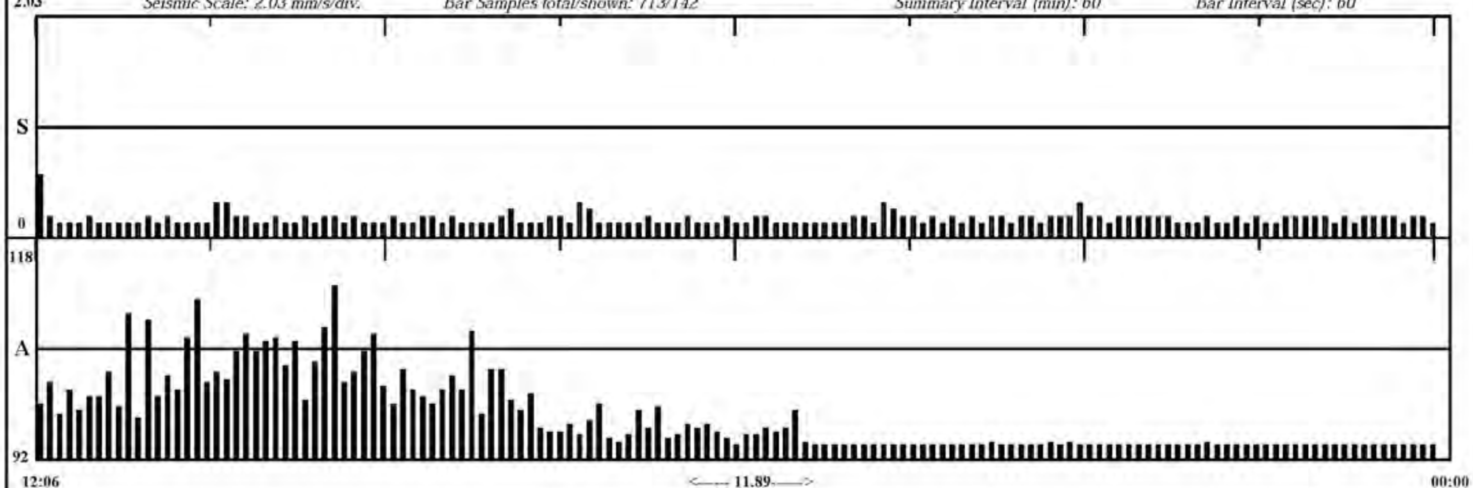


Figure 5-114 - Results for event #24 at 85m east of the existing JPSCo Old Harbour occurring at 12:06:44 pm on June 28, 2012

Version 3.2.1
Executable Date: 23Apr2012

File: C:\Consultancy\JPS 360MW\Vibration\New folder\26.NSZ

Nomis Seismographs, Inc.

C. L. Environmental Co. Ltd. - Report

Telephone: (876) 756-0338

Company: CL ENVIRONMENTAL CO LTD

Unit #: 12485

29/Jun/2012 at 00:00:17 Event # 26

Location: JPS

Operator:

Notes:

Distance-Source: N

End Time: 14:23:26
Sample Rate: 1024/sec
Last Calibration: 13Apr12

Seismic

Gain: 2

Vector Sum: 7.88 mm/s

Channel	Radial	Transverse	Vertical
Velocity (mm/s)	3.810	7.620	1.016
Frequency (Hz)	68.30	20.10	11.50
Time	09:17:55	09:17:55	09:17:55
Displacement (mm)	0.0089	0.0603	0.0141
Acceleration (g's)	0.167	0.098	0.007

Air

Gain: 1

Measurement	Value	
kPa	.0075	
dBL	111.5	
Hz	2.0	
Time	14:11:03	

BarGraph

Seismic Scale: 8.13 mm/s/div.   Bar Samples total/shown: 863/172   Summary Interval (min): 60   Bar Interval (sec): 60

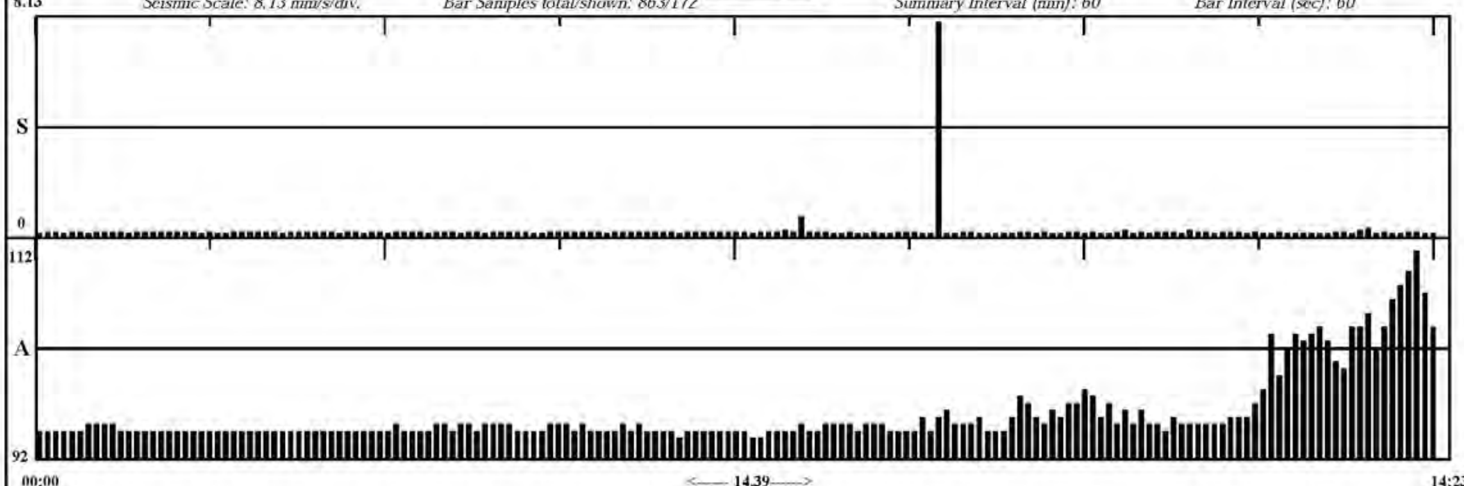


Figure 5-115 - Results for event #26 at 85m east of the existing JPSCo Old Harbour occurring at 00:00:17 am on June 29, 2012

5.1.19 Electromagnetic Frequency (EMF)

Electromagnetic fields (EMF) are invisible, but exist everywhere on Earth. EMF radiation is mainly characterized by its frequency and its strength. The frequency is measured in the unit hertz, which means “cycles per second”.

The gauss meter measures the strength of the low-frequency EMF radiation, like that coming from electrical wires (50 or 60 hertz). The better models can also show some higher frequencies (thousands of hertz, kilo hertz), which come from some electronic appliances, such as power supplies.

5.1.19.1 Methodology

EMF was measured at the 69 kV and 138 kV power lines on the proposed property and at approximately 10m intervals to determine the impact of distance from the source on EMF strength using a TM 192 triaxial Gauss meter. The readings were taken on May 19, 2012 between 9:00 and 11 am.

5.1.19.2 Results

While there is still no internationally accepted limit for EMF there are a number of guidelines that have been outlined by scientific bodies. In November, 2009, a scientific panel met in Seletun, Norway, for three days of intensive discussion on existing scientific evidence and public health implications. They recommended a Exposure Limit guideline of 1 mG for extremely low frequency (fields from electrical power) for all new installations, such as powerlines, indoor electric appliances, house-hold items, TVs, radios, computers, and telecommunication devices.

The data from the measuremant exercise are depicted in Figure 5-116 and Table 5-49.

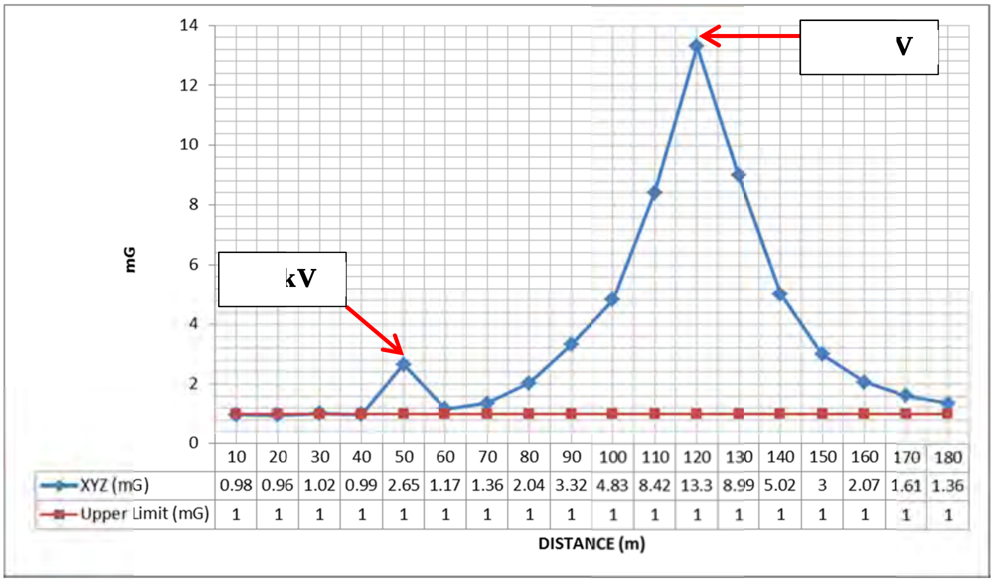


Figure 5-116 - EMF measurement results in relation to distance

Table 5-49 -EMF results by axis

DISTANCE (m)	DATE AND TIME	AXIS			XYZ (mG)
		X (mG)	Y (mG)	Z (mG)	
10	5/19/2012 9:00	0.52	0.81	0.2	0.98
20	5/19/2012 9:16	0.48	0.81	0.19	0.96
30	5/19/2012 9:24	0.52	0.85	0.24	1.02
40	5/19/2012 9:38	0.51	0.83	0.2	0.99
50	5/19/2012 10:31	0.93	0.97	2.29	2.65
60	5/19/2012 10:33	0.68	0.85	0.44	1.17
70	5/19/2012 10:34	0.93	0.82	0.57	1.36
80	5/19/2012 10:36	1.05	1.41	1.05	2.04
90	5/19/2012 10:39	1.14	1.97	2.43	3.32
100	5/19/2012 10:41	0.82	2.29	4.18	4.83
110	5/19/2012 10:42	1.72	2.32	7.91	8.42
120	5/19/2012 10:43	12.64	3.7	1.86	13.3
130	5/19/2012 10:45	0.65	5.44	7.13	8.99
140	5/19/2012 10:48	0.59	1.25	4.83	5.02
150	5/19/2012 10:49	0.47	1.56	2.52	3
160	5/19/2012 10:50	0.51	1.39	1.46	2.07
170	5/19/2012 10:51	0.48	1.27	0.87	1.61
180	5/19/2012 10:51	0.48	1.13	0.59	1.36

5.1.19.3 Easement Guidelines

The data obtained has indicated that a buffer of approximately 10 m is needed from the 69 kV and approximately 62 m for the 138 kV powerlines respectively at their present heights for the EMF values to fall within the guideline set by the Swedish sientists of 1 mG.

Information obtained has indicated that a buffer of approximately 7.6m on either side is required for the 69 kV and approximately 15.24 m for the 138 kV powerlines as guidelines set by the Jamaica Public Service Co. Ltd.

5.2 BIOLOGICAL

5.2.1 Protected Areas

Jamaica's Protected Areas

Jamaica currently lacks a comprehensive system of classification of protected areas. This reflects the ad hoc growth of the system under at least five Acts, each of which contains provisions that are relevant to protected area classifications. The four main governmental agencies whose legislation defines protected areas are:

- Department of Forestry
- Fisheries Department
- National Environment and Planning Agency

The following definitions are used as guidelines for the currently designated protected areas.

Protected Areas; Jamaica defines protected areas according to Article 2 of the Biodiversity Convention, which includes the following definition:

"Protected area" means a geographically defined area which is designated or regulated and managed to achieve specific conservation objectives”

A more detailed description is given by the IUCN definition:

"An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and natural and associated cultural resources, and managed through legal or other effective means."

The Portland Bight is one of three of these protected areas and represents Jamaica's largest and most dynamic protected area.

5.2.1.1 Portland Bight Protected Area

The project site is located in the Portland Bight Protected Area (PBPA), at 1,876.2 km2 (724.4 miles2) or 187,615 ha the PBPA is by far the largest protected area in Jamaica. Its land area [519.8 km2 (200.7 miles2) or 51,975 ha] is 4.7% of the island of Jamaica, and its marine area [1,356.4 km2 (523.7 miles2) or 135,640 ha] is a significant part of Jamaica's shallow shelf. In comparison, the land area of the PBPA is a bit larger than the area of the Blue Mountain/John Crow Mountain National Park [488.4 km2 (188.6 miles2) or 48,835 ha], and larger than each of the independent nation states of Barbados, Grenada (and its outer islands), Antigua & Barbuda and St. Vincent & the Grenadines.

More than half of the land area of the PBPA is in its natural state, in dry limestone forests [210.3 km2 (81.2 miles2) or 21,025 ha] and wetlands [82.0 km2 (31.7 miles2) or 8,200 ha]. The rest is cultivated in sugar cane, or is used for human settlement. About 50,000 persons live within the boundaries of the PBPA in some forty-four (44) residential communities.

Of the approx. 16,000 fishers in Jamaica, about 4,000 (approximately 25%) are based in the coastal communities of the PBPA, the highest concentration in Jamaica. The vast majority of the households in the PBPA fall at or below the poverty line.

Industrial activity in the PBPA includes portions of four sugar estates (Monymusk, New Yarmouth, Bernard Lodge, and Innswood), several small farming and livestock entities, several limestone mining and sand/aggregate quarrying operations, two international shipping ports (Port Esquivel and Rocky Point), two electricity-generating plants, and a bauxite-alumina plant (ALCOA). With substantial marine and terrestrial areas, hosting industry, commerce and human settlements in close proximity to wilderness ecosystems, the PBPA is a microcosm of an island state in urgent need of sustainable development.

According to the Portland Bight Sustainable Development Area Management Plan (C-CAM, 1999), the development site falls within the industrial zone in the protected area. The proposed site is on abandoned agricultural lands with several old fish ponds, a small mangrove forest and mudflats. The overgrown vegetation, seasonal wetlands, old fish ponds, mudflats and the mangrove wetland provide a habitat for several birds' species including the migratory birds. It should be noted that there is limited literature available on the avifauna in the disturbed areas in the Portland Bight protected area. Most of the works have been done on the Cays, undisturbed dry forest and the wetland areas.

Due to the size and diversity of the PBPA, baseline data is sparse and specific to entities/habitats identified as sensitive and of either national or international significance. Large expanses of the area have no baseline data and only generalizations of the identified ecosystems have been used for designated zoning/land uses guidelines. Several faunal species have been identified either by historical evidence or actual on site observations. This includes the Jamaican iguana, once thought to be extinct, and now was rediscovered in the Hellshire Hills. These hills represent the only known habitat of the iguana and are a dry limestone forest of global significance. This is in stark contrast to Old Harbour Bay an area zoned for industrial activities which includes an Ethanol plant, JEP barges and the JPS Power-plant within disturbed coastal systems. The marine environment in the area has also suffered from severe anthropogenic influences, including dynamiting and over fishing as well as hurricane damage. The coral cays in the bight also suffer from similar pressures but again in contrast are home to important birds, turtles and potentially manatees.

Table 5-50, Table 5-51 and Table 5-52 below summarizes the sensitive areas/habitats, major taxonomic/sensitive faunal groups and the proposed zonation within Portland Bight as outlined in C-CAM (2007) Management Plan, The Draft Three Bays Fish Sanctuary Management Plan (2010) and those documented in the EIA.

The project area is located in an area with disturbed vegetation, giving rise to a habitat of low diversity. That is, of the species of interest identified by C-CAM, only the American Crocodile was found on site. Sensitive ecosystems or those of international significance are also not found in the project area or in the zone of influence. A limited mangrove stand is located along the banks of the Bowers Gully. A mixed seagrass bed and a poor reef community were also observed in the back reef area. These systems are within the zone of influence but can be described as currently having major anthropogenic influences. None of the habitats are expected to be negatively impacted by the project.

Table 5-50 – Sensitive Areas, their locations and inclusion in Project Site and Zone of Influence

Sensitive Areas/Habitat	Location	Project Area	Zone of Influence	Impacts
RAMSAR Wetlands	The wetlands of Portland Bight received international recognition when they were designated Jamaica's 3rd RAMSAR site (i.e. Wetland of international importance) under the RAMSAR Convention for the Protection of Wetlands and Waterfowl on 2nd February 2006.	No	No	None
Dry Limestone Forest	Portland Ridge, Braziletto Mountain, Kemps Hill , Hellshire Hills	No	No	None
Forested Areas	Portland Ridge, Braziletto Mountain, Kemps Hill , Hellshire Hills	No	No	None
Seagrass Beds	Goat Islands, along sections of the Mainland, around sections of the cays	No	Yes	A mixed seagrass bed community was observed in the back reef area- within the zone of influence but can be described as currently having major anthropogenic influences.
Caves	Jackson Bay Caves, Jamaica's most extensive cave system	No	No	
Fish Sanctuaries	C-CAM No fish Zones- Galleon Harbour, Salt Harbour, Rocky Point, Three Bays, West Harbour	No	No	
Reef/Coral Areas	Fourteen (14) Coral Cays,	No	Few coral colonies in a poorly assembled reef area in-	A poor coral reef community was observed - within the zone of influence but can be described as currently

Sensitive Areas/Habitat	Location	Project Area	Zone of Influence	Impacts
			front of the project site	having major anthropogenic influences
Mangrove Areas	Over 30 miles of a mangroves extending from Galleon Harbour, West Harbour, Goat Islands and areas in between Pigeon Island	Yes (few Black Mangrove species located in the project area)	Few Riparian Mangroves line Bowers Gully	A limited mangrove stand is located along the banks of the Bowers Gully- within the zone of influence but can be described as currently having major anthropogenic influences

Table 5-51 - Sensitive Zones, their locations and inclusion in Project Site and Zone of Influence

Biologically Sensitive Zones	Location	Project Area	Zone of Influence	Impacts
Forest Conservation Areas	Peake Bay, Hellshire Hills, Portland Ridge	No	No	None
Wetland Conservation Areas	Extensive mangroves of West Harbour, Clarendon, wetlands between the Cockpit Salt Marsh and Peake Bay, Salt Island Lagoon, Rocky Point fishing beach and Jackson's Bay, Goat islands	No	No	None
Fish Nursery Conservation Areas	Three Bays Fish Sanctuary (Fisheries Division), Galleon Harbour Fish Sanctuary, Salt Harbour (C-CAM)	No	No	None
Wildlife Reserve	Western Cays, Hellshire Hills	No	No	None
Game Reserves	Peake Bay, Cockpit Salt Marsh, including Salt Island and Long and Short Island, Amity Hall mangal, Two Goat Islands and the mangroves joining them	No	No	None

Table 5-52 – Sensitive/Endangered Fauna, their locations and inclusion in Project Site and Zone of Influence

Sensitive/Endangered Fauna	Occurrence/ Location	Project Area	Zone of Influence	Impacts
American Crocodile *(Crocodylus acutus)*	Bowers River, Salt River, Cockpit River, Salt Island Creek, Bower's Gully, Breadnut Gully, Calabash Gully, Coleburn's Gully, Salt Gully, Rocky Point fishing beach and Jackson's Bay	Yes	Yes	Limited- slightly positive- afforded some protection by reduced human access to breeding areas
Hawksbill Turtle *(Eretmochelys imbricata)*	Nests on many of the Coral Cays and Parts of the Mainland	No	No	None
Green Turtle (*Chelonia mydas)*	Nests on many of the Coral Cays and Parts of the Mainland	No	No	None
West Indian Manatee *(Trichecus manatus*)	Historically observed within the Portland Bight	Historically Likely	Historically Likely	None
Magnificent Frigatebirds *(Fregata magnificens)*	Many of the Coral Cays and Parts of the Mainland (e.g. Bowers River, Salt River, Cockpit River, Salt Island Creek, Bower's Gully, Breadnut)	Yes	Yes	None- expected similarity in noise climate to the current state
Brown Noddies *(Anous stolidus)*	Many of the Coral Cays and Parts of the Mainland (e.g. Bowers River, Salt River, Cockpit River, Salt Island Creek, Bower's Gully, Breadnut)	No	Insufficient Data/Literature	Insufficient Data/Literature

Sensitive/Endangered Fauna	**Occurrence/ Location**	**Project Area**	**Zone of Influence**	**Impacts**
Yellow Boa *(Epicrates subflavus)*	Hellshire Hills and Portland Ridge	No	No	
Jamaican Iguana *(Cyclura collei)*	Hellshire Hills provides the last known habitat of the recently rediscovered (1990) endemic Jamaican Iguana (*Cyclura collei*), a globally threatened species and Jamaica's largest native land animal	No	No	None
Thunder Snake *(Tropidophis sp)*	Entirely restricted to Portland Ridge	No	No	None
Blue Tailed Galliwasp *(Celestes duquesneyi)*	Entirely restricted to Portland Ridge	No	No	None
Jamaican Hutia/Coney	Hellshire Hills and Portland Ridge	No	No	None
Jamaican Skink (*Mabouya sloanii)*	Entirely restricted to Portland Ridge	No	No	None
Endemic Cave Frog *(Eleutherodactylus cavernicola*)	Portland Ridge and Jackson Bay Caves	No	No	None
Bahama Mockingbird *(Mimus gundlachii hillii)*	Hellshire Hills and Portland Ridge	No	Insufficient Data/literature	Insufficient Data/Literature
Jamaican Pauraque *(Siphonorhis americanus)*	Last seen more than 100 years ago is rumoured to persist in the Hellshire Hills	No	No	None
West Indian Whistling Duck *(Dendrocygna arborea)*	Within the Portland Bight in particular Salt Island Lagoon, Rocky Point	No	No	None
Fish-eating bat *(Noctilio leporinus)*	Jackson Bay Caves, Jamaica's most extensive cave system	No	No	None

5.2.2 Vegetation

5.2.2.1 Introduction

This report entails the results and recommendations derived from two inland vegetation surveys conducted May 19 & 23, 2012. The report represents the flora component of an Environmental Impact Assessment (EIA) for the construction of a 360 MW electricity generating facility in St. Catherine. The new power plant is considered to be of national importance as it is intended to increase the generating capacity on the island as well as replace approximately 292 MW of inefficient, heavy-fuel-oil class of plants. The 68 MW surplus is projected to allow for increased load demand in the future.

The site is located in southern St. Catherine, due west of the town of Old Harbour Bay and approximately 0.73 km WNW of the existing Jamaica Public Service (JPS)/Jamaica Energy Partners (JEP) facility. The planned footprint for this development occurs on land with mild to poor drainage capacity and encompasses 12.6 hectares, which consists of a mosaic of severely disturbed, secondary-succession vegetation types. These terrestrial communities included a salina that transitioned into a degraded wetland as well as a patchwork of savannah and thorn savannah flora.

The main objective of this survey is to present a detailed description of the terrestrial flora of the area, with special emphasis on rare, threatened, endemic, protected and endangered species. The effects of habitat loss and fragmentation due to construction and operation were also considered and assessed.

5.2.2.2 Methodology

An important part of any vegetation survey is determining the most efficient way to effectively sample the plant community. It would be both impractical and time consuming to survey every metre of a study site in an attempt to take an inventory of every plant species present. Accordingly, two sampling techniques were employed. For highly disturbed and open areas a series of walk-though floral inventories were conducted. During these walk-throughs, the mean vegetation height as well as species composition was noted and later ranked according to a DAFOR[4] scale.

For vegetation located in the north-central section of the study site, where forest structure and composition appeared conspicuously different from its surroundings, the Point-Centred Quarter (PCQ) method was used coupled with a series of walk-throughs. The advantage of using *plot-less*[5] methods, such as the PCQ, rather than standard plot-based techniques (e.g. transects and quadrats), is that they tend to be faster, require less equipment, and usually require less labour (Barbour *et al.*, 1987; Mitchell, 2007).

The PCQ method involved the selection of a random point: the area around which was divided into four 90° quarters according to the directions of a compass. The nearest tree in each quarter was then identified and its height, diameter at breast height (DBH), and distance from the central sample-point, measured. Sample points were determined subjectively using a Trimble GeoExplorer™ 6000 Series GeoXT™ handheld GPS unit, in order to evenly distribute them throughout the stand of vegetation. The data collected from the PCQ surveys was used to help characterise the flora by estimating the absolute density for the phanerophytes present (equation 1).

Equation 1: Absolute density $(\lambda) = \frac{10000}{\bar{r}^2}$ (# of trees/ha). Where $\bar{r} =$ mean distance from all central points.

Virtually all plant species encountered during the field surveys were identified *in-situ* or samples collected and taken to the University of the West Indies Herbarium for later identification.

5.2.2.3 Results and Discussion

The areas surrounding the project site; the Hellshire Hills, Brazilletto Mountains, Portland Ridge and Kemps Hill possess significant stands of dry limestone forest; however, the two proximal areas, Brazilletto

[4] DAFOR occurrence rank: a subjective scale of species occurrence within an area of study. The acronym refers to, **D**ominant, **A**bundant, **F**requent, **O**ccasional, **R**are.

[5] Plot-less methods involve measuring distances for a random sample of trees, typically along a transect, and recording the characteristics of interest for this sample (Mitchell 2007)

Mountains and Helshire Hills, are far removed: approximately 4.5 km west and 10.5 km east of the study site respectively. Furthermore, the site is centred on an alluvial plain and not highland, limestone substratum. These factors, combined with the severity of disturbance observed on-site, have given rise to vegetation that differs notably in stature, structure and composition when compared to the forest flora in the Brazilletto Mountains and Helshire Hills (Halcrowe and Associates, 1998; C-CAM, 1999).

Approximately 3.0 km to the north of the study site is the New Harbour Housing Development, located on lands which were originally occupied by scrub savannah and abandoned pasture (ESL, 2006); vegetation types similar to those existing on the study site. The flora of the surrounding areas was described by the housing development's EIA as being severely disturbed and incapable of providing an easy source of re-colonising constituents (ESL, 2006a). No threatened or endangered plants were found on the site which was primarily occupied by African Star Grass (*Rhynchospora* sp.) and trees such as Guango (*Samanea saman*) and Cashaw (*Prosopis juliflora*).

The closest infrastructure to the study site is the ethanol processing facility at Port Esquivel, which is located approximately 2.3 km to the southwest of the proposed power plant. Environmental Solutions Ltd. (ESL, 2006b) reported that the vegetation was disturbed and consisted of several types such as, coastal mangrove, coastal thorn scrub, salt flat and residential (cultivated) vegetation. The former three communities are similar to what was encountered at the study site; however, in the Port Esquivel EIA, two endemic species were encountered, *Opuntia jamaicensis* and *Hylocereus triangularis* (God Okra).

From the data collected during the survey, the study area could be delineated into three contiguous zones based on the community-types present. There was a degraded Silt Mangrove wetland community towards the southern perimeters of the development site followed by a disturbed Salina. The occurrence of these vegetation types was probably due to their close proximity to the southern coastline, occasional sea inundation and high-saline (clay) substratum. The northern half of the property was occupied by a Thorn Savannah.

Overall, there appeared to be high levels of anthropogenic influence. This was evidenced especially by coppicing (tree cutting) (Plate 5-13), charcoal burning and grazing by domestic livestock. Paths have also been created through sections of the vegetation, indicating repeated human access (Plate 5-14). There were no endemic or endangered plants encountered during the survey.

Plate 5-13 - Evidence of coppicing in a forested section of the study site.

Plate 5-14 - High-tension power line located on study-site (background) and footpath/bicycle-track (foreground).

5.2.2.3.1 The Degraded Wetland

The degraded wetland was located towards the southern perimeter of the study area. This community appeared to be a remnant of the Silt Mangrove community located further towards the coast. The latter vegetation type is typically found on the coastal margins of alluvial plains (Asprey & Robbins 1953). Instances of vegetation clearing were noticed here, possibly accounting for the community's poor species composition and vegetation cover. The Black Mangrove (*Avicennia germinans*) was the only mangrove species encountered and was often associated with *Acacia tortuosa* (Wild Poponax). Mean tree height ranged from 2.5 m – 4 m.

The ground cover was noticeably void of *Avicennia* pneumatophores and several dead mangrove trees were noted in sections further south. The presence of dead mangrove trees may suggest a reduction in the frequency of inundation or overall water availability due to the seaward progression of accrued land and/or increased drainage of the area. The herb, *Eleocharis* sp. was a very common ground-layer constituent (Plate 5-15) as well as the halophytic scrambler, *Sesuvium portulacastrum* (Seaside Purslane). The cactus *Harrisia gracilis* (Torchwood Dildo) was also an occasional constituent (Plate 5-16).

Plate 5-15 - The herb, Eleiocharis sp. (foreground) over dry clay soil and a small stand of Black Mangrove (Avicennia germinans) (background)

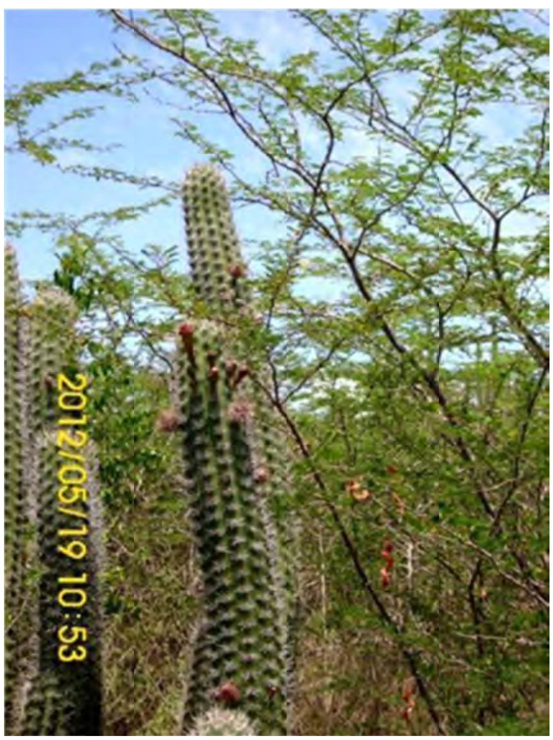


Plate 5-16 - The cactus Harrisia gracilis (Torchwood Dildo) associated with the thorny legume, Acacia tortuosa (Wild Poponax).

5.2.2.3.2 The Salina

As one progressed northward, the degraded wetland quickly transitioned into a Salina (Asprey and Robbins, 1953) or Estuarine Mud Flat (Grossman *et al.*, 1991). Here, the flora consisted mainly of herbaceous, secondary pioneer species that inhabited an area once used for the setup and operation of commercial, inland, fish ponds (CL Environmental, 2007). Several abandoned ponds were yet discernible from recent aerial imagery and existed as poorly defined depressions (pond basins) and banks (pond walls and access ways) at the time of this survey. Since their abandonment, it appeared that the seral reclamation of the ponds was in progress.

The species composition in this region was low but consistent with genera common to such communities. The halophyte, *Batis maritima* (Jamaican Sapphire) and the grass, *Sporobolus* sp. were primary constituents of the pond basins where there appeared to be an accumulation of clay soil (Plate 5-17). The occurrence of *Eleocharis* sp., *Sida acuta* (Broomweed) and *Urena lobata* (Ballard Bush) was also common near the edges and banks of these depressions. The average height of the vegetation was 0.30 m; however, *Acacia tortuosa* trees were conspicuous at 2 – 3 m tall.

Plate 5-17 - Abandoned pond basin populated mainly by Batis maritima (Jamaican Sapphire) and Sporobolus spp. Note presence of Acacia tortuosa trees.

On the pond banks and access ways, *Sporobolus* spp. was more consistent, growing alongside instances of *Sesuvium portulacastrum* and more frequent occurrences of *Acacia tortuosa*. The substrate of these raised areas was more compact and supported a community more prone to grazing and trampling than in the basins. As a result, the average plant height was limited to approximately 0.10 – 0.15 m.

5.2.2.3.3 The Thorn Savanna

The northern regions of the study area consisted mainly of large stands of the thorny leguminous phanerophyte, *Acacia tortuosa* surrounded by several introduced grass species. Expansive swards of *Panicum maximum* (Guinea Grass), *Adropogon* sp., *Cynodon dactylon* (Bermuda Grass) and *Paspalum* sp. were encountered (Plate 5-18, Plate 5-19 and Plate 5-20). Sedges, namely Cyperus spp. and *Rhynchospora nervosa* (Star Grass), and weeds, such as *Bidens pilosa* (Spanish Needle), *Sida* spp., *Asclepias curassavica* (Red Top) and *Rivina humilis* (Bloodberry), were common. Asprey & Robbins (1953) classified this community structure as a Thorn Savanna: a ruinate, secondary community growing on alluvium after burning, cutting and/or continuous grazing.

The substrate was undulating and water tended to collect in small or gentle depressions. In such instances, the occurrence of *Typha domingensis* (Reedmace) and *Commelina diffusa* (Water Grass) were noticeable due to the higher water content of the soil. The thorn savanna also appears to provide a habitat for crabs as several domatia were encountered.

Plate 5-18 - Thorn Savana grassland characterised by the presence of Acacia tortuosa (trees in background). The Guango tree (Samanea saman), in foreground, are occasional constituents of this vegetation type.

Plate 5-19 - Section of the thorn savanna with Sporobolus spp. and Panicum maximum (Guinea Grass).

Plate 5-20 - Section of the thorn savanna dominated by Panicum maximum and Acacia tortuosa.

The flora of the north-central sector was found to be notably different from the surrounding flora. Here, several large stands of *Samanea saman* (Guango) and *Guzuma ulmifolia* (Bastard Cedar) trees were observed (Plate 9). These trees had an average DBH of 52.4 cm and 28.4 cm and an average height of 11.3 m and 6.7 m respectively.

Plate 5-21 - Western section of Samanea saman (Guango) and Guazuma ulmifolia (Bastard Cedar) stand located within the thorn savannah.

Asprey & Robbins (1953) reported that *Samanea saman* was once introduced with cattle from Central America. The trees were planted within or adjacent to pastures along the alluvial plains on the south coast, where the pods were used as fodder. Therefore, the Guango/Bastard Cedar stand may probably be a remnant of the originally planted flora.

The density of the vegetation, here, was quite high and notably so in comparison to the open swards of grassland surrounding this stand (Figure 5-117).

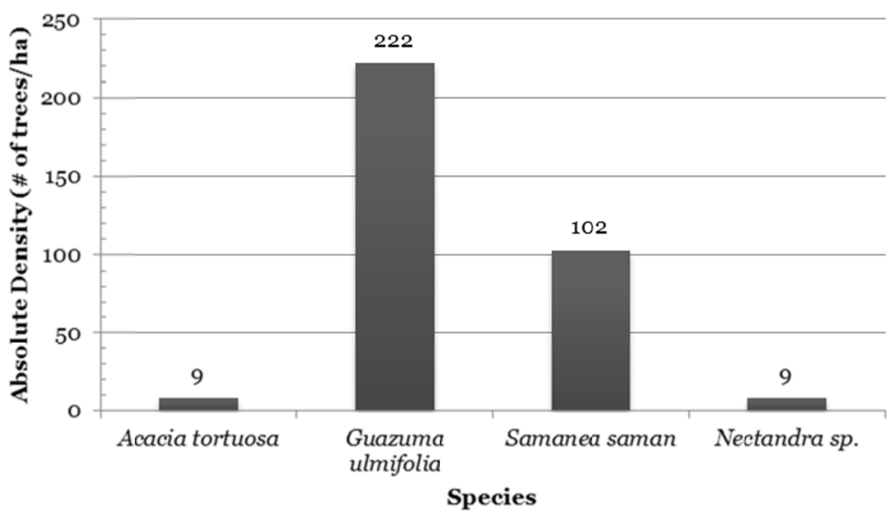


Figure 5-117 - Absolute densities for common trees found in the Samanea saman/Guazuma ulmifolia stand.

Plate 5-22 - A view of the crowded tree canopy of Samanea saman and Guazuma ulmifolia trees limiting light to the forest floor.

Plate 5-22 shows that the Guango/Bastard Cedar stand was a closed forest community with limited light permeating through to the forest floor in some sections. As a result, the shrub component of this stand was quite poor; however, the ground and epiphytic constituents were well represented. Climbers such as *Cissus sicyoides* (Soldier Withe), *Ipomoea* sp. and *Trichostigma octandra* (Basket Withe) were quite common and capable of positioning themselves on other plants to obtain adequate sunlight. Herbs, such as *Achyranthes indica* (Devil's Horse-whip) and *Ravina humilis*, were very common as these species were adapted to the low-light conditions.

Plate 5-23 - View through a section of the Guango/Bastard Cedar community. Note the close proximity of the tree species and the presence of climbers such as Cissus sicyoides and Ipomoea sp.

Owing to the closed nature of the community, soil and ambient moisture were maintained: enough to support lichens and several macrofungi species. Bracket fungi (phylum Basidiomycota) were encountered on decaying wood (Plate 5-24), while several members of the class Agaricomycetes (Toadstools) were encountered on the forest floor (Plate 5-25).

Plate 5-24 - A bracket fungus living on decaying wood on the forest floor.

Plate 5-25 - Pink toadstools (class Agaricomycetes) living on the forest floor among detritus.

A detailed vegetation survey species list can be found in Appendix 10.

5.2.2.3.4 Vegetation along proposed Pipeline Route

Two plant species of importance were encountered along this proposed pipeline corridor. One was the endemic epiphyte, *Hylocereus triangularis* (God Okra), which tended to grow on rarely occurring *Samanea saman* (Guango) trees (highlighted in yellow). The other was the equally rare national tree, *Guaiacum officinale* (Lignum Vitae). The proposed route of the planned waterworks runs parallel (in some instances) with an existing aqueduct/pipeline service and traverses grassland, pasture, grassy waste-places and a salina that was once an active aquaculture farm. These may be considered highly disturbed communities.

The species encountered are listed below in Table 5-53.

Table 5-53 - Plant species within proposed pipeline route

Scientific name	Common name	Growth form
Achyranthes indica	Devil's Horse-whip	Herbs
Batis maritima	Jamaican Sapphire	
Bidens cynapiifolia		
Bidens cynapiifolia	Spanish Needle	
Bidens pilosa	Spanish Needle	
Brassica oleracea	Cabbage (cultivar)	
Capsicum annuum	Sweet Pepper	
Capsicum chinese	Scotch Bonnet Pepper (cultivar)	
Cynodon dactylon	Bermuda Grass, Bahama Grass	
Cyperus sp.	Sedge	
Desmodium sp.		
Eichornia paniculata		
Eliocharis sp.		
Emilia sonchifolia	Lilac Tasselflower	
Euphorbia heterophylla		
Euphorbia hirta		
Gomphrena sp.		
Manihot esculenta	Cassava	
Musa sapientum	Banana	
Panicum maximum	Guinea Grass	
Paspalum sp.		
Priva lappulacea	Clammy Bur, Velvet Bur	
Ruellia brittoniana	Mexican Blue Bell	
Ruellia tuberosa	Duppy Gun	
Sesuvium portulacastrum	Seaside Purslane	
Solanum lycopersicum	Tomato	
Sporobolus sp.		

Scientific name	Common name	Growth form
Sporobolus virginicus		
Stachytarpheta jamaicensis	Vervine	
Tridex procumbens		
Vernonia cinerea		
Antigonon leptopus	Coralita	Runners/ Climbers /Twiners
*Hylocereus triangularis**	God Okra, Prickle Withe	
Ipomoea sp.		
Momordica balsamina	Cerasee	
Mucuna pruriens	Cowitch	
Passiflora maliformis	Sweet Cup	
Phaseolus vulgaris	Red Peas	
Urechites lutea	Nightshade, Nightsage	
Allamanda cathartica	Yellow Allamanda	Shrubs
Euphorbia pulcherrima	Poinsettia	
Harrisia gracilis	Torchwood Dildo	
Kopsia puriformis		
Lantana camara	White Sage, Wild Sage	
Plumbago sp.		
Sida acuta	Broomweed	
Cassia emarginata	Senna Tree, Yellow Candle Wood	Shrub/ Tree
Cordia alba	Duppy Cherry	
Pithecellobium unguis-cati	Privet	
Ricinus communis	Castor Oil Plant, Oil Nut	
Tecoma stans		
Abelmoschus esculentus	Okra	Shrubby Herb
Borreria verticillata	Wild Scabious	
Urena lobata	Ballard Bush, Bur Mallow	
Waltheria indica	Raichie	
Acacia macracantha	Park Nut	Trees
Acacia tortuosa	Wild Poponax	
Ceiba pentandra	Silk Cotton Tree	
Delonix regia	Poinciana	
Guaiacum officinale†	Lignum vitae	
Guazuma ulmifolia	Bastard Cedar	
Haematoxylum campechianum	Logwood	
Leucaena leucocephala	Lead Tree	
Nectandra sp.		
Samanea saman	Guango	
Ziziphus mauritiana	Coolie Plum	

***Endemic**

†National Tree

5.2.2.4 Conclusions and Recommendations

The vegetation present within the study area exhibited high levels of anthropogenic influence, which was evidenced by the secondary community observed. The study has shown that the planned development of the 360 MW power plant would not result in the inadvertent removal of endemic, endangered, threatened or rare species; however, the impact to the flora, especially during the construction phase, may vary.

5.2.3 Fauna

5.2.3.1 Crocodile Survey

The crocodile survey was carried out in the day and night along the bank of the river, Salina and coast on the property for the proposed Power Plant. The survey was not carried out in the mangroves because the vegetation was very dense and there was no water body within or leading to the mangroves. Hence, it was unlikely to find crocodiles in the dense mangrove vegetation.

The day activities entailed documenting the crocodiles seen or their presence in the area, such as tail drags, foot prints and nests (including active and non-active). The potential nesting sites were also noted. The trails for the night activities were cleared, marked with flagging tape and mapped with a Garmin GPS unit.

Crocodiles were identified by the use of the spotlight survey method during the night activities. This is where a spotlight is shown at a crocodile and under low light conditions the eye shine is a distinctive red or white colour. This eye shine can be seen from beyond a hundred metres away under ideal conditions (Sullivan, Holden and Williams 2010). The survey was carried out along the banks of the river, along the coast and within selected areas from sunset at 7:00 p.m. to 8:30 p.m.

5.2.3.1.1 Day Assessment

Coast and Salina

Previous studies within the area have noted the presence of crocodiles in the area, however only daytime surveys were carried out (CLE, 2005; ESL, 2009). No crocodiles were observed in another study by CL

Environmental Ltd. along the shore line and within the Salina habitat. However, the area is known to be frequented by crocodiles for nesting (CLE, 2007).

Bower's Gully, which runs along the western boundary of the proposed site, has been found to have crocodiles. Environmental Services Ltd. in June 2009 observed the presence of crocodiles in Bower's Gully near the mouth but didn't note the presence of nests or hatchlings (ESL, 2009). CL Environmental Ltd. in a different study observed a crocodile in the waters along the shoreline of the present site(CLE, 2005).

In the present study, no crocodiles or their presence (foot prints or tail drag) were observed on the beach, mangrove wetland and Salina on the property. However, on a section of the beach, there was a sand mound, which could have been an old nest or aborted nest. However, it was inconclusive because there were no eggshells present or tail drag. It could also be a hole dug by fishermen who uses the beach regularly (Plate 5-26)

Plate 5-26 - Sand mound found on a section of the beach.

There was a small white sand beach (17° 53.902'N, 77° 6.784'W) which could be an area for crocodiles and possible sea turtles to nest. However this beach is inundated at high tide.

River

Three species of mangroves were identified along the banks of the river: White mangrove *(Laguncularia racemosa)*, Black mangrove (*Avicennia germinans*) and Red mangrove *(Rhizophora mangle)*. The red mangroves were dominant near the mouth of the river and further up the river there was a gradual change to black mangroves and white mangroves.

During the assessment of the river, three crocodile nests were identified (Figure 5-118). The soil type along the section where the nests were found was loose sandy clay loam.

Crocodile Nest 1 (17° 54.033'N, 77° 6.999'W)

The first nest encountered was approximately 5 m from the river and the height of the slide was approximately 1.2 m from the water level (Figure 5-118).

Several freshly hatch egg shells, less than a few days old, were seen in the nest (Plate 5-27). The river was searched and 8 juvenile crocodiles with length of approximately 30 cm (snout to vent) were identified. There were seen swimming between the white mangrove roots in the water (Plate 5-28). The mother was not seen, however it is unlikely that she was very far from the juveniles.

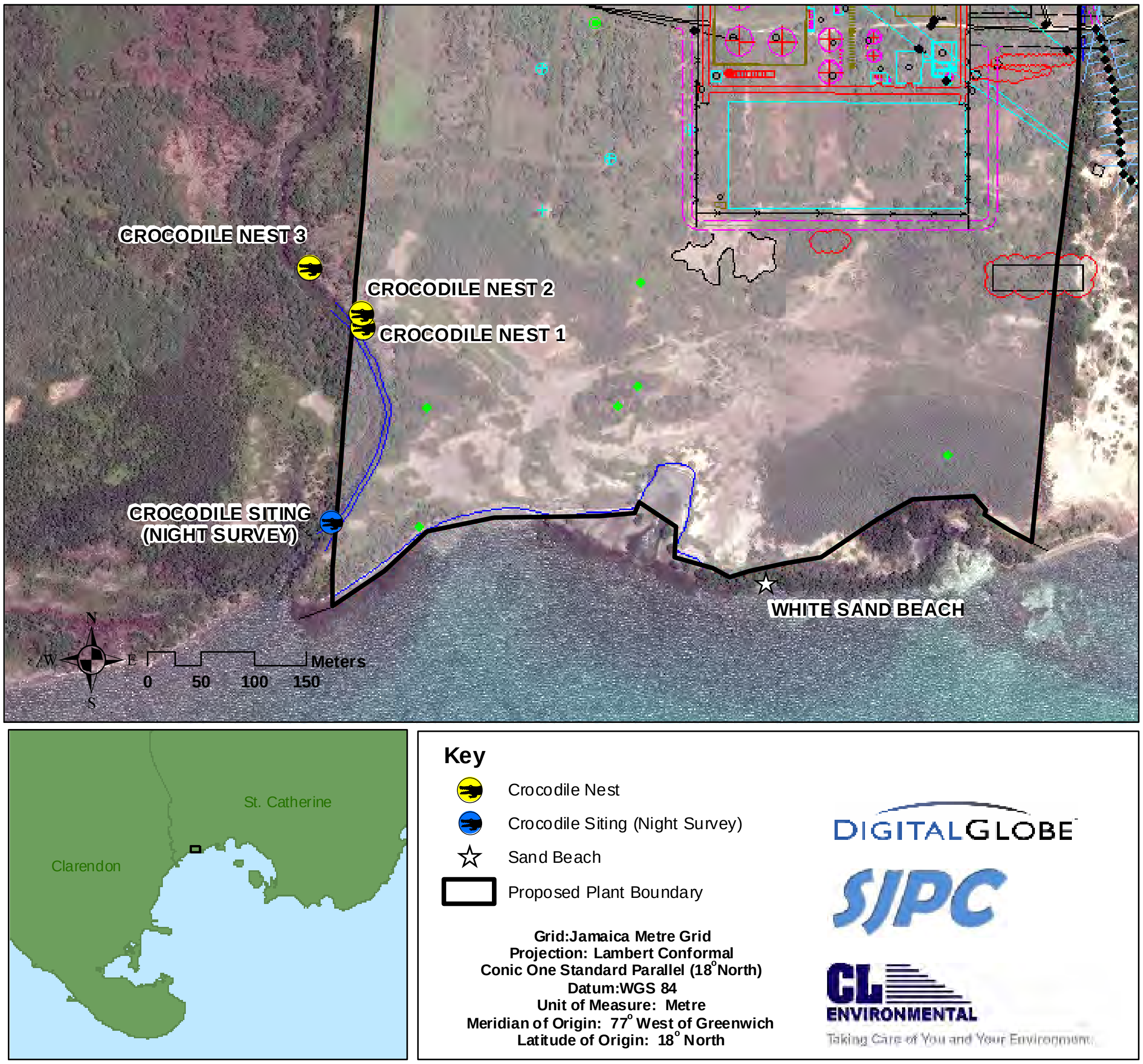


Figure 5-118 - The crocodiles (adult and nestling), crocodile nest identified along the river.

Plate 5-27 - Nest No. 1. Above: View of the area. Below: Nest showing recently hatched eggs.

Plate 5-28 - Juvenile crocodiles swimming at the edge of the river.

Plate 5-29 - Section of the river where juvenile crocodiles were seen (above). Note the extensive damage to the river bank caused by the high level of activity of the mature crocodile in the vicinity of Nest No. 1.

Crocodile Nest 2 (17° 54.040'N, 77° 7.000'W)

There was a mound of soil approximately 15 m from the first crocodile nest and the height of the slide was approximately 1.1 m from the water level. The mound was not excavated because it could have deleterious effect on the nest. In addition, several old nest holes and old egg shells were seen in the area (Plate 5-30)

Plate 5-30 - Nest No. 2 (above) and old nest with old egg shells in the vicinity of the nest (below).

Crocodile Nest 3 (17° 54.063'N, 77° 7.028'W)

The nest was located 10 m from crocodile nest 2 and the height of the slide was approximately 1 m. The crocodile activity at the nest site was very high. Several tail drag marks, not more than a day old, were seen near the hole. The hole could be an abandoned nest or a nest that is currently being excavated. Old eggs shells were also seen in the area, which indicates that several crocodiles breed in the general area.

Plate 5-31 - Nest No. 3, slip way to river (above) and tail marks, foot marks and nest No. 3 (below).

Informal Survey

Three farmers, which were seen on the property, were interviewed about the presence of crocodiles. They all said that they have seen crocodiles at the foundation of the old bridge in the upper section of the river and also near the mouth of the river. They have never seen crocodiles on the coast, although, crocodiles are known to breed in several areas on Hellshire coast.

One of the farmers also indicated that he has seen the crocodiles nesting on the bank of the river while fishing. He also reported that crocodiles are usually caught from the river for food.

5.2.3.1.2 Night Assessment

During the night survey only one crocodile was identified GPS 17° 53.933'N, 77° 7.016'W). It was seen in the river under the red mangrove roots in the river. It was an adult however the size could not be determined.

5.2.3.2 Avifaunal Survey

5.2.3.2.1 Methodology

A modified line transect bird survey method was used for the study along the established trails on the property. The method entailed walking slowly for a given distance along selected routes and noting all the birds seen or heard in the area (Wunderle, 1994). The trails were used as transects due to the size of the area and the easy accessible trails which pass through the different vegetation types. It should be noted that there was no need to create new trails because there was a network of trails on the property; no area was more than a few meters from a trail. In addition new trails would further disturb the fauna in the area. The bird survey was also carried out in the night for the nocturnal bird species.

5.2.3.2.2 Results and Discussion

The acacia woodland/vegetation will provide a habitat for local birds that are present in the protected area such as the Caribbean Dove, Parakeets, Hummingbirds, Jamaican Woodpeckers, Orioles, Warblers and even the Bahamas Mocking Bird, which is only found in the Portland Bight area. Studies have shown that dry forest, acacia forest, and scrubland vegetation are prime habitat for migrant warblers (Douglas, 2002). Of the

200 bird species found on the island, there are 74 winter visitors (Downer & Sutton, 1990). Overall, the migratory birds account for a large number of Jamaica's avifauna, which is almost doubled during winter season from August to May. The bird survey was not conducted in the winter migratory season and the bird species present in the area can only be carried out in a survey.

The old ponds, mudflats, mangrove wetland, coast and the temporary wetland will provide a habitat for wetland birds and several coastal species. Only a few birds were seen in the area during the survey. Portland Bight area is a habitat birds for wetland birds such as the West Indian Whistling Duck (*Dendrocygna arborea*) and migratory wetland birds such as ducks, herons and egrets. Several of the migratory waterfowls and even the West Indian Whistling Duck could be present in the old fish ponds and the areas that flood during wet season. The ponds and the temporary wetland were dry when the survey was carried out. In addition the species present in the areas can only be confirmed with a bird survey.

In a previous EIA, within a similar area to the present study, east of Bower's Gully, CL Environmental Ltd. assessed the avifauna of the wetlands. A roving assessment was carried out for an hour instead of the standard point count method due to the small size of the study site. A total of fourteen (14) species including two (2) endemic species; the Jamaican Mango (*Anthracothorax mango*) and the Jamaican Euphonia (*Euphonia jamaica*) were detected in the survey (CLE, 2005).

Similarly, Environmental Solutions Ltd. conducted an avifauna survey in August 2006 for an EIA for the ethanol plant which lies approximately 1.5 km west of the proposed site. Walking transects were carried out instead of the standard point count method due to the small site area. The presence of thirty five (35) species was detected with most species being found in the wetlands or along the beach. The dominant bird species was the Grey Kingbird (*Tyrannus dominicensis),* whilst only two (2) endemic species were observed; the Jamaican Woodpecker (*Melanerpes radiolatus)* and the Jamaican Vireo (*Vireo modestus*) was observed in the site. These endemics are widespread and are adaptable to many types of disturbed habitats. The only nocturnal bird observed was the Black–crowned Night Heron (*Nycticorax nycticorax*) (ESL, 2006b).

Twenty four (24) species of birds were observed in Salt River Bay by Environmental Science and Technology Ltd. for an EIA in 2005. One (1) endemic species, the Sad Flycatcher (*Myiarchus barbirostris*) was observed on the site with most of the birds observed being typical of a coastal wetland habitat (ESTECH, 2005).

The low diversity of bird species observed within the Portland Bight sites have been attributed to the disturbed nature of the sites (CLE, 2005; ESL. 2006b) and the migratory patterns (ESL, 2006b).

Wetland Coast and Salina

Fourteen birds were observed on the coast, mangrove forest and Salina which include Heron and Egrets (n=7), Pelicans (n=1), Ibises (n=2), Plovers (n=1), Sandpipers (n=1) and Frigate birds (n=1); 10 residents and 4 resident/ migrants (Table 5-54).

The number of wetland birds seen was very low and this could be as a result of the time of the year the survey was carried out. The survey was carried out during the dry season where water levels are low. During the rainy season, the wetland floods and the old fish ponds floods, providing habitats for waterfowls such as ducks, morehens and Coots. The survey was also conducted when the migrant wetland birds have already returned to North America.

Table 5-54 - The wetland birds observed in the study.

Groupings	Proper Name	*Scientific Name*	Status	Type	DAFOR
Herons and egrets	Black-crowned Night Heron	*Nycticorax nycticorax*	Resident	Wetland	R
Herons and egrets	Cattle Egret	*Bubulcus ibis*	Resident	Wetland	O
Herons and egrets	Great Blue Heron	*Ardea herodias*	Migrant Resident/ migrant	Wetland	R
Herons and egrets	Great Egret	*Ardea alba*	Resident/ migrant	Wetland	R
Herons and egrets	Green Heron	*Butorides virescens*	Resident	Wetland	R
Herons and egrets	Little Blue Heron	*Egretta caerulea*	Resident/ migrant	Wetland	O
Herons and egrets	Yellow-crowned Night Heron	*Nyctanassa violacea*	Resident	Wetland	R

Ibeses	Glossy Ibis	*Plegadis falcinellus*	Resident	Wetland	A
Ibeses	White Ibis	*Eudocimus albus*	Resident	Wetland	O
Pelicans	Brown Pelican	*Pelecanus occidentalis*	Resident	Wetland	F
Plover's	Semipalmated Plover	*Charadrius semipalmatus*	Resident	Shore bird	O
Sandpipers	Solitary Sandpiper	*Tringa solitaria*	Migrant	Shore bird	R
Frigatebird	Magnificent Frigatebird	*Fregata magnificens*	Resident	Coastal	O
Warbler	Yellow Warbler	*Dendroica petechia*	Resident	Terrestrial	R

Nb: DAFOR scale used to categorize the birds identified in the study; Dominant (n ≥ 20), Abundant (n= 15 – 19); Frequent (n=10 – 14); Odd (n= 5- 9); Rare (n< 4).

The Semipalmated Plover and the little Blue Heron were seen foraging in the sands in the Salina. There were several areas in the Salina that floods during the rainy season creating temporary ponds.

The Brown Pelican, Magnificent Frigate bird, Semipalmated Plover and the Solitary Sandpiper were seen on the coast. The Semipalmated Plover and the Sandpiper were seen foraging on the coast during low tide and on the coastal mudflats.

Great Egret, Little Blue Heron and Yellow- crowned night Heron were the only birds seen in the river. Birds such as the Coots, Common Morehen or Grebes, which are common in fresh water bodies and rivers, were not seen. It is possible that the flow and the salinity of the river could have been attributing to their absence. It is also possible that crocodile predation in the river is another factor which could attribute to the low numbers of wetland birds in the river.

Terrestrial Species

Twenty nine terrestrial bird species were observed during the survey of the property. The bird species diversity consisted of 10 endemic birds, 1 endemic/ sub species, 15 residents, and 3 migrants. Although the vegetation consists of Acacia scrubland, the birds observed during the assessment are typical of a dry limestone forest (Downer 1990). These birds include Caribbean Dove, Parakeets, Hummingbirds, Jamaican Woodpeckers, Orioles and Warblers. The most common bird species were the White-wing Dove (Table 5-55).

Four of the ten of endemic birds identified in the study are forest specialist. They were located in the upper section of the property, which is mostly woodland vegetation. The woodland vegetation and the forest adjacent to the property provide a habitat for the forest specialist.

Only a few migrant warblers were seen in the study as this was as a result of the time of the year the study was carried out where most of the migrants have returned to North America.

Table 5-55 - Terrestrial birds observed during the survey of the property.

Proper Name	Code Used	Scientific Name	Status	DAFOR
American Redstart	AMRE	Setophaga ruticilla	Migrant	R
Antillean Palm Swift	APSW	Tachornis phoenicobia	Resident	F
Bananaquit	BANA	Coereba flaveola	Resident	O
Black-Whiskered Vireo	BWVI	Vireo altiloquus	(Summer) Migrant	O
Common Ground Dove	COGD	Columbina passerina	Resident	O
Greater Antillean Bullfinch	GABU	Loxigilla violacea	Resident	R
Jamaica Tody	JATO	Todus todus	Endemic	O
Jamaican Euphonia	JAEU	Euphonia Jamaica	Endemic	R
Jamaican Lizard-cuckoo	JALC	Saurothera vetula	Endemic	R
Jamaican Mango	JAMH	Anthracothorax mango	Endemic	O
Jamaican Oriole	JAOR	Icterus leucopteryx	Endemic	O
Jamaican Pewee	JAPE	Contopus pallidus	Endemic	R
Jamaican Vireo	JAVI	Vireo modestus	Resident	O
Jamaican Woodpecker	JAWO	Melanerpes radiolatus	Endemic	O
Loggerhead Kingbird	LOKI	Tyrannus caudifasciatus	Resident	F
Northern Mockingbird	NOMO	Mimus polyglottos	Resident	F
Olive-throated Parakeet	OTPA	Aratinga nana	Endemic sub-species	F
Red-billed Streamertail	RBST	Trochilus polytmus	Endemic	O
Sad Flycatcher	SAFL	Myiarchus barbirostris	Endemic	R
Smooth-Billed Ani	SBAN	Crotophaga ani	Resident	F
Stolid Flycatcher	STFL	Myiarchus stolidus	Endemic	R
Turkey Vulture	TUVU	Carthartes aura	Resident	O
Vervain Hummingbird	VEHU	Mellisuga minima	Resident	O
White Crowned Pigeon	WCPI	Columba leucocephala	Resident	F
White-Collared Swift	WCSW	Streptoprocene zonaris	Resident	O
White-Winged Dove	WWDO	Zenaida asiatica	Resident	D
Yellow Warbler	YEWA	Dendroica petechia	Resident	R
Yellow-faced Grassquit	YEFC	Tiaris olivacea	Resident	F
Zenaida Dove	ZEDO	Zenaida aurita	Resident	O

5.2.3.3 *Invertebrate Survey*

5.2.3.3.1 Methodology

The many roadways and paths across the property were used as transects. Several methods were utilized: direct search for larger species in the field, this included searching habitats such as under stones, logs, bark of trees; sweep nets; and fight nets. Some specimens were identified in the field while others were taken back to the laboratory for identification.

5.2.3.3.2 Results

The fauna was very limited. Fifty four specie of insects, 5 species of spiders and 2 species of land snails were recorded. This was dominated by 14 species of Coleoptera, and 13 Lepidoptera. The dominant Coleoptera was a Cincindellidid (Tiger Beetle) which occurred in swarms on the sandy shoreline. Such large numbers of tiger beetles are not unusual for such environments. The two butterfly species which are restricted to this type of habitat in Jamaica was recorded; these were *Brephridium exilis isophthalma*, the Pygmy Blue, which is the smallest butterfly worldwide, and *Precis evarete*, The West Indian Buckeye, which has a West Indian distribution. Both species have a wide Jamaican distribution.

Table 5-56 - Invertebrate fauna recorded from the survey site, Class HEXAOPDA (Insecta).

Order & Family	Genus & Species	Common Name	DAFOR Ratings	Comments
LEPIDOPTERA				
Pieridae	*Eurema lisa euterpe*	The Little Sulphur	D	Occurs in Antilles, southern Central America to Canada
	Eurema messalina	Fabricius's White Small Sulphur	F	Non-endemic; occurs in Cuba, Bahamas, Cayman
	Ascia monuste	The Antillean Great White	F	Not endemic
	Phoebis sennae sennae	The Cloudless Sulphur	O	Widespread throughout Caribbean
Lycaenidae	*Hemiargus hanno ceraunus*	The Hanno Blue	F	Jamaica or Hispaniola,
	Brephridium exilis isophthalma	The Antillean Pygmy Blue	O	Bahamas, Cuba, Hispaniola, Cayman Isles, Common on sandflats near shoreline
Hesperiidae	*Urbanus proteus*	The Common Tailed Skipper	R	Occurs from southern U.S. to Uruguay, Argentina, West Indies
	1 sp.		R	

Order & Family	**Genus & Species**	**Common Name**	**DAFOR Ratings**	**Comments**
Heliconiidae	*Dione vanilla insularis*	The Tropical Silverspot	A	Occurs in Cuba, Bahamas and Jamaica
Nymphalidae	*Anartia jatrophae jamaicensis*	The Jamaican White Peacock	F	Endemic subspecies
	Precis genoveva	The West Indian Buckeye	A	Common in forest
	Precis evarete	The West Indian Buckeye	D	Common on sandflats near shoreline
Noctuidae	I sp.		R	
DIPTERA				
Tachinidae	1 sp.		F	Quite common in forest
Bombyliidae	1 sp.		F	
Tephritidae	*Toxomerus pulchellus*	Fruitfly	O	
ODONATA				
Libellulidae	*Erythrodiplax berenice*	Skimmer	D	
	Lepthemis vesiculosa		O	
	1 sp.		F	
HEMIPTERA				
Pentatomidae	*Oebalus pugnax*		F	
	1 sp.		R	
Lygaeidae	1 sp.		O	
	1 sp.		R	
	Niesthrea pictipes		O	
Berytidae	2 sp.		R	
Pyrrhocoridae	*Dysdercus andreae*	Love bug	O	
HOMOPTERA				
Cixiidae	1 sp.		A	
Cicadellidae	*Hortensia similis*		R	
	2 sp.		R	
NEUROPTERA				
Chrysopidae	*Chrysopa* sp.		O	
Myrmeliontidae	1 sp.		R	
COLEOPTERA				
Cicindelidae	*Cicindela carthagena jamaicana*	Tiger beetle	D	Swarms on seashore
Chrysomelidae	*Cerotoma ruficornis*		O	
	1 sp.		R	
	1 sp. Alticinae	A Flea beetle	D	

Order & Family	Genus & Species	Common Name	DAFOR Ratings	Comments
	1 sp. Alticinae	Flea Beetle	O	
Coccinellidae	*Scydmus roseicollis*		R	
	1 sp.		R	
	Brachyacantha bistrpustulata		R	
Buprestidae	*Polycesta oliviera*		R	
Cerambycidae	*Oxymerus* sp.		R	
Mordellidae	1 sp.	Tumbling flower Beetle	R	
Scydmaenidae	1 sp.	An Ant-like stone Beetle	O	
Scolytidae	1 sp.	A Bark beetle	R	
Cerambycidae	*Oxymerus* sp.		R	
ORTHOPTERA				
Acrididae	*Orphulella punctata*		F	
	Schistocera sp.		O	
Tettigoniidae	1 sp.		F	
HYMENOPTERA				
Vespidae	*Polistes crinitus*	Paper Wasp	O	
Pteromalidae	2 sp.		R	
Eurytomidae	1 sp.	A Seed Chalcid	R	
Formicidae	3 spp.		O	

Table 5-57 - Invertebrate fauna recorded from the survey site, Class: ARACHNIDA Order: Araneida (Spiders).

Family	Genus & species	Common Name	DAFOR Rating	Comments
Oxyopidae	1 sp.	Lynx spider	R	
	1 sp.		R	
	1 sp.		O	
Thomisidae	1 sp.		O	
Selonopidae	1 sp.		R	

Table 5-58 - - Invertebrate fauna recorded from the survey site, Phylum: MOLLUSCA Class: GASTROPODA

Family	Genus & species	DAFOR Rating	Comments
Helicinidae	*Helicinia neritella neritella*	A	Endemic, shells old, very brittle
Camenidae	*Eurycratera jamaicensis*	R	Endemic; old shell, washed down in river

5.2.4 Bowers Gully

Bower's Gully, which is located west along the proposed site area has water depths exceeding 1.5 meters towards the sea and is affected by tidal influences from the sea. A sediment bar at the mouth of the Gully reduces channel depths to less than 0.5 meters. The influence of the Gully and the sediment type results in water that is very turbid resulting in poor visibility (CLE, 2005; ESL, 2006b and ESL, 2009). Fish surveys in June 2009 by Environmental Solutions Limited within Bower's Gully near the mouth, have yielded the presence of 3 species of fish: Snook, Tarpon and Mangrove Snapper (ESL, 2009).

A freshwater survey of the Bowers River was conducted on October 7, 2012. The water quality, macroinvertebrate and fish communities, and riparian and in stream vegetation were assessed and a list A list of fauna and flora were generated. Based on the physico-chemical and biological data gathered, the river experiences intermittent high salinities as a result of fairly high penetration and mixing of coastal waters with the freshwater environment. This may have implications for the abundance and distribution of fish fauna throughout the Bowers River. However, further sampling is recommended after a period of not less than two months to allow for recovery of the fauna.

Methodology

Four sites suitable for sampling (Figure 5-119) were selected along the Bowers River/Gully. Site 1 was the point at which the Bowers River terminated at the salt flats, an estimated 100 m from the coast. Sites 2 to 3 were selected at approximately 100 m and 200 m upstream from Site 1 respectively. Site 4, located approximately 600 m upstream of Site 1 was used as a reference site. Sampling was conducted on October 7, 2012.

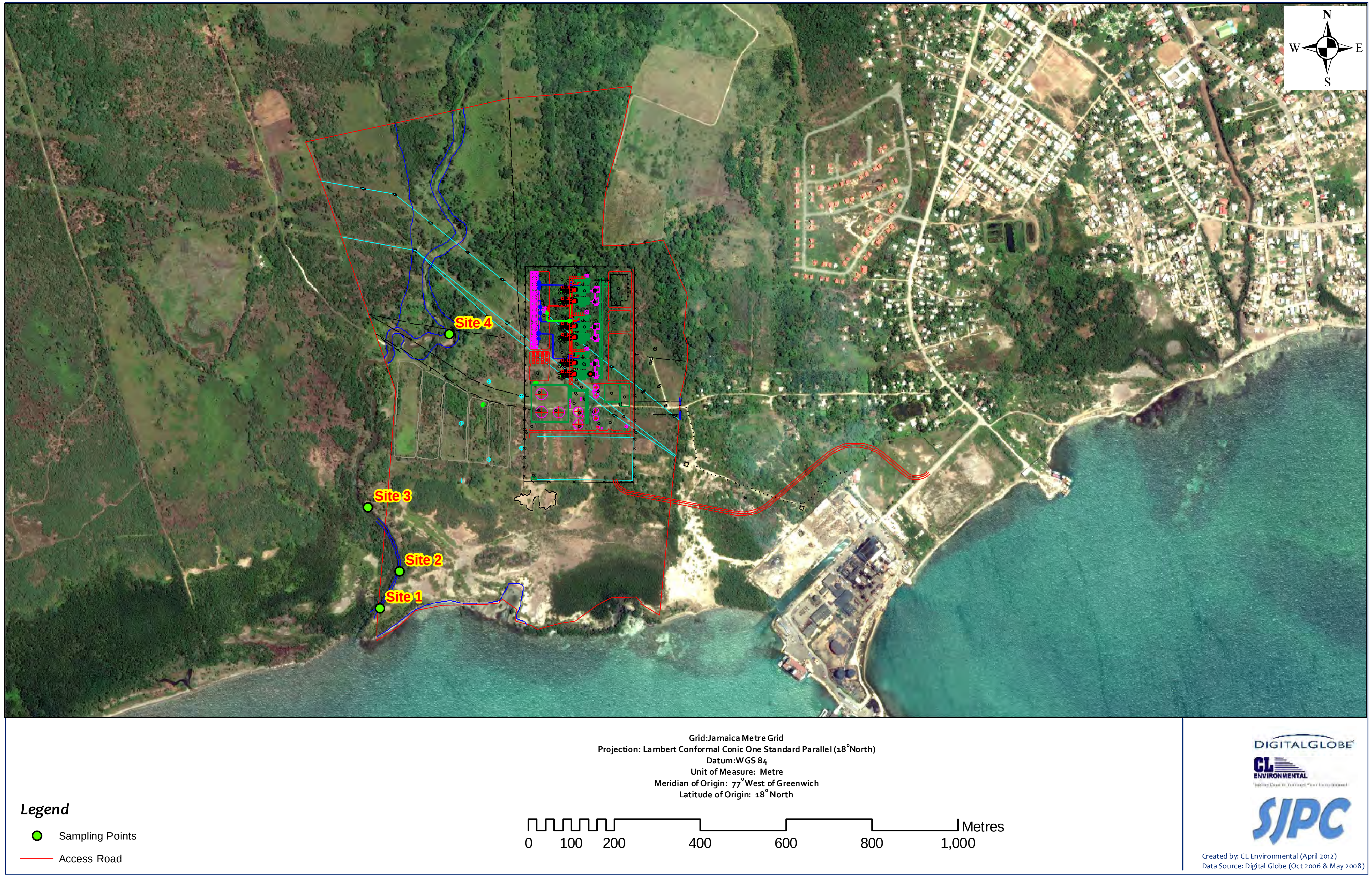


Figure 5-119 – Fresh water ecological study sampling sites

The aquatic resources, namely habitat quality, macroinvertebrate and fish communities, and riparian and in stream vegetation were assessed. A list of fauna and flora were generated through:

- Flora survey – vegetation in the river & riparian zone
- Fauna survey – macro invertebrates and fish species
- Habitat description - physical and biological
- General river substrate assessment and recording the physical conditions and water quality

Habitat Assessments: Habitat assessments were carried out for 15 metre stretches of the river at each sample location. Photographs were taken, and visual assessments made of selected riparian and water quality characteristics. A YSI multiparameter probe was used to assess water quality, with three readings taken at alternate locations within each site.

Macroinvertebrate assemblages: Qualitative sampling (using kick samples with aquatic bottom nets and general surveys – in sediments, vegetation, etc) was utilized. Identification of specimens was conducted to family level – or species level where appropriate. Fishermen's catches (using lines/angling method) were analysed and utilized to generate a taxonomic listing of fish species.

Site Description

The Bowers River exhibits potamonic characteristics for the last 600-700 m of its length (i.e. fine substrate size, relatively deep with slow flow and low gradients) (Plate 5-32 - Plate 5-34).

The 300 m stretch from Sites 1 to 3 is estuarine in nature, with salinity levels close to that of normal seawater. There was no in-stream vegetation. The entire area appears to function as a flood plain and the water mark from the previous week's heavy rains could be seen on the banks up to elevations of 3 m above the current channel. The water at all sites appeared turbid, owing to sediment resuspension resulting from the rains.

At sites 1 and 2, the channel appeared to be mostly unaltered with intact riparian vegetation bordering the river consisting primarily of mangroves, predominantly *Rhizophora mangle*. As the distance from the coast increases, the riparian vegetation changes to Guinea grass (*Panicum maximum*), with occasional stands of Bamboo, as well as Guango (*Samanea saman*), *Acacia* and other trees.

Site 4 exhibited characteristics of a true lotic freshwater habitat. Salinity levels were within the normal range for Jamaican rivers, and the substrate showed an increase from the fine sediments and mud at Site 3 to larger stones. The water regime alternated between fast-flowing riffles and small pools (Plate 5-35).

Plate 5-32 Photograph showing salt flats beyond Site 1

Plate 5-33 Photograph showing general conditions typical of Sites 1 and 2

Plate 5-34 Photograph showing general conditions at Site 3

Plate 5-35 Photograph showing general conditions at Site 4

Results of Freshwater Ecological Survey

The full data set collected is summarized in table 1 below. Based on the physico-chemical parameters, Sites 1 and 2 appeared to exhibit estuarine conditions, with salinity values close to that of normal seawater (and corresponding conductivity values), despite the distance from the coast. In contrast, Site 4, exhibited normal freshwater conductivity and salinity values, while Site 3 exhibited intermediate salinity and conductivity. Temperature was within the normal or expected range for a Jamaican river.

This survey was conducted during the rainy season[6], and immediately after a prolonged bout of heavy rains. As a result of this, the invertebrate fauna of the river, based on the data gathered, was depauperate (as expected, during or after a period of spate). Representatives from only two macroinvertebrate taxonomic groups were found – snails of the

[6] Typically lasting from April to June, and September to November, 2012.

families Thiaridae and Neritidae. Snails tend to be disproportionately represented in samples gathered from flooding rivers due to the stability offered by their shells. Abundance appeared to be very low, and the shells of all the observed snails exhibited damage, presumably the result of mechanical damage from the force of the waters.

The Thiaridae family is a typical inhabitant of freshwater streams, and would therefore be expected at Site 4. However, although freshwater Neritidae are found in rivers, the larval stages generally require saltwater to develop. This involves in-stream migration both down and up the river.

Based on reports of catches the composition of the fish community was fairly typical of a short lowland stream and consisted of several economically important fish species, including snook and snapper, typical of coastal marshes and estuaries, and black perch, which occur widely throughout Jamaican rivers. However, these inferences would be bolstered by additional quantitative data.

Results are shown in Table 5-59 and Table 5-60 below.

Table 5-59 - Physico-Chemical Parameters and Biological Composition of Bowers Gully

Parameter	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Depth (m)	1-4	2-4	1-2	>1
Temperature (˚C)	24.3	23.9	24.2	24.5
Salinity (ppt)	34.16	32.76	7.32	0.19
Conductivity (mS/cm)	54.6	31.2	5.5	0.4
DO (mg/l)	2.94	3.06	4.81	7.09

Table 5-60 Biological Composition of Bowers Gully

Invertebrates	**Site 1**	**Site 2**	**Site 3**	**Site 4**
Gastropods				
Family Thiaridae *(Thiara granifera)*				✓
Family Neritidae *(Neritina punctualata)*				✓
Vertebrates				
Fish				
Oreochromis niloticus (Black Perch)			✓	✓
Centropomus undecimalis (Snook)	✓	✓	✓	
Agonostomus monticola (Mountain Mullet)	✓		✓	

		✓		
Family Sciaenidae (Drum)	✓	✓	✓	
Strongylura sp. (Needle Fish)				✓
Reptiles				
Crocodylus acutus	✓	✓		

Conclusion

Salinity is a measure of all ionic or salt constituents of water (including halides, bicarbonates, and sodium chloride). The Total Dissolved Solids (TDS) is a measure of all the minerals, organic matter, and nutrients dissolved in the water. A decrease in TDS results in a decrease in salinity and vice versa. Sudden or extreme changes in TDS and salinity can be harmful to the aquatic fauna and flora as most organisms require or tolerate a certain range. As Bower's River has estuarine characteristics, there are a range of species from those which prefer predominantly saline conditions (such as snapper), to those which require predominantly freshwater conditions (e.g. Tilapiine species).

Of all the fish species noted for Bowers River in the Freshwater Ecological Survey, however, most can tolerate a fairly wide range of salinity. Generally, lowering TDS may have deleterious effects for those species which require more saline conditions (these may include not only some fish species but also vegetation such as Red Mangrove), resulting in a decrease in the overall productivity of the location. However, the precise impacts will depend on the quantity of the discharge relative to the total flow of the river. For example, the input of a known quantity of treated effluent resulting in a decrease in TDS (and salinity) may have a considerable impact on a small stream and river, but a minimal impact on a large river.

Limitations of Survey

Owing to inclement weather, the fast and heavy flow, sampling was conducted on only one occasion. These challenges also imposed constraints of the methods used for sampling the fish population. The method used for the composition of the fish population of the river provided qualitative data which allows for the generation of a taxonomic listing. This includes ancedotal information from the fishermen in the area. They cited three fish species “Drummer fish, Stoneballs and Shad’. However, the method did not facilitate estimation of population size, numbers or relative abundance of the species. Additional surveys would determine the importance of the river as an extended nursery or habitat for juvenile fish.

5.2.5 Marine Benthic Environment

5.2.5.1 Introduction

The benthic assessment was conducted on 17 May, 2012 between 7 am and 3pm. The weather was sunny with a moderate breeze. The study area extended approximately 2 kilometres, from the shoreline to the reef area (Figure 5-120). Two distinct zones were identified during the survey.

1. Backreef
2. Lagoon

The two distinct zones were surveyed using different methods due to both habitat types as well as environmental conditions.

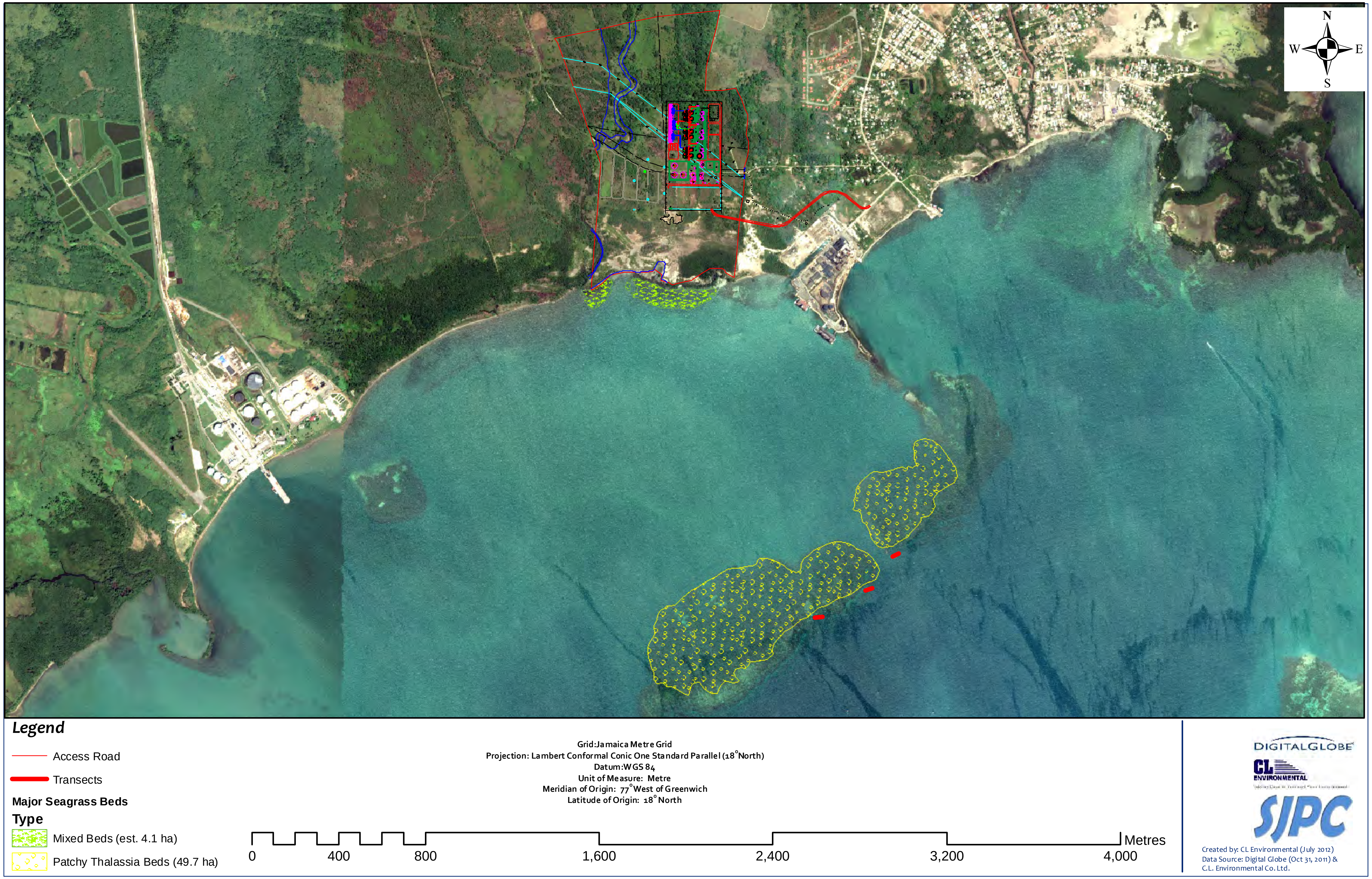


Figure 5-120- Map showing Benthic Study Area with transect locations as well as seagrass areas

5.2.5.2 The Backreef

The backreef is composed mainly of loosely unconsolidated rubble with some amounts of rock. Diversity in the backreef is low, with only eight species of hard coral, six species of fish and few invertebrates. The reef structure was found to be poor with a community dominated by algae instead of coral and very few fish or invertebrates.

5.2.5.2.1 Methodology

Belt transect surveys were used for the substrate and invertebrate assessments. Each transect line was run parallel to the shoreline along the identified reef area between 2.4 m and 3.7 m depths. A total of three 30m x 2m belt transects were conducted for Coral, Invertebrates and Substrate/Algae composition analysis. The reef area had to be identified by using both satellite imagery and in-situ assessment (snorkelling above areas prior to the start of the survey) in order to identify suitable areas. The loose substrate, patchy distribution of rock and rubble along with low visibility determined the survey to be used. The width of the transect line was based on the visibility at the time of the survey and photo transects were not used due to the poor quality of photos and videos in these conditions.

The first 1m band was recorded while swimming along the belt in an east-west direction and the second half along the reverse (west-east). This was conducted in conjunction with the fish survey (this was done for diver safety reasons in a low visibility and high risk environment, known to have Crocodiles and Bull Sharks according to locals).

Fish Surveys followed along the same transect line as the benthic assessments; including the seafloor to surface distance (a cubed area) and began prior to the start of the benthic survey. The fish survey team recorded all fish passing through the transect area for 3 minutes before the other dive team began their survey.

5.2.5.2.2 Results

Coral Community

A fringing reef system was reported approximately 3km from the shoreline (CLE, 2005), but no coral reef communities were observed (CLE, 2005; ESL, 2006b). The area was dominated by seagrass, *Thalassia testudinum*, and macroalgae with mounds of coral heads and coral rubble interspersed throughout (ESL, 2006b).

The coral community occurs in an area of rubble, composed of a combination of *Acorpora cervicornis* and *Porites porites* branches dominated by algae. Some small patch reef formations (very low relief) were also observed in the area.

Much of the unconsolidated substrate is dominated by fleshy algae with the main types being *Sargassum sp.*, *Dictyota sp.*, *Caulerpa sp.* Calcareous algae were less dominant and included *Halimeda spp.* and *Galaxura spp.* and small amounts of turf algae (Figure 5-121).

Table 5-61 - Table showing Algae species and Occurrence

Algae	Class	Occurrence
Sargassum sp.	Phaeophycae	25
Caulerpa sp.	Bryopsidophyceae	10
Dictyota sp.	Phaeophycae	19
Halimeda sp.	Bryopsidophyceae	5
Galaxaura sp.	Rhodophyceae	14
Fleshy Algae		5

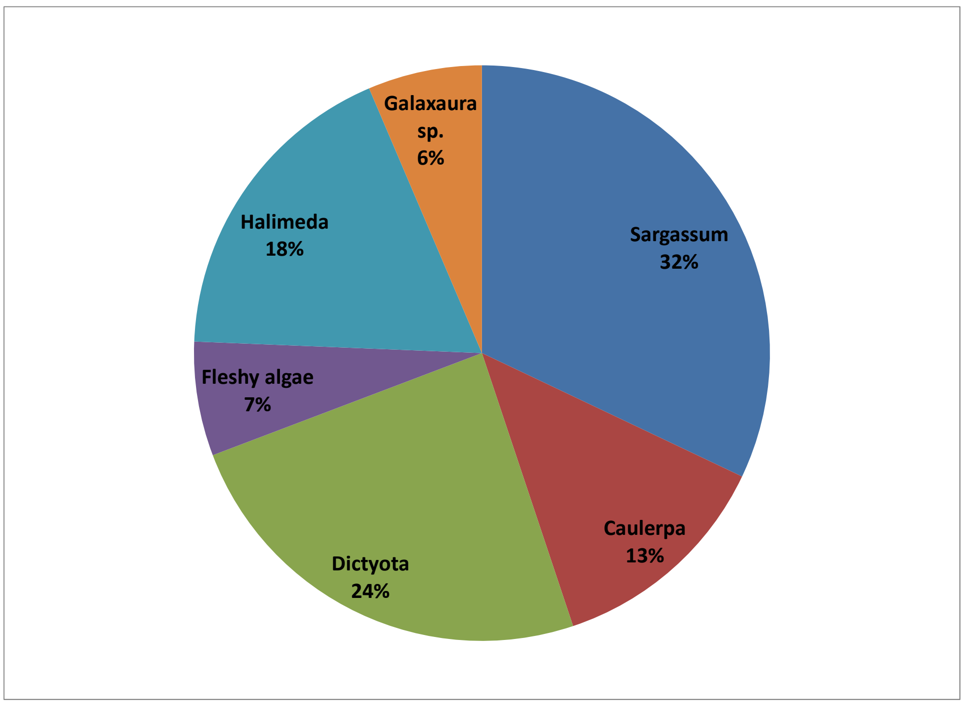


Figure 5-121 - Algal Composition of the Backreef Area

Plate 5-36 and Plate 5-37 show the general reef conditions including the dominant algal species. Some sponges were also seen holding the substrate together (Plate 5-38), however the typical nuisance sponges such as the 'chicken liver' (*Chondrilla nucula*) were not observed.

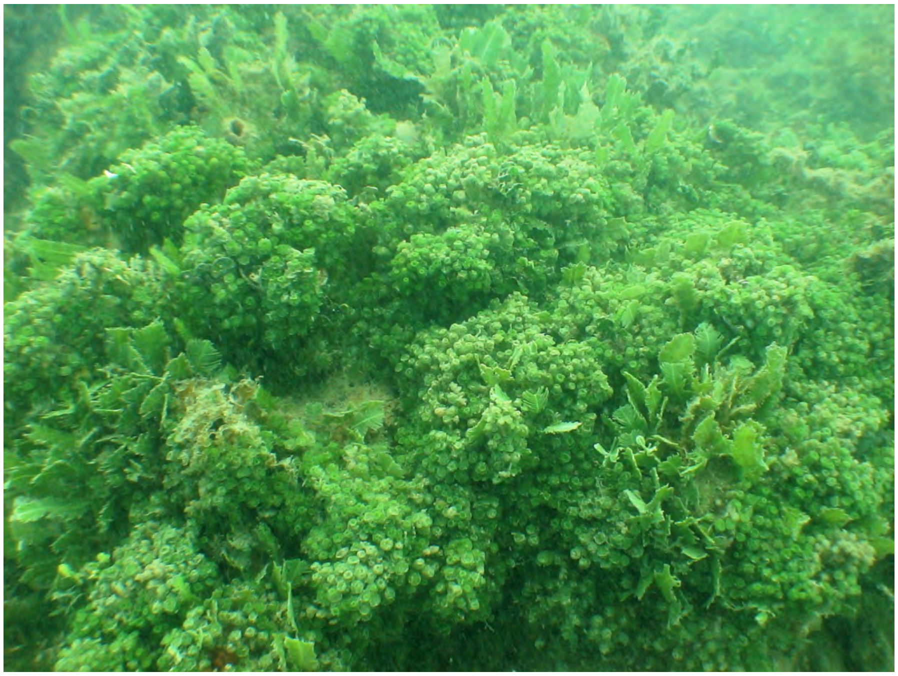


Plate 5-36 - Photo showing Algae covering the substrate (Caulerpa sp.)

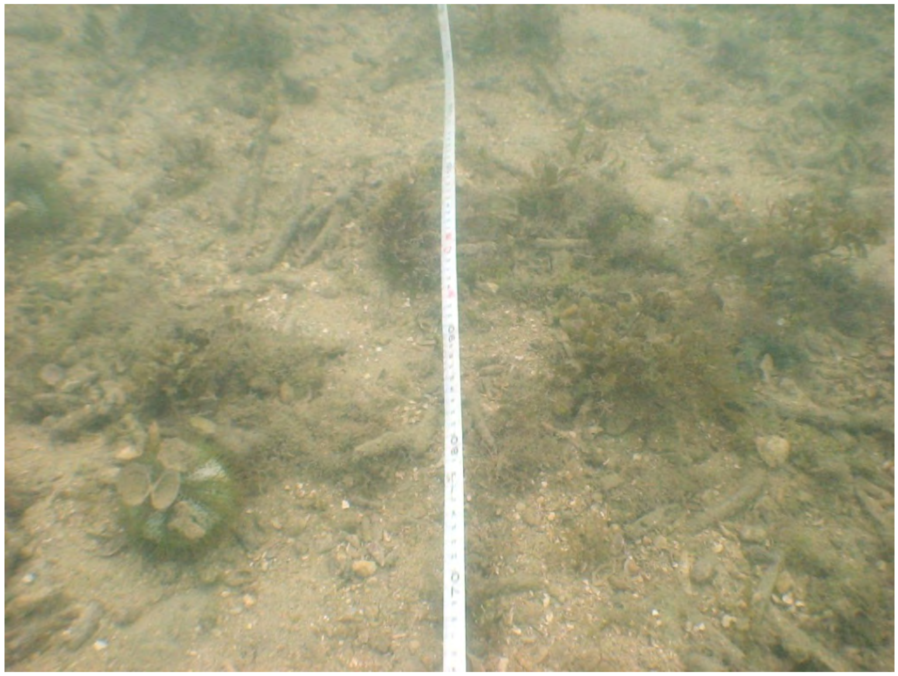


Plate 5-37 - Photo showing a sandy/rubble substrate with some macro algae.

Plate 5-38 - Photo sowing sponges and algae holding the substrate together

A total of seven hard coral species were observed (Table 5-62). These include *Colpophyllia natans, Oculia sp*. (Plate 5-39, Plate 5-40 respectively), *Porites asteroides* sp. (Plate 5-41) *Stephanocenia intersepta* and *Mancinia areolata* and *Montastrea annularis* (Plate 5-43) which was the largest live, hard coral colony observed in the area Gorgonians (Sea whips) along with some seagrasses (*T. testudinum*) were also observed in the backreef area.

The sample area of 90 m^2 was found to be a sufficient sample area for hard corals (Figure 5-122).

Table 5-62 - Table showing the Hard Coral Species observed in the area

Species	**Family**	**Frequency**	**Relative abundance (%)**
Oculina sp.	Oculinidae	5	11.36
Porites asteroides	Poritidae	5	11.36
Stephanocoenia sp.	Astrocoeniidae	8	18.18
Favia sp.	Favidae	1	2.27
Mancinia sp.	Favidae	21	47.72
Montastraea annularis	Favidae	3	6.82
Colophyllia natans	Favidae	1	2.27

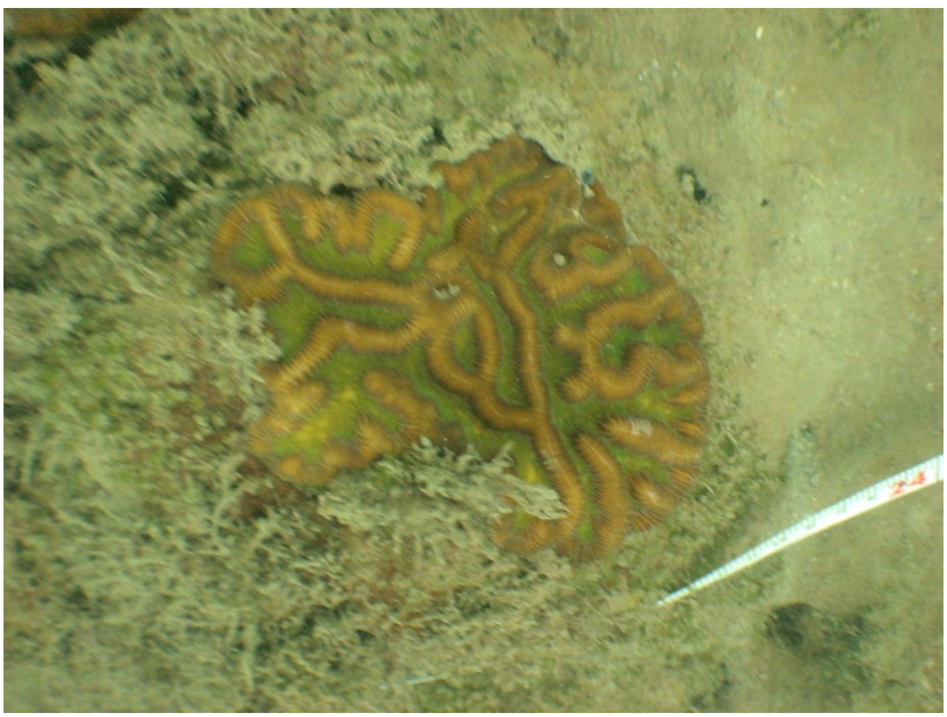


Plate 5-39 - Photo showing Colophyllia sp.

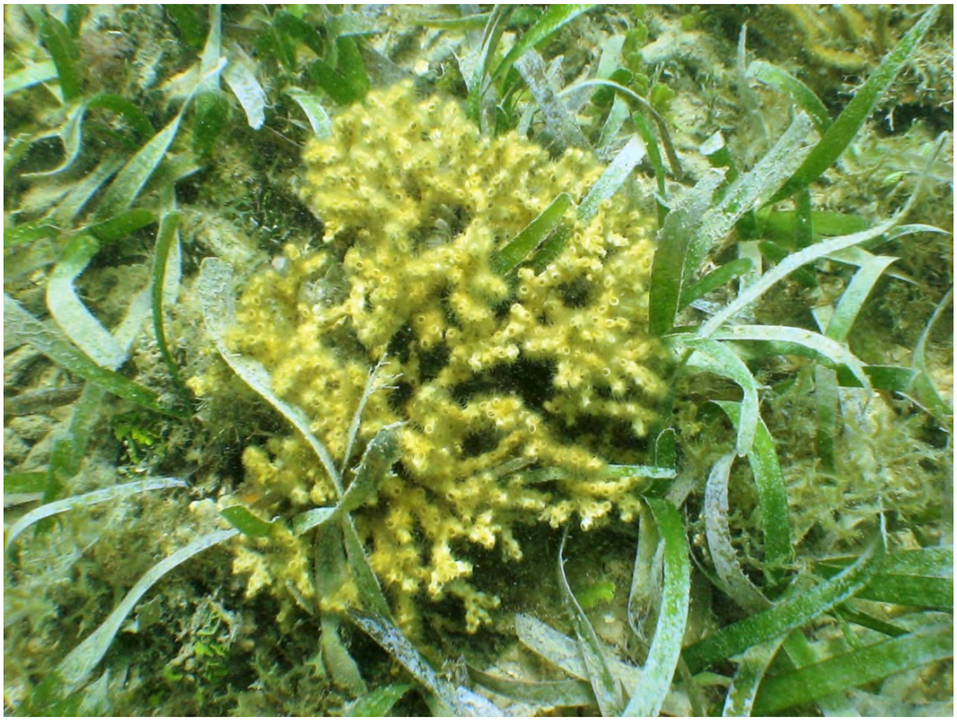


Plate 5-40 - Photo showing Oculina sp.

Plate 5-41 - Photo showing Porites asteroides.

Plate 5-42 - Photo showing Stephanocenia sp. and Mancinia sp.

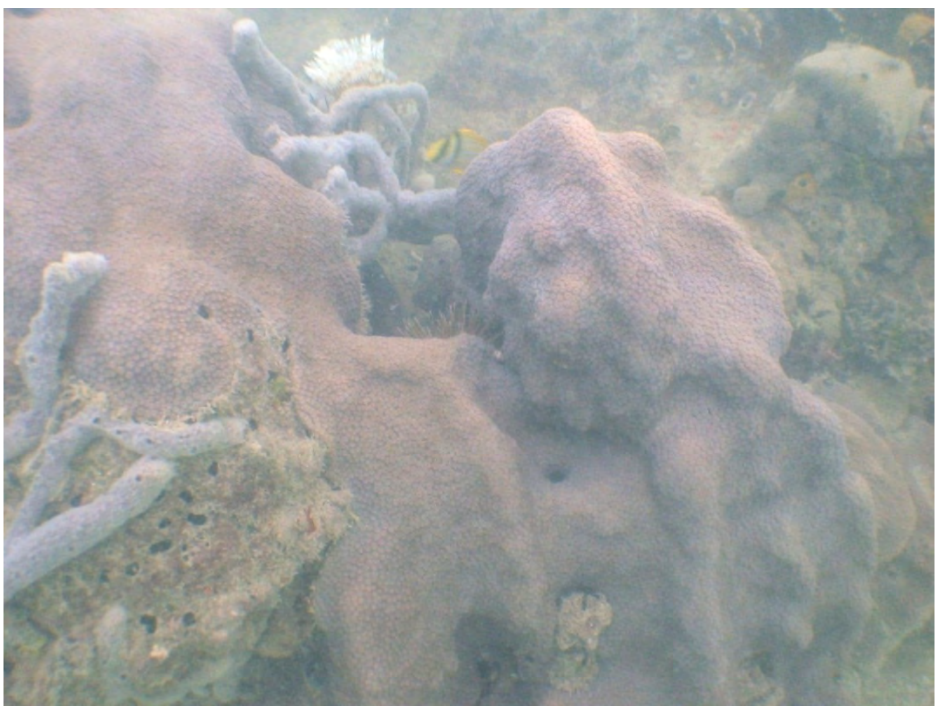


Plate 5-43 - Photo showing Montastrea annularis colony

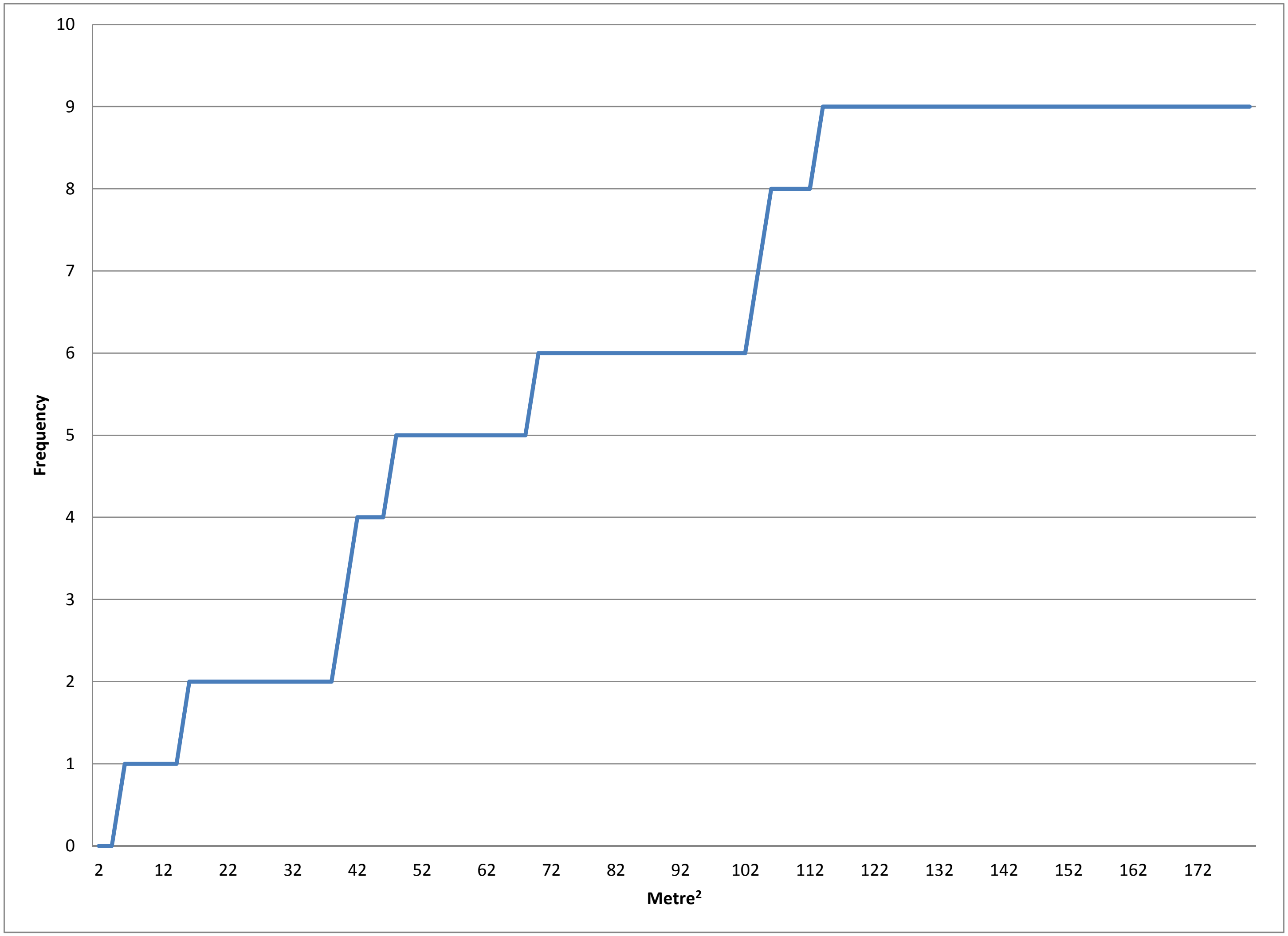


Figure 5-122 - Species Area Curve for Hard Coral Species in the Study Area

The results are similar to other surveyed reefs in the area. According to the 2005 JCRMN[7] (Jamaica Coral Reef Monitoring Network) report, The Portland Bright Protected Area (PBPA) consists of a marine area (approximately 70% of the PBPA) and has widespread coral reefs associated with the 16 cays and several shoals (Linton et al., 2003). Extensive surveys were conducted by the JCRMN in conjunction with CCAM during 2004 and 2005 at nine sites associated with the cays and shoals. The results from these assessments showed variable hard coral cover ranging from 0% to 34% with a mean of 20%. Between 8 and 13 coral species were identified and the most common species were those of *Porities spp* and *Montastrea spp*. At the site with no hard coral present the substrate was dominated by algae (48%). These results are similar in the study area which is an algal dominated reef with low hard coral cover and diversity.

The reef appears to have suffered severe damage as a result of natural and anthropogenic impacts, including wave damage during storms and hurricanes, possible dynamiting, nutrient loading and unsustainable fishing practices. The reef has shifted from a coral dominated reef to an algal dominated reef, resulting in the low coral cover and low species diversity. No disease or bleaching was observed during the survey. The poor substrate condition makes the settlement/recruitment of coral larvae difficult, that is unconsolidated substrates are not ideal for coral recruitment compounded by the large algal mats, sponges and other encrusting organisms which prevent the settlement of larvae. Crustose coralline algae were observed but the occurrence was low. Encrusting coralline algae makes a more suitable environment for coral recruitment.

Fish Community

In 2001, a Preliminary Assessment of Nearshore Fishable Resources of Jamaica's Largest Bay, Portland Bight was conducted. Samplings of mangrove, seagrass (*Thalassia*, *Syringodium* and *Halodule*) and nearshore sandy habitats over 13 months in Jamaica's largest bay, which included Galleon Harbour (and its associated Fishing Sanctuary established in 2010), were conducted. A total of 98 species were found within the Bight with sites in the east having higher species richness than

[7] 2005, JCRMN Report

the sites in the west of the Bight, despite nearly identical ecology and phys-chemical characteristics. This was confirmed with the Jaccard coefficient of similarity, with Manatee Bay and Galleon Harbour on the east side being most similar in diversity and the western sites being similar. Manatee Bay westward through to Galleon Harbour had a mean species number of 32 (±2.4) species, whereas the Cays sites had only 8 species. Sites along the east side of the Bight had relatively less diversity with 15 species being found (Aiken et al., 2002).

Table 5-63 - Species found at Manatee, Coquar, and Galleon Harbour 12 months apart, indicating nursery role (Aiken et al., 2002)

Species	Common Name
Anchoa lyolepis	Dusky anchovy
Archosargus rhomboilalis	Sea bream
Sparisome chrysopterum	Redtail parrot
Eucinostomus gula	Silver jenny
Selene vomer	Lookdown jack
Gerres cinereus	Yellowfin mojarra
Caranax latus	Horse-eye jack
Ocyurus chrysurus	Yellowtail snapper
Haemulon sculurus	Bluestriped grunt
Sphyraena barracuda	Great barracuda
Lutjanus apodus	Schoolmaster snapper
Odontoscion dentax	Reef croaker
Bothus lunatus	Peacock flounder
Lutjanussynargis	Lane snapper
Acanthurus chirurgus	Doctorfish
Sphoeroides spengleri	Bandtail puffer
Penaeus spp	Marine shrimp

Portland Bight has been identified as a nursery along the mangrove-seagrass interface due to the presence of juveniles at all times during a 12 month period. Galleon Harbour was identified as a Critical Habitat and as a nursery, with a special note being made of the fact that the muddy areas near Galleon Harbour had adult and juvenile marine commercial shrimp in larger numbers than elsewhere in this study (Aiken et al., 2002).

Environmental Solutions Limited reported the presence of juvenile fish at their offshore sites which comprised mainly of damselfish and parrotfish. These sites were characterized as seagrass meadows comprised solely of

Thalassia testudinum, with interspersed macroalgae and are used for feeding, and as nursery grounds for juvenile development (ESL, 2006b)

In the present study, the reef fish diversity was also low and several small fish were observed. Table 5-64 shows the species present, the size class, developmental stage and the feeding habit. Figure 5-123 shows the trophic level distribution of the fish types observed.

Table 5-64 - Table showing a summary of the Fish Survey

Fish	Genus/Family	Frequency		Adult/ Juvenile	Feeding Habit
		≤5cm	≥10cm		
Dusky damselfish	*Stegastes adusus*	8		A	Herbivore
Threespot damselfish	*Stegastes planifrons*	1		A	Herbivore
Surgeon Fish	Acanthuridae	1		A	Herbivore
Parrot fish	Scaridae	4	4	J	Herbivore
Wrasse	Labridae	5		A	Omnivore
Remora	*Echeneis neucratoides*		1	J	Planktivore

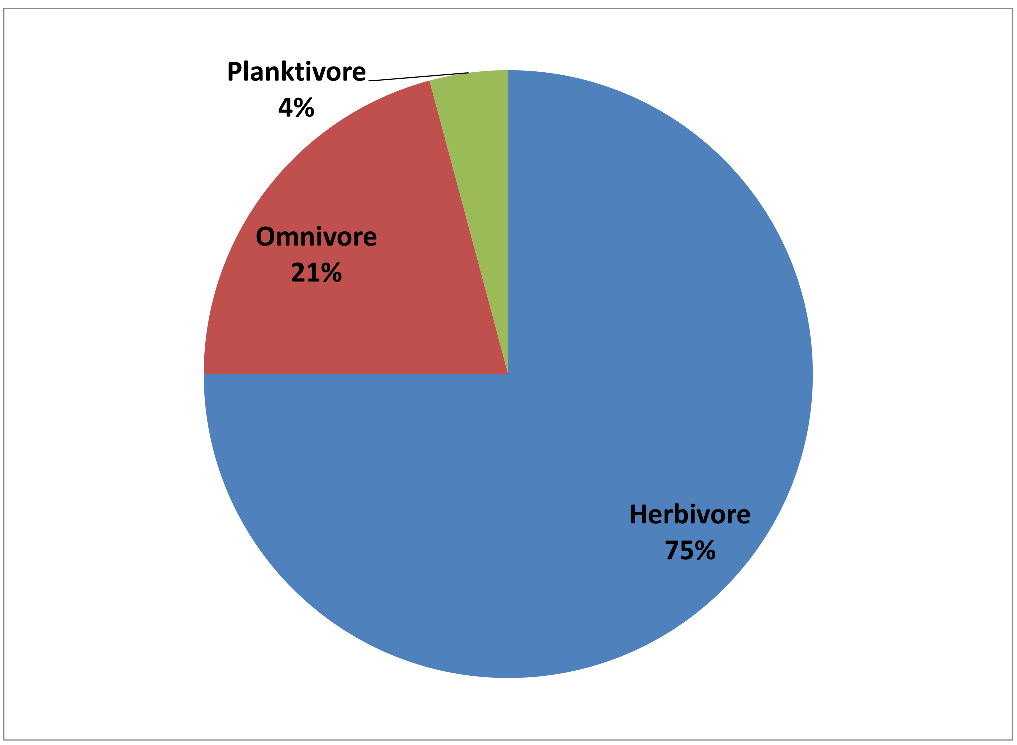


Figure 5-123 - Trophic Level Composition of the Fish Community

The numbers of fish observed were very low and most of these were small adult herbivores suggesting that the reef and surrounding areas are heavily fished and much of the nursery function of the habitat is either gone or severely reduced. Damselfish were the most abundant while surgeonfish and wrasses were the least abundant.

Invertebrate Community

Invertebrates were surveyed along with the substrate survey belt transect. Invertebrates seen in the backreef include star fish (*Oreaster sp.*), sea cucumbers such as Donkey Dung (*Holothuria mexicana*) and sea urchins (*Echinometra* sp and *Lytechinus* sp.).

Table 5-65 - Invertebrate Frequency and Classification

Invertebrates	**Frequency**	**Characteristics**	**Class**	**Main Diet**	**Frequency in *Thalassia* dominated Areas**
Lytechinus sp	78	Collector Urchin	Echinoidea	Algae, Seagrass	11
Echinometra sp	65	Rock Boring Urchin	Echinoidea	Algae	3
Starfish	16	Predators	Asteroidea	Slow moving organisms	1
Sea Cucumber	4	Scavengers	Holothuroidea	Organic Debris	0
Brittle Star	1	Scavengers	Ophiuroidea	Organic Debris	0

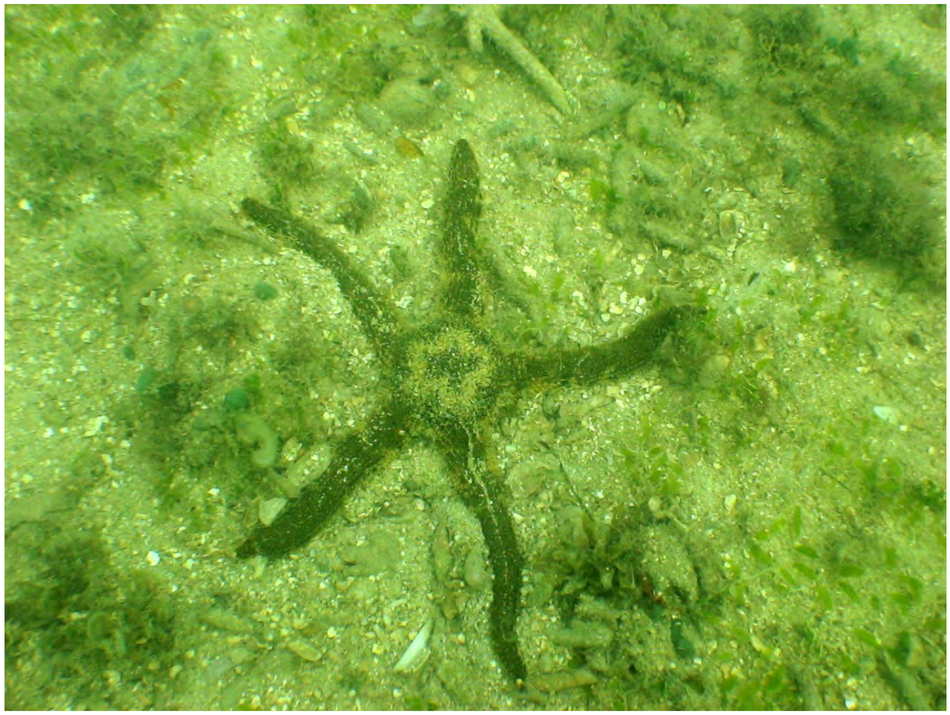


Plate 5-44 - Photo showing Brittle Star

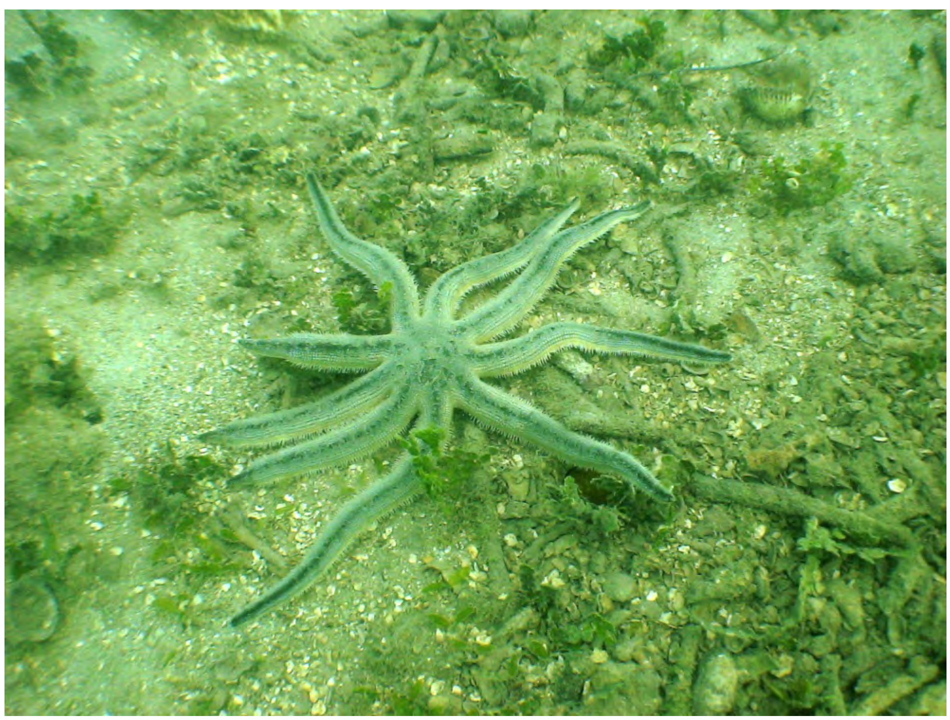


Plate 5-45 - Photo showing Starfish

Plate 5-46 - Photo showing Starfish

Sea urchins (*Lytechinus* and *Echinometra*) were the most abundant invertebrate observed (Figure 5-124), followed by starfish, sea cucumbers and brittle stars which had the lowest occurrences. No commercially important species were observed (lobster or conch) and no *Diadema antillarium* were seen in the study area. Jones (2006) reported that invertebrate diversity is generally low but parrotfish were abundant at most sites in the Reef Check surveys of 2004-2005.

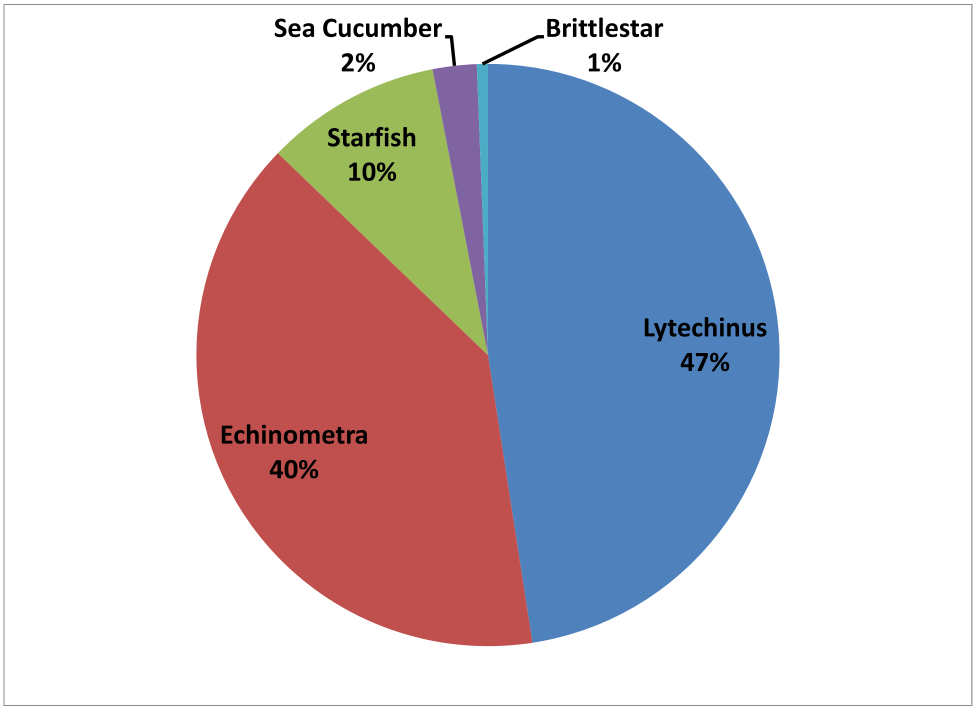


Figure 5-124 - Invertebrate community composition (relative invertebrate presence along transect)

Reefs play an important structural role in shoreline protection as well as providing habitat, nursery and foraging ground for fish and many other animals. However the reef community and structure in the study area is severely affected. With low diversity in all communities (corals, fish, invertebrates), the reef has experienced a phase shift from a coral dominated community to an algal dominated one. Coral colony size was generally small with some typical backreef species present. The substrate is also largely unconsolidated, making coral recruitment very difficult. The fish and invertebrate communities have both very low population sizes along with very low diversities. The functionality of the reef system is significantly reduced and the recovery reef community would require drastic changes.

No commercially important fish or invertebrate species were observed. No invasive species were seen (*Pterois volitans/miles*-Lionfish *or Perna viridis* – Green Mussel).

5.2.5.3 Lagoon

The lagoon area lies directly behind the reef. A patchy distribution of seagrass was observed, extending towards the shoreline (Figure 5-120).

This area is characterised by low visibility and soft/muddy substrate with mixed seagrass types.

5.2.5.3.1 Methodology

Surveys were conducted on 17 May, 2012 between 11 am and 3 pm, using a VideoRay Remote Operated Vehicle (ROV) and visual surveys. The ROV was used in the lagoon area due to the low visibility caused by siltation from the Bowers Gully and other operations in the area. This area is also known to have large crocodiles, making diving or snorkelling unsafe.

The ROV was used to estimate both the limits of the seagrass beds as well as the composition. Visual surveys were conducted along the shoreline; estimating the limits of each bed and the species composition. Anecdotal information about the location of other patches of seagrass was also used during the survey. This was useful when visual confirmation was impossible.

The ROV was allowed to sit on the bottom of the sea floor for short periods of time in-order to capture video and or images of any possible fauna in the area.

5.2.5.3.2 Results

The mixed bed area of seagrasses along the shoreline of the proposed site was identified with an estimated area of 4.1 hectares. In contrast, ESL found very small patches of seagrass seagrass (*Thalassia testudinum* and *Syringodium filiforme*) in front of their site, approximately 1.5km west of the present study site. The patchy distribution of *Thalassia testudinum* seagrass immediately behind the reef area had an estimated area of 49.7 hectares (Figure 5-120).

Directly behind the reef, *T. testudinum* occurs in a patchy distribution on a rockier substrate (Plate 5-47). Moving northwest, towards the shoreline the sediment type changes becoming more muddy and silty. The mud-flat area consists of very small patches of algae but shows signs of several burrowing animals, mainly worms (Plate 5-48). It was unclear as to the full extent of the seagrass as visibility decreases significantly towards the shoreline (Plate 5-49and Plate 5-50). Using video and images obtained from the ROV, the dominant seagrass observed appeared to be *Thalassia testudinum*, with a smaller percentage of *Syringodium filiforne* also present in the southern beds while mixed beds account for majority of the major beds (Plate 5-51) *S. filiforne* begins to dominate approaching and along the shoreline (Plate 5-52 and Plate 5-53). This poor visibility is possibly due to sediment from the fresh water tributaries along the coastline and the general high turbidity in the area due to wave action.

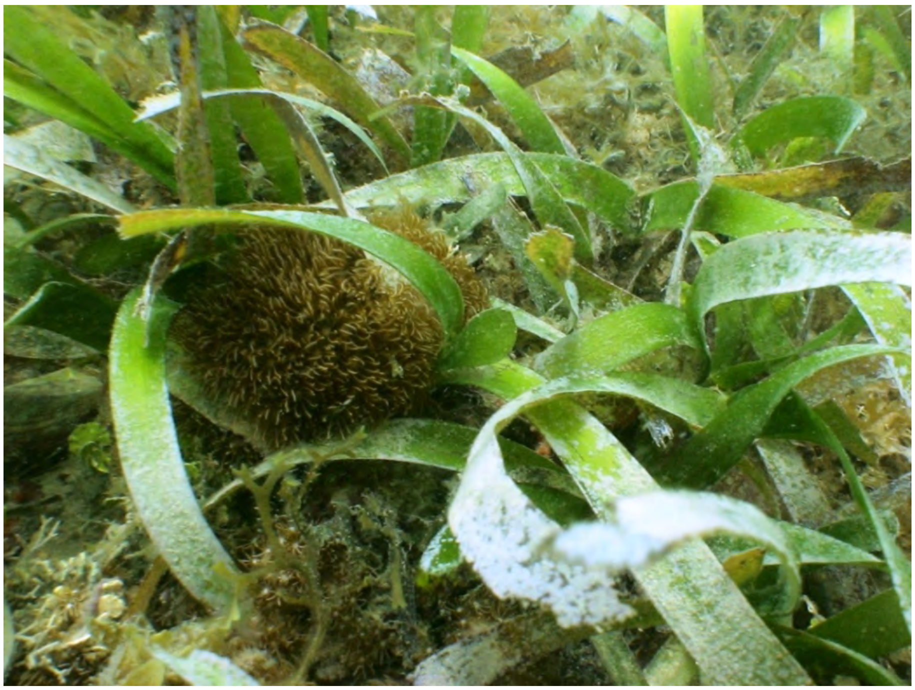


Plate 5-47 - Photo showing Seagrass mixed with Algae and a Soft Coral in the Lagoon

Plate 5-48 - ROV Photo of muddy substrate with burrow holes made by animals in a low visibility area

Plate 5-49 - ROV Photo of T. testudinum in a low visibility area

Plate 5-50 - ROV Photo of S. filiforne in a low visibility area

Plate 5-51 - ROV Photo of a patchy distribution of T. testudinum and S. filiforne in a low visibility area

Plate 5-52 - Photo of a patchy distribution of T. testudinum and S. filiforne along the shoreline

Plate 5-53 - Photo of a patchy distribution of T. testudinum and S. filiforne along the shoreline

5.3 HERITAGE AND CULTURAL SITES

The Jamaica National Heritage Trust (JNHT) conducted an Archaeological Impact Assessment (AIA) on the site of the proposed South Jamaica Power Company Limited (SJPC) 360MW Power Plant. The field survey was conducted over a 2 day period, May 16 and 17, 2012.

Historically, the area contains historic and archaeological sites dating back to Jamaica's first known inhabitants (The Taíno) and later those who came the Spanish, the Africans and the British. The area has seen various land uses over the past centuries. Cattle rearing were the main activity in the area during pre and post emancipation periods. It should be noted that all the plantations, pens and estates in the area had plantation houses and enslaved villages. In the more recent past aquaculture was done on some areas of the property.

Currently the section slated for development is in ruinate with charcoal burning occurring.

No pre-historical or historical cultural material or feature was observed in the area designated for the construction of the plant. It is worth noting, however, that survey of the area was restricted by the dense vegetation cover. Pre historical cultural material in the form of pottery sherds, both Spanish and English bricks and concrete troughs associated with cattle rearing were found to the immediate east and west of the site. Detailed results of the assessment may be found in the accompanying Archaeological Impact Assessment report.

5.4 HUMAN AND SOCIAL

5.4.1 Introduction

The Social Impact Area (SIA) for this study was demarcated as three (3) kilometres from the proposed plant location (Figure 5-125). By means of the socio-economic data, an understanding of the SIA population can be gleaned and used to develop an appreciation for the potential impacts of the proposed project.

5.4.2 Methodology

Socio-economic data including population, education, fuel, garbage disposal, housing and sewage disposal data were extracted from the STATIN 2001 Population Census database for the SIA by enumeration district. This was undertaken using Geographic Information Systems (GIS) methodologies, which were also used to derive visual representations of the data. The Census data forms the basis of the information presented in subsequent sections.

In order to derive information from the census data the following computations were made:

- Population growth - was calculated using the formula [$i_2 = i_1 (1 + p)^x$]; where i_1 = initial population, i_2 = final population, p = actual growth rate and x = number of years.
- *Population density* – was derived by dividing the population by the land area. This is useful for determining the locations of greater concentrations of population.
- *Dependency ratio* – was calculated using the formula [child population + aged population /working population X 100], where the child population is between ages 0-14, the aged population is 65 & over and the working population is between ages 15-64 years. This ratio is useful for understanding the economic burden being borne by the working population.
- *Male sex ratio* – was calculated by using the formula [male population / female population X 100]. This in effect denotes the amount of males there are to every 100 females and is useful for determining the predominant gender in a particular area.
- *Domestic water consumption* - was calculated based on the assumption that water usage is 227.12 litres/capita/day and sewage generation at 80% of water consumption. Water consumption for workers in Jamaica is calculated at 19 litres/capita/day and sewage generation at 100% water consumption.
- *Domestic garbage generation* - was calculated at 4.11 kg/household/day (National Solid Waste Management Authority).

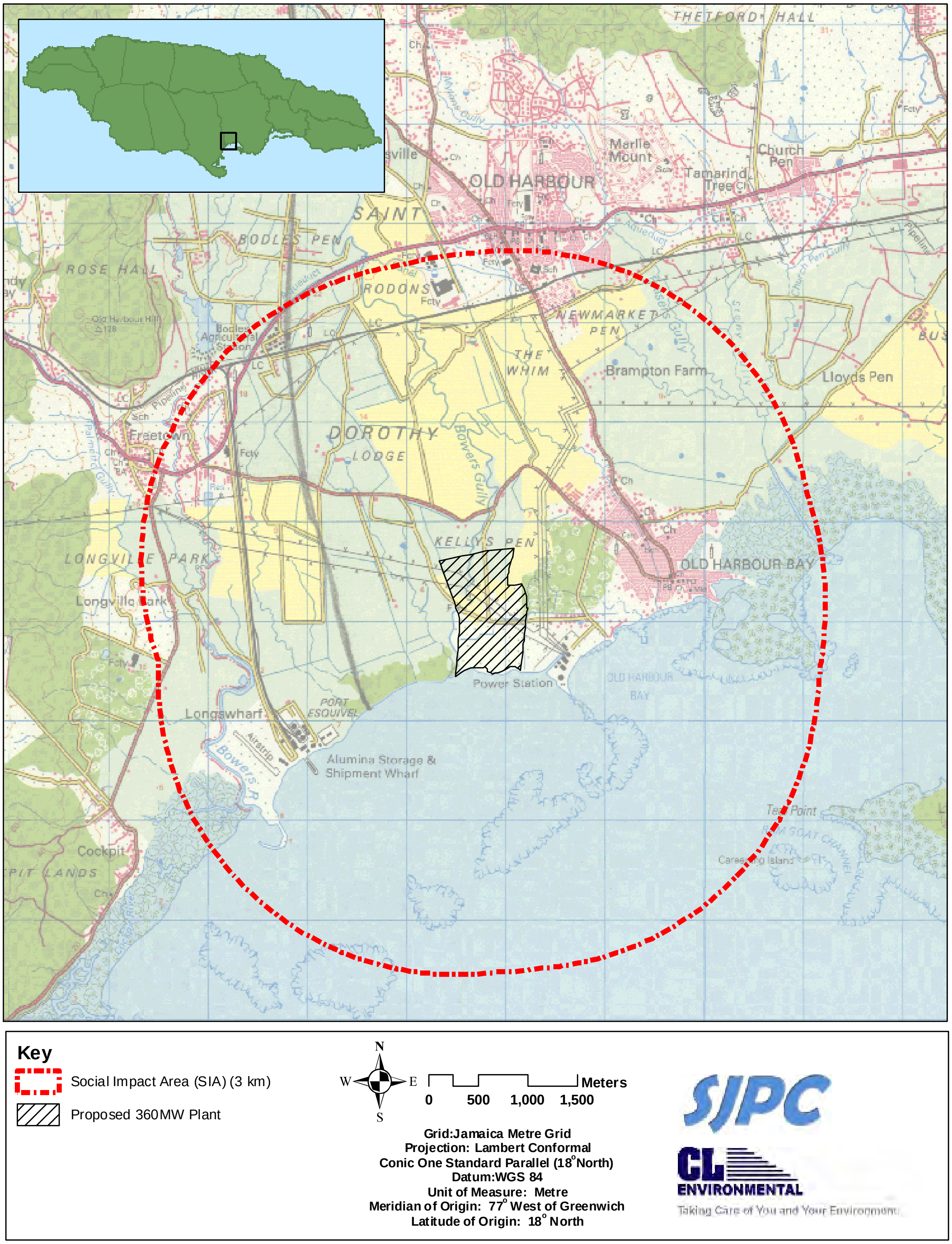


Figure 5-125 - Map showing the Social Impact Area (SIA)

5.4.3 Demography

5.4.3.1 Population Growth Rate

The total population within the SIA in 2001 was approximately 9,492 persons (STATIN 2001 Population Census). The growth rate for the Parish of St. Catherine over the last intercensal period (1991-2000) was 2.36 % per annum. However, examination of the 1991 population data showed that there were approximately 9,332 persons within the 3 km radius of the proposed plant location in 1991. From this population, and that calculated for the year 2001 (9,492 persons), it was estimated that the actual growth within the SIA between 1991 and 2001was approximately 0.17% per annum, which is far less than that of the parish.

Based on this growth rate of 0.17% for the SIA, at the time of this study (2012), the population was approximately 9,672 persons and is expected to reach 10,093 persons over the next twenty five years if the current population growth rate remains the same.

5.4.3.2 Age & Sex Ratio

The 15-64 years age category accounted for 60% of the 2001 population for the SIA, with the age 0-14 years (34%) and the age 65 and over category accounting for 6%. The segment of a population that is considered more vulnerable are the young (children less than five years old) and the elderly (65 years and over). In this population, approximately 12% were in the young category and 6% were in the 65 years and older category as mentioned previously.

Table 5-66 shows the percentage composition of each age category to the population. This is compared on a national, regional and local level. The data show that the percentage contribution to the population for each category were comparable.

Table 5-66 - Age categories as a percentage of the population

AGE CATEGORIES	JAMAICA (%)	ST. CATHERINE (%)	SIA (%)
0-14	32	32	34
15 - 64	60	62	60
65 & Over	8	6	6

(Source: STATIN Population Census 2001)

A Social Development Commission (SDC) Community Profile for the community of Old Harbour Bay (2007) has indicated the population can be considered as a working age population with 63% of the Community's population being between the ages of 15-64 years. It also had a significant youth population with 50% of the Community being 24 years or younger. The Profile also indicated that most males were 0-4 years and 5-9 years age cohorts whereas most females were found to be in the age groups of 30-34 and 5-9 years.

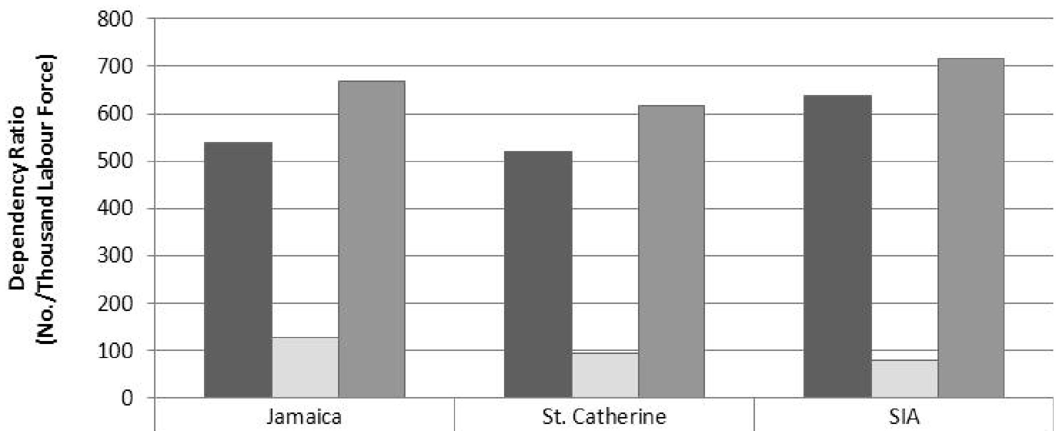
The sex ratio (males per one hundred females) in the SIA in 2001 was 104.48, which indicates that a higher percentage of the population in the SIA were males. Only the 65 years and older category had more females than males. This sex ratio was greater than both the national (Jamaica (96.9) and regional (St. Catherine (94.4) ratios indicating that both populations have a higher level of females.

In 2007, the SDC Profile of Old Harbour Bay indicated that the distribution of the population by gender, that there were more females (53.9%) than males (46.1) in the population.

5.4.3.3 Dependency Ratio

The child dependency ratio for the SIA in 2001 was 637 per 1000 persons of labour force age; old age dependency ratio stood at 80 per 1000 persons of labour force age; and societal dependency ratio of 717 per 1000 persons of labour force. This indicates that the youth (child dependency) is more dependent on the labour force for support when compared with the elderly.

Comparisons of the dependency ratios at varying extents indicate that the child dependency ratio for the study area (SIA) was higher than the regional and national figures (Figure 5-126). The old age dependency ratio for the study area was lower than both the regional and national figures, whilst societal dependency was greater than the regional and national figures.



	Jamaica	St. Catherine	SIA
Child Dependency	539	521	637
Old Age Dependency	128	95	80
Societal Dependency	667	616	717

Figure 5-126 - Comparison of dependency ratios for the year 2001

The SDC Profile in 2007 showed that the age cohort 0-14 years accounted for 32% of the population and the age cohort 65+ accounted for 5% of the Community population. In comparison to the national figures there were more children (0-14 years) and elderly persons of 65+ year in the community when compared to the national figures of 28.3% and 10.8% respectively (The Economic and Social Survey (ESSJ), 2007).

5.4.3.4 Population Density

The land area within the SIA was calculated to be approximately 25,980,304 m^2 (25.98 km^2). With a population of 9,492 persons the overall population density was calculated to be 365.4 persons/km^2. This population density is lower than the regional level for the parish of St. Catherine, which is approximately 391.2 persons/km^2. When compared to the national figure however (237.7 persons/ km^2), this density for the SIA is considerable higher.

5.4.3.5 Population Growth Areas

Figure 5-127 depicts the population within each enumeration district (ED) for the years 1991 and 2001. There were population increases between those two years, mainly within the proposed site, as well as to the east of it. It should mentioned that a larger 1991 ED located to the east of the plant site was broken into four smaller EDs in the year 2001 perhaps owing to increases in population density.

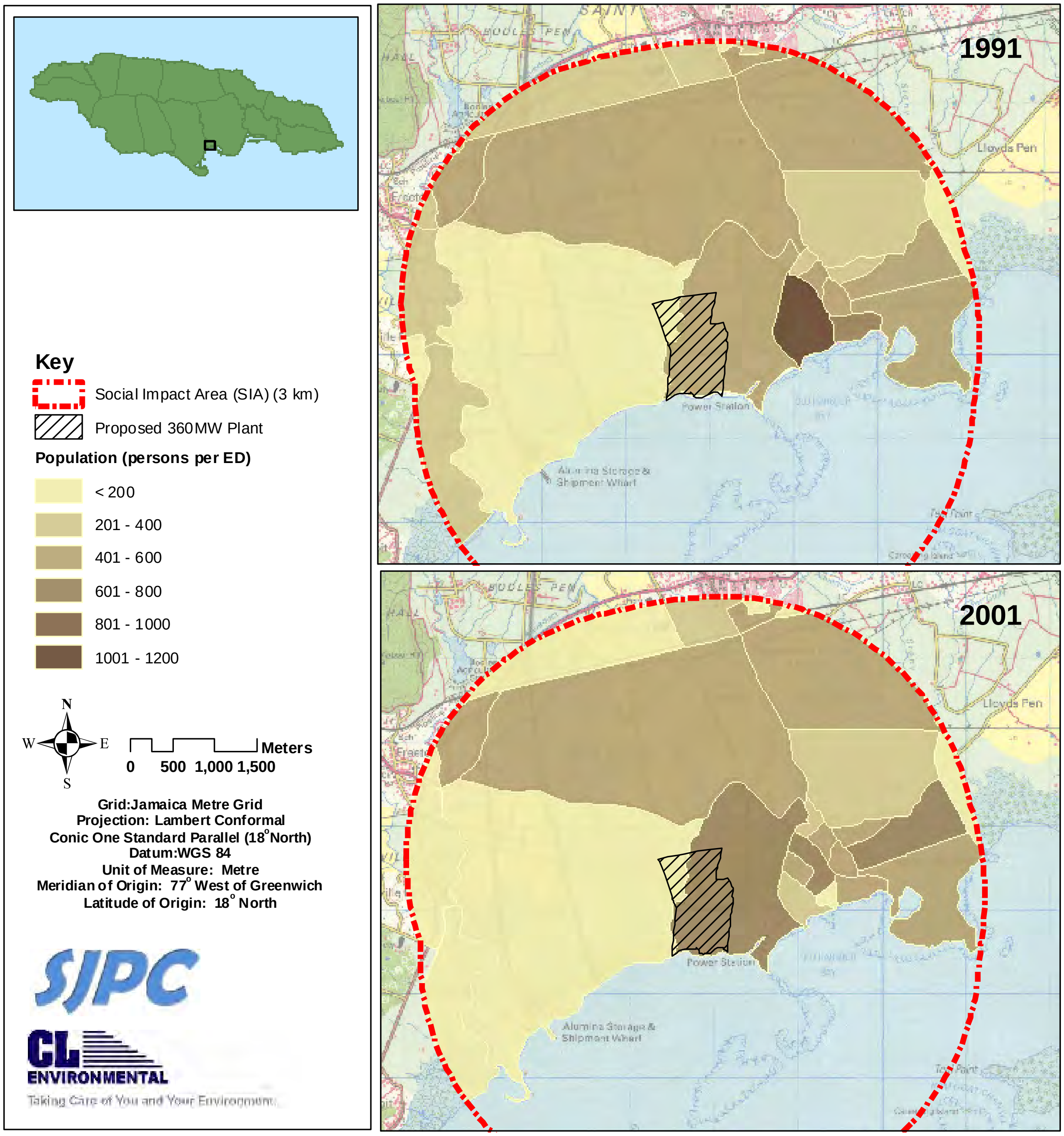


Figure 5-127 - SIA 1991 and 2001 population data represented in enumeration districts

5.4.3.6 Migration Patterns

Data gathered showed that approximately 66.9% of the household heads living in the Community were born in St. Catherine. Migration is quite uncommon in the Community, as most residents (88.6%) have lived in the Community for 10 or more years (SDC 2007).

5.4.4 Education

The educational attainment of persons four years and older are represented in Table 5-66. When educational attainment within the SIA is calculated as a percentage of the total population it becomes evident that there is a propensity towards the attainment of a primary and secondary school education. Most persons within the SIA attained a secondary school education (52.0%) followed by those attaining a primary education (31.9%). The educational statistics of the SIA were similar to the national and parish data, however, there were a noticeably lower percentage of those attaining a tertiary education. This may be due to the fact that the area is mainly an agricultural one with sugar cane, aquaculture and fisheries being the main activities, wherein Jamaica tends not to attract persons with tertiary education.

Table 5-67 - Educational attainment as a percentage of the population for persons 4 years and older

CATEGORY	JAMAICA	ST. CATHERINE	SIA
Pre-Primary	4.7	4.7	5.3
Primary	31.2	28.5	31.9
Secondary	49.7	49.3	52.0
University	3.1	3.7	0.9
Other Tertiary	5.9	7.7	3.1
Other	2.8	3.4	3.0
Not Stated	1.7	2	2.8
None	0.9	0.7	1.0

The relatively high proportion of the population in proximity to the proposed plant location attaining a secondary education suggests that the labour pool is relatively educated, and as such, there should be no problem in obtaining non-technical workers from the community by the developers. This is shown in Figure 5-128 which also depicts the location of schools in proximity to the proposed location. Only one school (Old Harbour High) is found within the 3km buffer SIA, with three primary schools, namely Old Harbour, Eltham Park and Freetown situated between 3 and 4 km of the proposed site boundary.

In 2007, a large majority of the household heads had attained some level of education (93.5%). This was either, pre-primary, primary, secondary, all age, university, vocational, other tertiary or post-secondary. The highest educational level attained by most household heads was Secondary (51.2%). Only 3.3% of the household heads obtained university level education and 0.8% received vocational training (SDC 2007).

Approximately 83% of the household members in the community of Old Harbour Bay had no academic qualification. When further broken down it can be seen that 83% of the male and 84% of the female population had no qualification (SDC 2007) (Table 5-68).

Table 5-68 **-** *Educational Attainment as a percentage of household members in the community of Old Harbour Bay*

QUALIFICATIONS	**%MALE**	**%FEMALE**
None	83.3	83.5
CXC Basic, JSC, JHSC, JSCE, SSC,JC or 3rd JLCL	3.3	1.7
CXC General, GCE ‘O’, AEB 1-2 Subjects	0.8	0.8
CXC General, GCE ‘O’ , AEB 3-4 Subjects	1.7	3.3
CXC Gen, GCE ‘O’, AEB 5+ Subjects	0.8	0.8
GCE ‘A’ Level/ Cape 1-3 Subjects, HSC	0.8	0.8
College Certificate/Diploma	1.7	0.8
Vocational (Certificate)	1.7	1.7
Associate Degree / Diploma / Other Certificates and Degrees MOE Recognized	0.0	0.8
Degree / Postgraduate Degree/Professional Qualification	0.8	0.8
Other	3.3	1.7
Not Stated	1.7	3.3
Total	100.0	100.0

Source: SDC 2007

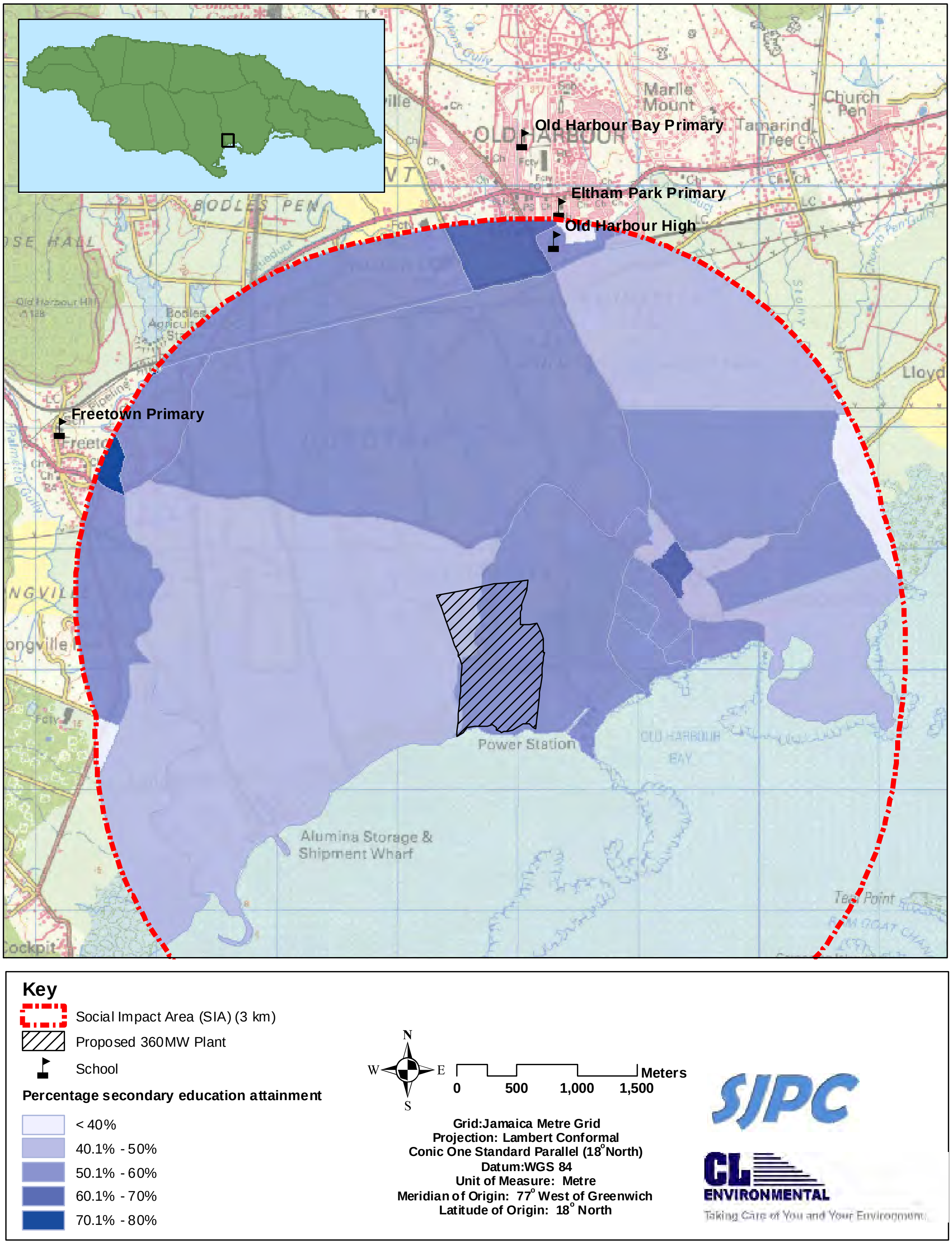


Figure 5-128 - Percentage population attaining a secondary education

5.4.5 Employment

The SDC 2007 Community Profile data revealed that 63% of the Old Harbour Bay Community population falls within the working age group (15 – 64). Approximately 56.3% of the labour force population in the community was employed at the time of the survey (2007), while 43.8% were unemployed. The data also revealed that on average two persons in each household were employed.

Of the Employed persons in the community the main categories of employment were full time (33%) and self-employed (50%). Of the remaining employed household members 8.9% were seasonally employed, 5.2% employed part time and 3% contractually employed. The highest percentage of employed persons throughout the cohorts fell between the ages of 35-39 years (21.5%), whereas, notable percentages were within the age range 40- 44 years (16.3%), 30-34 years (14.8%), 25-29 years (12.6%) and 45-49 years (12.6%). Approximately 61.6% of household heads were employed (SDC 2007).

For household heads who stated their monthly income, the most common income bracket reported was $6,000-$24,999 monthly which accounted for 56.8% of employed residents. This was followed by the income brackets of $25,000-$39,999 which accounted for 25.7% of employed residents. 40,000 – 79,999 (9.5%), 3,201 – 5,999 (4.1%), 80,000 – 129,999 (2.7%) and 250,000 and over (1.4%). The main additional source of income for household heads was from remittance (17.6%) (Table 5-69). However a large amount of persons (35.2%) reported having no source of income (SDC 2007).

Table 5-69 - Additional Financial Support received by Household Heads

SOURCES	**%PERCENT**
State Assistance	1.6
Remittances	17.6
Support from local network of family and friends	6.4
Salaries from other members your household	7.2
No additional sources	35.2

***Questionnaire allowed for multiple responses (SDC 2007)**

5.4.5.1 Unemployed Persons

Males accounted for 33.3% and females 66.7% of the unemployed persons in the community of Old Harbour Bay. Unemployment was highest among cohorts 20-24 years and 60+ years accounting for 22.9% respectively. Unemployed persons were among the cohorts 30-34 years (13.3%), 14-19 years (9.5%), 25-29 years (7.6%) and 35-39 years (7.6%) (SDC 2007) (Table 5-70).

Among the unemployed persons sixty years and older females accounted for 15.2% and males 7.6%, while the cohort 20-24 years was equally distributed between males and females. Overall youth unemployment accounted for 32.4% of the total unemployed population (SDC 2007).

Table 5-70 - Unemployment Status of Household Members by Gender

AGE COHORTS	%MALE	%FEMALE	%TOTAL
14 – 19	5.7	3.8	9.5
20 – 24	11.4	11.4	22.9
25 – 29	3.8	3.8	7.6
30 – 34	1.0	12.4	13.3
35 – 39	0.0	7.6	7.6
40 – 44	1.0	3.8	4.8
45 – 49	1.0	3.8	4.8
50 – 54	1.0	4.8	5.7
55 – 59	1.0	0.0	1.0
60 +	7.6	15.2	22.9

Source: SDC 2007

A somewhat significant amount of unemployed persons had been unemployed for five years or more accounting for 7.2% of males and 18.4% of females. A somewhat significant amount of unemployed persons had been unemployed for five years or more accounting for 7.2% of males and 18.4% of females.

For household heads that were unemployed, the reasons given for their unemployment were:

- Other reason “not specified (15.2%)
- Trying to find work but do not have the necessary skills or qualifications (12%)
- No Reason (9.6%)
- Illness (5.6%)
- Awaiting a promised job (3.2%)
- Amount of pay (0.8%)
- Have to stay with sick parent/child/elderly relative (0.8%)

For unemployed family members the main reason for unemployment was lack of skills/qualification (19.2%), no reason (9.6%), illness (4.8%), attending school (2.4%), amount of pay and awaiting promised job (1.6% respectively) and have to stay with sick parent/children/elderly (0.8%). The percentages may not add up due to the fact that persons were allowed multiple responses.

5.4.5.2 Main Occupations by Gender

The most common occupation group among household members was service, shop and market sales which accounted for 50%. This was followed by agriculture and fishery, craft and related trades work and elementary occupations with 18.6%, 12.7% and 10.2% respectively.

Females dominated the area of service, shop and market sales, while agriculture and fishery craft and related trade work had male dominance (Table 5-71).

Table 5-71 - Main Occupations by Gender

OCCUPATION GROUP *(Categorizations Taken from STATIN Labour Force Survey)*	**%MALE**	**%FEMALE**	**%TOTAL**
Professional	3.4	8.3	5.9
Service workers and shop and market sales workers	32.8	66.7	50.0
Skilled agricultural and fishery	34.5	3.3	18.6
Craft and related trades workers	24.1	1.7	12.7
Elementary occupations	5.2	15.0	10.2
Clerks	0.0	5.0	2.5

Source: SDC 2007

5.4.5.3 Existing Skills

The data representing the skill sets present among household members in the community of Old Harbour Bay shows that the dominant areas were construction and cabinet making (19.2%), agriculture/farming (15.4%), beauty care and service (9.6%) and hospitality (9.6%).

Most males had the aptitude in construction and cabinet making (33.3%) and agriculture/farming (27.8%), while most of the females were skilled in hospitality (20%), beauty care and service (18%) and commercial and sales (12%) (SDC 2007) (Table 5-72).

Table 5-72 - Skill Distribution by Gender

SKILLS	%MALE	%FEMALE	%TOTAL
Beauty care and service	1.9	18.0	9.6
Hospitality	0.0	20.0	9.6
Construction and cabinet making	33.3	4.0	19.2
Machine and appliance	9.3	0.0	4.8
Commercial and sales	0.0	12.0	5.8
Professional and technical	11.1	6.0	8.7
Agricultural/farming	27.8	2.0	15.4
Secretarial/office clerk	0.0	4.0	1.9
Art and craft	1.9	0.0	1.0
Apparel and sewn products	3.7	8.0	5.8
Other	9.3	20.0	14.4
Not specified	1.9	6.0	3.8
Total	**100.0**	**100.0**	**100.0**

Source: SDC 2007

5.4.5.4 Beneficiaries Social Safety Net Programmes

Approximately 9.5% of the households within the Community had members benefitting from Social Safety Net Programmes. Of the 9.5% households with beneficiaries approximately 4.8% were on the Programme of Advancement through Health and Education (PATH programme), 0.8% for the National Health Fund (NHF) and 0.8% other (SDC 2007).

5.4.5.5 Fishers

There are approximately one thousand four hundred (1,400) fishers operating out of the Old Harbour Bay region of which approximately one hundred (100) are a part of the Old Harbour Bay Fishing Co-op (CLE 2005).

The fishers interviewed indicated their average weekly income from fish sales. Approximately 4.3% indicated an income of less than J$1,000.00 per week; 10.9% indicated an income of between $1,000.00 and $2,000.00 per week; 13% indicated an income of $2,000.00 to $4,000.00 per week. Approximately 23.9% respectively indicated incomes ranging between $4,000.00 and $6,000.00, $6,000.00 and $8,000.00 and more than $8,000.00 per week.

5.4.5.6 The Proposed Project

It is anticipated that approximately 70 persons will be employed during the site clearance activity, a peak of 1,200 persons during the construction phase and 65 persons during the operation of the proposed 360 MW LNG power plant. A number of indirect jobs are expected to be created this further benefitting the community.

5.4.6 Housing

For the purposes of this study the definition of housing unit, dwelling and household are those used in the population census conducted by the Statistical Institute of Jamaica. The definition states that:

- A "housing unit is a building or buildings used for living purposes at the time of the census.
- A dwelling is any building or separate and independent part of a building in which a person or group of persons lived at the time of the census". The essential features of a dwelling unit are both "separateness and independence". Occupiers of a dwelling unit must have free access to the street by their own separate and independent entrance(s) without having to pass through the living quarters of another household. Private dwellings are those in which private households reside. Examples are single houses, flats, apartments and part of commercial buildings and boarding houses catering for less than six boarders.

There were 2,288 housing units, 2,675 dwellings and 2,734 households within the SIA in 2001. The average number of dwelling in each housing unit was 1.17 and the average household to each dwelling was 1.02. The average household size in the SIA was 3.47 persons/household (Table 5-73). A comparison of the SIA and national and regional ratios indicate that they were generally similar except for the higher regional (parish) average household size.

Table 5-73 - Comparison of national, regional and local housing ratios for 2001

	JAMAICA	ST. CATHERINE	SIA
Dwelling/Housing Unit	1.2	1.3	1.17
Households/Dwelling	1.03	1.03	1.02
Average Household Size	3.48	3.59	3.47

(Source: STATIN Population Census 2001)

Approximately 86.5% of the housing units in the SIA were of the separate detached type, 11.5% were attached, 0.4% part of a commercial building, 0.4% improvised housing, 0.2% categorized as other and 1.0% did not state.

More than three quarters (78.5%) of the households in the SIA in 2001 used 1-2 rooms for sleeping (Figure 5-129). Approximately 13.9% of the households occupied three rooms, 4.4% used four rooms, 2.7% used five rooms and 0.6% did not report the number of rooms used for sleeping. Most of the households (47.6%) used one room for sleeping.

5.4.6.1 Household Headship

The percentage of male household heads to female household heads in the community of Old Harbour Bay was equally distributed at 50% respectively. This finding slightly contrasts with national presentation in the Jamaica Survey of Living Conditions (JSLC) 2007, where slightly more males (53.4%) than females (46.6%) were heading households in Jamaica (SDC 2007).

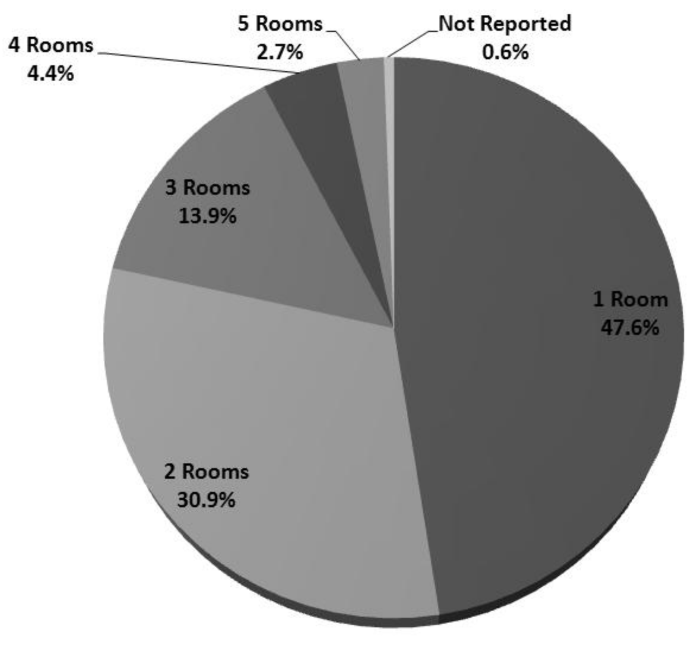


Figure 5-129 - Rooms used for sleeping in the SIA as percentage of population

5.4.6.2 Informal Settlement – Terminal Lane

Terminal is part of the wider Old Harbour Bay community, which was originally known as Burkesfield. The name Terminal came into existence due to the construction of the Marine Terminal by the United States Marine Corps. The topography is generally flat and is characterized by ponds and swamps. This informal settlement has a street pattern that is made up of unpaved roads and footpaths. This informal residential area has 41 houses and assets such as three (3) shops and three (3) livestock farms (CLE 2007).

The building typology and particularly housing in the area were predominantly poor structures built with temporary materials This is evident in the fact that 42% were very poor while only 7% were deemed very good, 24% were poor, 17% were good and 10% were fair. Another finding was that of the forty one (41) houses identified, thirty eight (38) were occupied while three (3) were unoccupied. Five (5) houses were abandoned and/or derelict and three houses were under construction.

The materials of housing construction ranged from a few well-built block and steel structures to a plethora of poorly built wooden houses. Only 24% of houses were made of block and steel while 66% were made of wood. 10% were constructed of mixed materials, most of which were a combination of block and steel, and wood.

According to statistics, the population of the original study boundary was 144 persons, while the average household size was 3.97 persons per household. This statistics is slightly higher than the average household size for Jamaica and that of rural areas within Jamaica which stands at 3.4 and 3.6 persons per household (PIOJ, 2002) respectively.

5.4.7 Land Tenure

In 2001, 24.8% of the households in the SIA owned the land on which they lived. Approximately 4.9% leased the land on which they were, 11.5% rented, 23.0% lived rent free, 8.3% “squatted” and 3.0% had other arrangements. A very high percentage (24.5%) did not report the type of ownership arrangements they had, probably due to informal arrangements (“squatting”), to which they did not want to admit to (Table 5-74). The lower percentage of households in the SIA owning the land they are living on, coupled with the fact that there was a higher percentage living rent free, squatting and having other ownership arrangements indicates that there were a higher percentage of households in the SIA compared to the national and regional setting with temporary living arrangements.

As shown inFigure 5-130, the proposed plant site is situated within areas of the SIA that are recorded to have low percentages of land ownership (< 15%), as well as higher percantges (45.1 - 60%).

Table 5-74 - Percentage household tenure nationally, parish and SIA in 2001

CATEGORY	JAMAICA (%)	ST. CATHERINE (%)	SIA (%)
Owned	37.5	29.6	24.8
Leased	5	7.3	4.9
Rented	14.8	9.6	11.5
Rent free	17	11.6	23.0
Squatted	2.9	2.5	8.3
Other	0.9	0.7	3.0
Not Reported	21.9	38.7	24.5

(Source: STATIN Population Census 2001)

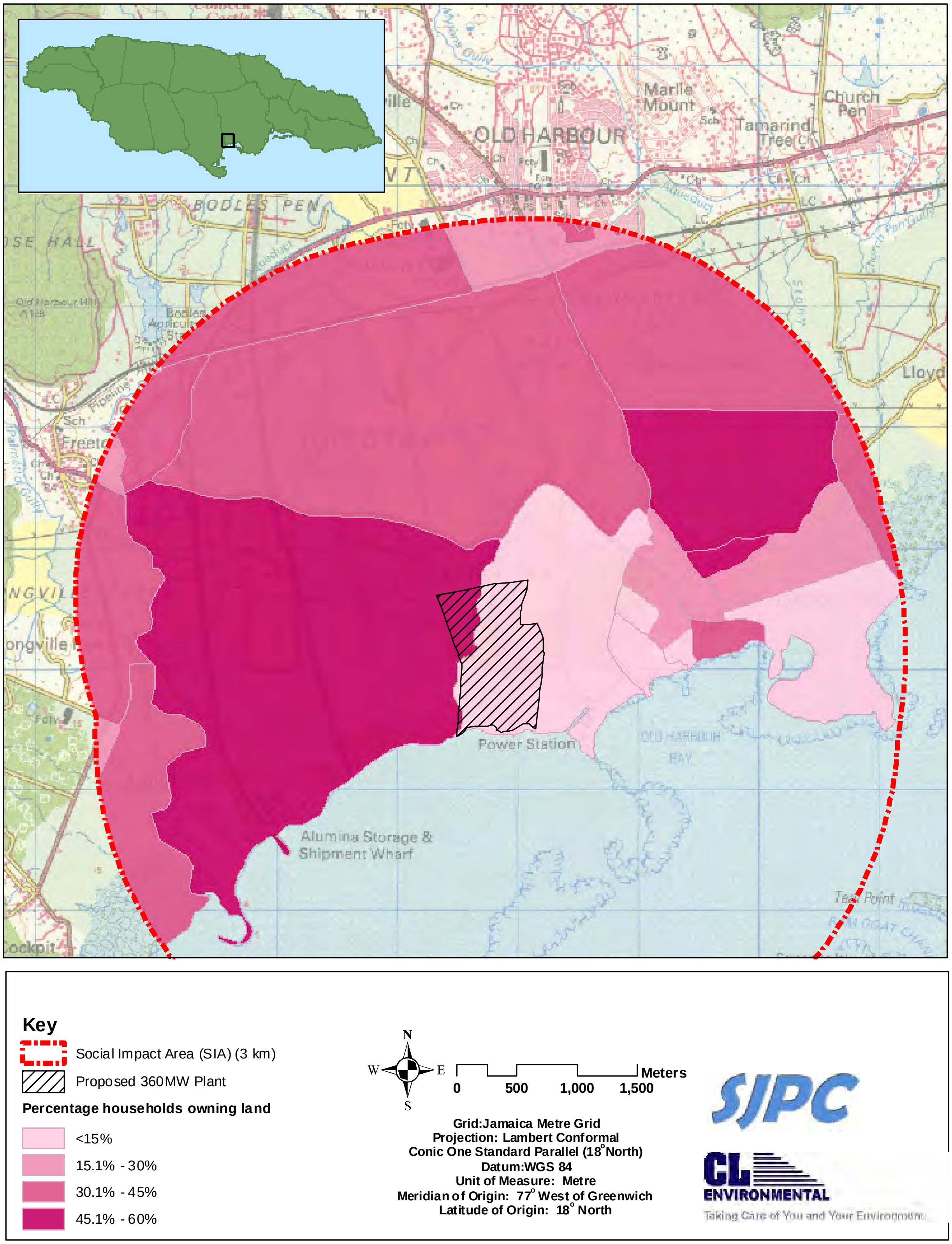


Figure 5-130 - Percent land ownership within the SIA

5.4.8 Infrastructure

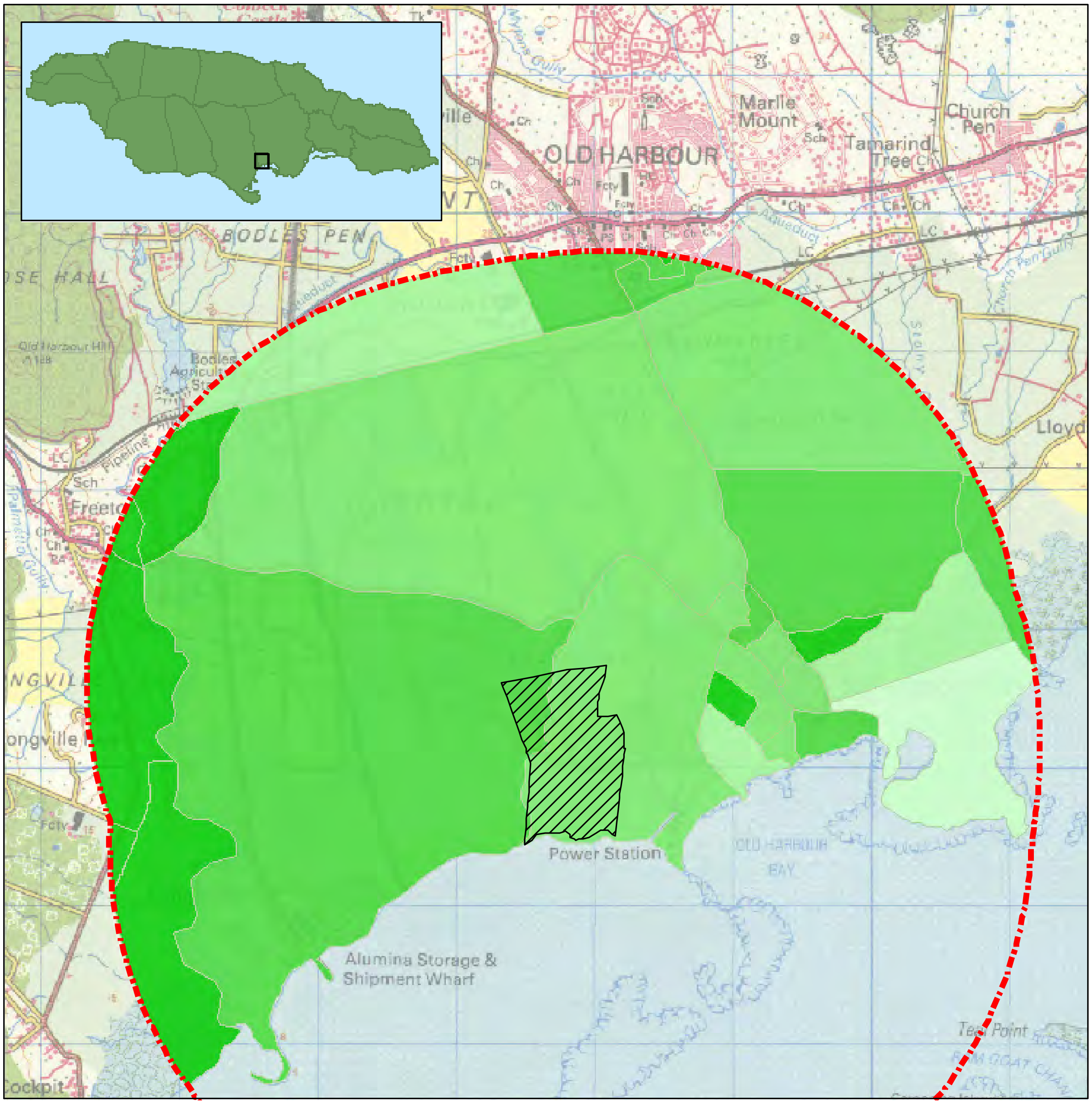
5.4.8.1 Lighting

While the national and regional data were generally similar, it is notable that there were a much lower percentage of households in the SIA using electricity when compared with the national and regional households. There was an approximately twofold increase in the households using kerosene as their main means of lighting, when compared with the national and regional context. Table 5-75 details the percentage of households using a particular category of lighting and Figure 5-131 depicts the percentage households in the SIA using electricity.

Table 5-75 - Percentage households by source of lighting

CATEGORIES	JAMAICA (%)	ST. CATHERINE (%)	SIA (%)
Electricity	87	89.3	78.0
Kerosene	10.6	8.1	18.5
Other	0.4	0.4	0.3
Not reported	2	2.2	3.2

(Source: STATIN Population Census 2001)



Key
Social Impact Area (SIA) (3 km)
Proposed 360MW Plant
Percentage electricity usage
< 60%
60.1% - 70%
70.1% - 80%
80.1% - 90%
90.1% - 100%

N W E S
0 500 1,000 1,500 Meters

Grid:Jamaica Metre Grid
Projection: Lambert Conformal
Conic One Standard Parallel (18° North)
Datum:WGS 84
Unit of Measure: Metre
Meridian of Origin: 77° West of Greenwich
Latitude of Origin: 18° North

SJPC
CL ENVIRONMENTAL
Taking Care of You and Your Environment

Figure 5-131 - Percent dwelling with electricity within the SIA

5.4.8.2 Telephone/Telecommunications

The parish of St. Catherine and the study area are served with landlines provided by Cable and Wireless: LIME Jamaica Limited. Wireless communication (cellular) is provided by Cable and Wireless (LIME) and Digicel Jamaica Limited. A network to support internet connectivity is also provided by Cable and Wireless (LIME) and Flow.

It is not anticipated that there will be any problems as it relates to the provision of telephone service to the proposed development.

5.4.8.3 Domestic Water Supply

Eighty-three percent (83.4%) of the households within the SIA received their domestic water supply from the National Water Commission (NWC) in 2001 (Table 5-76). This public agency is responsible for providing Jamaica's domestic water supply. Water demand for the SIA in 2012 is estimated to be 2,196,702.4 litres/day (~580,307.5 gals/day) and is expected to increase to 2,292,247.4 litres/day (605,547.8 gals/day) over the next twenty five years. Water is obtained from a series of deep wells located in Old Harbour area. These are the Graham, Colbeck, Bowers and Marlie Mount wells.

Table 5-76 - Percentage of households by water supply

	CATEGORY	JAMAICA (%)	ST. CATHERINE (%)	SIA (%)
Public Source	Piped in Dwelling	43.8	55.6	36.2
	Piped in Yard	16.3	18	44.1
	Stand Pipe	10.5	2.7	1.6
	Catchment	1.9	2.2	1.6
Private Source	Into Dwelling	6.3	4.1	2.3
	Catchment	9.9	5.2	2.3
	Spring/River	4.6	4.9	0.0
	Other	4.5	4.8	8.5
	Not Reported	2.2	2.5	3.5

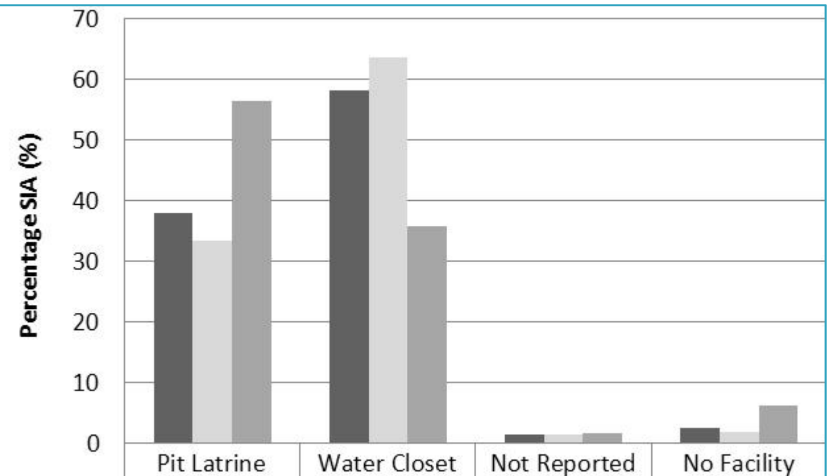
(Source: STATIN Population Census 2001)

5.4.8.4 Wastewater Generation and Disposal

It is estimated that approximately 1,757,362.0 litres/day (~464,246.0 gals/day) of wastewater is generated within the study area (for 2012) and is expected to increase to 1,833,797.9 litres/day (~484,438.2 gals/day) over the next twenty five years.

Within the SIA a higher percentage of households used pit latrines or had no facilities when compared to the national and parish data (Figure 5-132). This may be a result of the higher numbers of informal settlements, which would not have had the benefit of official planning approvals. The high percentage of households in the SIA with inadequate sewage disposal methods, coupled with the fact that there is a high water table, increases the potential for groundwater pollution.

Wastewater generation from the operation of the proposed power plant is estimated to be 111.1 cubic metres per day.



	Pit Latrine	Water Closet	Not Reported	No Facility
JAMAICA (%)	37.9	58.2	1.4	2.5
ST. CATHERINE (%)	33.3	63.5	1.4	1.8
SIA (%)	56.4	35.7	1.6	6.3

(Source: STATIN Population Census 2001)

Figure 5-132 - Sewage disposal methods as a percentage of the households

According to the SDC 2007 Community Profile of Old Harbour Bay, a significant number of households in the Community used pit latrine (48%), water closet linked to sewer (36%), water closet not linked to sewer (13.6%) and 6.4% soakaways (percentage won't add up as multiple responses were allowed). 15.7% of the households shared toilet facilities. On average these facilities were shared with approximately four other families.

5.4.8.5 Solid Waste Generation and Disposal

The National Solid Waste Management Authority is responsible for domestic solid waste collection within the study area. Presently, collection is done twice per week. This service is provided free (partial covered by property taxes) for the households within the area. The waste is transported to the Riverton City landfill located in St. Andrew, approximately 39 km northeast of the proposed plant location.

Solid waste collection for commercial and industrial facilities is done by arrangements by these entities with private contractors.

It is estimated that households in the study area generated approximately 11,236.74 kg (~11.2 tonnes) of solid waste in 2001. Based on the population growth, it has been estimated that at the time of this study (2012), approximately 11,449.22 kg (~11.4 tonnes) of solid waste was being generated and it is expected that within the next twenty five years, if the population growth rate remains the same, the amount will be 11,947.20kg (~11.9 tonnes).

The 2001 census data indicated that approximately 58.6% of the households in the parish of St. Catherine had their garbage collected by public means (North Eastern Parks and Markets Waste Management Limited), with a much lower percentage (41.6%) in the SIA. It also showed that the most preferred method of disposal in the SIA was by burning (55.2%) and this was much higher than the national and regional figures (43% and 33.7% respectively) (Table 5-77, Figure 5-133). This high percentage of households burning their garbage as a means of disposal is a cause for concern, as it has the potential to impact on ambient air. All the other categories of garbage disposal in the SIA were comparable with or lower than the national and regional figures.

Table 5-77 - Percentage households by method of garbage disposal

DISPOSAL METHOD	JAMAICA (%)	ST. CATHERINE (%)	SIA (%)
Public Collection	47.7	58.6	41.6
Private Collection	0.5	0.3	0.2
Burn	43	33.7	55.2
Bury	1.2	0.8	0.5
Dump	6	5.1	1.1
Other Method	0.3	0.3	0.1
Not reported	1.3	1.2	1.3

(Source: STATIN Population Census 2001)

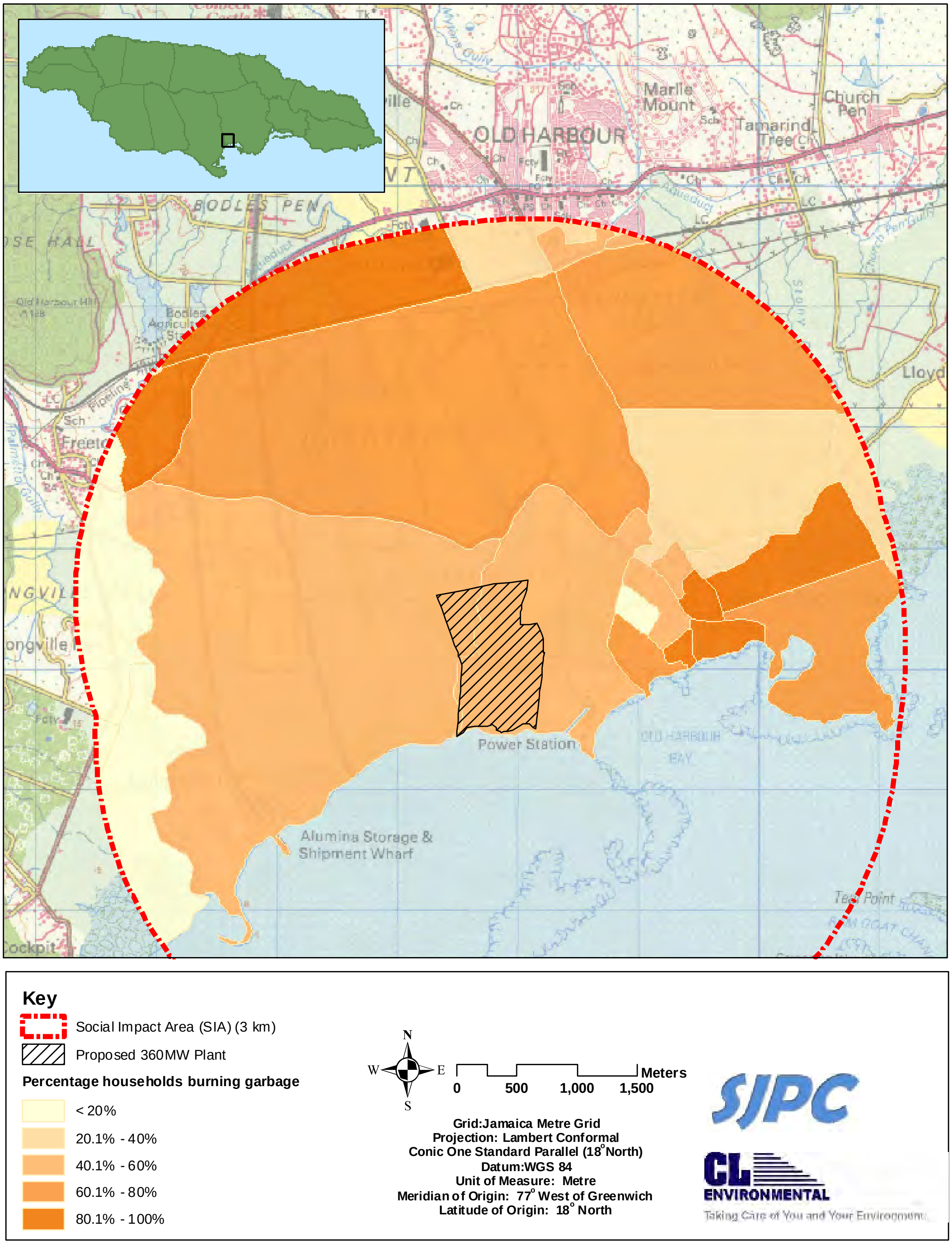


Figure 5-133 - Percentage households in the SIA burning garbage

5.4.8.6 Health Services

There are no hospitals within the SIA (Figure 5-134). Spanish Town and May Pen are the closest hospitals to the proposed plant location. Spanish Town, a Southeast Health Region Type B hospital is located 20 km northeast of the proposed plant. May Pen Hospital is also a Type B hospital, however belonging to the South Health Region and is located 17 km northwest of the proposal plant. Inpatient and outpatient services in at least the five basic specialties (general surgery, general medicine, obstetrics and gynaecology, paediatrics and anaesthetics) are typically offered at Type B hospitals. X-ray and laboratory services are usually available to serve hospital patients as well as those from Primary Health Care and the local private sector.

There is one health centre, namely Old Harbour Bay Health Centre located within the SIA. Just 150 m north of the SIA however, is the Old Harbour Health Centre, which is a Type III centre. The main types of problems are asthma, diabetes and arthritis. It has a seating capacity of 150 persons; however, the facility experiences overcrowding when at times more than 400 patients are present.

The public health facilities are without an ambulance; however, in case of emergencies, help is sought from the Jamaica Public Service, JAMALCO, WINDALCO or from the Spanish Town Hospital.

Approximately 35.5% of the household heads reported the presence of a longstanding health problem in their household. Among household heads the most common health problem was hypertension (10.4%), followed by arthritis (3.2%), and diabetes (2.4%). The data also showed that among family members within the households, hypertension was the number one health problem (9.6%) followed by asthma (5.6%) and diabetes (5.6%) (Table 5-78).

The survey also found that 4.0% of the residents in the Community had a disability. The types of disabilities identified were physical disability (2.4%), multiple disabilities (0.8%) and slowness of learning (0.8%) (SDC 2007).

Table 5-78 - Health Problems that affect Household Heads and Family Members

HEALTH PROBLEMS	%HOUSEHOLD HEADS	% FAMILY MEMBERS
Hypertension	10.4	9.6
Hypotension	0.8	0.0
Heart disease	0.0	0.8
Kidney disease	0.8	0.8
Asthma	0.8	5.6
Diabetics	2.4	5.6
Arthritis	3.2	0.8
Glaucoma	0.0	0.0

Questionnaire allowed for multiple responses (SDC 2007)

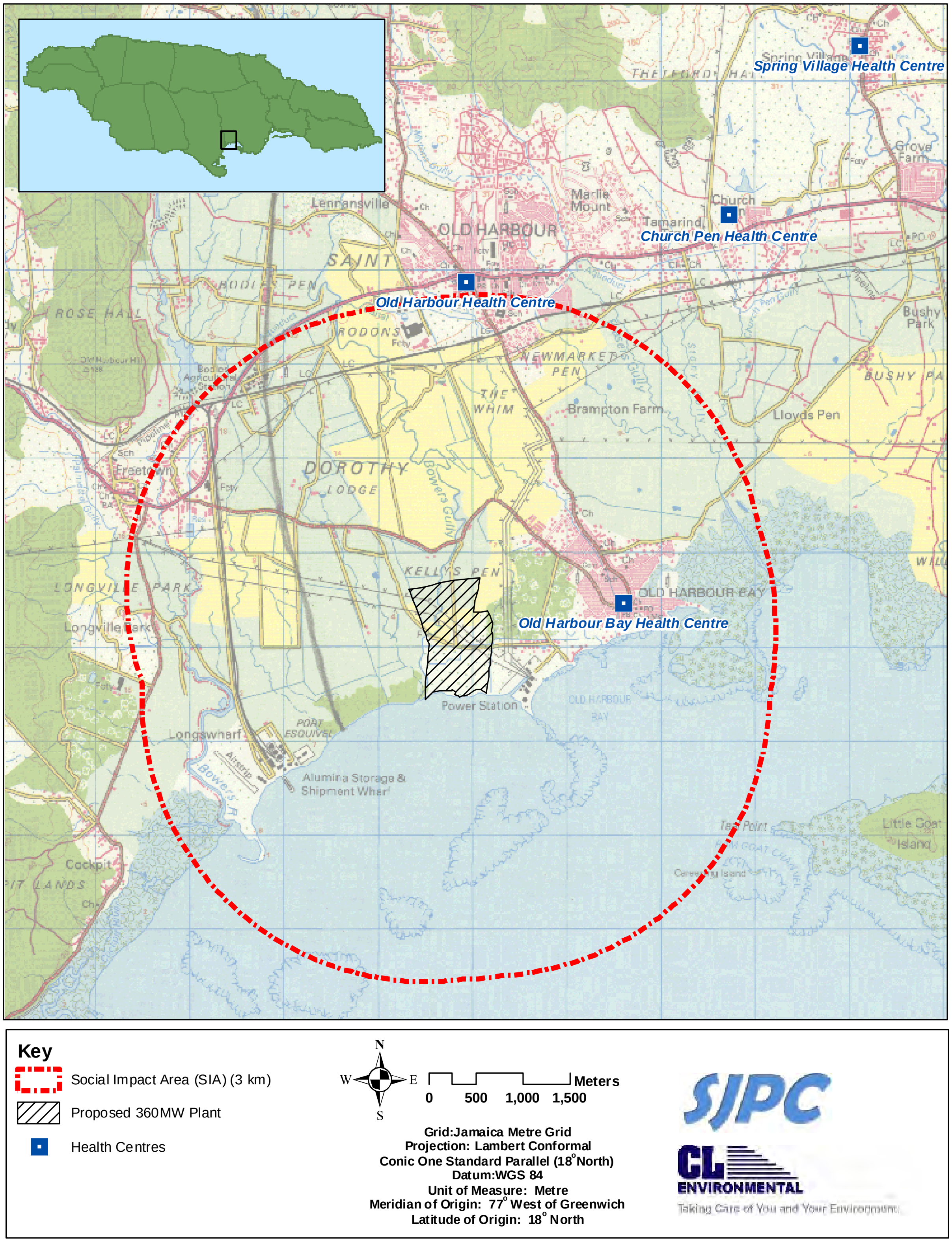


Figure 5-134 - Health services located within the 3km SIA for the proposed plant location

5.4.9 Other Services

5.4.9.1 Fire Station

The fire station that would respond to an emergency at the proposed site is located at Old Harbour approximately 3.5 km from the proposed plant site (not within the SIA 3 km buffer). Currently, this station has one fire engine with a water capacity of 1,818 – 2,273 litres (400-500 imperial gallons). If additional help is needed, backup would be called from the Spanish Town Fire Station, some 20 km away or May Pen Fire Station some 17 km away.

5.4.9.2 Police Station

The Old Harbour Bay police station is situated within the SIA and is 1.5 km east of the proposed plant (Figure 5-135). It is this station that would respond to any events at the proposed site. In the Old Harbour Bay area the main crimes are related domestic disputes. The police station is adequately staffed and is in possession of a police vehicle.

5.4.9.3 Post Office

There are no post offices located within the demarcated SIA; however the Old Harbour Bay Post Office would likely serve the area in proximity to the proposed plant location.

5.4.9.4 Market/Shopping

There are two markets in proximity of the proposed site, namely the Old Harbour market (just outside the SIA) and the Old Harbour Bay market (within SIA).

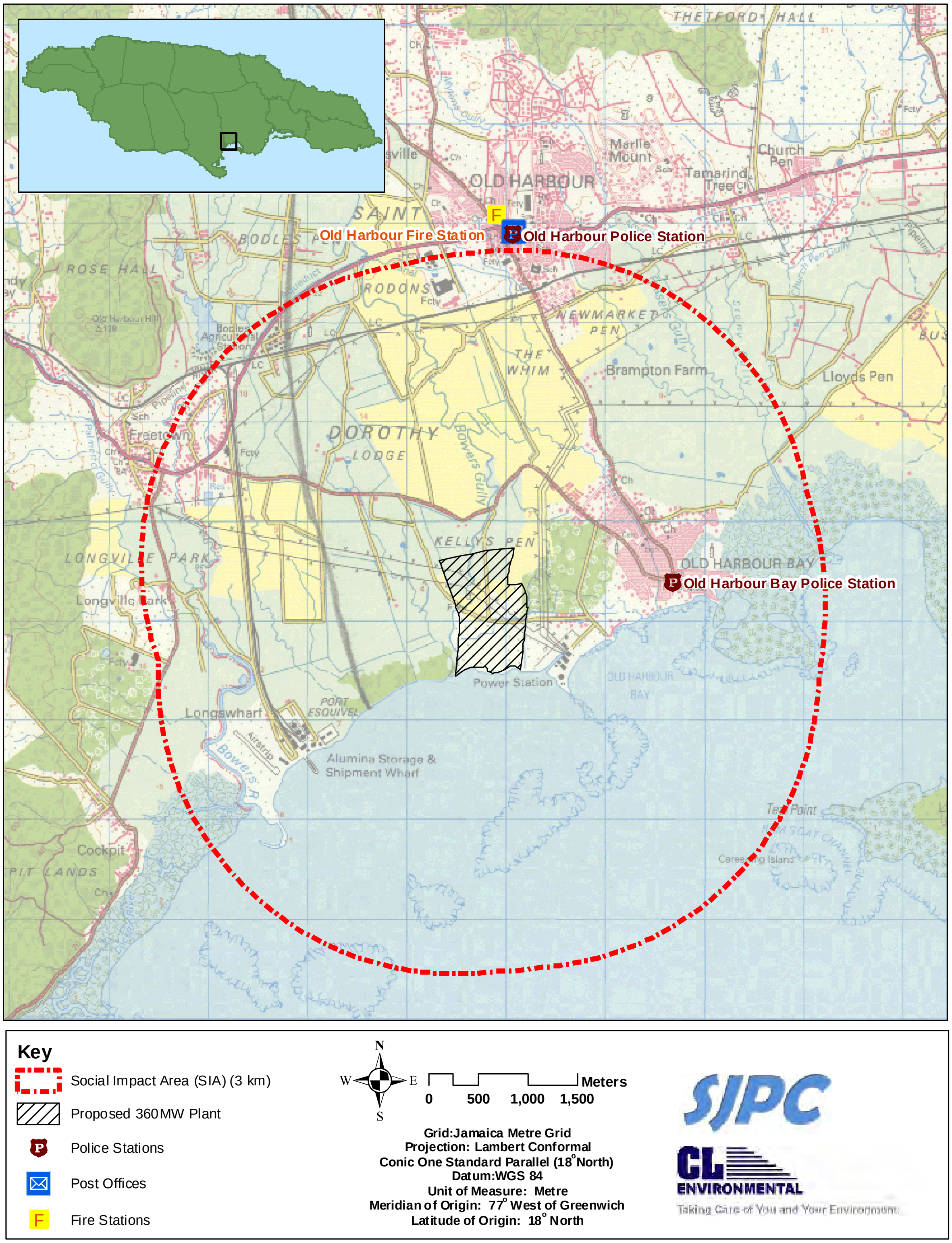


Figure 5-135 - Police stations, post offices and fire stations located within the 3km SIA for the proposed plant location

5.4.10 Community Consultation and Perception

5.4.10.1 Perception Survey

5.4.10.1.1 Introduction

On June 15, 15 and 17, 2012 One Hundred (100) community questionnaires were administered within a two kilometre radius of the area proposed for the construction the Jamaica Public Service Company's 360 Megawatt Combined Cycle Power Plant. Of this, 62% respondents were female and 38% were male.

Of the One Hundred (100) respondents age cohort distribution was as follows; 19% were age 18-25 years , 20% were age 26-33 years, 19 % were age 34-41 years, 17% were age 42 – 50 years, 19% were age 51-60 years and 6% were older than sixty years of age.

Nine communities were visited. These communities were Blackwood Gardens, Dagger Bay, Belmont Park, Station Lane, Bay Bottom, Burkesfield Meadows, Main Street Old Harbour Bay, Buddho and Terminal/ Terminal Road.

5.4.10.1.2 Results and Findings

Approximately eighty-nine percent (89%) of all respondents were aware that the Jamaica Public Service Company (JPS) operates the power plant in Old Harbour Bay. Eighty-four percent (84%) of respondents were aware that JPS uses fuel oil in the production of electricity. As it related to awareness of the of the invitation for proposals by the Office of Utilities Regulation (OUR) to supply up to 480 MW of Base Load Generating Capacity to increase Jamaica's generating capacity for electricity; only twenty-eight percent (28%) of respondents were aware. Seventy-two percent (72%) of respondents were not aware of the OUR's invitation. Regarding respondents' awareness of plans by the Jamaica Public Service Company to construct a 360 MW (Megawatt) combined cycle power plant near/adjacent to the existing Old Harbour facility; it was observed that seventy nine percent (79%) of respondents were aware of this proposal while twenty-one percent (21%) of respondents were not aware.

In general, interviewees response while indicating some awareness of the projects details were not conclusive to confirm that their details were factual as respondents indicated the use of coal. Additionally, respondents in some instances were not familiar with the natural gas component of the project. As it related to how the project may affect individuals lives, interviewees indicated no effect as well as positive and negative impacts. Where positive impact was mentioned interviewees were anticipating job creation and employment opportunities. Where negative impact was mentioned, some of the interviewees concerns' were related to elevated noise levels, pollution, vibrations, and soot emissions.

As it related to respondents awareness of recreational and historic sites and nature reserves, many respondents were not aware. Those aware of a recreational facility mentioned mainly the Blackwood Gardens Community Centre. Goat Island was names as both a historic site and nature reserve.

In general respondents were aware of JPS and the proposal to construct a new power plant but did not understand the details associated with the plant and had concerns related to experiences they have had in the past.

Percentages presented for community respondents are for the total number of respondents.

5.4.10.1.3 Blackwood Gardens

19% of respondents were interviewed in the Blackwood Gardens Community. 73.7% respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay, and were also aware that JPS uses fuel oil to generate electricity. Regarding awareness of the Office of Utilities Regulation's invitation for proposals to increase Jamaica's electricity generating capacity only 26.3% of respondents were aware of this request. 78.9% of respondents interviewed were aware that the Jamaica Public Service Company proposed to construct a 360 Megawatt combined cycle power plant adjacent to the existing plant. 57.9% of respondents were not aware of any details of the project. Of the 42.1% of respondents indicating some awareness of project details 62.5% were aware of the plans for the plant to be constructed while 12.5% indicated that they were aware of the plant being built within a 2.5 year time frame; 12.5% indicated awareness of a lessening of fuel oil and 12.5 % indicated awareness that gas will be obtained from Trinidad.

On the issue of project concerns 42.1% of respondents indicated that they had concerns about the project. 57.9% of respondents indicated that they did not have any concerns related to the project. Of the 42.1% of respondents expressing concern about the project 12.5% were concerned about the project being done in an environmentally friendly manner. 25% expressed concern regarding health hazards but did not specify the hazard. 25% expressed concern regarding whether or not the project would generate employment opportunities. 25% were concerned about whether or not the project would result in a reduction of electricity rates. 12.5% were concerned that there would be some discrimination as only persons from Old Harbour Bay would be given employment opportunities

36.8% of interviewees indicated that the project as proposed would have an effect on their lives. Of the 36.8% indicating some effect, 85.7% indicated a positive effect. 33.3% of respondents indicating a positive effect anticipated job creation; 33.3% anticipated a reduced electricity cost; 16.7% expected the project to be environmentally friendly and 16.7% did not specify how their lives would be positively affected. Of the 14.3% of respondents indicating a negative impact on their lives, all respondents indicated that the project would have negative impact on their health. None of the respondents indicated that they depended on the proposed location for business.

47.4% of respondents stated that the area had a recreational facility. Of the 47.4% indicating the presence of a recreational facility, 88.9% mentioned the Blackwood Gardens Community Centre and 11.1% mentioned a community centre but did not name it. 10.5% of respondents indicated the presence of a historic or cultural site in or nearby the area. Of the 10.5%; 50% of respondents indicated Goat Island as a historic and cultural areas and 50% indicated the St. Philip's Anglican Church. 100% of interviewees were not aware of the presence of any nature reserves.

Dagger Bay

7% of respondents were interviewed in the Dagger Bay area. 100% respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay, 71.4% of respondents were also aware that JPS uses fuel oil to generate electricity. Regarding awareness of the Office of Utilities Regulation's invitation for proposals to increase Jamaica's electricity generating capacity only 28.6% of respondents were aware of this request. 57.1% of respondents interviewed were aware that the

Jamaica Public Service Company proposed to construct a 360 Megawatt combined cycle power plant adjacent to the existing plant. 71.4% of respondents were not aware of any details of the project. Of the 28.6% of respondents indicating some awareness of project details 50% were aware of the plans for the plant to be constructed specifically of the use of windmills while 50% indicated that they were aware of the plant using cheaper gas.

On the issue of project concerns 42.9% of respondents indicated that they had concerns about the project. 57.1% of respondents indicated that they did not have any concerns related to the project. Of the 42.9% of respondents expressing concern about the project 33.3% were concerned about possible effects on health but did not specify. 33.3% expressed concern regarding vibration and sooty emissions and 33.4% expressed concerns regarding pollution and stated that residents in the community have been diagnosed with asthma and cancer.

71.4% of interviewees indicated that the project as proposed would have an effect on their lives. Of the 71.4% indicating some effect, 20% indicated a positive effect as there was the expectation of lowered electricity bills. Of the 80% of respondents indicating a negative impact on their lives, 25% of respondents expressed concern about noise and smoke causing severe coughing; 25% were concerned about sickness as it affected the sinuses; 25% did not specify how they would be negatively affected and 25% were concerned about impacts based on the type of fuel to be used. 14.3% of respondents indicated that they depended on the proposed location for business, specifically cutting posts for farming.

28.6% of respondents stated that the area had a recreational facility. Of the 28.6% indicating the presence of a recreational facility, 50% mentioned the Blackwood Gardens Community Centre while 50% mentioned a community centre but did not name it. 14.3% of respondents named Dagger Bay as a historic or cultural site in or nearby the area and stated that Indians used to reside there. 85.7% of interviewees were not aware of the presence of any nature reserves. Of the 14.3% aware of the presence of a nature reserve all respondents indicated Goat Island as a Part of Portland Bight.

Belmont Park

6% of respondents were interviewed in the Belmont Park Area. 100% respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay, and were also aware that JPS uses fuel oil to generate electricity. Regarding awareness of the Office of Utilities Regulation's invitation for proposals to increase Jamaica's electricity generating capacity only 33.3% of respondents were aware of this request. 100% of respondents interviewed were aware that the Jamaica Public Service Company proposed to construct a 360 Megawatt combined cycle power plant adjacent to the existing plant. 66.7% of respondents were not aware of any details of the project. Of the 33.3% of respondents indicating some awareness of project details, 50% were aware of the plans for the plant to be constructed and jobs being provided while 50% indicated that they were aware of persons selling power to JPS

On the issue of project concerns 33.3% of respondents indicated that they had concerns about the project. 66.7% of respondents indicated that they did not have any concerns related to the project. Of the 33.3% of respondents expressing concern about the project 50% were concerned about possible electricity rates while the other 50% did not specify the concerns.

33.3% of interviewees indicated that the project as proposed would have an effect on their lives. Of the 33.3% indicating some effect, 50% indicated a positive effect as there was the expectation of more reliability in the service offered by JPS plus an employment opportunity would be created. Of the 50% of respondents indicating a negative impact on their lives, the main concern was pollution. 100% of respondents indicated that they did not depend on the proposed location for business.

16.6% of respondents stated that the area had a recreational facility and stated it was located at the Old Harbour High School. 100% of respondents indicated that they were not aware of any historic or cultural site in or nearby the area nor were they aware of any nature reserves.

Station Lane

2% of respondents interviewed were from Station Lane. 100% respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay, 50% of respondents were also aware that JPS uses fuel oil to generate electricity. Regarding awareness of the Office of Utilities Regulation's invitation for proposals to increase Jamaica's electricity generating capacity only 100% of respondents were not aware of this request nor were they aware that the Jamaica Public Service Company proposed to construct a 360 Megawatt combined cycle power plant adjacent to the existing plant. 100% of respondents were not aware of any details of the project.

On the issue of project concerns all respondents indicated that they did not have concerns about the project.

50% of interviewees indicated that the project as proposed would have an effect on their lives with the main impact being an increase in employment opportunities. 100% of respondents indicated that they did not depend on the proposed location for business.

100% of respondents stated that the area did not have any recreational facilities or historic and cultural areas or nature reserves.

Bay Bottom

12% of respondents were interviewed in Bay Bottom. 91.6% respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay, 75% of respondents were also aware that JPS uses fuel oil to generate electricity. Regarding awareness of the Office of Utilities Regulation's invitation for proposals to increase Jamaica's electricity generating capacity only 25% of respondents were aware of this request. 50% of respondents interviewed were aware that the Jamaica Public Service Company proposed to construct a 360 Megawatt combined cycle power plant adjacent to the existing plant. Only 25% of respondents indicated awareness of some details of the project; however the accuracy of details could not be verified. Of this 25%, 33.3% indicated that construction of the new plant is scheduled to begin by the end of 2012. 33.3% indicated that the new plant will be run using coal and 33.4% indicated that they were aware that a new plant was to be built

On the issue of project concerns 8.3% of respondents indicated that they had concerns. These concerns were specifically related to noise and black sooty emissions presently experienced with the existing plant. 91.7% of respondents indicated that they did not have any concerns related to the project.

33.3% of interviewees indicated that the project as proposed would have no effect on their lives. 66.7% of respondents indicated that the project could have impact on lives. 25% indicated a negative impact and 75% indicated a positive impact. Of the 25% of respondents indicating a negative impact, 50% expressed concern regarding pollution and 50% expressed concern specifically to more noise exposure. Of the 75% of respondents indicating a positive impact, 83.3% of respondents expect increased employment opportunities while 16.7% of respondents anticipate cheaper electricity rates and expect a different plant that that currently existing. 100% of respondents indicated that they did not depend on the proposed location for business.

33.3% of respondents stated that the area did not have any recreational, historic or cultural, or nature reserves in or nearby the area. The remaining 66.7% of respondents indicated the presence of at least one type of facility that was recreational, cultural or historic, or a nature reserve. Of the 66.7%, 37.5% of respondents indicated the Blackwood Gardens Community Centre as a recreational facility; 37.5% indicated a community centre but did not name it, 12.5% stated that there was a facility at Buddho but did not name it and 12.5% referred to the Old Harbour Bay Football Club. Of the 66.7% of respondents indicating at least one type of facility that was recreational, cultural or historic, or a nature reserve 100% indicated that they were not aware of a historical or cultural area in or nearby the community and 12.5% stated the mangroves near the shoreline were a nature reserve.

Burkesfield Meadows

10% of respondents were interviewed in Burkesfield Meadows. 80% respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay, 80% of respondents were also aware that JPS uses fuel oil to generate electricity. Regarding awareness of the Office of Utilities Regulation’s invitation for proposals to increase Jamaica’s electricity generating capacity only 30% of respondents were aware of this request. 80% of respondents interviewed were aware that the Jamaica Public Service Company proposed to construct a 360 Megawatt combined cycle power plant adjacent to the existing plant. 60% of respondents were not aware of any details of the project. Of the 40% of respondents indicating some awareness of project details 75% were aware of the plans for the plant to be constructed while 25% indicated that they were aware of a coal facility to be built starting September 2012. It could not be determined if another project will be undertaken in the area as interviewees could not provide specific information.

On the issue of project concerns 60% of respondents indicated that they had concerns about the project. 40% of respondents indicated that they did not have any concerns related to the project. Of the 60% of respondents expressing concern about the project 16.7% were concerned about the project being done in an environmentally friendly manner. 33.3% expressed concern regarding noise pollution. 50% expressed concern about potential air pollution associated with exhaust from smoke release Respondents expressing concern about air pollution were also concerned about the possibility for employment opportunities for the community and also the proximity of the project site to residences and residents' farm plots.

50% of interviewees indicated that the project as proposed would have an effect on their lives. Of the 50% indicating some effect, 40% indicated a positive effect. 50% of respondents indicating a positive effect anticipated job creation. Of the 60% of respondents indicating a negative impact on their lives, 33.3% of respondents expressed concern about noise and vibration levels similar to that being experienced; 33.3% were concerned about relocation and the increased potential for disasters and 33.4% were concerned about the possibility of loss of lives in the event of an accident. 10% of respondents indicated that they depended on the proposed location for business, specifically cutting posts for fences and buildings.

80% of respondents stated that the area had a recreational facility. Of the 80% indicating the presence of a recreational facility, 37.5% mentioned the Blackwood Gardens Community Centre, 50% mentioned a community centre but did not name it and 12.5% mentioned a community centre in Old Harbour Bay. 30% of respondents indicated the presence of a historic or cultural site in or nearby the area. Of the 30%; 33.4% of respondents indicated Goat Island as a historic and cultural areas and 33.3% indicated Brampton Farm and 33.3% indicated Old Harbour Bay and stated that Christopher Columbus landed there. 80% of interviewees were not aware of the presence of any nature reserves. Of the 20% aware of the presence of a nature reserve all respondents indicated that there was an area in the sea but no specific details could be obtained.

Main Street Old Harbour Bay

10% of respondents interviewed resided along Main Street Old Harbour Bay. 70% respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay, 90% of respondents were also aware that JPS uses fuel oil to generate electricity. Regarding awareness of the Office of Utilities Regulation's invitation for proposals to increase Jamaica's electricity generating capacity only 40% of respondents were aware of this request. 90% of respondents interviewed were aware that the Jamaica Public Service Company proposed to construct a 360 Megawatt combined cycle power plant adjacent to the existing plant. 100% of respondents were not aware of any details of the project.

On the issue of project concerns 40% of respondents indicated that they had concerns about the project. 60% of respondents indicated that they did not have any concerns related to the project. Of the 40% of respondents expressing concern about the project 25% were concerned about the safety of the community. 25% expressed concern regarding an increase in electricity bills. 25% expressed concern about the potential benefit for the community and the possibility of employment opportunities. 25% of respondents while indicating a concern did not specify any particular concern.

70% of interviewees indicated that the project as proposed would have an effect on their lives. 28% of respondents indicated that there could be effects on health specifically air pollution. 14.3% indicated the expectation of lower electricity costs. 42.9% of respondents indicated the potential positive impact as employment opportunities are expected. 30% of respondents indicated that the project would not have an impact on their lives. 100% of respondents indicated that they did not depend on the proposed location for business.

60% of respondents stated that the area did not have any recreational facilities while 40% of respondents indicated a recreational facility. Of the 40% indicating the presence of a recreational facility, 50% mentioned the Blackwood Gardens Community Centre, 25% mentioned a community centre in Settlement and 25% mentioned the Old Harbour Bay Police Youth Club. 20% of respondents indicated the presence of a historic or cultural site in or nearby the area. Of the 20%; 50% of respondents indicated Goat Island as a historic and cultural areas and 50% indicated the St. Philip's Anglican Church. 60% of interviewees were not aware of the presence of any nature reserves. Of the 40% aware of the presence of a nature reserve, 50% mentioned that protected birds are on Goat Island and 50% indicated the mangroves

Buddho

5% of respondents were interviewed in Buddho. 80% respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay, 100% of respondents were also aware that JPS uses fuel oil to generate electricity. Regarding awareness of the Office of Utilities Regulation's invitation for proposals to increase Jamaica's electricity generating capacity only 40% of respondents were aware of this request. 100% of respondents interviewed were aware that the Jamaica Public Service Company proposed to construct a 360 Megawatt combined cycle power plant adjacent to the existing plant. Only 20% of respondents indicated awareness of some details of the project; however the accuracy of details could not be verified. Of this 20%, 100% indicated that the new plant is to be built a few meters from the existing site.

On the issue of project concerns 60% of respondents indicated that they had concerns about the project. 40% of respondents indicated that they did not have any concerns related to the project. Of the 60% of respondents expressing concern about the project 33.3% were concerned about personal safety and the ability to commute to and from work safely. 33.3% expressed noise pollution as a concern. 33.4% expressed concern about the potential new levels of vibration and risk as the present levels of vibration caused by the existing plant and stated that there was an explosion at the plant in the past.

100% of interviewees indicated that the project as proposed would have an effect on their lives. 20% of respondents indicated that there could be radiation and other health implications but did not specify the implications. 20% thought the project could have a positive impact on lives as the community would be safer. 60% indicated a negative impact. Of the respondents indicating a negative impact 33.3% indicated that there would not be any employment opportunities for individuals within the community. 33.4% indicated possible impact from noise and air pollution. 33.3% while indicating a negative impact did not specify. 100%

of respondents indicated that they did not depend on the proposed location for business.

60% of respondents stated that the area did not have any recreational facilities while 40% of respondents mentioned the Blackwood Gardens Community Centre. 60% of respondents indicated the presence of a historic or cultural site in or nearby the area. Of the 60%; 66.7% of respondents indicated Goat Island as a historic and cultural areas and 33.3% indicated the St. Philip's Anglican Church. 100% of interviewees were not aware of the presence of any nature reserves.

Terminal/Terminal Road

The Terminal/Terminal Road area is located nearest to the proposed power plant site. 29% of respondents were interviewed in the Terminal/Terminal Road area. Of the 29% of respondents interviewed in the Terminal/Terminal Road area, 100% respondents knew that the JPS owns and operates the Old Harbour Power Station in Old Harbour Bay, 93.1% of respondents were also aware that JPS uses fuel oil to generate electricity. Regarding awareness of the Office of Utilities Regulation's invitation for proposals to increase Jamaica's electricity generating capacity only 24.1% of respondents were aware of this request. 89.7% of respondents interviewed were aware that the Jamaica Public Service Company proposed to construct a 360 Megawatt combined cycle power plant adjacent to the existing plant. Only 17% of respondents indicated awareness of some details of the project; however the accuracy of details could not be verified. Of this 17%, 40% indicated that the new plant is scheduled to finish in 2014. 20% indicated that the new plant will be built as part of the existing plant and the existing plant would be closed. 20% indicated that construction was scheduled to start between September and November 2012 and that three types of fuel will be used at the new plant, namely natural gas, light fuel oil and heavy fuel oil. 20% of the respondents indicated that only natural gas would be used at the new plant.

On the issue of project concerns 34.5% of respondents indicated that they had concerns about the project. 65.5% of respondents indicated that they did not have any concerns related to the project. Of the 34.5% of respondents expressing concern about the project 40% were concerned about potential health issues but did not specify the health issues. The remaining 60% expressed noise pollution as a concern. Of the 60% expressing concern about noise, 16.7% expressed concern about smoke and 83.3% expressed concern about the levels of vibration which they may be exposed to.

37.9% of interviewees indicated that the project as proposed would have no effect on their lives. 3.4% of respondents indicated that the project could have both a positive and negative impact on lives. 17.3% indicated a negative impact and 41.4% indicated a positive impact. 100% of respondents indicating a positive impact indicated that the project provided employment opportunities. Of the respondents indicating a negative impact 16.6% indicated that by virtue of proximity to the site, they would be the first to be affected in the event of an incident. 16.6% indicated possible impact from the plant's exhaust. 50% indicated impact from noise pollution. 16.8% of respondents indicated loss of farm crops.

13.8% of respondents indicated that they depended on the proposed location for business. 50% use the area as a feeding ground for goats; 25% reside close to the site and 25% burn coal on the site.

34.5% of respondents stated that the area did not have any recreational, historic or cultural, or nature reserves in or nearby the area. The remaining 65.5% of respondents indicated the presence of at least one type of facility that was recreational, cultural or historic, or a nature reserve. Of the 65.5%, 73.7% of respondents indicated the Blackwood Gardens Community Centre as a recreational facility; 5.3% indicated the JPS Homework Centre and 5.3% indicated an open field nearby the beach where football is played. The remaining 15.7% did not indicate the presence of a recreational facility. Of the 65.5% of respondents indicating at least one type of facility that was recreational, cultural or historic, or a nature reserve 26.3% of respondents indicated that they were aware of a historical or cultural area in or nearby the community. 20% indicated the fishing village; 40% indicated Old Harbour Bay; 60% indicated the Anglican Church; 20% indicated the Baptist Church. Respondents indicated that the Old Harbour Bay is culturally significant as the East Indians landed in Jamaica at Old Harbour Bay. Additionally respondents indicated that the Old Harbour Bay Fishing Village is the Oldest in Jamaica. Respondents also indicated that the Anglican Church was established in the 18th Century.

5.4.10.2 Non-Governmental Organization (NGO) Perception

5.4.10.2.1 Jamaica Environment Trust (JET)

Consultation with the Chief Executive Officer of the Jamaica Environment Trust, Mrs. Diana Macaulay, indicated that she had concerns with the proposed project.

These issues related to:

- The use of Automotive Diesel Oil (ADO) as a backup fuel
- The health of the residents in the community

5.4.10.2.2 Caribbean Coastal Area Management Foundation (CCAM)

Consultation with Ms. Ingrid Parchment and Mr. Brandon Hay of CCAM indicated that they had concerns with the proposed project.

These issues related to:

- The proposed ADO delivery pipeline route
- Proposed access road to run through informal settlements in the area

5.4.10.2.3 Fishers

On September 12 and 13, 2012 Forty-Six (46) community questionnaires specifically aimed at fisher folk were administered at the Old Harbour Bay Fishing Beach, in an attempt to gather the opinions of the fishers within a two kilometres radius of the area proposed for the construction the Jamaica Public Service Company's 360 Megawatt Combined Cycle Power Plant. Thirty seven percent (37%) respondents were female and 63% were male.

Of the Forty-Six (46) respondents, age cohort distribution were as follows; 6.5% were between 18-25 years, 4.3% were age 26-33 years, 8.7 % were age 34-41 years, 37% were age 42 – 50 years, 30.4% were age 51-60 years and 13% were older than sixty years of age.

Approximately sixty one percentage (60.9%) of respondents indicated they were fishers (fishermen/women); 28.3% of respondents indicated they were fish vendors and 10.9% indicated that they did fishing and also sold fish. Approximately eleven percent (10.9%) of interviewees indicated they were fishing or selling fish for up to five years; 6.5% six to eleven years; 8.7% twelve to seventeen years; 8.7% eighteen to twenty-four years; 13% twenty five to thirty years and 52.2% for over thirty years. All respondents indicating they were fish vendors specified that they sold fish at the Old Harbour Bay Fishing Beach.

Of the respondents indicating that they fished 9.1% indicated that they used both lines and nets, 3% indicated they use the spear, net and fishpot; 18.2% used only the net, 30.3% used only the fish pot, 21.2% used both the net and fish pot; 9.1% indicated they used the line, net and fish pot, 3% indicated they used the spear only and 6.1% indicated they used both the spear and net.

Approximately fifty four percent (54.5%) of fishers indicated that they fished only in the Old Harbour Bay area; 3.0% said they fished in Windad. Fifteen percent (15.2%) of fishers fished in both the Old Harbour Bay area and Pelican Cay; 12.1% fished in both the Old Harbour Bay area and Pedro Cay. 6.1% fished only in Pedro Cay and 9.1% fished only on Pelican Cay.

Ninety seven percent (97%) of respondents used canoes with engine for fishing while 3% of fishers used canoes without an engine for fishing. Of the respondents having canoes with an engine, all canoes used one engine. 3.1% used 25 horsepower (hp) engines, 84.4% 40hp engines, 3.1% 60hp engines and 6.3% 75hp engines. 3.1% of fishers interchanged between a 40hp and 75hp engine.

On the issue of how many persons worked on fishing canoes, one person worked on 3% of vessels, two to three persons worked on 5.8% of vessels, three to four persons worked on 9.1% of vessels, five to seven persons worked on 12.1% of vessels.

Regarding the frequency of fishing and selling fish, fishers indicated that they fished mainly twice or three times per week. Fishers indicating that they fished once per week also indicated that they remained at sea for one week before returning to Old Harbour Bay. The type of fish reported by fishers included, doctor fish, parrot, snapper, sprat, angel, grunt, jack. Respondents also included that they caught lobster. Some fishers stated that they caught “reef fish” which they explained encompassed the varying species of fish they catch.

Regarding the pound catch of fish, fishers indicated that they caught total weights ranging from five pounds to one hundred pounds. The main reported weight was ten to twenty pounds. Respondents indicating heavier pound catch were those who spent multiple days at sea. Interviewees were not able to state the weight per species of fish they caught; they instead indicated that the average weight per fish they caught/sold ranged between 0.5, 0.75 and 1.0 lb.

Relating to the changes in earnings from fish sale as well as changes in the types and sizes of fish caught respondents indicated fluctuations. These fluctuations were based on fish supplied by the fishers in the case of vendors. Weather conditions, damage to nets and fish pots and the increase in fuel and material costs, overfishing and spear fishing of large fish were stated as contributing factors to the fluctuations in fish earning and fish catch.

Approximately ninety six percent (95.7%) of all respondents were aware that the Jamaica Public Service Company (JPS) operates the power plant in Old Harbour Bay while 4.3% were not aware.

Approximately ninety six percent (95.7%) of respondents were aware that JPS uses fuel oil in the production of electricity. As it related to awareness of the of the invitation for proposals by the Office of Utilities Regulation (OUR) to supply up to 480 MW of Base Load Generating Capacity to increase Jamaica’s generating capacity for electricity; only 39.1% of respondents were aware. Sixty one percent (60.9%) of respondents were not aware of the OUR’s invitation. Regarding respondents’ awareness of plans by the Jamaica Public Service Company to construct a 360 MW (Megawatt) combined cycle power plant near/adjacent to the existing Old Harbour facility; it was observed that 56.5% of respondents were aware of this proposal while 43.5% of respondents were not aware.

On the issue of project concerns, 15.2% of all respondents expressed concern, 69.6% did not express concern and 15.2% of respondents were uncertain if they had any concerns. Interviewees expressing concern were concerned about the availability of possible work opportunities and benefit to the community. Additionally, respondents were concerned about waste disposal of liquid and solid waste. Concerns were also expressed about noise and dust pollution. Impact on fisher folk was also highlighted but no specific details were mentioned.

Thirteen percent (13%) of respondents anticipated a positive impact on their lives as a spin off from the project; 23.9% of respondents were unsure of any impact on their lives. Approximately fifty six percent (56.5%) of respondents indicated that they did not expect the project to affect their lives in any way while 6.5% of respondents expected a negative impact. Interviewees anticipating a negative impact on their lives anticipated an increase in pollution, especially noise. Interviewees also expected negative impact as they expected that employment opportunities would not be available to residents in the nearby communities. A positive impact on individuals' lives was anticipated as cheaper electricity cost was expected as a spin-off of the project. It was also expected that more jobs would be created and an environmentally friendly energy alternative would be created.

All of respondents indicated that they did not depend on the proposed site for any type business/fishing/residence. Approximately ninety one percent (91.3%) of fishers interviewed indicated that they did not think the proposed project would affect their business/trade, 4.3% of interviewees expected an impact on their business/trade from the project and 4.3% were not sure if there would be any impact. Respondents indicating an impact expected more pollution (50%) and more business opportunities (50%).

5.4.10.2.4 Old Harbour Bay - Community Development Association (CDA)

A meeting was held on August 13, 2012 at the Old Harbour Bay Primary School with members of the Old Harbour Bay CDA, which included the President (Errol Cobourne) and members of his executive; Charles Moodie from the Fishermans Co-op and the Councillor of the division (Peter Davis) (See Appendix 11 for full list of attendees). Below is a list of questions and concerns raised by CDA members during the meeting:

Questions:

- How would the exhaust from the plant be controlled?

- How would the wastewater from the plant affect the gully? Can the data be made available to the community? Can community members take part in monitoring?
- Will the effluent be less harmful to the wildlife e.g crocodiles and fishes?
- How will the fuel be stored?
- How much of the coastline will be lost?
- How will the health assessment be done? Will it be random or will the entire community be assessed?
- Should the people living near the plant be relocated?
- Will the LNG emissions be less? Will it cause a negative impact?
- What are the concerns from diesel? Will there be any protection from the diesel?
- Will the transportation of materials affect the roads and bridges in the community? Will homes be tested?
- Who will be responsible for these mitigations?
- What is the minimum distance required by law for people to live close to a plant/high tension lines?
- How flammable is LNG?
- What are the benefits of the power plant?
- Will the well water provide enough water for cooling?

Points Raised:

- People are living along the sports complex wall towards the site. The access road will cut through their homes.
- Land should be allocated near Brompton for relocation.
- An environmental committee should be put in place to ensure proper management of the site/plant.
- A liaison/community member should be included in all meetings.
- The bridges and roads in the community are unsuitable for heavy trucks and machinery

5.4.11 Land Use

5.4.11.1 Past

Historically, the area contains historic and archaeological sites dating back to Jamaica's first known inhabitants (The Taíno) and later those who came the Spanish, the Africans and the British. The area has seen various land uses over the past centuries. Cattle rearing were the main activity in the area during pre and post emancipation periods. It should be noted that all the plantations, pens and estates in the area had plantation houses and enslaved villages. In the more recent past, aquaculture was done on some areas of the property. Pre historical cultural material in the form of pottery sherds, both Spanish and English bricks and concrete troughs associated with cattle rearing are found to the immediate east and west of the proposed site. *(Source: Jamaica National Heritage Trust Archaeological Impact Assessment for the JPS 360MW Plant)*

5.4.11.2 Existing

Existing land use in the study area is agricultural, commercial, industrial, residential, educational and recreational. Other uses include a cemetery (Old Harbour Bay Cemetery), telecommunication modules and cellular towers, an airstrip and informal solid waste disposal. The proposed site is used as an informal dump.

Agricultural facilities dominate the land use of the study area. Sugar cane farming, fishing and aquaculture (pond fish) are the major agricultural activities. However, subsistence farming also occurs in the area. There is also the Bodles Research Facility which conducts agricultural research activities.

Commercially, the study area has restaurants, bars, a market and a fishing village (Old Harbour Bay), factories such as the Caribbean Boilers Hatchery, car wash, charcoal burning and scrap metal recovery operations.

Industrial facilities include the Jamaica Energy Partners “Dr. Bird” power barge, Jamaica Public Service Company Ltd. Old Harbour Bay electric power station, Windalco’s Port Esquivel Alumina Storage and Port and Jamaica Broilers Ethanol Dehydration Plant (Figure 5-136).

There are seven (7) major residential areas within the (Social Impact Area (SIA). These are sections of Old Harbour, New Harbour Village Phase I and II, Free Town and Longville Park Estates, Belmont Park Community and Old Harbour Bay. Other areas include Kellys Pen and an informal community adjunct to the SJPC northern boundary.

Recreational facilities are located at Old Harbour Bay where there is a community centre, which has a football field and a hard court for netball and basketball. There are also areas within the community where individuals set up for their recreational activities.

For transportation purposes, there is the Highway 2000 east-west link which runs through the SIA.

5.4.11.3 Future

Future developments in the area include:

- Cement and Quarry Operations and 39MW Coal-fired Power plant (Cement Jamaica Limited)
- Government of Jamaica LNG Project (located 500 m southwest of the proposed SJPC 360MW Plant)
- Longville Park Phase III Housing Scheme
- Salt Harbour Special Fishery Conservation Area

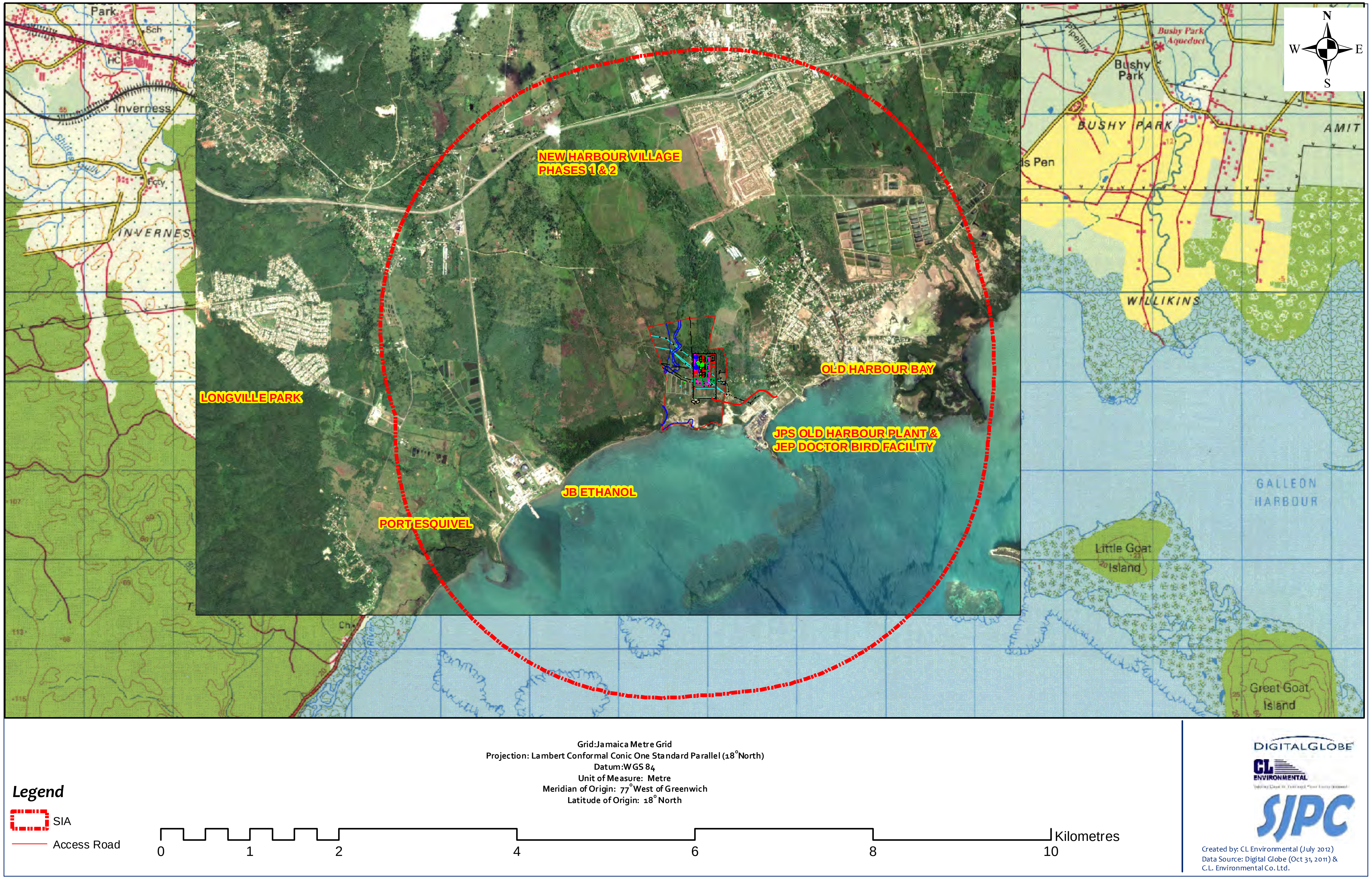


Figure 5-136 - Map depicting existing land use

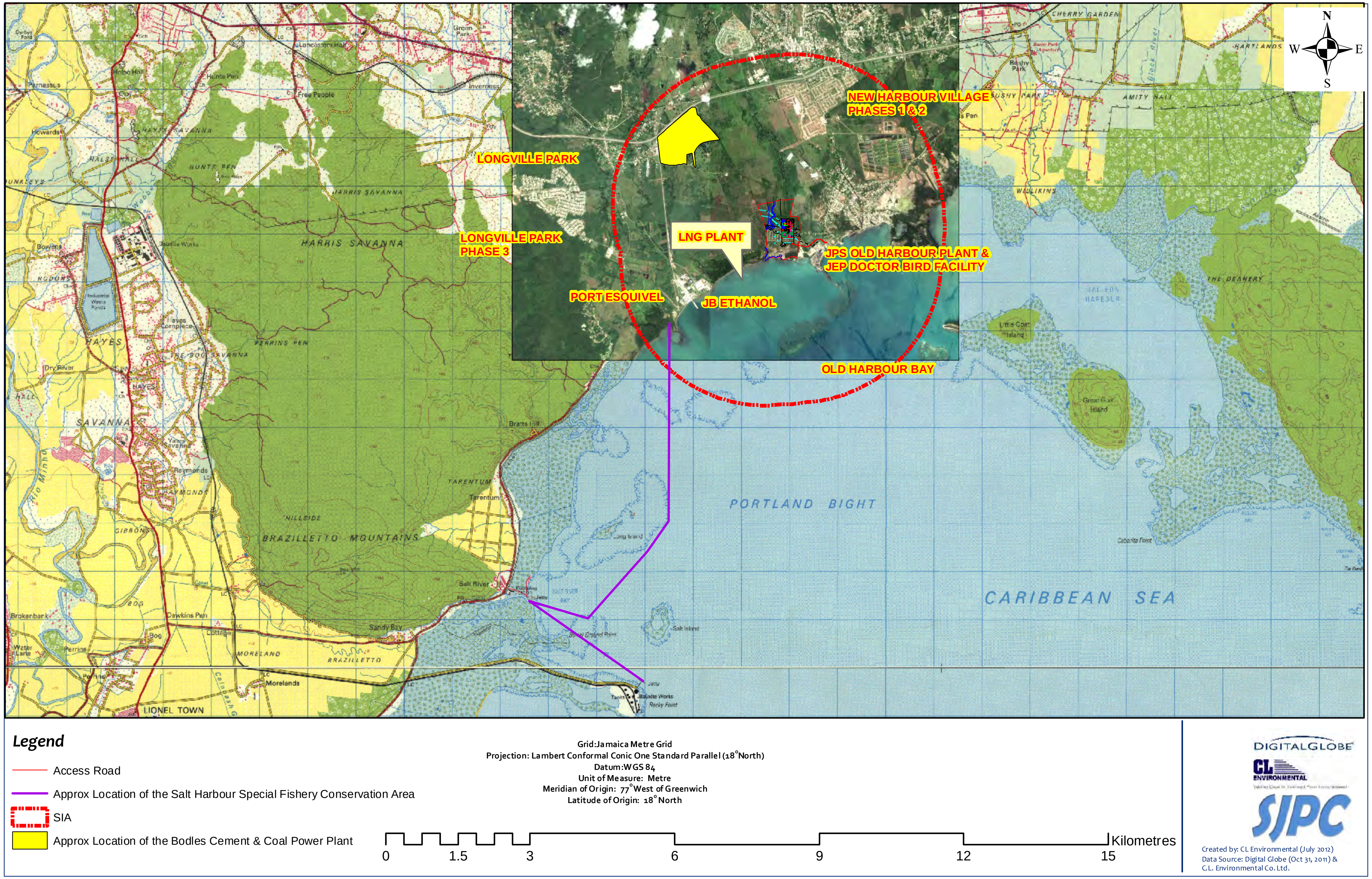


Figure 5-137 –Map depicting future land use

5.4.11.4 *Portland Bight Protected Area*

The proposed project falls within the Portland Bight Protected area. The area covers approximately 1,876 km^2 of terrestrial and marine environment and is co-managed by the Caribbean Coastal Area Management Foundation (CCAM) and the National Environment and Planning Agency (NEPA) (Figure 5-138). CCAM is a registered non-governmental organization (NGO) in Jamaica which is very active within the area.

5.4.11.4.1 Fisheries Resources

The proposed Project area is bounded by Special Fishery Conservation Areas (SFCA). Special Fishery Conservation Areas are no-fishing zones reserved for the reproduction of fish populations. Located to the west is the Salt Harbour Fish Sanctuary, whilst towards the east are the Three Bays Fish Sanctuary and the Galleon Harbour Fish Sanctuary (Figure 5-139). Thus, any fishing activities would be limited to areas offshore and outside the Bay.

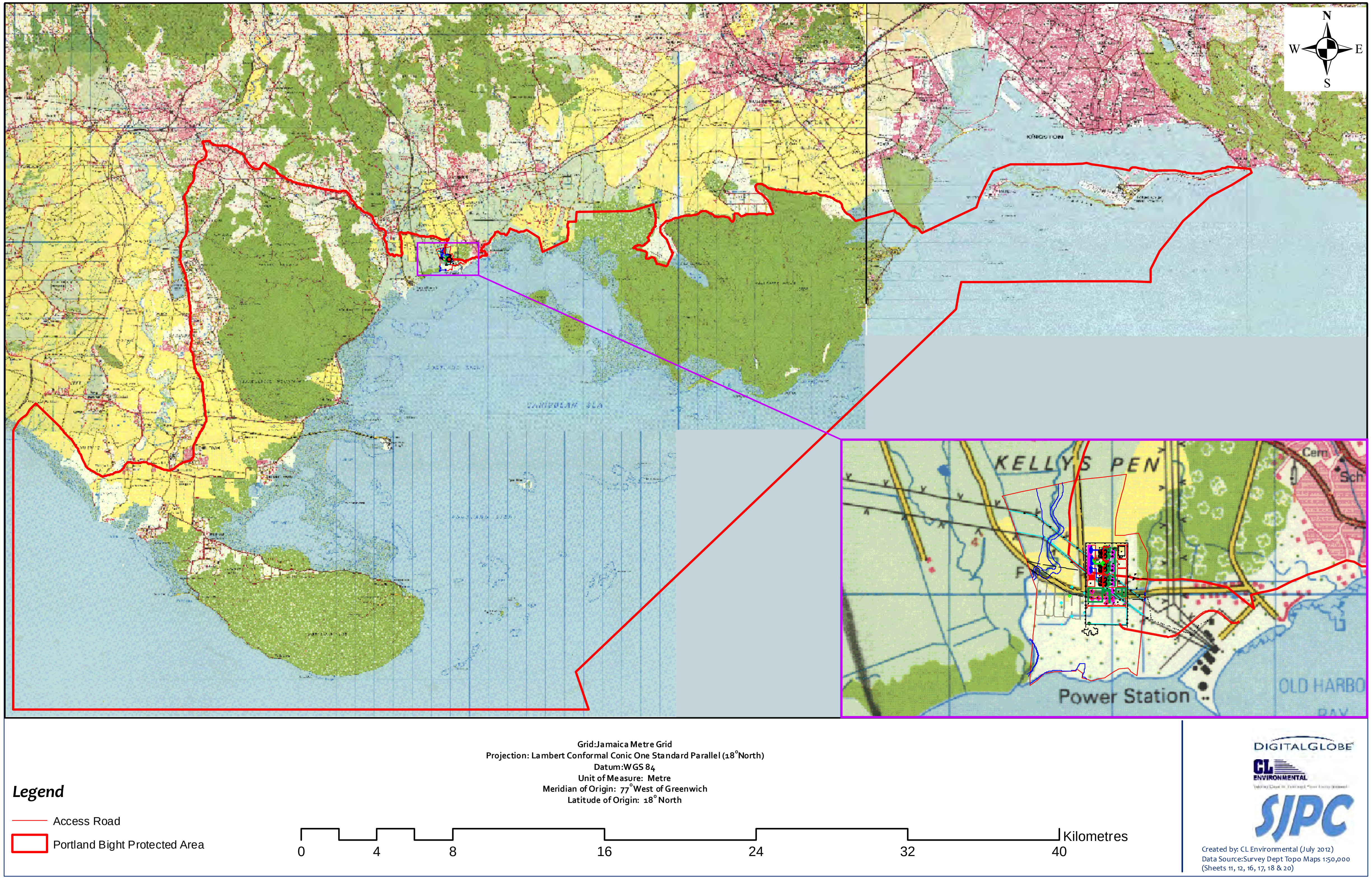


Figure 5-138 - Portland Bight Protected Area

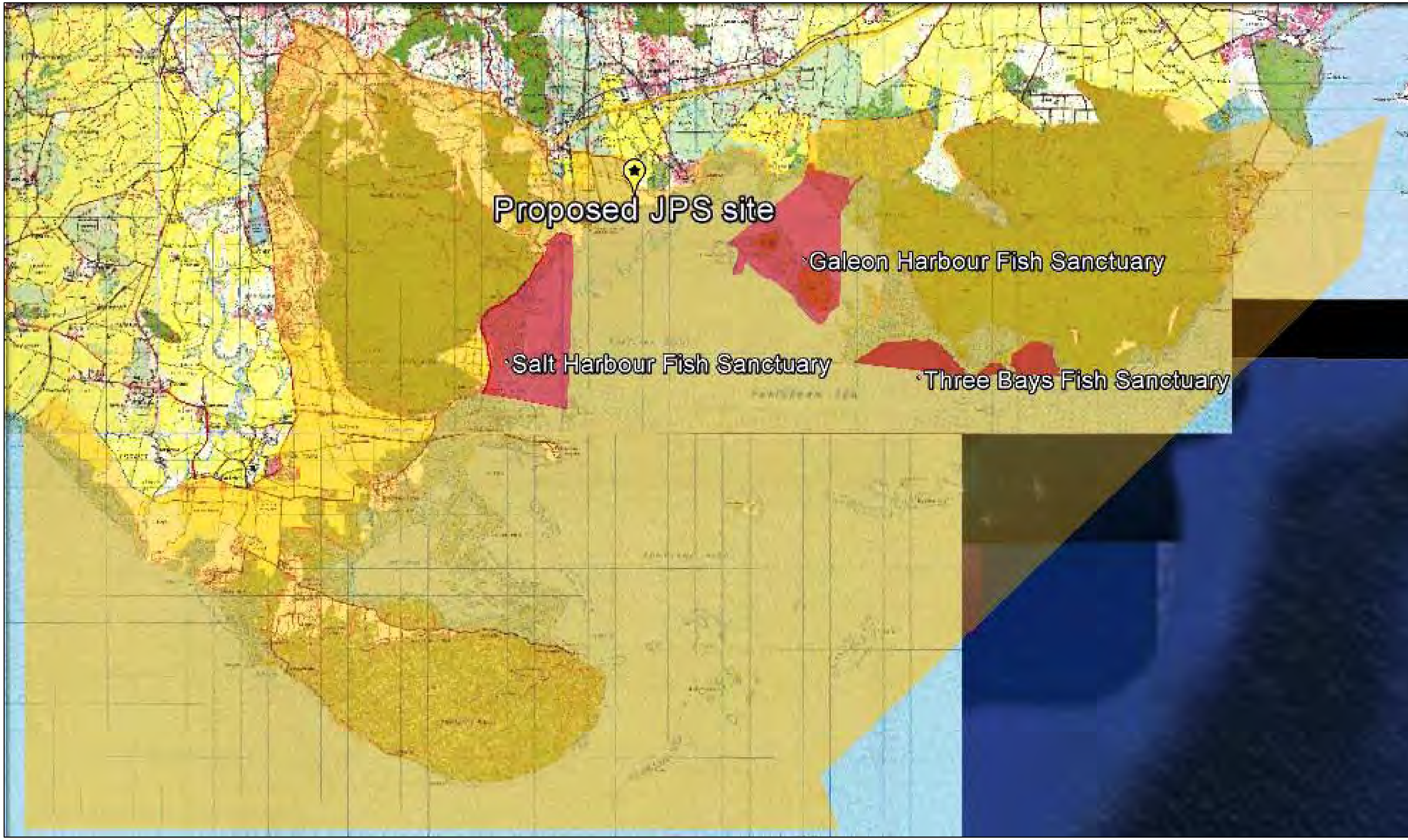


Figure 5-139 – Locations of the three fish sanctuaries in proximity to the proposed site

5.4.11.5 Highway 2000 Corridor - Portmore to Clarendon Park

Arising from the development of Highway 2000, a Land Use zonation map was developed by the Government of Jamaica to guide development along the H2K corridor (Figure 5-140). The proposed SJPC 360MW LNG plant falls within an area that has been zoned for “heavy industry”. Therefore, the proposed development complies with the Land Use zone for Portmore to Clarendon Park Highway 2000 Corridor Development Plan 2004 – 2025.

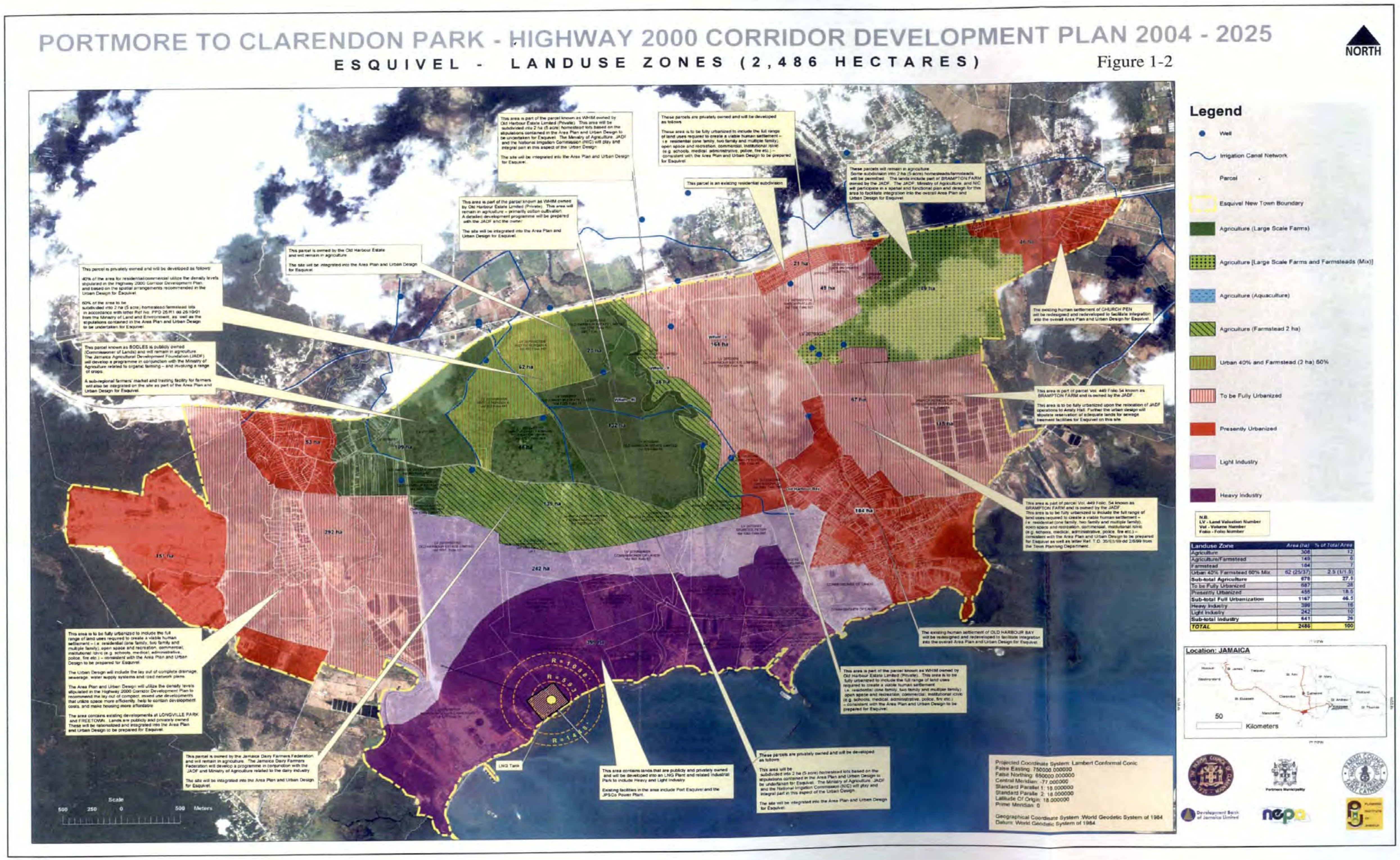


Figure 5-140 - Map showing Land Use of Highway 2000 Corridor Development (Portmore to Clarendon Park)

5.4.12 Road Network and Transportation

Roads within the social impact area are in various states of repairs. Access to the site is the Old Harbour to Old Harbour Bay main road which may be entered from the Old Harbour square (beside the police station) or from Highway 2000 exit ramp. From the Old Harbour one would travel approximately 2.5km along the road to the turn off at the outskirts of the town of Old Harbour Bay. This section of the road is in need of repairs. There are sections along the asphaltic concrete surface where the surface becomes undulating (CLE, 2007). Some interior roads are unpaved such as Terminal Lane as well as there are paths which are in poor condition.

The public transportation system within the community was considered to be reliable as there are a number of licensed taxis, unlicensed taxis available for commute throughout the community.

A large majority of the Old Harbour Bay Community utilized licensed taxis as their main type of transportation, accounting for 93.6% of residents. Other means were unlicensed taxis (“robot”), bicycles and private motor cars (SDC 2007).

5.4.12.1.1 Transportation Route from Port Esquivel to proposed Project Site

A route survey was conducted by Zoukie Trucking in February 2011 to determine the potential obstacles along the possible transportation routes. The assessment was done based on information supplied by the Client which consisted of the loads with different configurations. Based on this assessment standard size cargo can be transported along the normal route with normal access not interrupting vehicular traffic. Standard size loads are considered 8ft wide or less, 9 ft tall or less, 45ft in length or less.

For oversize loads, excess in height, width, weight, different routes can be chosen depending on the nature of each load. There is only one route (from Port Esquivel) which does not have permanent overhead obstructions and this is similar to the route in Figure 5-141, but to detour around the underpass. There would be two underpasses along this route. One is very high and doesn’t pose an obstruction and one is low - 16.9 feet. Plate 5-54 depicts the first underpass one would encounter from Port Esquivel. This bridge does not pose a problem as it relates to transporting the oversized loads. Plate 5-55 shows the underpass to enter Old Harbour Bay. This underpass is 16.9 feet high and poses a problem with oversized loads.

A solution to this problem is to bypass the underpass by entering the highway heading to Kingston and making a U turn to exit on the opposite side of the road to continue to Old Harbour Bay. In order to make the U turn, special arrangements will need to be made with the Highway Authority (National Road Operating and Constructing Company) to remove approximately 100 feet of railings along the highway and also for traffic management (Figure 5-141 and Plate 5-56). There are a number of overhead wires that will need to be lifted or raised prior to the transports (Plate 5-57). These wires are mainly through Old Harbour town area and the residential areas. There are also areas on the road heading to Old Harbour Bay which will need to be widened in order to create space to manoeuvre the oversize loads (Plate 5-58). General cargo and equipment will be transported by truck from Kingston.

5.4.12.1.2 Access Road

Two possible access roads were investigated. One through the existing informal settlement area (Route 1) and the other from the JPSCo Sports Club heading north-westerly to the proposed site (Route 2). The latter route was chosen to reduce the potential negative impacts on the residents (Figure 5-141).

This access road will be approximately 830 m long, width of 9 m and way-leave requirements of 11 meters. The existing parish council access road will not be used to access the site based on the proximity to the informal settler. The Owner intends to build a new access road from the existing power plant to the new site and to make provisions for the existing access road to be connected to the roadway around the plant on the south boundary.

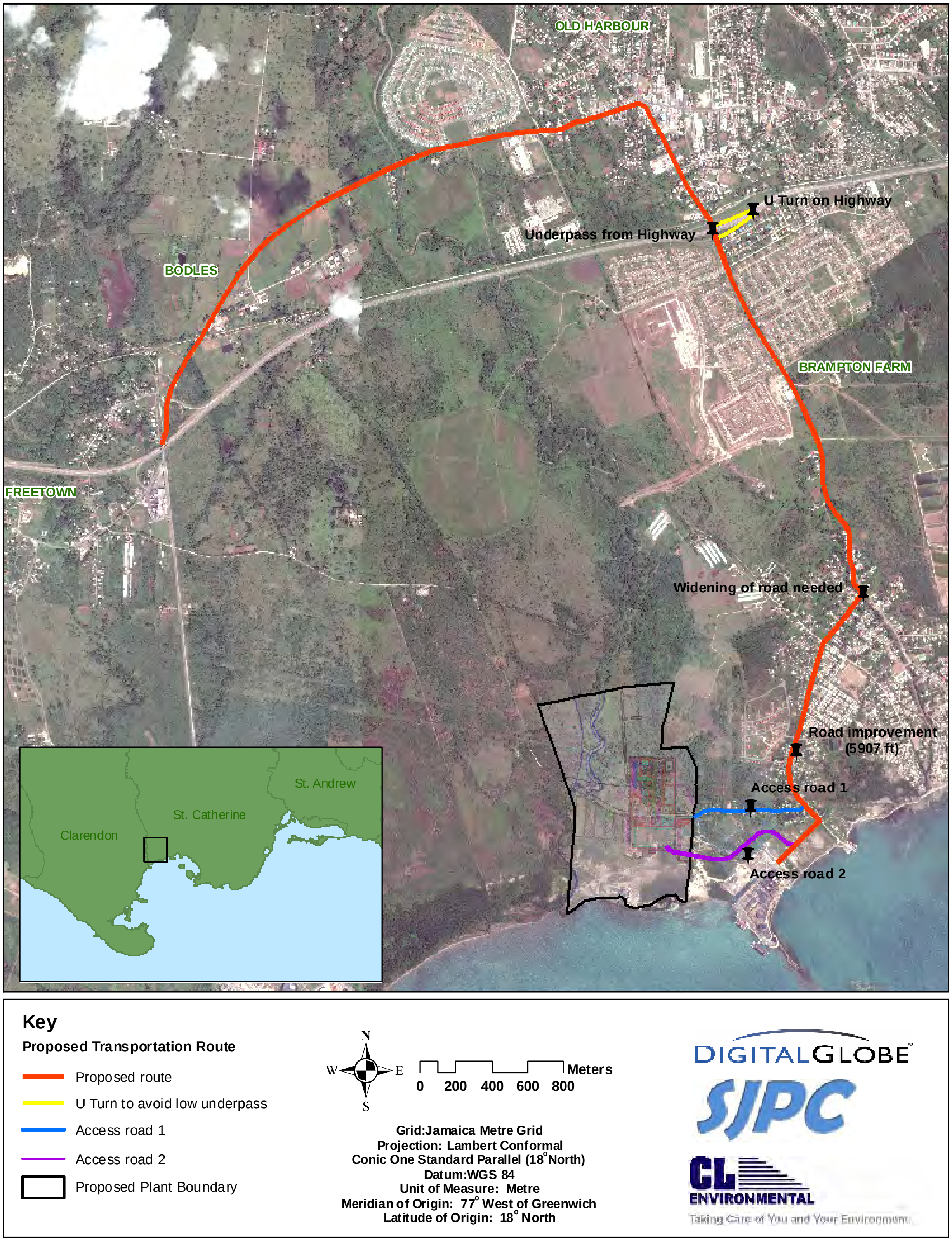


Figure 5-141 - Proposed transportation route to plant site via Old Harbour

Plate 5-54 - Underpass at the exit of Port Esquivel (Source:Zoukie Trucking)

Plate 5-55 - Low underpass on the way to Old Harbour Bay (Source:Zoukie Trucking)

Plate 5-56 - Possible location for the removal of the railings for the U Turn (Source: Zoukie Trucking)

Plate 5-57 - Some overhead wires in Old Harbour Town (Source: Zoukie Trucking)

Plate 5-58 - An area on the road heading to Old Harbour Bay that needs to be widened (Source: Zoukie Trucking)

5.5 AESTHETICS AND LANDSCAPING

The area of the proposed development is an industrialized area with the existing JPS Old Harbour Bay power plant (to be shut down), Port Esquivel, Best Dressed Chicken Feed Mill, Jamaica Energy Partners Dr Bird I and II Barges and Jamaica Broilers Ethanol Dehydration Plant in close proximity.

The proposed development along with proposed landscaping will improve the visual impact of the site.

6.0 IDENTIFICATION AND ASSESSMENT OF POTENTIAL DIRECT AND INDIRECT IMPACTS

This Section will discuss the impacts associated with construction and operation of the proposed power plant project. Construction activities are mainly divided into site preparation (vegetation clearing and excavation) and construction of the facilities for the power plant. Operation activities will consider the power plant by itself. Section 7.0 will address cumulative impacts of the proposed project and other existing operations nearby.

An environmental impact is defined as any change to an existing condition of the environment. The nature of the impacts may be categorised in terms of:

- Direction (overall effect on the environment) - positive or negative
- Duration (length of time effect expected to occur) - long or short term
- Location (impact of effect on specific site area) - indirect or direct
- Magnitude (scale of predicted impact) - large or small
- Extent (range of predicted impact) - wide or local
- Significance (of predicted impact to developer and site) - large or small

To systematically identify the impacts associated with the proposed plant, an impact matrix was constructed which arrayed the main project activities against the relevant environmental factors. This matrix is shown in Table 6-1and Table 6-2.

Table 6-1 - Impact matrix for site preparation and construction phases

ACTIVITY /IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE		EXTENT		SIGNIFICANCE	
	Pos	Neg	Long	Short	Direct	Indirect	Major	Minor	Wide	Local	Large	Small
1. Site Preparation												
Vegetation clearance		x	x		x			x		x		x
Fauna (removal of habitats)		x	x			x		x		x		x
Excavation works		x		x	x			x		x		x
Increased infiltration/runoff and flooding hazard		x		x		x		x		x		x
Solid waste generation		x		x	x			x		x		x
Piling/building Foundation		x		x	x			x		x		x
Air quality		x		x	x			x		x		x
Noise		x		x	x			x		x		x
Water quality		x		x		x		x		x		x
Land use		x	x		x			x		x		x
2. Material Transport												
Dusting & spillage		x		x	x			x		x		x
Traffic congestion, road wear		x		x	x			x		x		x
Power Outages		x		x	x			x		x		x
3. Material Storage												
Dusting		x		x	x			x		x		x
Suspended solid runoff		x		x	x			x		x		x
4. Construction Works												
Noise		x		x	x			x		x		x
Water demand and supply		x		x		x		x		x		x
Refueling of vehicles and fuel storage onsite		x		x	x			x		x		x
Repair of vehicles onsite		x		x	x			x		x		x
Landscaping	x		x		x			x		x		x
Fauna (replacement of habitat)	x		x			x		x		x		x
5. Construction Crew												
Sewage/wastewater generation		x		x	x			x		x		x
Solid waste management		x		x	x			x		x		x
Emergency response		x		x	x			x		x		x
6. Socioeconomics												
Employment	x			x	x		x			x	x	
Businesses (established)		x		x		x		x		x		x
7. Cultural and Historical												
Historic sites		x	x		x			x		x		x

Table 6-2 - Impact matrix for operation phase

ACTIVITY/ IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE		EXTENT		SIGNIFICANCE	
	Pos	Neg	Long	Short	Direct	Indirect	Major	Minor	Wide	Local	Large	Small
1. Plant Maintenance												
Polluted run off from wash-down activities		x	x		x			x		x		x
2.Storm Water/Drainage												
Increased flow, siltation and flooding hazard		x	x			x		x		x		x
Water quality		x	x			x		x		x		x
3. Landscaping												
Vegetation maintenance	x		x		x			x		x		x
Fauna (increased access to wildlife)		x	x			x		x		x		x
5. Air Quality												
Increased pollutants in air shed		x	x		x		x		x		x	
6. Noise												
Increased noise pollution		x	x		x		x		x			x
7. Health and Safety												
Increased air emissions exposure		x	x		x		x		x		x	
Increased noise exposure		x	x		x		x		x			x
8. Spills and Waste Disposal												
Increased potential for oil spills		x	x			x	x		x		x	
Improper oily water disposal		x	x			x		x		x		x
Improper solid waste disposal		x	x			x		x		x		x
Improper black & grey water disposal		x	x			x		x		x		x
9. Occupational Health												
Increased noise exposure		x	x		x		x			x		x
Increase exposure to air pollutants		x	x		x		x			x		x
Increased accident potentials		x	x		x			x		x		x
10. Socioeconomics												
Employment	x		x			x	x			x	x	
Stable electricity supply and lower electricity costs	x		x			x	x		x		x	
Increased worker productivity	x		x		x		x			x	x	
Economic growth nationally	x		x		x			x	x		x	

ACTIVITY/ IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE		EXTENT		SIGNIFICANCE	
	Pos	Neg	Long	Short	Direct	Indirect	Major	Minor	Wide	Local	Large	Small
Water demand and supply		x	x			x		x		x		x

6.1 SITE PREPARATION AND CONSTRUCTION

6.1.1 Water Resources

The Bowers Gully located to the west of the proposed site may be affected by the implementation of the proposed power plant. Debris generated during the site clearance and preparation may infiltrate the natural freshwater system by means of runoff. In addition, any filling or excavation may play a major role in the contamination of the river due to dust and sheet flow runoff.

6.1.2 Noise

Site clearance for the proposed development necessitates the use of heavy equipment to carry out the job. These equipment include bulldozers, backhoes etc. They possess the potential to have a direct negative impact on the climate. Noise directly attributable to site clearance activity should not result in noise levels in the residential areas to exceed 55dBA during day time (7am – 10 pm) and 50dBA during night time (10 pm – 7 am). Where the baseline levels are above the stated levels then it should not result in an increase of the baseline levels by more than 3dBA at the nearest residence.

The proposed project has the potential to be a noise nuisance during both the construction and the operation phases. However, with the proper mitigative steps the proposed project will have minimal if any impact on the surrounding community.

Construction noise can result in short-term impacts of varying duration and magnitude. The construction noise levels are a function of the scale of the project, the phase of the construction, the condition of the equipment and its operating cycles, the number of pieces of construction equipment operating concurrently. To gain a general insight into potential construction noise impacts that may result from the project, the typical noise levels associated with various types of construction equipment are identified in Table 6-3.

Table 6-3 - Typical construction equipment noise levels

Equipment	**Noise Level at 15m (dBA)**
Air Compressor	81
Asphalt Spreader (paver)	89
Asphalt Truck	88
Backhoe	85
Bulldozer	87
Compactor	80
Concrete Spreader	89
Concrete Mixer	85
Concrete Vibrator	76
Crane (derrick)	88
Delivery Truck	88
Diamond Saw	90
Dump Truck	88
Front End Loader	84
Hoist	76
Motor Crane	83
Jackhammer	88
Pump	76
Roller	80
Shovel	82
Truck	88

Sources: *Patterson, W.N., R.A. Ely, and S.M. Swanson, "Regulation of Construction Activity Noise," Bolt Beranek and Newman, Inc., Report 2887, for the Environmental Protection Agency, Washington, D.C., November 1974 and New York State Department of Environmental Conservation, "Construction Noise Survey," Report No. NC-P2, Albany, NY, April 1974.*

6.1.2.1 Access Road

During the site clearance and construction phases of the Proposed Project, an access road will be built to the site which will facilitate the movement of heavy vehicles and equipment. It is anticipated that during the site filling phase is when the highest daily volume of vehicular traffic will occur. It is anticipated that during this phase approximately 70 truck trips per day to carry fill material to the site. SoundPlan 7.1 model was used to determine the potential noise impact to the community for this activity (worst case scenario). A speed limit of 30 km/h for the trucks was used in the model.

Table 6-4 shows the predicted noise along Old Harbour Main Road, Terminal Road and the Access Road. Sixteen locations (receivers) were assessed (two sensitive receptors – church & school) of which eight were found to be in exceedance of the NEPA daytime noise standard. The day time noise standard was used as the trucking will be done during day time hours.

Table 6-4 - Predicted noise levels along Old Harbour Bay Main Road, Terminal Road and Access Road from approximately 70 truck trips per day

RECEIVER	PREDICTED NOISE (dBA)	NEPA DAY TIME NOISE STD (dBA)
House 1 OHB Main Road	53.2	55
House 2 OHB Main Road	**62.9**	55
House 2 Terminal Road	50.7	55
House 3 Terminal Road	**63.0**	55
House 5 Blackwood Gardens	**58.7**	55
House 6 Terminal Road	**59.4**	55
House 7 Terminal Road	**61.7**	55
House 8 Terminal Road	**59.4**	55
House 9 Burkesfield Meadow	46.1	55
House 10 Burkesfield Meadow	43.7	55
House 11 Terminal Road	**60.8**	55
House 12 Terminal Road	**57.8**	55
New Harbour Phase 1	51.5	55
New Harbour Village Phase 2	51.8	55
Blackwood Gardens Basic School	40.6	45
Mount Refuge Baptized Church	51.8	55

N.B. Numbers in red are in exceedance of the standard

Figure 6-1 depicts the NEPA day time noise limit (55 dBA) along the access road.

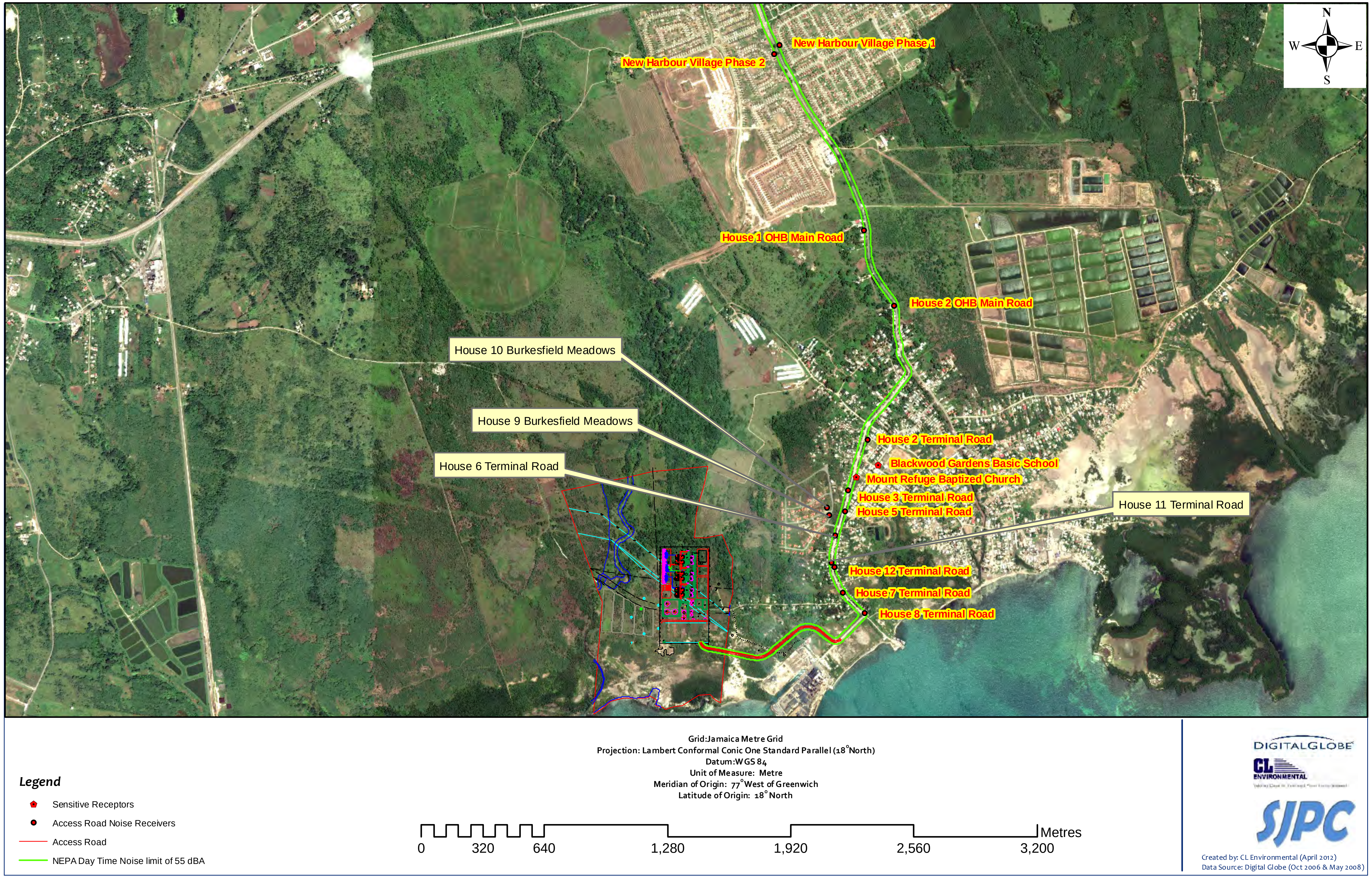


Figure 6-1 - Map showing the 55 dBA noise contour along the access road noise and modelled noise receivers

6.1.3 Air Quality

Site preparation has the potential to have a two-folded direct negative impact on air quality. The first impact is air pollution generated from the construction equipment and transportation. The second is from fugitive dust from the proposed construction areas and raw materials stored on site. Fugitive dust has the potential to affect the health of construction workers, the resident population and the vegetation. Both types of impacts will be of high intensity but of relatively short duration, so no permanent, significant impacts are anticipated from these activities.

6.1.4 Solid Waste Generation

During this construction phase of the proposed project, solid waste generation may occur mainly from two points:

i. From the construction site.
ii. From construction activities such as site clearance and excavation.

The construction of the power plant facilities will generate large amounts of solid waste, comprised of mainly concrete blocks, timber, steel, used packaging, containers etc. Other lightweight waste such as styrofoam, paper and plastics have the potential to be blown and washed into the nearby Bowers Gully.

6.1.5 Stormwater Runoff and Flooding

6.1.5.1 Changes to flood levels and extent due to construction of power plant

It is possible for the flood extents and depths to be changed as a result of the construction of the foundation pad. The flood plain model was used to assess the flood levels after the construction of the plant. This was done by modifying the terrain model to reflect the pad being constructed above to 0.5m above the preconstruction water surface. The results indicated the changes are negligible. See Figure 6-2 and Figure 6-3 below.

6.1.5.2 Pollution of Surface Waters

There is a possibility of siltation and debris in drains and gullies from construction activities.

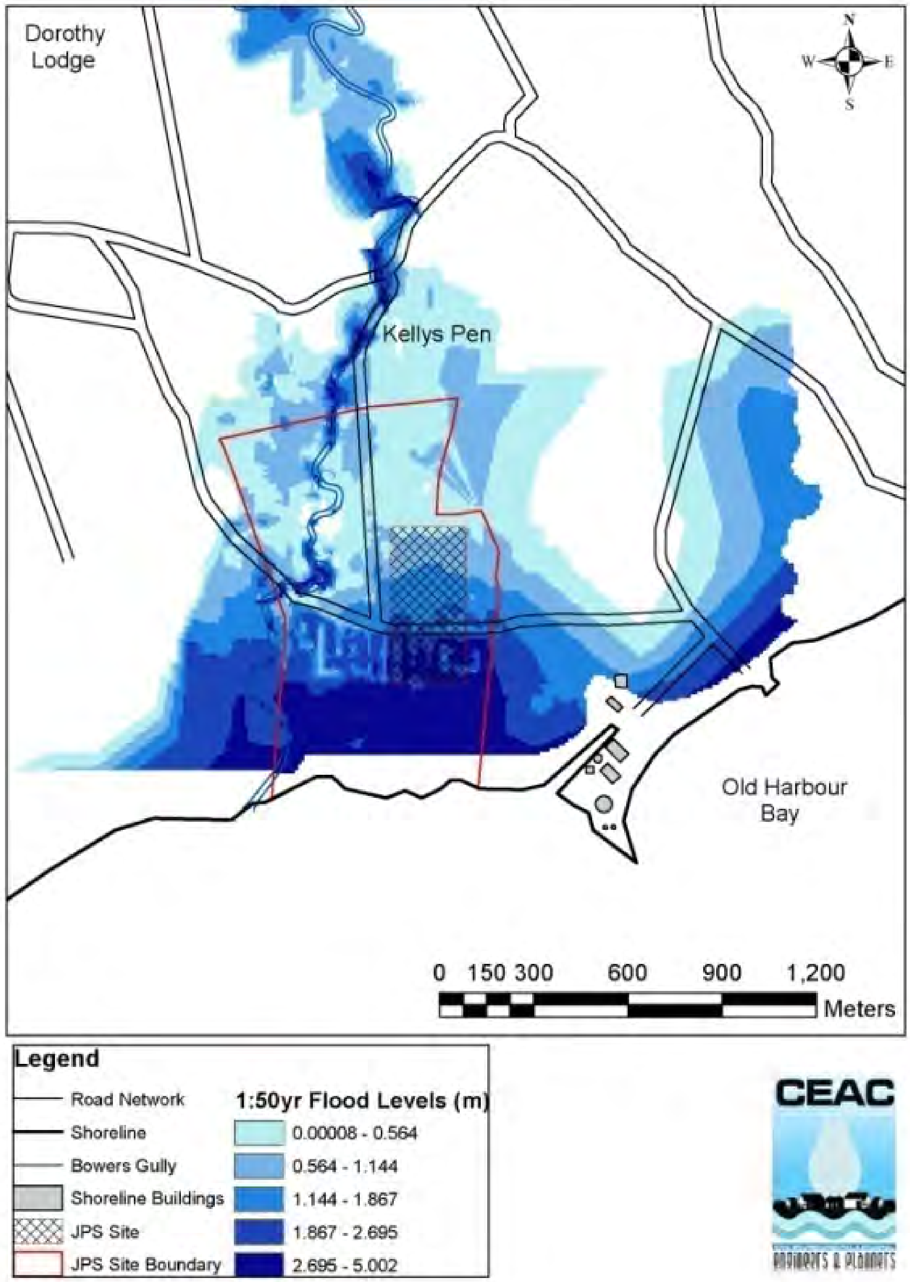


Figure 6-2 - Floodplain map showing flood levels predicted for the pre-construction scenario

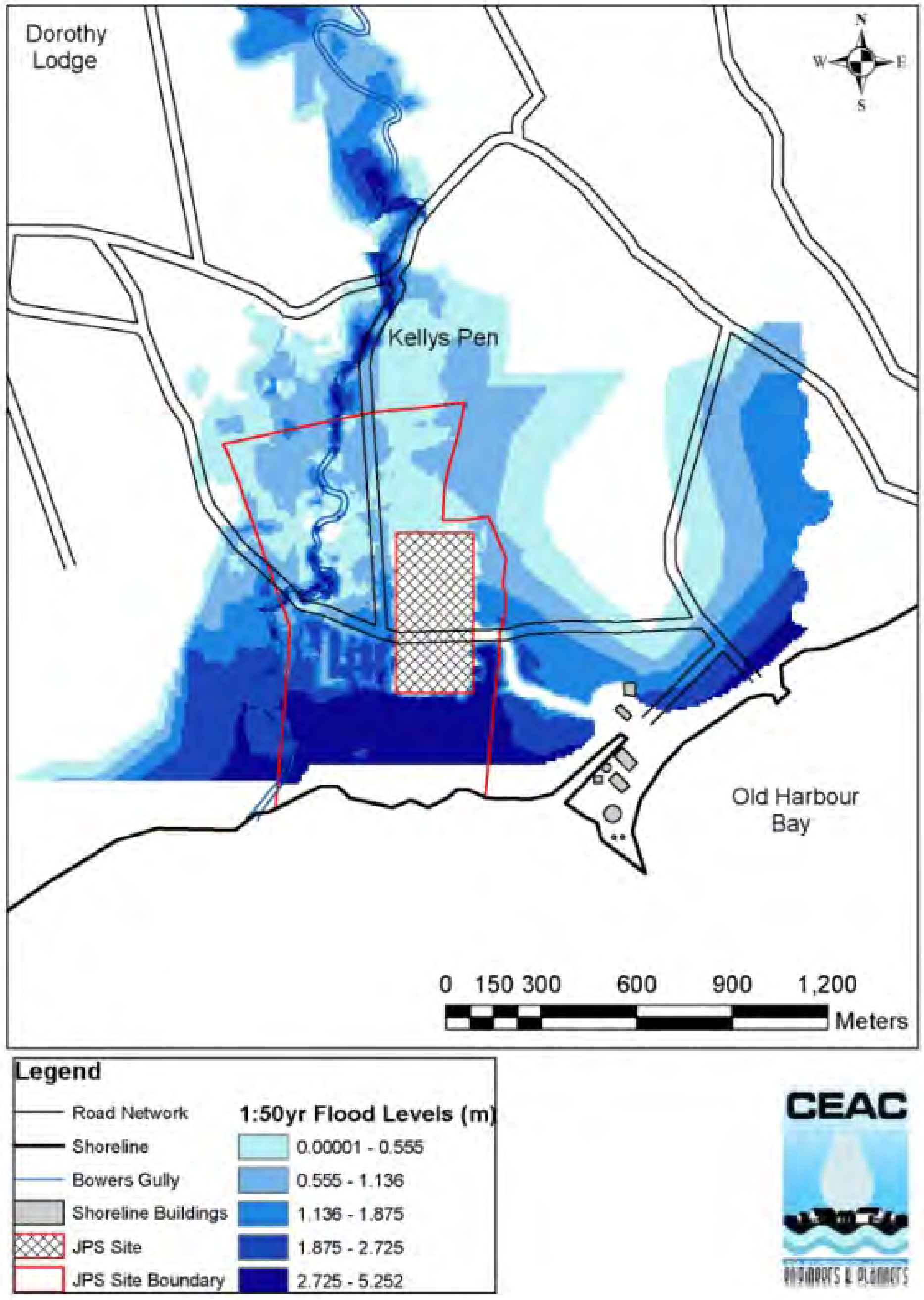


Figure 6-3 - Floodplain map showing flood levels predicted for the post-construction scenario

6.1.6 Wastewater Generation and Disposal

With every construction campsite comes the need to provide construction workers with showers and sanitary conveniences. The disposal of the wastewater generated at the construction campsite has the potential to have a minor negative impact on the surface water (Bowers Gully) and marine environment.

6.1.7 Raw Material Storage and Transport

Raw materials, for example sand and marl, used in the construction of the proposed power plant will be stored onsite. There will be a potential for them to become air or waterborne.

6.1.8 Storage of Fuels and Chemicals

It is anticipated that refuelling and maintenance of large machinery will take place on the construction site and that, correspondingly, there will be storage of fuel and lubricants on the site. With the storage of fuels and maintenance of construction equipment, there is the potential of leakage of hydraulic fuels, oils etc.

Spilled chemicals can contaminate soil, as well as pollute the surface water and marine environment.

6.1.9 Transportation of Raw Material and Equipment

The various materials required for construction and building (e.g. sand, marl, aggregate, steel, blocks, lumber, asphalt, cement, etc.) will be obtained from sources elsewhere and transported to the site. In the case of fine earth materials, dusting and spillages could occur on the roadways between source and site, particularly when materials are transported in uncovered or improperly sealed trucks. Dusting degrades local air quality and material spillages worsen driving conditions and increase the risk of road accidents.

The transportation and use of heavy equipment and trucks is required during construction. Trucks will transport raw materials and heavy equipment. This has the potential to directly impact traffic flow along local roads.

6.1.10 Traffic and Site Access

The construction of the new power plant may introduce traffic delays thereby increasing in travel time. Negative impacts on traffic are expected during the construction stages, and these include:

- Reduced level of service in the areas surrounding Old Harbour and Old Harbour Bay due to increased large/construction vehicle on the roads.
- Damage to existing roads due to the increase number of heavy vehicles transporting construction material.
- Increased risk of accidents or damage to vehicles due to objects falling from a truck.
- Increased potential for accidents with pedestrians especially with children along the Terminal Road.

In addition, the parochial road which leads to the present JPS plant is currently in disrepair and has two box culverts.

6.1.11 Vegetation

6.1.11.1 Habitat Fragmentation

Habitat fragmentation is the process whereby a large, continuous area of habitat is both reduced in area and divided into two or more fragments by roads, fields, towns and many other human constructs (Primack, 2006). These fragments are often isolated from each other by a highly modified or degraded landscape and their edges experience an altered set of microclimate conditions called "edge effect". Edge effect refers to the variation in the observed microenvironment at the fragment edge. Differences in microclimate factors such as light, temperature, wind and humidity may each significantly impact species composition and vigour within the fragment.

Fragmentation normally occurs during circumstances of severe habitat loss where, for example, large areas of natural vegetation may be cleared for agricultural, residential or industrial developments such as this. The development may reduce the passive movement of spores and seeds across a landscape as well as restrict the movement of animal species that often act as pollen and seed vectors. Fragmentation may also lead to increased vulnerability of the fragment to invasion by exotic and native pest species as well as diseases.

The effects of habitat fragmentation, however, are expected to be minimal since the study site and surrounding areas were already degraded and the species composition limited by current land use practices (e.g. logging, burning and livestock grazing). Although planned access roads and fencing may limit the movement of animal vectors, the grasses and some of the common herbs present are wind propagated.

6.1.11.2 Accidental or Intentional Removal of Important Plant Species or Plant Communities

Over 72 plant species were encountered. This somewhat high species richness is possibly due to the mixture of vegetation types present. Although none were endemic, endangered, threatened or rare, the diversity of the area is important. Therefore, minimising the impact on the flora during the construction phase of the development is also important.

Two areas of possible importance include the degraded Silt Mangrove wetland to the south and the large *Samanea saman/Guazuma ulmifolia* (Guango/Bastard Cedar) stand to the north.

- Mangroves are very important land stabilisers in a wetland community and help to provide conditions necessary for other plant species to become established. They are also important because they may be used as a habitat for faunal species.
- The Guango/Bastard Cedar stand provided a microhabitat for several plant and fungal species not common to the surrounding vegetation. Based on their basal diameter it may be estimated that several of the trees were quite old (a tree-core analysis would be necessary to determine their actual age). The herb, *Rivina humilis* (Bloodberry) frequently occurred here and is known to have tremendous potential for medicinal remedies.

6.1.11.3 Increased Soil/Substrate Erosion

The potential for land erosion and flooding is greatly increased as a result of vegetation removal. A plant’s roots act as a mesh within the substrate increasing its cohesiveness and improving drainage. Areas where bare ground is exposed tend to erode faster than areas inhabited by plants as they help percolate rainwater into the substrate below.

6.1.11.4 Storage and Transportation of Raw Materials

Plant growth and health can be significantly affected by dust, grime and toxic emissions. Leaching from storage areas can disturb the pH balance in the soil and result in plant loss.

6.1.12 Fauna

6.1.12.1 Crocodiles

Crocodiles are present on the property and they were only seen in the river. There is also an established nesting site which is heavily used by the crocodiles.

The hatchlings are confined to the mangroves roots in the river, until they reach some form of maturity. Although, crocodiles were not seen in the coastal water, it is possible that they migrate to other wetlands.

6.1.12.2 Avifauna

Few wetland birds were encountered in the river, Salina and the mangroves, which could be attributed to the dry season in which the survey was conducted. The survey was also carried out when most of the migrant birds have returned to North America. Several of the birds on the property will be displaced during the development.

6.1.12.3 Invertebrates

The sparse invertebrate fauna is the result of the very dry conditions prevailing at the time of the survey. Previous work in the southern areas of Jamaica has revealed a major change in fauna from dry to wet season.

6.1.13 Emergency Response

Construction of the proposed power plant has the potential for accidental injury. There may be either minor or major accidents.

6.1.14 Power Outages

The transportation of heavy equipment and machinery to the proposed site will involve the temporary removal of power lines.

6.1.15 Workers Safety

Construction of the proposed power plant and its infrastructure may entail workers being suspended in the process. This has the potential for increase construction accidents.

6.1.16 Employment

There is the potential for increased employment during the pre-clearance and construction phases. It is anticipated that approximately 70 persons will be employed directly during the site clearance and 1,200 at the peak during construction. A number of indirect jobs are expected to be created this further benefitting the community.

6.1.17 Heritage and Cultural

The surveying of the proposed Project area by the JNHT was restricted by the dense vegetation cover. However, pre-historic cultural material in the form of pottery sherds, both Spanish and English bricks and concrete troughs associated with cattle rearing were found to the immediate east and west of the site. This means that when the vegetation cover is removed from the proposed site, there is a high probability of finding prehistoric and historic cultural material.

During project site clearance and construction Watching Brief will be conducted by the archaeological officer and his/her team to observe ground work in the event unpredicted archaeological assets are discovered. These are done in order to protect, retrieve and record archaeological resources and ensure compliance with JNHT regulations. In the case where the discovery is of cultural or archaeological value, the team will carry out the Chance Find Procedure. This gives them the right under the JNHT Act, to issue a Preservation Order which is an emergency preliminary protective device that covers sites and buildings for at least 6 months. The JNHT will carry out investigations to determine the extent of cultural/archaeological value. They may inform the land-owner as a courtesy but it is not essential. Legislation regarding the discovery of artefacts is weak, however those that have been determined as important to the nation’s heritage may have a Preservation Order and Declaration put on it. However, if it is on private property the JNHT does not have the right of confiscation. The legislation is weak in that it does not make provision for the compulsory submission of artefacts found to the JNHT nor for the JNHT to prosecute in cases where artefacts are found and not submitted.

6.1.18 Human/Social

The site clearance for and construction of the proposed 360 MW LNG plant will reduce the area used for subsistence farming, animal husbandry, charcoal burning and logging.

It will also reduce the area used for illegal dumping which is a positive impact.

6.1.19 Carrying Capacity

Carrying capacity refers to the number of individuals who can be supported in a given area within natural resource limits, and without degrading the natural social, cultural and economic environment for present and future generations.

Currently, the use of fossil fuels has artificially increased the carrying capacity of the world by the use of stored sunlight, albeit at many other expenses.

In the case of the proposed 360 MW LNG plant it will lower the amount of greenhouse gases emitted compared with the existing JPSCo Old Harbour plant. The lowering of the emissions means that the contribution to global warming is reduced and therefore contributes to the reduction in the increase in sea level rise, thereby reducing the potential negative impact on the coastline of Jamaica and more specifically Old Harbour Bay and even more specific the site of the proposed plant.

The plant will obtain water from existing wells and will not impact on the water supply the community.

Wastewater collection, treatment and disposal will be done through facilities on the proposed plant and therefore will not be dependent on existing systems within the SIA.

Solid waste will be collected by private contractors and will be disposed of at an approved waste disposal facility. This will not impact on solid waste collection or disposal in the SIA.

There will be no net increase in vehicular traffic as the existing JPSCo Old Harbour plant will be closed after the commissioning of the new 360 MW LNG plant and the vehicular traffic diverted to the new plant site.

The proposed power plant will have its own fire fighting facility. It will be equipped with fire tanks, water pumps, hoses, extinguishers, etc. Therefore, it will be able to deal with any eventualities as it relates to fires on the facility.

6.1.20 Aesthetics and Landscaping

The construction and landscaping of the proposed plant will improve the aesthetics of this area zoned for industrial purposes.

6.2 OPERATION

6.2.1 Fauna

The modelled composite wastewater to be discharged will be at an average rate of 111.1 cubic metres per day with a TDS value of 3,867 mg/l, which is considered brackish water (TDS of 1,500 – 5,000 mg/l). Presently, the TDS values within the Bowers Gully adjacent to the proposed site are 29,780 – 30,370 mg/l, which is considered saline water (TDS of >5,000 mg/l). Therefore, the potential negative impact on crocodiles which live along the banks is expected to be minimal.

6.2.2 Air Quality

6.2.2.1 Introduction

As part of the Environmental Impact Assessment that is being conducted for the proposed facility, an air dispersion modelling analysis is being undertaken to determine the impact of the air pollutants from the proposed facility on the ambient air quality. A determination will also be made whether a significant air quality impact will be created based on the incremental contribution of the proposed facility to the cumulative air quality impact. According to the Natural Resources Conservation Authority (Air Quality) Regulations, 2006, a “significant air quality impact”, means:

a) The increment in the predicted average concentration of sulphur dioxide (SO_2), total suspended particulates (TSP), particulate matter less than ten microns (PM_{10}) or nitrogen dioxide (NO_2) is greater than an annual average of 21 µg/m^3 or a 24-hour average concentration of 80 µg/m^3; or
b) The increment in the predicted average concentration of CO is greater than 500 µg/m^3 as a 8-hour average or 2000 µg/m^3 as a 1-hour average

Additionally, the cumulative air quality impact of all sources within the project area (including the proposed power plant) will be determined.

This report describes the air dispersion modelling analysis for SO_2, TSP/PM_{10}, NO_2 and CO and the various priority air pollutants from the proposed facility only and the consequent comparison with the Jamaican

National Ambient Air Quality Standards, as well as a determination whether the proposed facility's air emissions will create a significant air quality impact. The cumulative air quality impact analysis will also be included.

It should be observed that the existing JPS 220 MW power plant at Old Harbour Bay will be retired as soon as the proposed 360 MW power plant has been fully commissioned.

6.2.2.2 Process Description and Air Pollutant Sources

The proposed power plant will be located in the Old Harbour Bay area of St. Catherine, Jamaica in the vicinity of existing power plants (the existing JPS 220 MW and the Dr. Bird power generating facility). Some of the other air pollution sources within the air shed include a feed mill, an ethanol dehydration facility, as well as a permitted cement manufacturing plant. The proposed facility will generate electricity for sale to the public grid.

6.2.2.2.1 Potential Air Emissions

The air pollutants of concern to be discharged into the ambient air from the proposed power plant will be TSP/PM_{10}, NOx, SO_2, CO and various priority air pollutants. These priority air pollutants are listed in Table 6-5.

Table 6-5 - Potential Priority Air Pollutants

Pollutant
Acetaldehyde
Acrolein
Benzene
Formaldehyde
Xylenes
1,3 Butadiene
Arsenic
Beryllium
Cadmium
Chromium
Lead
Manganese
Mercury
Nickel
Selenium

6.2.2.2.2 Historical Ambient Air Quality Monitoring Data

Data from the Lauderwood Air Quality Monitoring Station operated by JPS are indicated in Table 6-6. The table shows the measured 1-h and 24-h maximum and annual mean SO_2 concentrations, the 1-h maximum and annual mean NO_x concentrations and the 1-h maximum O_3. All measurements are below the National Ambient Air Quality Standards for the respective averaging periods.

Table 6-6 - Historical Ambient Air Quality Monitoring Data

Pollutant	Year	Max 1-h, µg/m³	Max 24-h, µg/m³	Annual Mean, µg/m³
SO_2	2009	235.4	75.6	15.5
SO_2	2010	47.1	17.95	8.9
SO_2	2011	258.2	174.7	3.1
SO_2	Standard	700	280	60
NO_2	2009	103.4	N/A	11.2
NO_2	2010	105.3	N/A	6.4
NO_2	2011	157.9	N/A	5.5
NO_2	Standard	400	N/A	100
O_3	2009	134.4	N/A	18.3
O_3	2010	51	N/A	9.9
O_3	2011	82.4	N/A	15.75
O_3	Standard	235	N/A	N/A

6.2.2.3 Methodology

6.2.2.3.1 Modelling Approach

The assessment methodology for the air dispersion modelling exercise follows the guidance specified in the Natural Resources Conservation Authority (NRCA) Ambient Air Quality Guideline Document of 2006.

The detailed model recommended in the Ambient Air Quality Guideline Document is AERMOD. The model of selection was the commercially available AERMOD View dispersion model, developed by Lakes Environmental. This model is used extensively to assess pollution concentration and deposition from a wide variety of sources. AERMOD View is a true, native Microsoft Windows application and runs in Windows applications. The **A**MS/**E**PA **R**egulatory **Mod**el (AERMOD) was specially designed to support the EPA's regulatory modelling programs. AERMOD is a regulatory steady-state plume modelling system with three separate components: AERMOD (AERMIC Dispersion Model), AERMAP (AERMOD Terrain Preprocessor), and AERMET (AERMOD

Meteorological Preprocessor). 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. Some of the modelling capabilities of AERMOD include the following:

- The model may be used to analyze 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. For this project all emission rates were treated as constant.
- The model can account for the effects of aerodynamic downwash due to buildings that are nearby point source emissions.
- Receptor locations can be specified as gridded and/or discrete receptors in a Cartesian or polar coordinate system.
- For applications involving elevated terrain, the U.S. EPA AERMAP terrain preprocessing program is incorporated into the model 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 and wet 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 AERMET meteorological preprocessor programme.

6.2.2.3.2 Model Inputs

Source Emissions

A critical step for conducting air dispersion modelling is to quantify the emissions from the various sources at the facility. The emission rates from the sources identified were estimated in accordance with the recommendation outlined in the Ambient Air Quality Guideline Document. According to Davis & Associates (2006), emission rates should be estimated in the following order of preference:

- Continuous emissions monitoring data
- Stack Emission Testing data
- Manufacturer's emission data
- Mass balance calculations
- Emission factors
- Engineering calculations

Table 6-7 shows the source information data determined for the proposed power plant, while Table 6-8 displays the emission rates that were calculated based on the use of manufacturer's emission specifications. The emission rates for the priority air pollutants from the proposed power plant were determined based on the USEPA emission factors for Stationary Gas Turbines and these are outlined in Table 6-9 shows.

Source information data for the permitted cement manufacturing facility to be located at Bodles, St. Catherine, as well as their associated criteria and priority air pollutant emission rates are shown in Table 6-10, Table 6-11 and Table 6-12, respectively. While Table 6-13 and Table 6-14 display source characteristic information and emission rates, respectively, for the other main air pollution sources in the air shed – namely the Best Dressed Feed Mill, JB Ethanol dehydration facility, JPS existing power plant and JEP power plant. These data were obtained from the Air Dispersion Modelling Report for the cement manufacturing facility to be located at Bodles, St. Catherine, dated July 2011.

The locations of the sources at the proposed power plant were obtained from plant drawings and are identified in Figure 6-4.

Table 6-7 - Source Information Data for the Proposed Power Plant

Source ID	Type	Description	X Coord, m	Y Coord, m	Elevation, m	Height, m	Diameter, m	Diesel Oil		LNG	
								Velocity, m/s	Temp., degC	Velocity, m/s	Temp., degC
MS1	POINT	Main Stack 1	276160.41	1981006.83	7.56	65	3.3	16.69	131	15.62	100
MS2	POINT	Main Stack 2	276159.20	1980980.96	6.7	65	3.3	16.69	131	15.62	100
MS3	POINT	Main Stack 3	276159.19	1980921.69	5.72	65	3.3	16.69	131	15.62	100
MS4	POINT	Main Stack 4	276157.86	1980895.82	4.96	65	3.3	16.69	131	15.62	100
MS5	POINT	Main Stack 5	276157.73	1980836.67	3.89	65	3.3	16.69	131	15.62	100
MS6	POINT	Main Stack 6	276156.40	1980810.80	3.03	65	3.3	16.69	131	15.62	100

Note that the Bypass stacks were not modelled because the HRSG stacks have lower exit gas velocities and temperatures that would result in lower exhaust plume heights and higher ambient impacts.

Table 6-8 - Air Pollutant Emission Rates for the Proposed Power Plant using Liquefied Natural Gas

Source ID	Description	TSP/ PM_{10}, g/s	SO_2, g/s	NOx, g/s	CO, g/s	Acetaldehyde, g/s	Acrolein, g/s	Benzene, g/s	Formaldehyde, g/s	Xylenes, g/s
MS1	Main Stack 1	0.4	0.0586	4.8	0.6	6.9E-04	1.1E-04	2.07E-04	1.22E-02	1.1E-03
MS2	Main Stack 2	0.4	0.0586	4.8	0.6	6.9E-04	1.1E-04	2.07E-04	1.22E-02	1.1E-03
MS3	Main Stack 3	0.4	0.0586	4.8	0.6	6.9E-04	1.1E-04	2.07E-04	1.22E-02	1.1E-03
MS4	Main Stack 4	0.4	0.0586	4.8	0.6	6.9E-04	1.1E-04	2.07E-04	1.22E-02	1.1E-03
MS5	Main Stack 5	0.4	0.0586	4.8	0.6	6.9E-04	1.1E-04	2.07E-04	1.22E-02	1.1E-03
MS6	Main Stack 6	0.4	0.0586	4.8	0.6	6.9E-04	1.1E-04	2.07E-04	1.22E-02	1.1E-03

Table 6-9 - Air Pollutant Emission Rates for the Proposed Power Plant using Diesel Oil

Source ID	TSP/ PM_{10}, g/s	SO_2, g/s	NOx, g/s	CO, g/s	Arsenic, g/s	Beryllium, g/s	Cadmium, g/s	Chromium, g/s	Lead, g/s	Manganese, g/s	Mercury, g/s	Nickel, g/s	Selenium, g/s	1,3 Butadiene, g/s
MS1	0.4	26.3	9.2	0.6	1.72E-04	5.17E-06	8.28E-05	1.9E-04	2.41E-04	1.36E-02	2.07E-05	7.76E-05	4.14E-04	2.59E-04
MS2	0.4	26.3	9.2	0.6	1.72E-04	5.17E-06	8.28E-05	1.9E-04	2.41E-04	1.36E-02	2.07E-05	7.76E-05	4.14E-04	2.59E-04
MS3	0.4	26.3	9.2	0.6	1.72E-04	5.17E-06	8.28E-05	1.9E-04	2.41E-04	1.36E-02	2.07E-05	7.76E-05	4.14E-04	2.59E-04
MS4	0.4	26.3	9.2	0.6	1.72E-04	5.17E-06	8.28E-05	1.9E-04	2.41E-04	1.36E-02	2.07E-05	7.76E-05	4.14E-04	2.59E-04
MS5	0.4	26.3	9.2	0.6	1.72E-04	5.17E-06	8.28E-05	1.9E-04	2.41E-04	1.36E-02	2.07E-05	7.76E-05	4.14E-04	2.59E-04
MS6	0.4	26.3	9.2	0.6	1.72E-04	5.17E-06	8.28E-05	1.9E-04	2.41E-04	1.36E-02	2.07E-05	7.76E-05	4.14E-04	2.59E-04

Table 6-10 -Source Information Data for the Permitted Cement Manufacturing Facility

Source ID	Type	Description	X Coord, m	Y Coord, m	Elevation, m	Height , m	Diameter, m	Exit Velocity, m/s	Exit Temperature, K
PAREA1	AREA_ POLY	Quarry - Drilling, loading, unloading, hauling	271733.33	1983463.33	39.57	5	N/A	N/A	N/A
LC&C	POINT	Limestone Crushing and Conveying	272414.05	1984565.14	49.6	15	0.9	17.5	298.15
LPSP&C1	POINT	Limestone pre-blending stock pile and conveying	273369	1983930	21.65	15	0.45	15.6	298.15
LPSP&C2	POINT	Limestone pre-blending stock pile and conveying	273751.87	1982899.21	21.17	15	0.45	15.6	298.15
LPSP&C3	POINT	Limestone pre-blending stock pile and conveying	274155.81	1983220	21.39	15	0.45	15.6	298.15
CC&C1	POINT	Clay Crushing & Conveying	274151.7	1983254	18	15	0.6	17.5	298.15
CC&C2	POINT	Clay Crushing & Conveying	273796	1982928	18	15	0.45	15.6	298.15
RMPSP&C1	POINT	Raw Material Pre-blending stockpile & conveying	273781	1982930	18	15	0.45	15.6	298.15
RMPSP&C2	POINT	Raw Material Pre-blending stockpile & conveying	273817.59	1982890	18	15	0.45	15.6	298.15
RMPS&C1	POINT	Raw Material Proportioning Station & Conveying	273867.83	1982941	21	40	0.45	15.6	298.15
RMPS&C2	POINT	Raw Material Proportioning Station & Conveying	274465	1983133	20.97	15	0.4	15.3	298.15

Source ID	Type	Description	X Coord, m	Y Coord, m	Elevation, m	Height, m	Diameter, m	Exit Velocity, m/s	Exit Temperature, K
RMPS&C3	POINT	Raw Material Proportioning Station & Conveying	274465	1983114	21	15	0.4	15.3	298.15
RMPS&C4	POINT	Raw Material Proportioning Station & Conveying	274425	1983122	20.8	15	0.4	15.3	298.15
RMPS&C5	POINT	Raw Material Proportioning Station & Conveying	274410	1983114	20.7	25	0.3	15.7	298.15
RMPS&C6	POINT	Raw Material Proportioning Station & Conveying	274398	1983105	21	25	0.3	15.7	298.15
RMPS&C7	POINT	Raw Material Proportioning Station & Conveying	274400	1983140	20	25	0.3	15.7	298.15
RMG&EX1	POINT	Raw Material Grinding and Exhaust Gas Treatment	274414.54	1983078	21	15	0.4	13.3	333.15
RMG&EX2	POINT	Raw Material Grinding and Exhaust Gas Treatment	274330.58	1983031	21	35	0.5	15.8	333.15
RMG&EX3	POINT	Raw Material Grinding and Exhaust Gas Treatment	274338.58	1983004	20.47	110	4	19.9	423.15
RMHS&KF1	POINT	Raw Meal Homogenizing Silo and kiln feeding	274304	1982997	21	65	0.8	12.3	333.15
RMHS&KF2	POINT	Raw Meal Homogenizing Silo and kiln feeding	274304	1982989	21	10	0.5	15.8	333.15
C&EX	POINT	Cooler and exhaust gas treatment	274315.36	1982928	19.65	40	3.75	16.4	523.15
BP&GT1	POINT	By-Pass and Gas Treatment	274368	1982964	20	40	2.24	12.7	553.15
BP&GT2	POINT	By-Pass and Gas Treatment	274349	1982955	20.02	35	0.45	15.6	333.15
CS&C1	POINT	Clinker Storage and Conveying	274281	1982885	20	15	0.45	15.6	333.15
CS&C2	POINT	Clinker Storage and Conveying	274275	1982870	20	15	0.45	15.6	333.15
CS&C3	POINT	Clinker Storage and Conveying	274262	1982868	20	15	0.45	15.6	333.15
CS&C4	POINT	Clinker Storage and Conveying	274239	1982874	20	15	0.45	15.6	333.15
CS&C5	POINT	Clinker Storage and Conveying	274232.53	1982887	20	15	0.5	15.8	333.15
CS&C6	POINT	Clinker Storage and Conveying	274249.24	1982902	20	15	0.5	15.8	333.15
CS&C7	POINT	Clinker Storage and Conveying	274212.88	1982913	20	15	0.5	15.8	333.15
CS&C8	POINT	Clinker Storage and Conveying	274208.93	1982894	20	50	0.8	12.3	333.15
CH&C	POINT	Coal Hopper and Conveying	273775	1982786	17	15	0.45	15.6	298.15
CBSP&C1	POINT	Coal Blending Stock Pile and Conveying	273832	1982936	18	15	0.45	15.6	298.15
CBSP&C2	POINT	Coal Blending Stock Pile and Conveying	273815	1982921	18	15	0.45	15.6	298.15
CG&D1	POINT	Coal Grinding and Dosing	274387	1982989	20	35	1.5	18.1	353.15

Source ID	Type	Description	X Coord, m	Y Coord, m	Elevation, m	Height, m	Diameter, m	Exit Velocity, m/s	Exit Temperature, K
CG&D2	POINT	Coal Grinding and Dosing	274394	1983004	20	35	0.45	15.7	313.15
CG&D3	POINT	Coal Grinding and Dosing	274408	1982995	20	35	0.4	11.1	313.15
GYPC&C1	POINT	Gypsum Crushing and conveying	274127	1983190	21	15	0.8	9.8	298.15
GYPC&C2	POINT	Gypsum Crushing and conveying	274112	1983184	21	15	0.45	15.6	298.15
CMILL1	POINT	Cement Proportioning station	274207	1982788	19	15	0.4	15.3	298.15
CMILL2	POINT	Cement Proportioning station	274194	1982775	19	15	0.4	15.3	298.15
CMILL3	POINT	Cement Proportioning station	274175	1982762	19	15	0.4	15.3	298.15
CMILL4	POINT	Cement Proportioning station	274158	1982741	19	15	0.4	15.3	298.15
CMILL5	POINT	Cement Proportioning station	274190.56	1982808	19	15	0.4	15.3	298.15
CMILL6	POINT	Cement Proportioning station	274181.79	1982799	19	15	0.4	15.3	298.15
CMILL7	POINT	Cement Proportioning station	274162.79	1982784	19	15	0.4	15.3	298.15
CMILL8	POINT	Cement Proportioning station	274141.56	1982767	19	15	0.4	15.3	298.15
CMILL9	POINT	Cement Proportioning station	274116.21	1982739	19	15	0.4	15.3	298.15
CMILL10	POINT	Cement Proportioning station	274124.68	1982727	19	15	0.4	15.3	298.15
CMILL11	POINT	Cement Proportioning station	274146	1982847	19.9	30	0.45	15.6	298.15
CMILL12	POINT	Cement Proportioning station	274137	1982843	19.79	30	0.45	15.6	298.15
CMILL13	POINT	Cement Proportioning station	274050	1982866	19	30	0.45	15.6	298.15
CMILL14	POINT	Cement Proportioning station	274037	1982856	19	30	0.45	15.6	298.15
CG&C1	POINT	Cement Grinding and conveying	274120.12	1982692	18.82	38	2.5	13	353.15
CG&C2	POINT	Cement Grinding and conveying	274092.47	1982663	18	38	2.5	13	353.15
CG&C3	POINT	Cement Grinding and conveying	274064.59	1982637	18	36	1.25	13.6	353.15
CG&C4	POINT	Cement Grinding and conveying	274024.32	1982680	18	36	1.25	13.6	353.15
CG&C5	POINT	Cement Grinding and conveying	274050.32	1982705	18.01	15	0.4	13.3	353.15
CG&C6	POINT	Cement Grinding and conveying	274071.32	1982729	18.71	15	0.4	13.3	353.15
CEM_S&C1	POINT	Cement Storage and conveying	273982.74	1982678	18	45	0.5	15.8	313.15
CEM_S&C2	POINT	Cement Storage and conveying	273957.31	1982680	17.91	45	0.5	15.8	313.15
CEM_S&C3	POINT	Cement Storage and conveying	273940.37	1982659	17.22	45	0.5	15.8	313.15
CEM_S&C4	POINT	Cement Storage and conveying	273948.84	1982640	17	45	0.5	15.8	313.15
CEM_S&C5	POINT	Cement Storage and conveying	274073.84	1982588	18	15	0.4	15.3	313.15
CEM_S&C6	POINT	Cement Storage and conveying	274086.55	1982567	17.65	15	0.4	15.3	313.15
CEM_S&C7	POINT	Cement Storage and conveying	274067.48	1982539	17	15	0.4	15.3	313.15

Source ID	Type	Description	X Coord, m	Y Coord, m	Elevation, m	Height , m	Diameter, m	Exit Velocity, m/s	Exit Temperature, K
CEM_S&C8	POINT	Cement Storage and conveying	274039.94	1982550	17.33	15	0.4	15.3	313.15
CEM_S&C9	POINT	Cement Storage and conveying	273980.62	1982600	17.45	45	0.5	19	313.15
CEM_S&C10	POINT	Cement Storage and conveying	274031.47	1982619	18	45	0.5	19	313.15
CEMBULK1	POINT	Cement Bulk Loading	273904.35	1982631	16.1	25	0.4	15.3	298.15
CEMBULK2	POINT	Cement Bulk Loading	273917.06	1982619	16.16	25	0.4	15.3	298.15
CEMBULK3	POINT	Cement Bulk Loading	273881.04	1982617	16	15	0.3	15.7	298.15
CEMBULK4	POINT	Cement Bulk Loading	273893.76	1982604	15.96	15	0.3	15.7	298.15
CEMPACK1	POINT	Cement Packing and loading	273840.79	1982591	15.01	25	0.8	13.8	298.15
CEMPACK2	POINT	Cement Packing and loading	273861.98	1982572	15.19	25	0.8	13.8	298.15
CEMPACK3	POINT	Cement Packing and loading	273881.04	1982553	15.94	25	0.8	13.8	298.15
CEMPACK4	POINT	Cement Packing and loading	273900.11	1982536	16	25	0.8	13.8	298.15
CEMBIG1	POINT	Cement Big Bag Packing	273792.06	1982633	16	25	0.5	15.8	298.15
CEMBIG2	POINT	Cement Big Bag Packing	273777.23	1982621	16	25	0.5	15.8	298.15
CCV	POINT	Coal Crusher Vent	274190.36	1982559	18	26.5	0.35	15	303.15
CPFBV	POINT	Coal Pulverizer Feed Bin Vent	274215.78	1982600	18	35.25	0.35	15	303.15
PPMS	POINT	Power Plant Main Stack	274226.38	1982549	17.96	120	2.8	13.5	318.15
CLAY	LINE	Clay Transport	273792.06	1982633	16	25	0.5	15.8	298.15
MATER	LINE	Gypsum, Pozzolan and Coal Transport	273777.23	1982621	16	25	0.5	15.8	298.15
CEMENT	LINE	Cement Transport	274190.36	1982559	18	26.5	0.35	15	303.15

Source: Revised Air Dispersion Modelling Report for the Proposed 5000 MTPD Cement Manufacturing Facility to be located at Bodles, St. Catherine, Jamaica

Table 6-11 - Criteria Air Pollutant Emission Rates for Permitted Cement Plant

Source ID	Description	TSP/PM_{10} Emission (g/s)	SO_2 Emission (g/s)	NOx Emission (g/s)	CO Emission (g/s)
PAREA1	Quarry - Drilling, loading, unloading, hauling	0.4273			
LC&C	Limestone Crushing and Conveying	0.31			
LPSP&C1	Limestone pre-blending stock pile and conveying	0.066			
LPSP&C2	Limestone pre-blending stock pile and conveying	0.066			
LPSP&C3	Limestone pre-blending stock pile and conveying	0.066			
CC&C1	Clay Crushing & Conveying	0.14			
CC&C2	Clay Crushing & Conveying	0.07			
RMPSP&C1	Raw Material Pre-blending stockpile & conveying	0.07			
RMPSP&C2	Raw Material Pre-blending stockpile & conveying	0.07			
RMPS&C1	Raw Material Proportioning Station & Conveying	0.07			
RMPS&C2	Raw Material Proportioning Station & Conveying	0.0533			
RMPS&C3	Raw Material Proportioning Station & Conveying	0.0533			
RMPS&C4	Raw Material Proportioning Station & Conveying	0.0533			
RMPS&C5	Raw Material Proportioning Station & Conveying	0.03			
RMPS&C6	Raw Material Proportioning Station & Conveying	0.03			
RMPS&C7	Raw Material Proportioning Station & Conveying	0.03			
RMG&EX1	Raw Material Grinding and Exhaust Gas Treatment	0.04			
RMG&EX2	Raw Material Grinding and Exhaust Gas Treatment	0.08			
RMG&EX3	Raw Material Grinding and Exhaust Gas Treatment	4.84	16.11	80.55	0.4679
RMHS&KF1	Raw Meal Homogenizing Silo and kiln feeding	0.15			
RMHS&KF2	Raw Meal Homogenizing Silo and kiln feeding	0.08			
C&EX	Cooler and exhaust gas treatment	2.83			
BP&GT1	By-Pass and Gas Treatment	0.74			
BP&GT2	By-Pass and Gas Treatment	0.06			
CS&C1	Clinker Storage and Conveying	0.06			
CS&C2	Clinker Storage and Conveying	0.06			
CS&C3	Clinker Storage and Conveying	0.06			
CS&C4	Clinker Storage and Conveying	0.06			
CS&C5	Clinker Storage and Conveying	0.0766			
CS&C6	Clinker Storage and Conveying	0.0766			
CS&C7	Clinker Storage and Conveying	0.0766			
CS&C8	Clinker Storage and Conveying	0.15			

Source ID	Description	TSP/PM$_{10}$ Emission (g/s)	SO_2 Emission (g/s)	NOx Emission (g/s)	CO Emission (g/s)
CH&C	Coal Hopper and Conveying	0.07			
CBSP&C1	Coal Blending Stock Pile and Conveying	0.07			
CBSP&C2	Coal Blending Stock Pile and Conveying	0.07			
CG&D1	Coal Grinding and Dosing	0.74			
CG&D2	Coal Grinding and Dosing	0.07			
CG&D3	Coal Grinding and Dosing	0.04			
GYPC&C1	Gypsum Crushing and conveying	0.14			
GYPC&C2	Gypsum Crushing and conveying	0.07			
CMILL1	Cement Proportioning station	0.053			
CMILL2	Cement Proportioning station	0.053			
CMILL3	Cement Proportioning station	0.053			
CMILL4	Cement Proportioning station	0.053			
CMILL5	Cement Proportioning station	0.053			
CMILL6	Cement Proportioning station	0.053			
CMILL7	Cement Proportioning station	0.053			
CMILL8	Cement Proportioning station	0.053			
CMILL9	Cement Proportioning station	0.053			
CMILL10	Cement Proportioning station	0.053			
CMILL11	Cement Proportioning station	0.0675			
CMILL12	Cement Proportioning station	0.0675			
CMILL13	Cement Proportioning station	0.0675			
CMILL14	Cement Proportioning station	0.0675			
CG&C1	Cement Grinding and conveying	1.48			
CG&C2	Cement Grinding and conveying	1.48			
CG&C3	Cement Grinding and conveying	0.385			
CG&C4	Cement Grinding and conveying	0.385			
CG&C5	Cement Grinding and conveying	0.04			
CG&C6	Cement Grinding and conveying	0.04			
CEM_S&C1	Cement Storage and conveying	0.08			
CEM_S&C2	Cement Storage and conveying	0.08			
CEM_S&C3	Cement Storage and conveying	0.08			
CEM_S&C4	Cement Storage and conveying	0.08			
CEM_S&C5	Cement Storage and conveying	0.05			

Source ID	Description	TSP/PM_{10} Emission (g/s)	SO_2 Emission (g/s)	NOx Emission (g/s)	CO Emission (g/s)
CEM_S&C6	Cement Storage and conveying	0.05			
CEM_S&C7	Cement Storage and conveying	0.05			
CEM_S&C8	Cement Storage and conveying	0.05			
CEM_S&C9	Cement Storage and conveying	0.095			
CEM_S&C10	Cement Storage and conveying	0.095			
CEMBULK1	Cement Bulk Loading	0.055			
CEMBULK2	Cement Bulk Loading	0.055			
CEMBULK3	Cement Bulk Loading	0.03			
CEMBULK4	Cement Bulk Loading	0.03			
CEMPACK1	Cement Packing and loading	0.19			
CEMPACK2	Cement Packing and loading	0.19			
CEMPACK3	Cement Packing and loading	0.19			
CEMPACK4	Cement Packing and loading	0.19			
CEMBIG1	Cement Big Bag Packing	0.085			
CEMBIG2	Cement Big Bag Packing	0.085			
CCV	Coal Crusher Vent	0.392			
CPFBV	Coal Pulverizer Feed Bin Vent	0.0277			
PPMS	Power Plant Main Stack	2.15	4.5166	28.611	0.2068
CLAY	Clay Transport	0.06			
MATER	Gypsum, Pozzolan and Coal Transport	1.15			
CEMENT	Cement Transport	0.21			

Source: Revised Air Dispersion Modelling Report for the Proposed 5000 MTPD Cement Manufacturing Facility to be located at Bodles, St. Catherine, Jamaica

Table 6-12 - Priority Air Pollutant Emission Rates for nearby Sources

Pollutants, g/s	**RMG&EX3**	**PPMS**	**JBE**	**JBE1**	**JBE2**	**JBE3**	**FEEDE**	**FEEDB1**	**FEEDB 2**
Antimony		1.25E-04							
Arsenic	3.47E-04	2.85E-03		5.13E-05	5.13E-05	5.13E-05		3.24E-06	5.82E-06
Beryllium	1.91E-05	1.46E-04		1.08E-06	1.08E-06	1.08E-06		6.82E-08	1.23E-07
Cadmium	6.37E-05	3.54E-04		1.55E-05	1.55E-05	1.55E-05		9.77E-07	1.76E-06
Chromium	4.05E-03	5.49E-04		9.65E-06	9.65E-06	9.65E-06		6.09E-07	1.09E-06
Cobalt	N/A	6.94E-04							
Lead	2.17E-03	2.92E-03		5.87E-05	5.87E-05	5.87E-05		3.71E-06	4.65E-06
Manganese	N/A	3.40E-03		1.17E-04	1.17E-04	1.17E-04		7.36E-06	3.1E-06
Mercury	6.94E-04	5.76E-04		4.39E-06	4.39E-06	4.39E-06		2.77E-07	1.55E-06
Nickel	N/A	1.94E-03		3.29E-03	3.29E-03	3.29E-03		2.07E-04	1.55E-06
Selenium	5.79E-03	9.03E-03		2.66E-05	2.66E-05	2.66E-05		1.68E-06	7.76E-06
Acetaldehyde			3.46E-06				1.3E-05		
Acrolein			1.08E-06				4.07E-06		
Benzene			1.07E-04	8.32E-06	8.32E-06	8.32E-06	4.01E-06	5.25E-07	9.44E-07
Formaldehyde			1.62E-04	1.28E-03	1.28E-03	1.28E-03	6.1E-04	8.1E-05	2.12E-04
Xylenes			2.65E-05				9.98E-05		

Table 6-13 - Source Information Data for other nearby Existing Facilities

Source ID	Type	Description	X Coord, m	Y Coord, m	Elevation, m	Height, m	Diameter, m	Exit Velocity, m/s	Exit Temperature, K
JEP2	POINT	JEP2 Generators	276706	1980109	0.2	35	2.42	36.38	649.15
JEP1_6	POINT	JEP Existing Barge - 6 Generators	276813	1979972	3.9	30	2.66	43.01	602.15
JEP1_7	POINT	JEP Existing Barge - DG7	276772	1980003	3.97	30	1.08	43.01	602.15
JEP1_8	POINT	JEP Existing Barge - DG8	276772	1980003	3.97	30	1.08	43.01	602.15
JPS1	POINT	JPS Unit #1	276907	1980368	2	45.72	2.48	12.61	438.15
JPS2	POINT	JPS Unit 2	276895	1980346	2	45.72	2.84	15.04	438.15
JPS3	POINT	JPS Unit 3	276866	1980334	2	45.72	2.93	21.61	431.15
JPS4	POINT	JPS Unit 4	276849	1980310	2	45.72	2.93	21.61	431.15
FEEDE	POINT	Feed Mill Engine	273410	1982465	15.44	2.4	0.35	10	550
FEEDB1	POINT	Feed Mill Boiler 1	273412	1982445	15.27	9.14	0.46	15.3	449.5
FEEDB2	POINT	Feed Mill Boiler 2	273413	1982442	15.23	6.1	0.35	15.3	494.2
FEEDGR	POINT	Feed Mill Grain Receiving	273473	1982496	15.2	15.24	0.21	15	330
MILL	POINT	Feed Mill	273478	1982481	14.72	10.36	0.2	15	330
JBE	POINT	JB Ethanol Engine	274434	1979825	4	6.1	0.61	10	500
JBE1	POINT	JB Ethanol Boiler 1	274426	1979787	5	19.91	0.61	20.33	463
JBE2	POINT	JB Ethanol Boiler 2	274428	1979784	5	19.91	0.61	20.33	463
JBE3	POINT	JB Ethanol Boiler 3	274432	1979780	5	19.91	0.61	20.33	463

Source: Revised Air Dispersion Modelling Report for the Proposed 5000 MTPD Cement Manufacturing Facility to be located at Bodles, St. Catherine, Jamaica

Table 6-14 - Criteria Emission Rates for other nearby Existing Facilities

Source ID	Description	PM_{10} Emission (g/s)	SO_2 Emission (g/s)	NOx Emission (g/s)	CO Emission (g/s)
JEP2	JEP2 Generators	7.8	122.7	210	10.2
JEP1_6	JEP Existing Barge - 6 Generators	7.44	118.4	226.8	10.8
JEP1_7	JEP Existing Barge - DG7	1.24	19.7	37.8	1.8
JEP1_8	JEP Existing Barge - DG8	1.24	19.7	37.8	1.8
JPS1	JPS Unit #1	8.99	149.64	8.22	0.29
JPS2	JPS Unit 2	13.11	287.99	21.29	4.59
JPS3	JPS Unit 3	15.13	267.25	53.03	38.34
JPS4	JPS Unit 4	10.58	277.52	33.08	267.2
FEEDE	Feed Mill Engine	0.09175	0.36084	2.936	0.78
FEEDB1	Feed Mill Boiler 1	0.094	4.6057	0.517	0.047
FEEDB2	Feed Mill Boiler 2	0.01514	0.4441	0.1514	0.03785
FEEDGR	Feed Mill Grain Receiving	0.4			
MILL	Feed Mill	1.91			
JBE	JB Ethanol Engine	0.092	0.361	2.936	0.78
JBE1	JB Ethanol Boiler 1	0.26	7.97	1.429	0.13
JBE2	JB Ethanol Boiler 2	0.26	7.97	1.429	0.13
JBE3	JB Ethanol Boiler 3	0.13	3.985	0.715	0.065

Source: Revised Air Dispersion Modelling Report for the Proposed 5000 MTPD Cement Manufacturing Facility to be located at Bodles, St. Catherine, Jamaica

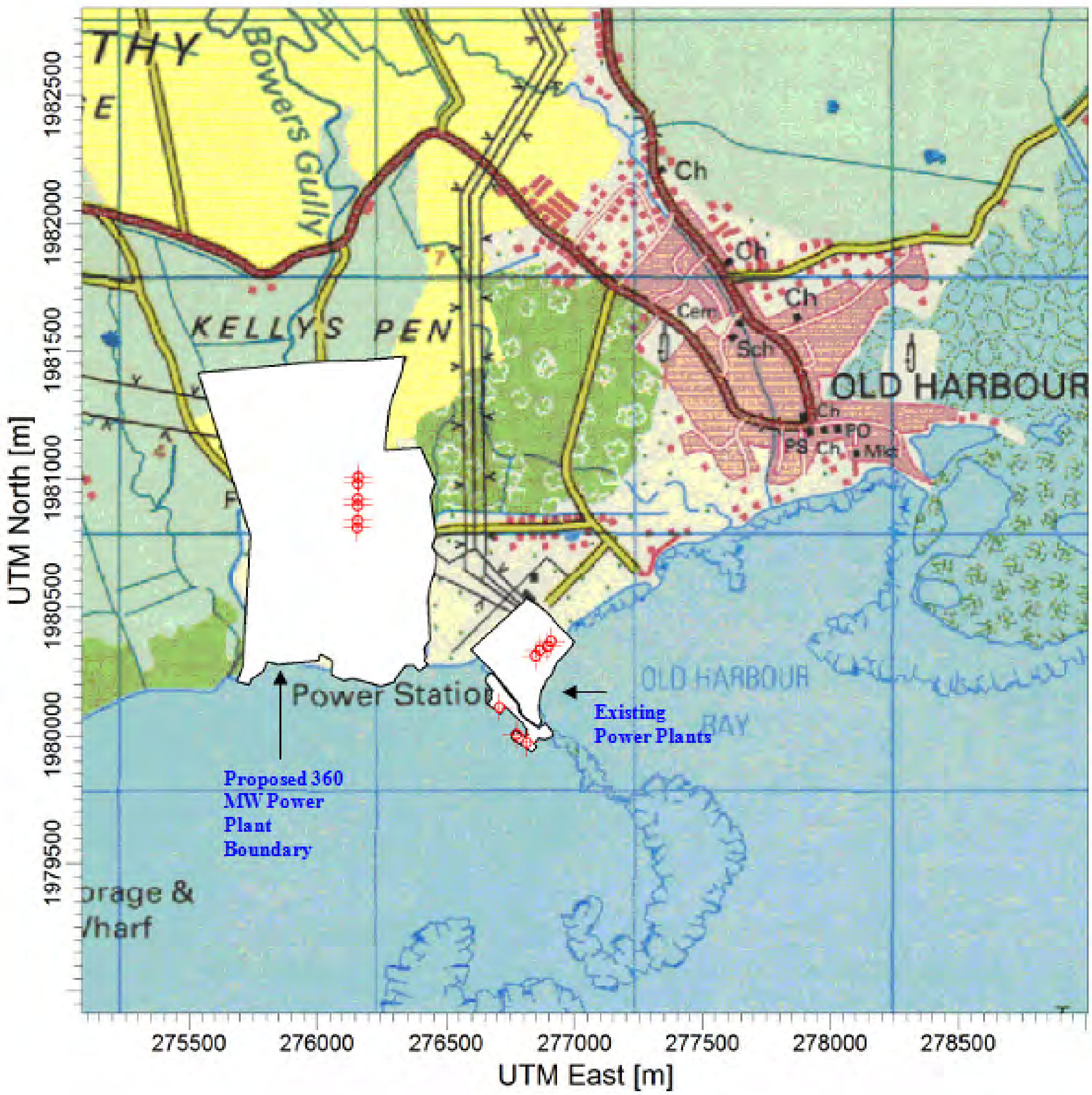


Figure 6-4 - Map showing the Proposed Power Plant Sources

Comparison of Proposed Emission Rates with Emission Standards

Table 6-15 highlights the emission standards to be applied to the proposed power plant and these standards are based on the NRCA (Air Quality) Regulations, 2006 and the emission rates from the proposed power plant. The table reveals total compliance with the respective emission standards.

Table 6-15 - Emission Rate Comparison with Emission Standards

Facility	Pollutant	Emission Standard, ng/J	Emission Rate, ng/J
New Fuel Combustion - Gas Fired 29-73 MW	NOx	40	39.89
	CO	125	5.27
	PM	13	3.45
New Gas Turbine Fuel Combustion – Oil Fired >20 MW	NOx	380	76.43

Building Downwash Effects

Buildings located close to point sources may significantly affect the dispersion of the pollutants from the source. If the point source is relatively low, the air pollutants released may be trapped in the wake zone of nearby obstructions (structures or terrain features) and may be brought down to ground level in the immediate vicinity of the release point (down-wash). It is therefore necessary to determine if such effects are present for each point source.

The "Good Engineering Practice" (GEP) height is defined as the height necessary to ensure that point source emissions do not result in excessive pollutant concentrations in the immediate vicinity of the source. These excessive concentrations may be the result of atmospheric downwash, eddies, or wakes that may be created by the source itself, nearby structures, or nearby terrain obstacles. If a point source is below the GEP height, then the plume entrainment must be taken into account by modifying certain dispersion parameters used in the dispersion model. However, if the point source height meets GEP, then entrainment within the wake of nearby obstructions is unlikely and need not be considered in the modeling.

The GEP height formula is: $Hg = H + 1.5*L$ where Hg is the GEP height measured from ground level elevation at the base of the point source, H is the height of nearby structure(s) measured from the ground level elevation at the base of the point source, and L is the lesser dimension, height or projected width, of the nearby structure(s). This definition will allow the consideration of all stacks up to a height of 65 m.

A building or structure is considered sufficiently close to a point source to cause wake effects when the minimum distance between the point source and the building is less than or equal to five times the lesser of the height or projected width of the building (5L). This distance is commonly referred to as the building's "region of influence." If the source is located near to more than one building, each building and point source configuration would have to be assessed separately. If a building's projected width is used to determine 5L, then the apparent width of the building must be determined. The apparent width is the width as seen from the source looking toward either the wind direction or the direction of interest. For example, for short-term modeling, the AERMOD model requires the apparent building widths (and also heights) for every 10 degrees of azimuth around each source. The AERMOD model also contains algorithms for determining the impact of downwash on ambient concentration and was used for determining predicted maximum estimates.

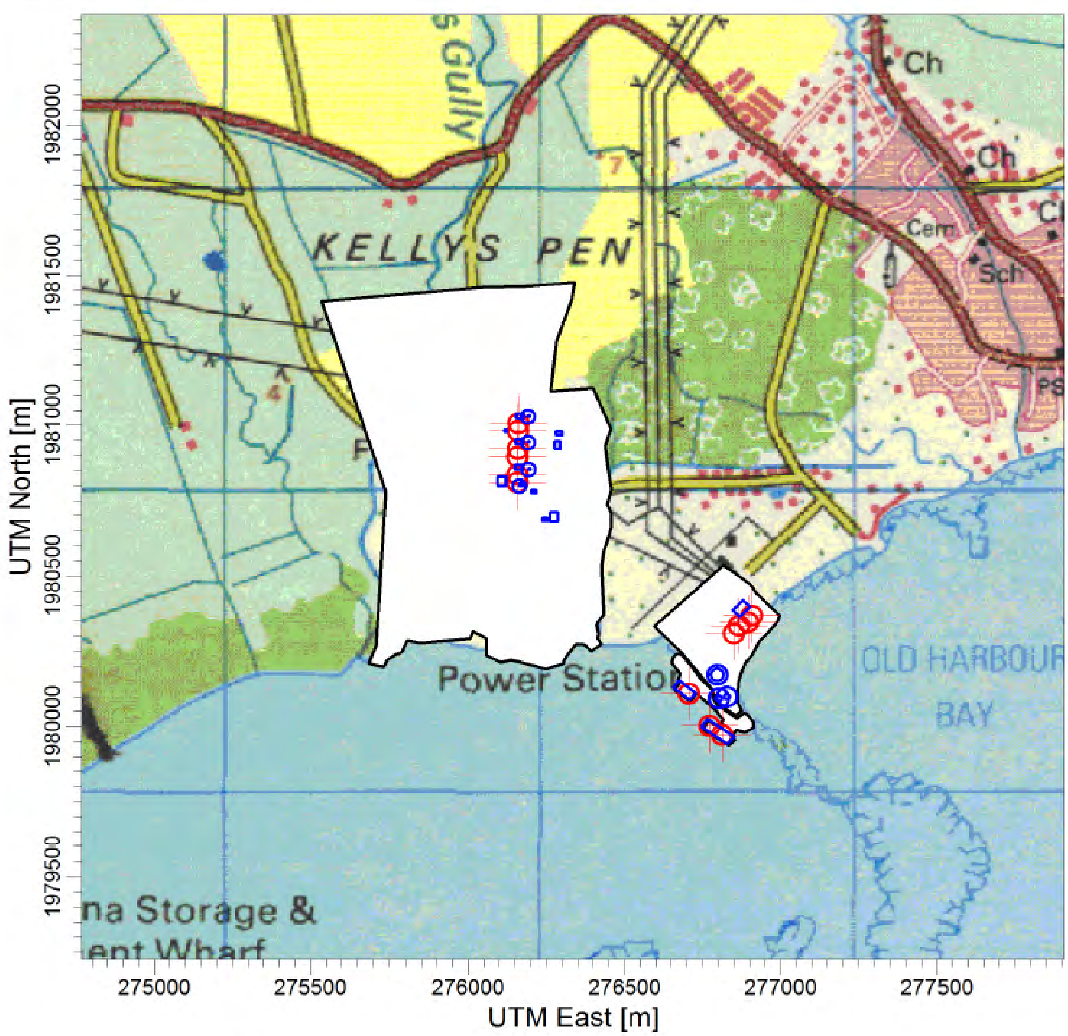
There are a number of buildings nearby the point sources that were identified in the modeling project and these are sufficiently close to cause wake effects for the plumes. The dimensions of the various buildings (and process vessels) as well as the parameters for the various point sources were inputted into the Building Profile Input Program (BPIP) to generate the necessary building heights and widths.

The USEPA BPIP was designed to incorporate the concepts and procedures expressed in the GEP technical support document (EPA, 1985), the Building Downwash guidance (Tikvart 1988, Tikvart 1989, and Lee 1993), and other related documents into a program that correctly calculates building heights (BHs) and projected building widths (PBWs). The BPIP model is divided into two parts.

Part one (based on the GEP technical support document) is designed to determine whether or not a stack is subject to wake effects from a structure or structures. Values are calculated for GEP stack height and GEP-related BHs and PBWs. Indication is given to which stacks are being affected by which structure wake effect. Part two calculates building downwash BHs and PBWs values based on references Tikvart, 1988, Tikvart 1989, and Lee 1993, which can be different from those calculated in part one. Part two only performs the calculations if structure wake effects are influencing a particular stack.

Table 6-16 shows the calculated GEP stack heights for the proposed power plant facility. It was observed that the recommended stack heights were equal or above the calculated GEP stack heights and hence, the unmodified algorithms for building downwash were used by the model to generate the building heights and projected building widths that were calculated using part two of the BPIP program. Hence, it is expected that point source emissions would not result in excessive pollutant concentrations in the immediate vicinity of the source, but rather significantly beyond the facility's fenceline.

PROJECT TITLE:
Sources & Main Buildings



COMMENTS:	SOURCES: 105	COMPANY NAME: **AIR QUALITY CONSULTANTS LIMITED**	
	RECEPTORS: 5979	MODELER:	
		SCALE: 1:20,000 0 0.5 km	
			PROJECT NO.:

AERMOD View - Lakes Environmental Software
C:\Users\haughton\Documents\Lakes\AERMOD View\360mwco\360mwco.isc

Figure 6-5 - Proposed Facility Point Sources and Main Buildings

Table 6-16 Preliminary GEP Stack Heights

PRELIMINARY* GEP STACK HEIGHT RESULTS TABLE
(Output Units: meters)

Stack Name	Stack Height	Stack-Building Base Elevation Differences	GEP** EQN1	Preliminary* GEP Stack Height Value
MS1	65.00	-0.44	30.94	65.00
MS2	65.00	-1.30	31.80	65.00
MS3	65.00	-0.28	30.78	65.00
MS4	65.00	1.96	37.29	65.00
MS5	65.00	0.89	38.36	65.00
MS6	65.00	0.03	39.22	65.00

* Results are based on Determinants 1 & 2 on pages 1 & 2 of the GEP Technical Support Document. Determinant 3 may be investigated for additional stack height credit. Final values result after Determinant 3 has been taken into consideration.

** Results were derived from Equation 1 on page 6 of GEP Technical Support Document. Values have been adjusted for any stack-building base elevation differences.

Meteorological Data

The AERMOD model requires hourly surface data values for wind speed, wind direction, temperature, rainfall, relative humidity, pressure, cloud cover and ceiling height and solar radiation and at least once daily mixing height data. In view of a number of critical missing data from the meteorological data sets obtained from the Norman Manley International Airport (NMIA), a modeled five year (2007 to 2011) meteorological data set was obtained and utilized as output from a mesoscale numerical weather prediction model.

These data were submitted directly into the AERMET meteorological preprocessor programme, which take three stages to process the data. The first stage extracts meteorological data and assesses data quality through a series of quality assessment checks. The second stage merges all data available for 24-hour periods and writes these data together in a single intermediate file. The third and final stage reads the merged meteorological data and estimates the necessary boundary layer parameters for dispersion calculations by AERMOD.

The 2007-2011 meteorological preprocessed data was used to determine its corresponding Wind Rose plot (Figure 6-6) The Wind rose show that the most predominant wind direction blows from the southeast, with the secondary wind direction being from the east-southeast. This means that the emissions plume will be dispersed mainly in the northwestern direction, and secondarily in the west-northwestern direction from the proposed plant site.

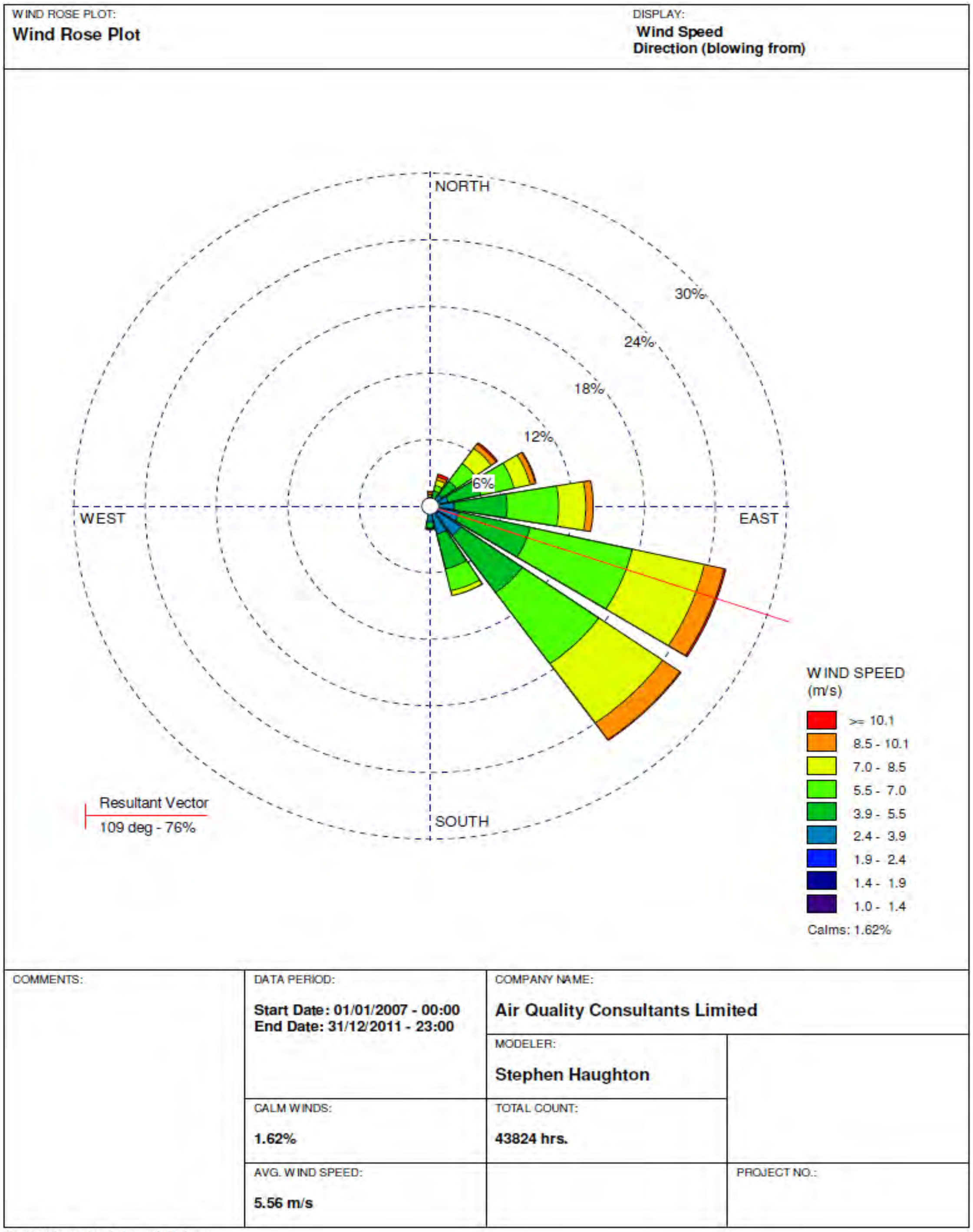


Figure 6-6 - Wind Rose Plot - (2007-2011) Preprocessed Met Data

Model Domain Receptor Network and Terrain Considerations

The selected model domain was 20 km in both the east-west and north-south directions, with the centre of the domain being Main Stack #3, with coordinates 276,159.19 m UTME and 1,980,921.69 m UTMN. Figure 6-7 shows the model domain that was utilized in the project, including the receptor grid and the plant boundaries. The model domain is overlain on a Jamaica Metric Grid 1:50,000 topographic map.

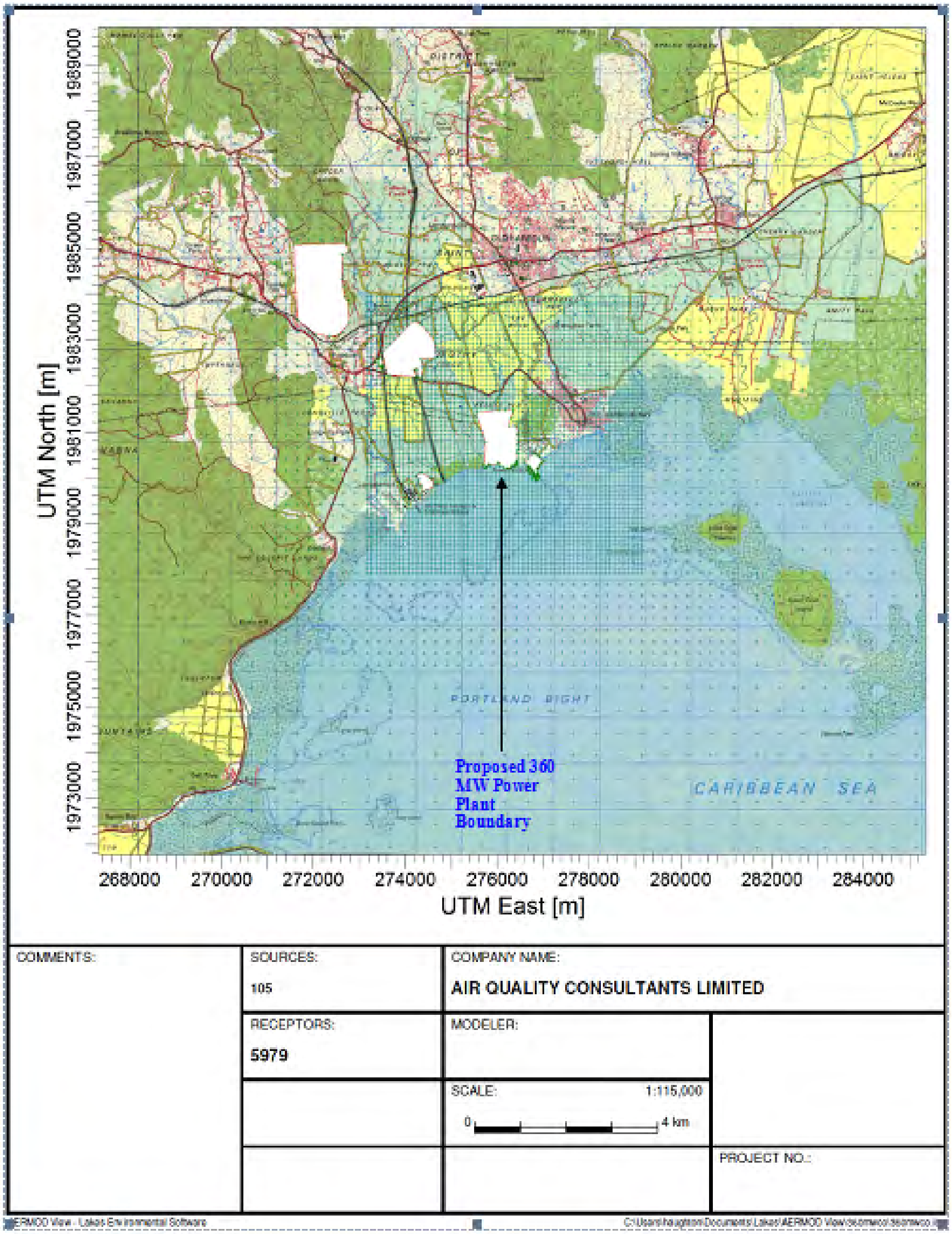


Figure 6-7 - Model Domain showing the Receptor Grid

Receptor Network

The selection and location of the receptor network are important in determining the maximum impact from a source and the area where there is significant air quality impact. Impacts were assessed at locations beyond the fence line. Consequently, the receptor locations were selected as a multi-tier grid that is defined by discrete Cartesian receptors, square in shape, and with origin at Main Stack #3. Certain special receptor locations were also defined, including schools, church buildings, postal agencies, health centres, post offices, police stations and a courthouse.

The entire receptor network locations include the following:

- A 100-meter spaced grid within 3 km from the subject source; and
- A 250-meter spaced grid between 3 and 5 km from the subject source; and,
- A 500-meter spaced grid between 5 and 10 km from the subject source; and,

A total of 44 special receptors that include schools, church buildings, postal agencies, health centres, post offices, police stations, a courthouse and air quality monitoring stations. The classification of the land use in the vicinity of the proposed power plant is needed because dispersion rates differ between urban and rural areas. In general, urban areas cause greater rates of dispersion because of increased turbulent and buoyancy-induced mixing. This is due to the combination of greater surface roughness caused by more buildings and structures and greater amounts of heat released from concrete and similar surfaces. The USEPA guidance provides two procedures to determine whether the character of an area is predominantly urban or rural. One procedure is based on land-use type, and the other is based on population density. Both procedures require an evaluation of characteristics within a 3-km radius from the subject source, but the land-use methodology is considered more accurate. Hence, this method was applied and it was determined that the rural dispersion coefficient be selected for this modeling project.

According to the land-use type methodology, a 3 km radius circle was circumscribed about the centre of the proposed power plant boundary. Then using the Auer land use types, about 25% (less than the 50% threshold) of the 3 km radius area around the project site matches the urban zones of I1, I2, C1, and R2 (Table 6-18). The majority of the area was cultivated land and the sea, and hence the rural option was selected.

A total of 5,979 receptors were considered, and some of these are represented in The classification of the land use in the vicinity of the proposed power plant is needed because dispersion rates differ between urban and rural areas. In general, urban areas cause greater rates of dispersion because of increased turbulent and buoyancy-induced mixing. This is due to the combination of greater surface roughness caused by more buildings and structures and greater amounts of heat released from concrete and similar surfaces. The USEPA guidance provides two procedures to determine whether the character of an area is predominantly urban or rural. One procedure is based on land-use type, and the other is based on population density. Both procedures require an evaluation of characteristics within a 3-km radius from the subject source, but the land-use methodology is considered more accurate. Hence, this method was applied and it was determined that the rural dispersion coefficient be selected for this modeling project.

Terrain Considerations

The classification of the land use in the vicinity of the proposed power plant is needed because dispersion rates differ between urban and rural areas. In general, urban areas cause greater rates of dispersion because of increased turbulent and buoyancy-induced mixing. This is due to the combination of greater surface roughness caused by more buildings and structures and greater amounts of heat released from concrete and similar surfaces. The USEPA guidance provides two procedures to determine whether the character of an area is predominantly urban or rural. One procedure is based on land-use type, and the other is based on population density. Both procedures require an evaluation of characteristics within a 3-km radius from the subject source, but the land-use methodology is considered more accurate. Hence, this method was applied and it was determined that the rural dispersion coefficient be selected for this modeling project.

Table 6-17 - Special Receptors

Description	X Coordinate,	Y Coordinate, m	Elevation, m
Freetown Postal Agency	272484	1982422	22.15
Freetown Church	272459	1982476	24.53
Freetown Church	272397	1982529	25.2
Freetown Primary School	272492	1982820	26.93
Freetown Church	273122	1982894	20.47
Freetown Church	272695	1982517	15.32
Sandy Bay Church	270905	1984336	47.17
Green Park Health Centre	269678	1984465	40.83
Green Park Church	269919	1984552	41.81
Green Park Primary & Junior High School	269956	1984693	42.9
Green Park Church	269861	1985136	53.71
Green Park Church	269889	1985700	62.7
Lancasters Church	267755	1985199	77.47
Lancasters Church	266052	1985000	93.4
Cross Primary & Junior High School	266046	1985479	93
Palmer's Cross Postal Agency	266015	1985541	93
Palmer's Cross Church	266008	1985703	93.01
Palmer's Cross Church	265567	1985858	96.09
Palmer's Cross Church	265437	1985970	94.1
Palmer's Cross Church	265897	1986610	97.84
Palmer's Cross Church	265990	1986865	97.17
Palmer's Cross Church	266469	1986878	96.45
Hazard Primary School	263553	1986859	78.37
Trenton School	263528	1986915	77.13
Staines Preparatory School	270509	1986927	108.87
Rosewell Postal Agency	270472	1986865	110.21
Rosewell Church	270584	1986567	95.9
Old Harbour Church	275706	1985398	37.93
Old Harbour Church	275532	1985125	35.23
Old Harbour Church	275681	1984920	32
Old Harbour Church	276042	1985007	31
Old Harbour Church	276123	1984808	29.24
Old Harbour Church	276266	1984590	29.87
Old Harbour Courthouse	276297	1984677	30
Old Harbour Post Office	276377	1984690	30
Old Harbour Police Station	276421	1984677	28.97
Old Harbour Church	276533	1984658	27.06
Old Harbour Bay Primary School	276663	1984621	24.9
Old Harbour High School	276595	1984323	25.25
Old Harbour Health Centre	276639	1984976	27.96
Monsignor Colin Bryan School	276701	1985522	32
Old Harbour Primary School	277925	1985386	44.2
Lauderwood Air Quality Station	272095	1986049	132.97
Longville Park Air Quality Station	270754	1981594	70.75

Table 6-18 - Land Use Categories

Auer Land Use Categories I1, I2, C1, & R2 (Auer 1978)

Type	Use and Structure	Vegetation
I1	Heavy Industrial	Grass and tree growth extremely rare; <5% vegetation
	Major chemical, steel and fabrication industries; generally 3-5 story buildings, flat roofs	
I2	Light-moderate industrial	Very limited grass, trees almost totally absent; <5% vegetation
	Rail yards, truck depots, warehouses, industrial parks, minor fabrications; generally 1-3 story buildings, flat roofs	
C1	Commercial	Limited grass and trees; <15% vegetation
	Office and apartment buildings, hotels;>10 story heights, flat roofs	
R2	Compact Residential	Limited lawn sizes and shade trees; <30% vegetation
	Single, some multiple, family dwelling with close spacing; generally <2 story, pitched roof structures; garages (via alley), no driveways	

Source: Auer, A. H. 1978. Correlation of Land Use and Cover with Meteorological Anomalies, Journal of Applied Meteorology, 17:636-643.

Additionally, the topography in the region of the proposed power plant is defined as either simple terrain (terrain lying below the stack top elevation) or complex terrain (terrain above the top of the stack). Measurements of the terrain in the area surrounding the proposed facility were made and obtained as Digital Elevation Maps derived by the Mona Informatix Limited's personnel. It was determined that the topography from the east through south western directions of the proposed facility, up to 10 km, have terrain elevations less than 20 m and include the marine environment (Figure 6-8). Also, the areas from southwest through to the northern direction had elevations greater than 30 m and up to 400 m.

Therefore, since terrain elevations extend above the proposed facility's highest top stack elevation, complex terrain algorithms were included as part of the dispersion modelling analysis.

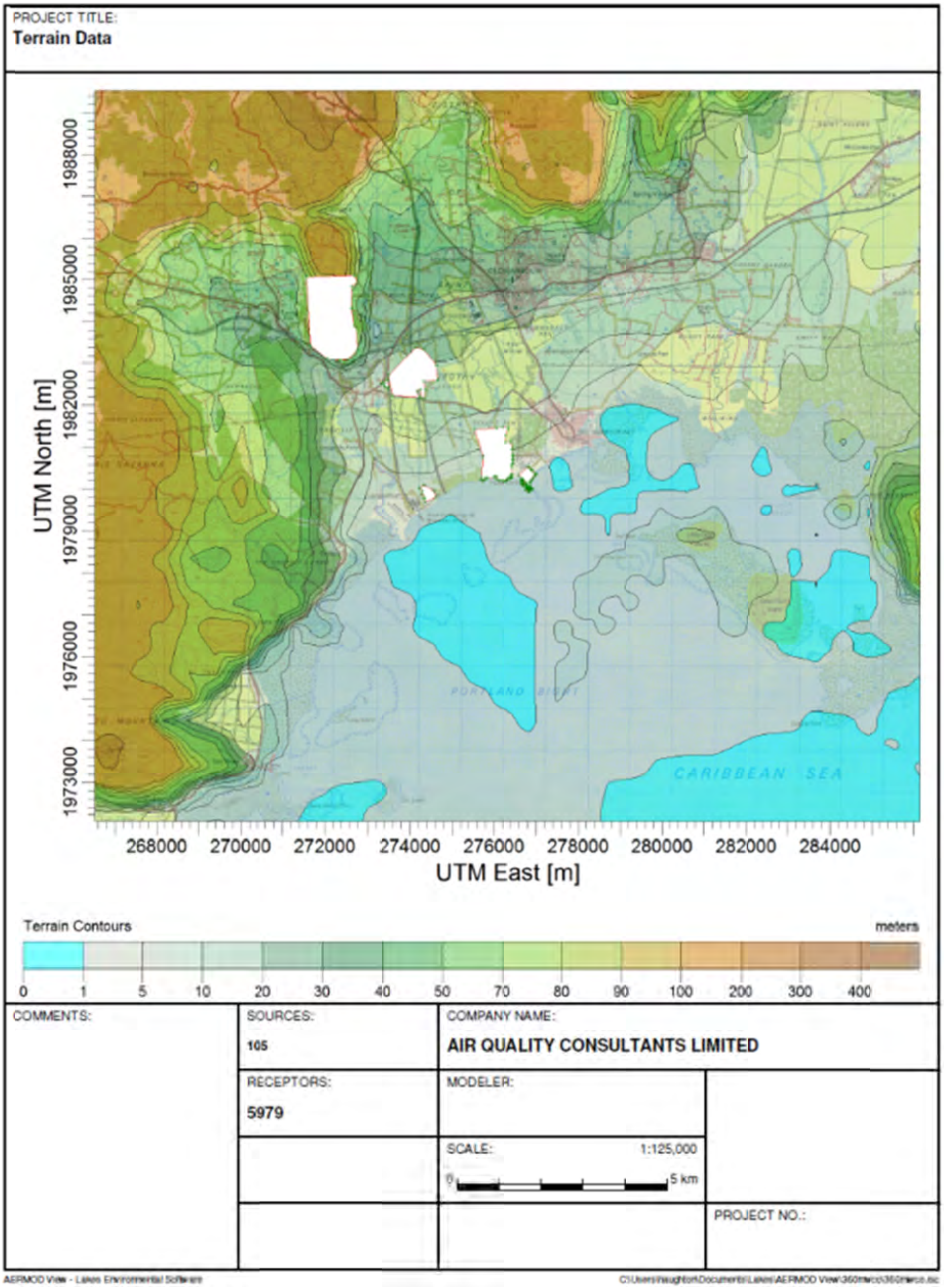


Figure 6-8 - Terrain Data for project area

6.2.2.4 Model Results

With the various sources identified, a model domain established of 20 km in the east-west direction and 20 km in the north-south direction and centred at Main Stack #3, and the necessary input files created, model predictions were made for the pollutants SO_2, NO_x, TSP/PM_{10}, CO and various priority air pollutants for averaging periods for which there are Jamaican National Ambient Air Quality Standards or Guideline Concentrations. Model runs were conducted for the proposed power plant's air pollutant sources alone, as well as the cumulative air quality impact in combination with the other defined sources in the vicinity of the proposed facility. As part of the future scenario with the 360 MW power plant being in full operation, the existing JPS 220 MW will be retired, and hence those air pollution sources will be removed from the future scenario.

During the NO_x model runs, the Ozone Limiting Method (OLM) was applied to convert NOx to NO_2. The in-stack NO_2/NOx ratio 0.1 was utilized in the OLM and this was applied to a five year (2007 to 2011) ozone concentration data file that was obtained for the Lauderwood ambient air quality monitoring station in Northern Clarendon.

6.2.2.4.1 Proposed Power Plant Impacts Only

Table 6-19 and Table 6-20 summarize the maximum predicted concentrations for the proposed power plant sources for LNG and ADO, respectively, as well as their comparison with the Significant Impact Concentrations and the Jamaican National Ambient Air Quality Standards (JNAAQS) and Guideline Concentrations.

The results revealed that when combusting LNG (the primary fuel), the maximum predicted ground level concentrations from all the proposed sources of the power plant did not exceed any of the Significant Impact Concentrations (SICs). Additionally, the maximum predicted ground level concentrations from all the proposed power plant sources plus the background concentrations (as recommended in the Air Quality Guideline Document) were all less than the JNAAQS and Guideline Concentrations.

When the proposed power plant is combusting ADO, Table 6-20 revealed that the predicted concentrations will exceed the 24h SO_2 SIC, while the maximum predicted ground level concentrations only exceeded the 1h SO_2 ambient air quality standard.

Table 6-19 - Model Results – Proposed Power Plant using Liquefied Natural Gas

Pollutant	Avg. Period	Background ($\mu g/m^3$)	Significant Impact Concentration ($\mu g/m^3$)	Jamaican NAAQS ($\mu g/m^3$)	Proposed Power Plant Sources		
					Max Conc ($\mu g/m^3$)	UTME (m)	UTMN (m)
TSP/PM_{10}	24-hr	14	80	150	4.4	273159	1988422
	Annual	20	21	60	0.2	275259	1981922
NO_2	1-hr	0	N/A	400	83.2	268159	1980422
	24-hr	0	80	N/A	14.7	267659	1980922
	Annual	0	21	100	0.6	268159	1981922
SO_2	1-hr	0	N/A	700	7.1	278159	1986922
	24-hr	0	80	280	0.6	273159	1988422
	Annual	0	21	60	0.03	275259	1981922
CO	1-hr	0	2000	40000	73.2	278159	1986922
	8-hr	0	500	10000	19.5	273159	1988422
Acetaldehyde	1-hr	0	N/A	1250	0.08418	278159	1986922
	24-hr	0	N/A	500	0.00757	273159	1988422
Acrolein	1-hr	0	N/A	58.75	0.01342	278159	1986922
	24-hr	0	N/A	23.5	0.00121	273159	1988422
Benzene	Annual	0	N/A	1	0.00009	N/A	N/A
Formaldehyde	1-hr	0	N/A	162.5	1.48843	278159	1986922
	24-hr	0	N/A	65	0.13392	273159	1988422
Xylenes	1-hr	0	N/A	5750	0.1342	278159	1986922
	24-hr	0	N/A	2300	0.01208	273159	1988422

Table 6-20 - Model Results – Proposed Power Plant using Diesel Oil

Pollutant	Avg. Period	Background ($\mu g/m^3$)	Significant Impact Concentration ($\mu g/m^3$)	Jamaican NAAQS ($\mu g/m^3$)	Proposed Power Plant Sources		
					Max Conc ($\mu g/m^3$)	UTME (m)	UTMN (m)
TSP/PM_{10}	24-hr	14	80	150	3.7	273159	1988422
	Annual	20	21	60	0.15	275259	1981922
NO_2	1-hr	0	N/A	400	123.8	277159	1987422
	24-hr	0	80	N/A	20.2	267659	1980922

Pollutant	Avg. Period	Background (µg/m³)	Significant Impact Concentration (µg/m³)	Jamaican NAAQS (µg/m³)	Proposed Power Plant Sources		
					Max Conc (µg/m³)	UTME (m)	UTMN (m)
	Annual	0	21	100	0.84	268159	1981922
SO_2	1-hr	0	N/A	700	**2884.4**	277159	1987422
	24-hr	0	80	280	**242.6**	273159	1988422
	Annual	0	21	60	9.6	275259	1981922
CO	1-hr	0	2000	40000	65.8	277159	1987422
	8-hr	0	500	10000	16.5	271909	1985922
Arsenic	1-hr	0	N/A	0.75	0.01886	277159	1987422
	24-hr	0	N/A	0.3	0.00159	273159	1988422
Beryllium	Annual	0	N/A	0.0013	0.0	N/A	N/A
Cadmium	1-hr	0	N/A	5	0.00908	277159	1987422
	24-hr	0	N/A	2	0.00076	N/A	N/A
Chromium	1-hr	0	N/A	3.75	0.02084	277159	1987422
	24-hr	0	N/A	1.5	0.00175	273159	1988422
Lead	1-month	0	N/A	N/A	0.00026	N/A	N/A
	3-month	0	N/A	2	N/A	N/A	N/A
Manganese	Annual	0	N/A	119	0.00497	275259	1981922
Mercury	1-hr	0	N/A	5	0.00227	277159	1987422
	24-hr	0	N/A	2	0.00019	N/A	N/A
Nickel	1-hr	0	N/A	5	0.00851	277159	1987422
	24-hr	0	N/A	2	0.00072	273159	1988422
1,3 Butadiene	1-hr	0	N/A	0.04	0.0284	277159	1987422
Selenium	1-hr	0	N/A	25	0.0454	277159	1987422
	24-hr	0	N/A	10	0.00382	273159	1988422

Bold type indicate exceedences above the respective standard

Figure 6-9 through to Figure 6-18 show the pollutant contour plot-files for TSP/PM_{10}, NO_x and CO for the proposed power plant when combusting LNG. The plot files show the most impacted areas based on the predicted pollutant concentrations generated by the model runs. The colour coded scale in the figures indicates the various impact concentrations obtained up to the predicted maximum concentrations achieved.

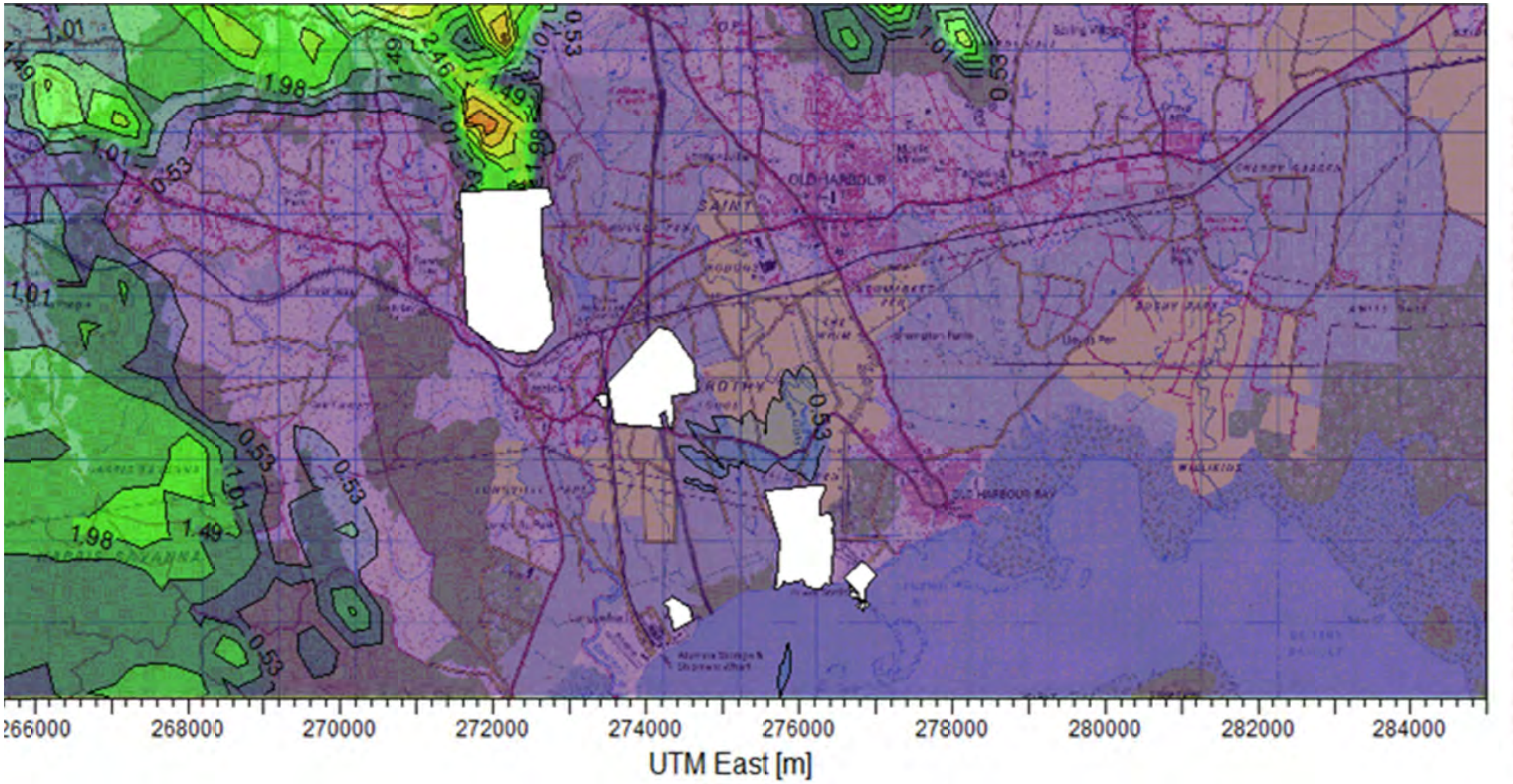


Figure 6-9 - Predicted 24-h TSP/PM_{10} Concentrations – Proposed LNG Power Plant Only

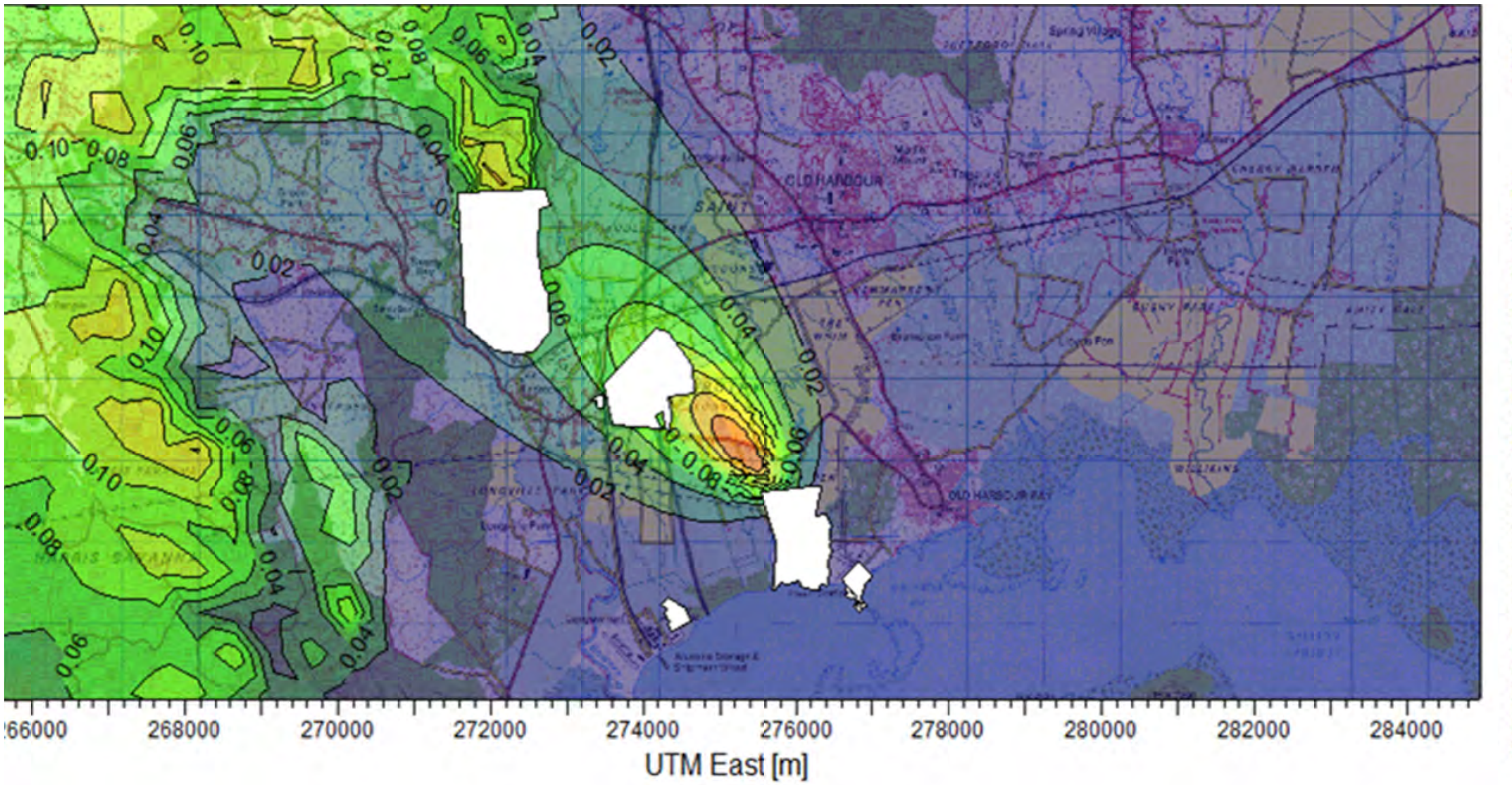


Figure 6-10 - Predicted Annual TSP/PM_{10} Concentrations – Proposed LNG Power Plant Only

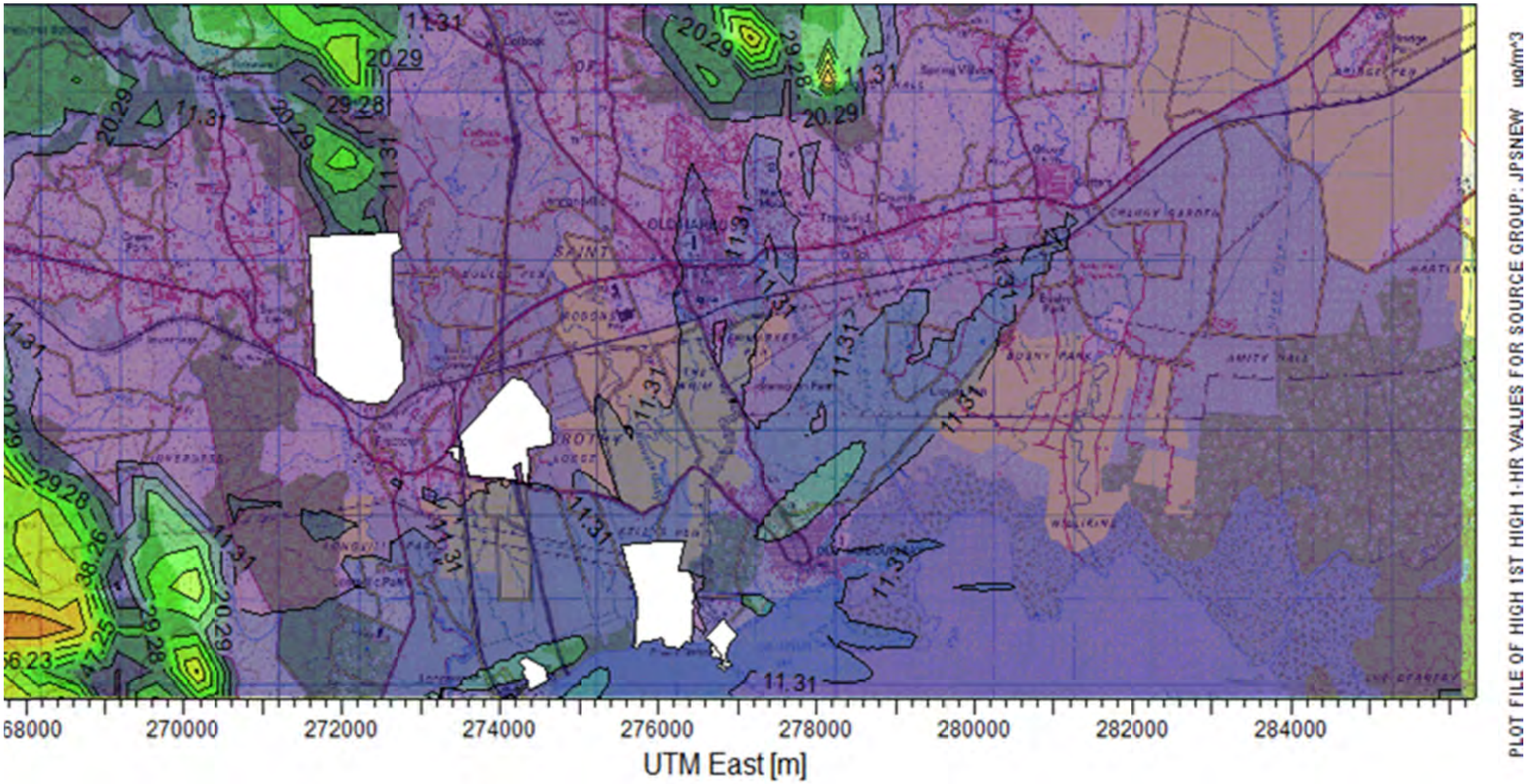


Figure 6-11 - Predicted 1-h NO_2 Concentrations – Proposed LNG Power Plant Only

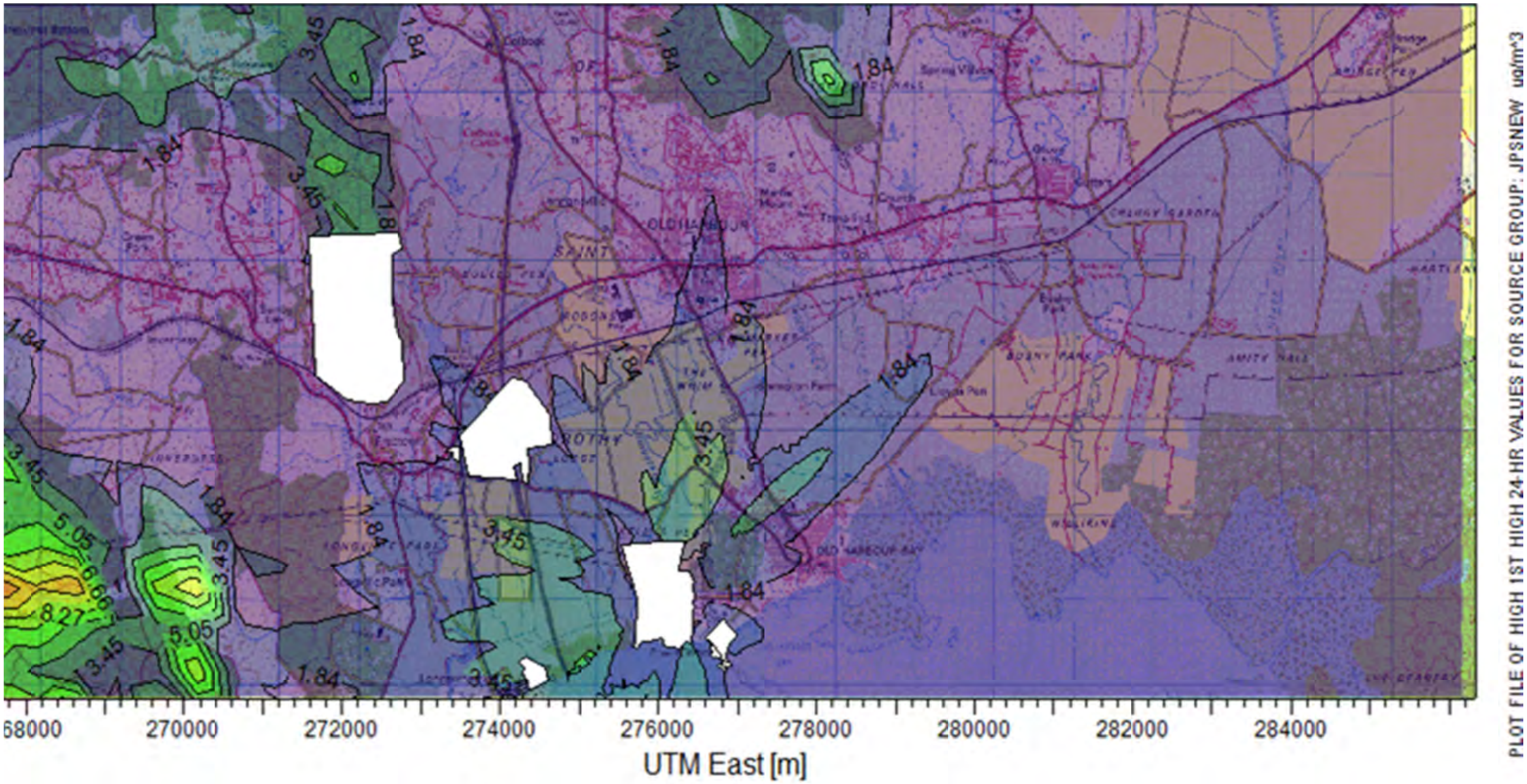


Figure 6-12 - Predicted 24-h NO_2 Concentrations – Proposed LNG Power Plant Only

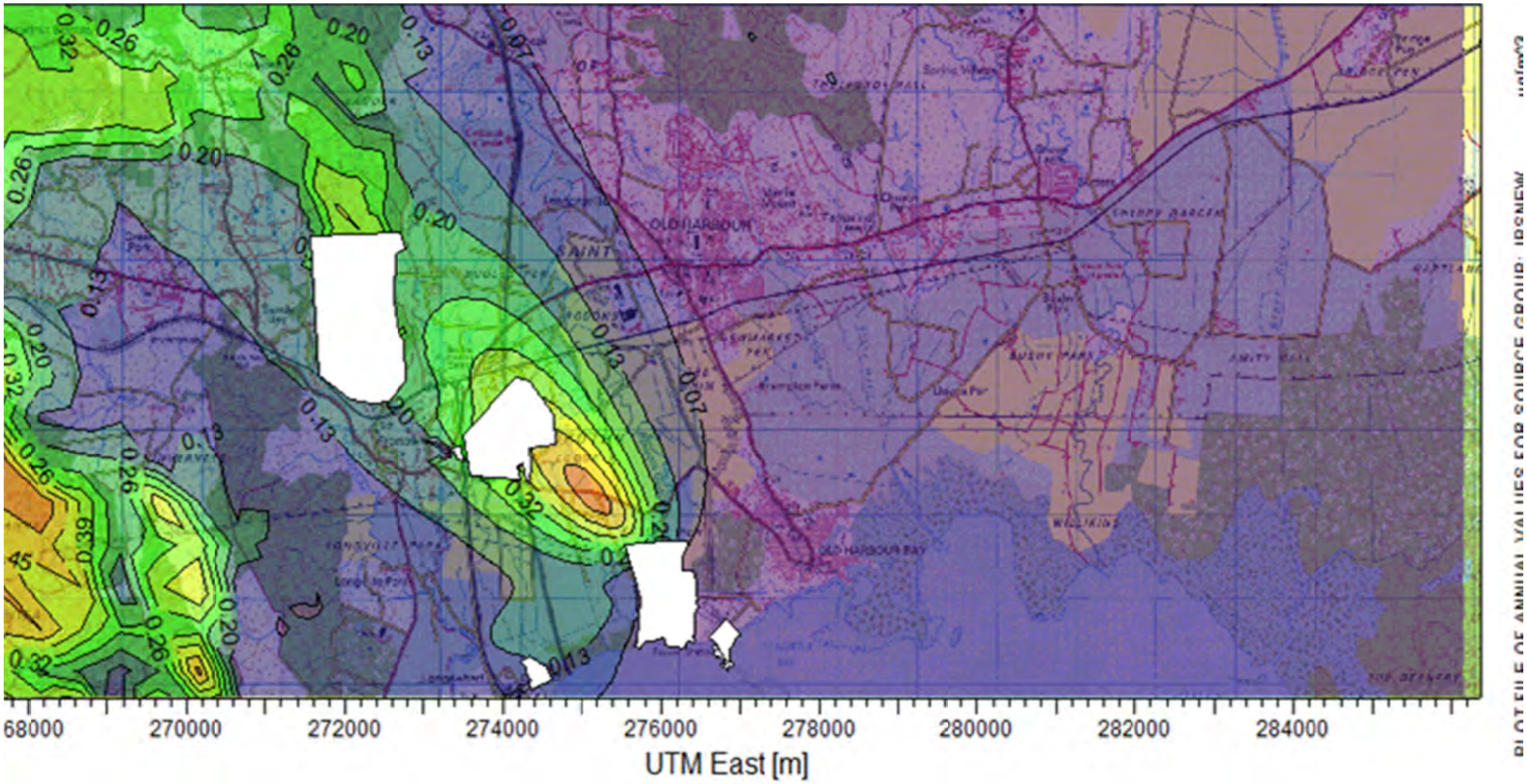


Figure 6-13 - Predicted Annual NO_2 Concentrations – Proposed LNG Power Plant Only

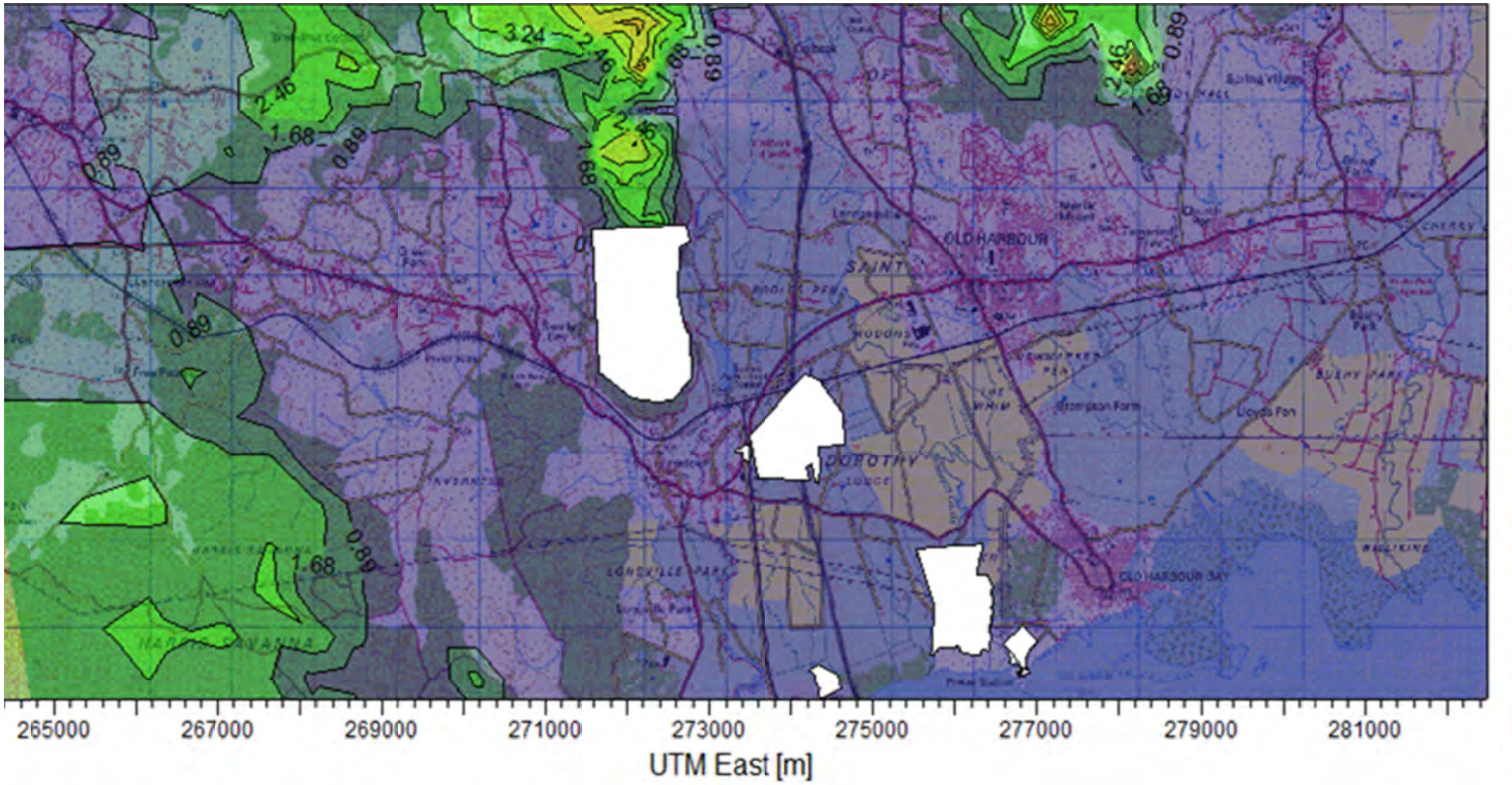


Figure 6-14 - Predicted 1-h SO2 Concentrations – Proposed LNG Power Plant Only

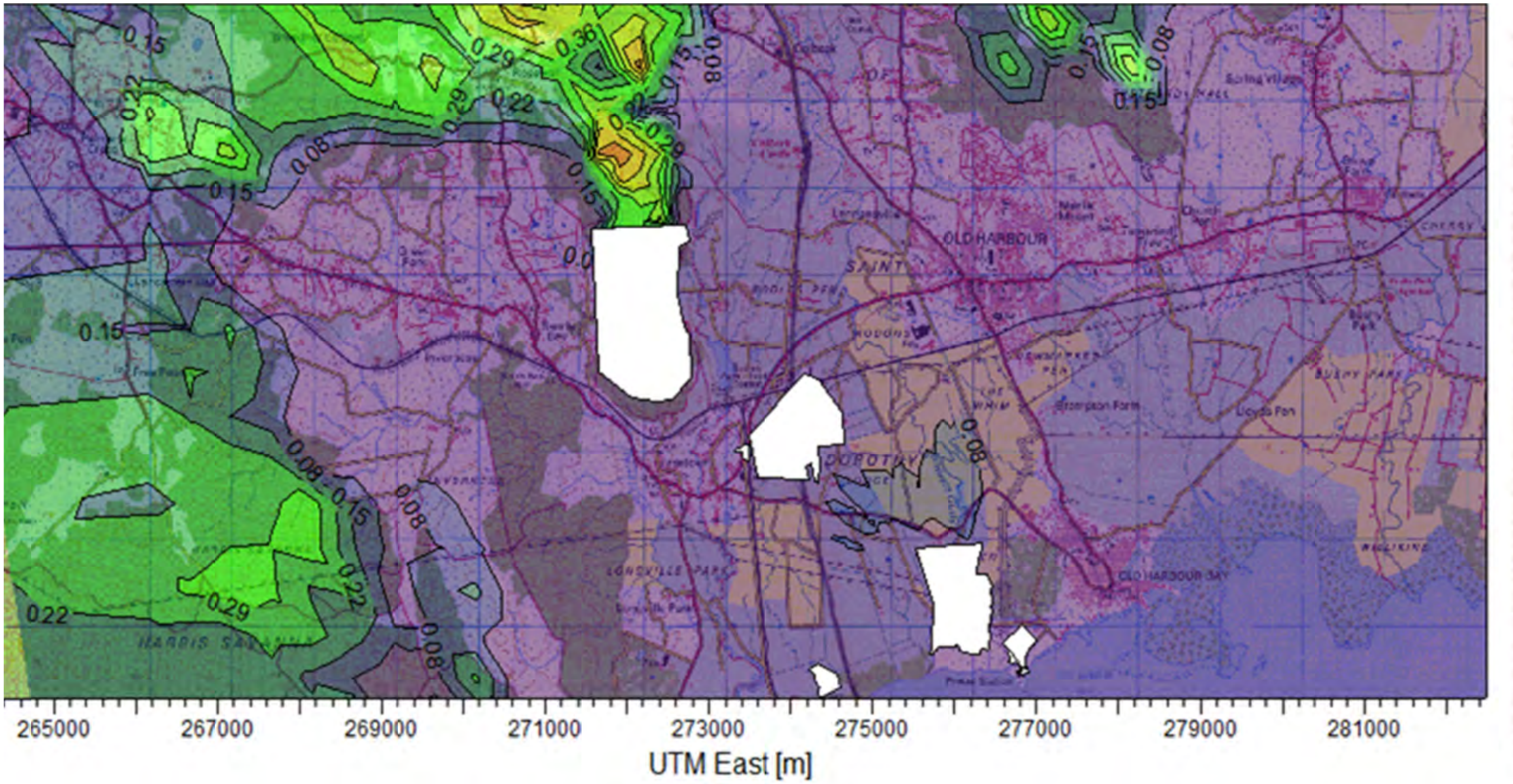


Figure 6-15 - Predicted 24-h SO2 Concentrations – Proposed LNG Power Plant Only

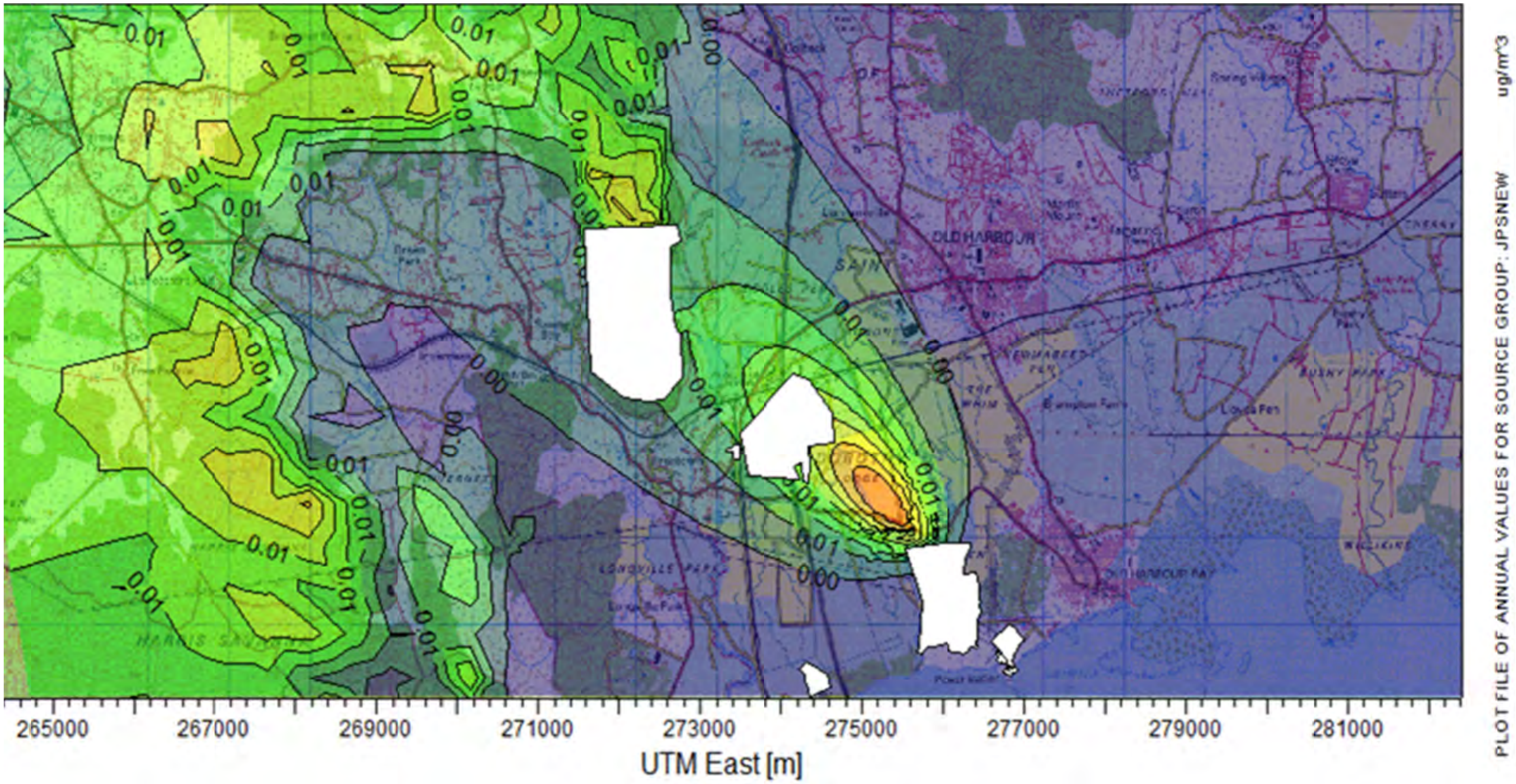


Figure 6-16 - Predicted Annual SO_2 Concentrations – Proposed LNG Power Plant Only

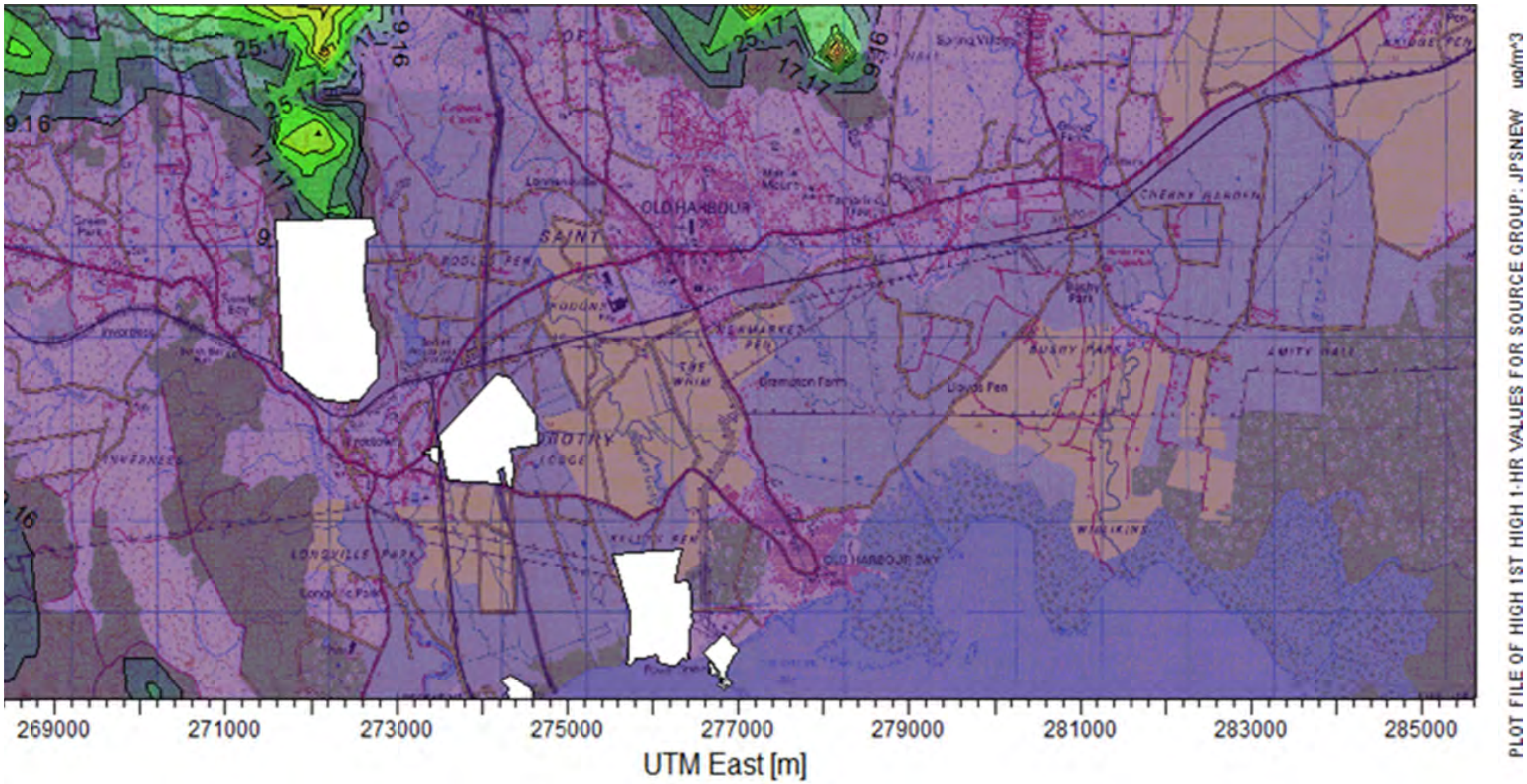


Figure 6-17- Predicted 1-h CO Concentrations – Proposed LNG Power Plant Only

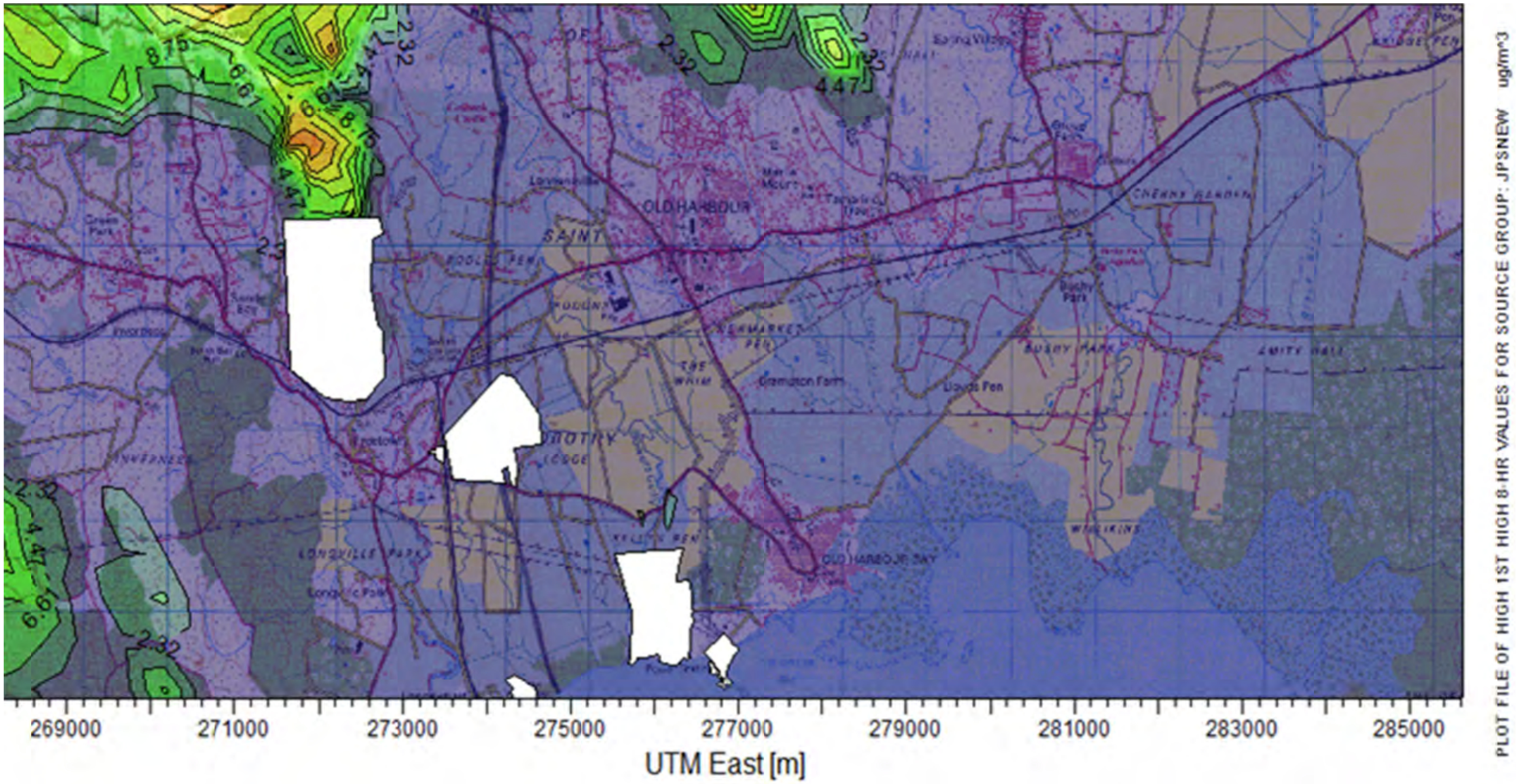


Figure 6-18 - Predicted 8-h CO Concentrations – Proposed LNG Power Plant Only

6.2.2.5 Greenhouse Gases Emissions

The existing JPS Old Harbour power plant of the capacity of 220 MW emits greenhouse gas into the atmosphere according to the following listed in Table 6-21.

Table 6-21 – Greenhouse gas emissions from the JPSCo Old Harbour Power Plant

Fuel Type	Amount, L	CO_2, tonnes/y	CH_4, tonnes/y	N_2O, tonnes/y
HFO	306,099,807.02	956,255.80	10.41	19.59

Calculations based on the use of GHG Emission Factors from Canada's National Inventory Report 2011

The proposed combined cycle gas turbine power plant is characterized by a significantly lower GHG emission rates, but only when combusting LNG. When burning ADO, the proposed facility will generate a lot more GHG emissions. The table below shows the calculated values.

Table 6-22 – Calculated greenhouse gas emissions from the proposed 360 MW Power Plant

Fuel Type	Amount, L	CO2, tonnes/y	CH4, tonnes/y	N2O, tonnes/y
ADO	505,429,415	1,345,958.53	67.22	202.17
LNG	11,870,199,649.55 L @ 425,599,378 MMBtu/y with a LHV of 47.997 MJ/kg and a fuel density of 0.7881 kg/L	22,743.30	5.82	0.58

Calculations based on the use of GHG Emission Factors from Canada's National Inventory Report 2011

6.2.3 Noise

The predicted noise from the proposed power plant was determined by using SoundPlan version 7.1. The model was calibrated to give the manufacturers' guaranteed noise output of 85 dBA at 1m from the plant equipment (turbines). The noise spectrum for both the Steam Turbine Generators and the Gas Turbine Generators provided by the manufacturer was used to calibrate the model. Once the model was calibrated then structures such as the auxiliary buildings, tank farm, ground and other buildings within the area were added.

The noise impact from the proposed plant at the fence line (industrial), institutional (schools) and residential location were assessed below in Table 6-23 and depicted in Figure 6-19 and Figure 6-20.

6.2.3.1 Comparison with NEPA Guidelines

All stations will be compliant with both the NEPA day time and night time guidelines. However, it should be noted that the baseline noise level at Stations 7, 8 and 9 exceeded both the NEPA day and night time guidelines.

6.2.3.2 Comparison with World Bank Guidelines

All stations will be compliant with the World Bank day time guidelines. Only Station 6 will exceed the World Bank night guidelines.

Table 6-23 - Comparison of anticipated noise readings with NEPA and World Bank guidelines

STATION			DAY TIME (7 am. – 10 pm.) (dBA)				NIGHT TIME (10 pm. – 7 am.) (dBA)			
No.	**LOCATION**	**CATEGORY**	**BASELINE**	**PREDICTED NOISE FROM THE PLANT**	**NEPA STD.**	**WORLD BANK GUIDELINE**	**BASELINE**	**PREDICTED NOISE FROM THE PLANT**	**NEPA STD.**	**WORLD BANK GUIDELINE**
1	Northern Property Boundary	Industrial	51.3	70.6	75	70	45.1	70.6	70	70
2	Eastern Property Boundary	Industrial	53.1	61.6	75	70	51.1	61.6	70	70
3	Southern Property Boundary	Industrial	58.7	55.3	75	70	56.4	55.3	70	70
4	Western Property Boundary	Industrial	50.9	66.9	75	70	53.4	66.9	70	70
5	JPS Guard House	Industrial	61.4	47.2	75	70	54.9	47.2	70	70
6	Informal Settlement	Residential	52.6	48.7	55	55	48.1	**48.7**	50	45
7	Old Harbour Bay Police Station	Residential	59.1	42.2	55	55	50.1	42.2	50	45
8	New Harbour Village Phase 1	Residential	59.9	37.3	55	55	55.8	37.3	50	45
9	Church Pen	Residential	59.4	31.1	55	55	53.6	31.1	50	45
10	Bodles	Commercial	53.5	32.2	65	70	50.6	32.2	60	70
11	Longville Park	Residential	51.7	28.0	55	55	49.9	28.0	50	45

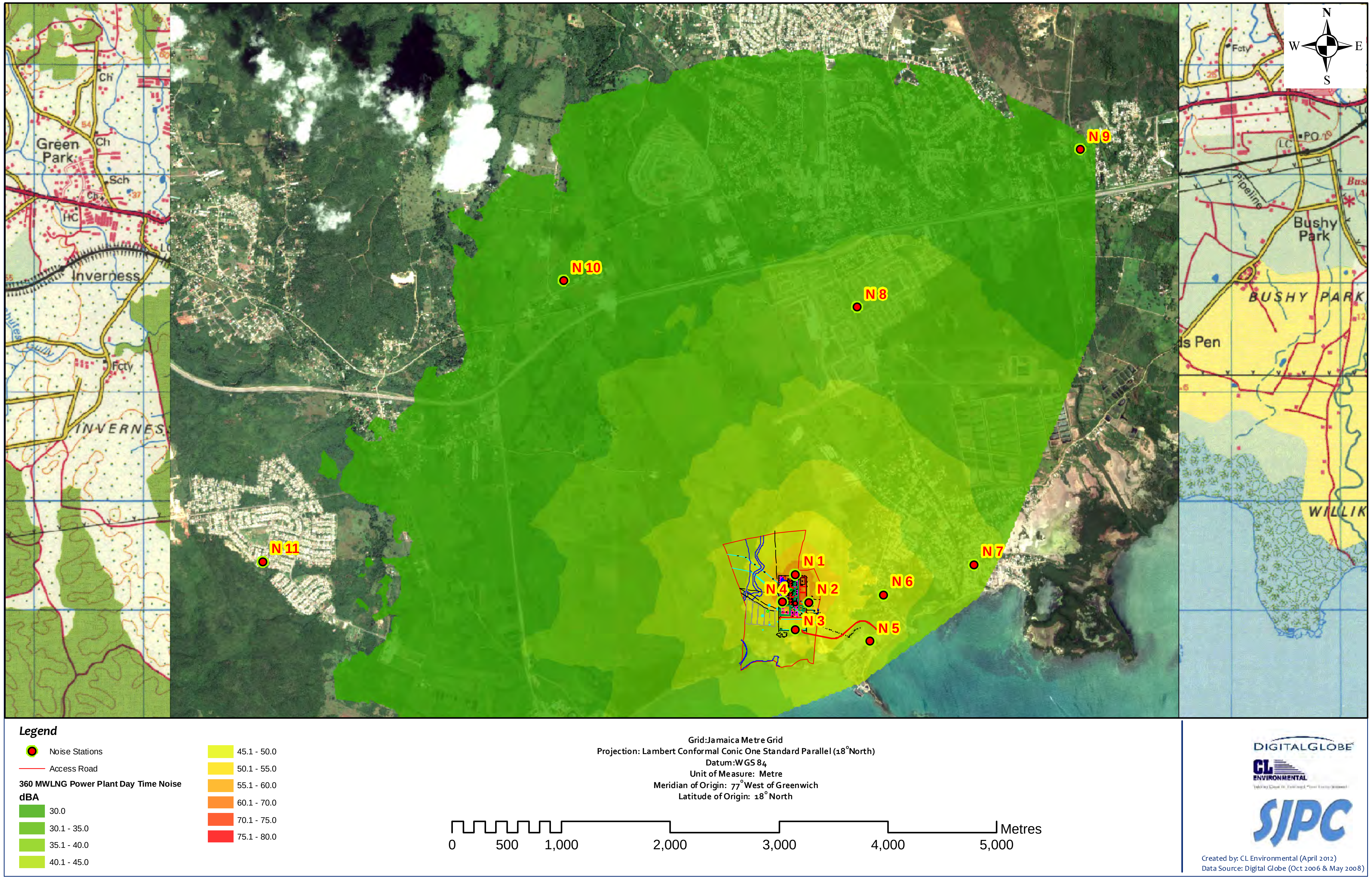


Figure 6-19 - Predicted day time noise level of the proposed 360 MW LNG power plant

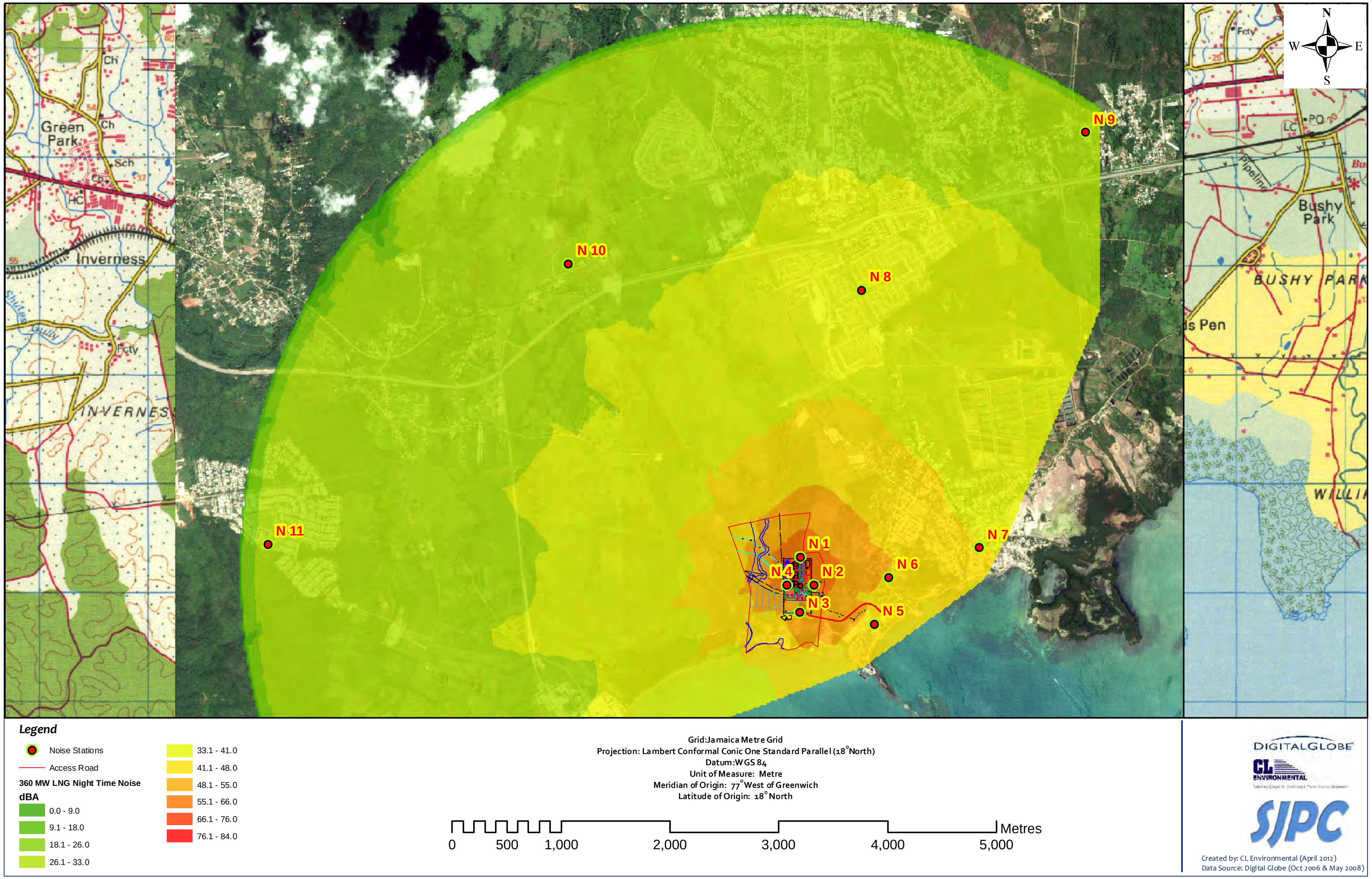


Figure 6-20 - Predicted night time noise level of the proposed 360 MW LNG power plant

Although the locations at which noise levels were taken during the conduct of the EIA were compliant with the NEPA and World Bank guidelines, there were areas in proximity to the proposed Plant where the noise generated by the Plant would be non-compliant. This assessment was done using the night time noise limit of 50 dBA, since once the night time noise limits are met then automatically the day time night standard would be met.

Based on this, a 50 dBA noise limit was predicted using the noise model. This identified the following areas to be non-compliant with the 50 dBA limit;

1. Sections of Burkesfield Meadows
2. Sections of Terminal Lane
3. Sections of Terminal Road

These are depicted in Figure 6-21 below.

6.2.3.3 Avifauna

Birds act as biological receptors, their community, behaviour and dynamics can be greatly affected by factors such as noise. The avian community (including migratory species) of PBPA has not been studid for the effects of noise from the existing industrial, commercial and other anthropgenic activities within the area. Interactions between male-female birds have been shown to be disrupted by high environmental levels (Swaddle and Page, 2007; Francis et al., 2009; Halfwerk et al., 2011). Studies showing noise effects on male- female bird communications (Swaddle and Page, 2007; Francis et al., 2009; Halfwerk et al., 2011) and nesting (Francis et al., 2009) have been done.

Noise appears to decrease a females' preference in a male-female pair bond in a monogamous bird species, Zebra Finch. The decrease in preference may result from the masking or distortion of the paired males' pair-bond maintaining call, although the decrease could also be due to a failure of the female to recognize her pair-bonded male. This would suggest that songbirds in areas of high environmental noise may have (temporarily or permanently) weakened pair bonds resulting in extrapair behaviours (Swaddle and Page, 2007). Within urban areas, noise impairs male-female communication and that signal efficiency depends on song frequency in the presence of noise. High frequency songs have a response advantage during sexual signalling in noisy conditions, whereas low-frequency songs are likely to be preferred (Halfwerk et al., 2011).

Nesting species richness was reduced due to noise which leads to different avian communities. However, it was found that noise indirectly facilitates reproductive success of nesting in noisy areas as a result of the disruption of predator-prey interactions. Urban-adapted species would be more successful in noisy habitats whereas loss of birds less tolerant of noise (Francis et al., 2009).

The avian community within the project area and its zone of influence is currently shaped by the existing noise environment and as such the impacts of noise (both during construction and operation) on the community structure is expected to be minimal. That is the current industrial activities, including the operational noise from JPS Old Harbour plant and JEP barges have already influenced and shaped the avian community.

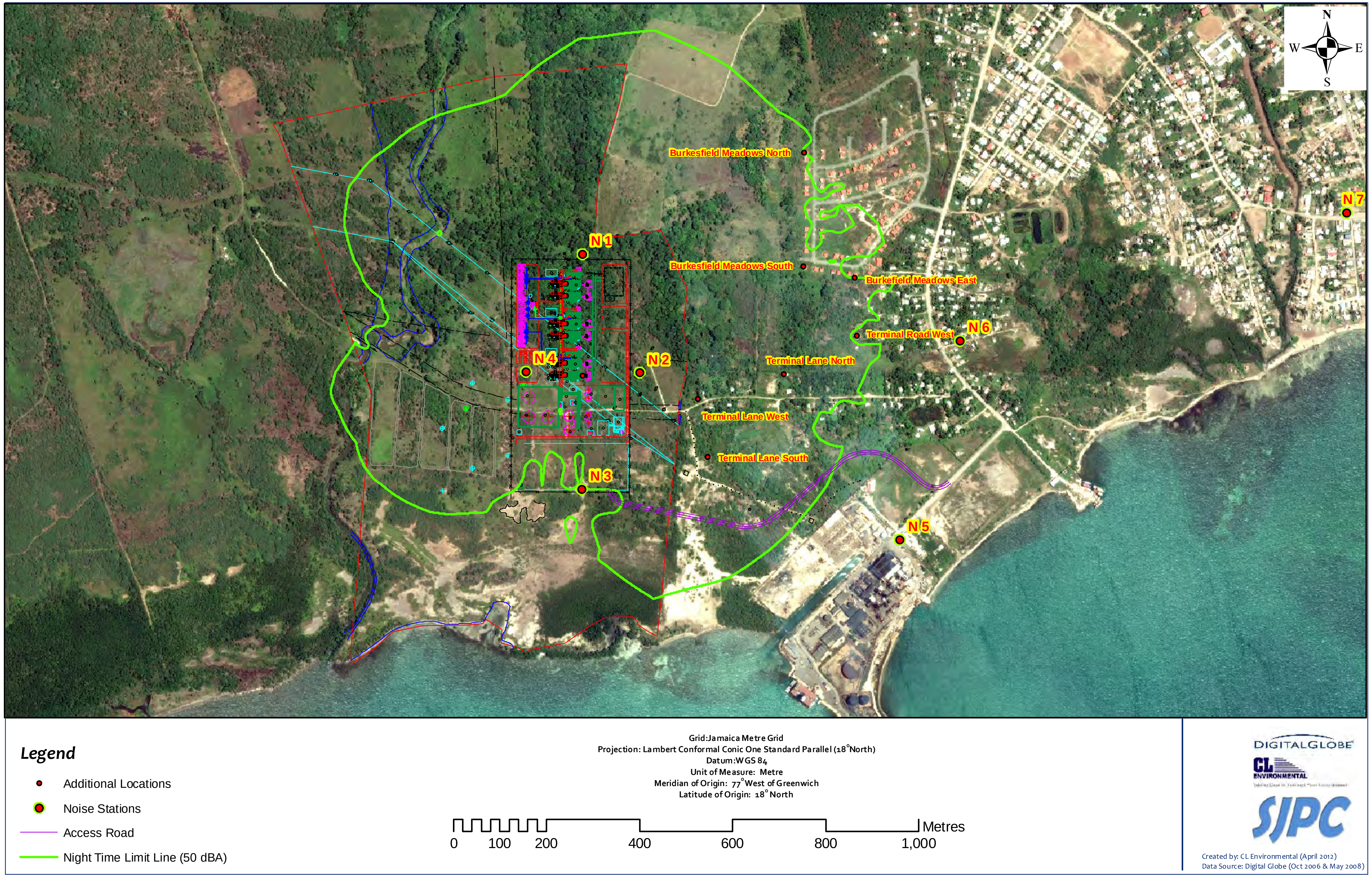


Figure 6-21 – Predicted night time limit of 50 dBA(green line)

6.2.4 Natural Hazards

The following points require consideration:

- The site for the plant building is 2 m or less in elevation above present sea level. Steps to protect it from hurricane surge (2 to 4 m in hurricane Dean, 2007) and possible tsunami should be taken.
- Attention should be paid to the likely changes in sea-level (0.8 to 1.4 m rise by 2100) during the design life (and beyond) of the plant.
- Liquefaction during a seismic event and post-depositional settling of subsurface sediments need to be considered for the life of the plant.

6.2.5 Manmade Hazards

The following points require consideration:

- Fire is one of the major and most common risks. This can result from incidences such as transformer failure and gas and steam turbine malfunctions.
- Correct operation and monitoring of machines is critical. Attention should be paid to all steps in operation, including start up and pre-start checks.
- Improperly controlled maintenance activities can lead to problems. The use of correct components and properly designed spare parts are of equal importance during maintenance activities and manufacturer's guidelines should be properly adhered to. Cleanliness is important in preventing damage to machine blading, as debris or foreign objects left following maintenance activities can get drawn into the turbine can be dangerous and cause damages.
- Quality assurance of component parts and materials is extremely important as gas turbines operate at high speed with high operating temperatures and pressures, and low tolerances between blades and veins. Failure of a relatively minor component within the machine can cause extensive damage.
- Use of proper fuel is very critical. Fuel quality is of importance as rogue chemicals can cause deposits, erosion or corrosion of

machine internals leading to long-term damage. Fuel pulsations as a result of varying fuel quality or irregular supply systems can cause vibration in combustion systems and turbine areas leading to mechanical damage that is exacerbated as it is exposed to high temperatures and further operation.

6.2.6 Stormwater Runoff and Flooding

6.2.6.1 Increased Runoff to Bowers Gully

Stormwater runoff from the Plant will be discharged to the Bowers Gully. The additional runoff will increase the peak flows to the sea by 1.9 to 2.6 percent for the 10year to 100year flows. There are no developments downstream of SJPC to be impacted by this additional peak runoff.

Table 6-24 – 10yr, 50yr and 100yr post development flows

Post-development Flows	**Bowers Gully (m^3/s)**	**Project site (m^3/s)**	**Increase**
10yr	236	6.2	2.6%
50yr	464	9.7	2.1%
100yr	537	10.4	1.9%

6.2.6.2 Pollution of Surface Waters

During the operational phase, the oil or other chemicals may end up into the storm drains and into the river.

6.2.7 Wastewater Discharge

The water balance for plant as outlined in the Case Study for Wastewater TDS Report by Daelim (the contractor) indicates water for plant and sanitary processes will be obtained from a well source. The wastewater produced from the power plant operations will include wastes from the following sources:

- RO plant reject water (brine)
- Demineralization waste water
- Filter backwash water
- Cooling tower

Three cases were however presented to highlight the likely TDS levels of wastewater discharge volumes to the Bowers Gully (Table 6-25), they include the following conditions:

Table 6-25 - Different scenarios showing likely TDS levels in wastewater discharge volumes

Case	Description	Final Discharge
1	No treatment after WWTP	Q = 111.1m3/d TDS = 3867mg/l
2	Treatment of brine from RO plant and changing the cooling water system	Q = 10.7m3/d TDS = 500mg/l
3	Treat combined wastewater from all systems prior to discharge	Q = 77.8m3/d TDS = 230mg/l

Case 1 was determined to be the worst case scenario and was therefore modelled to determine the impact on the water quality in the nearshore area. The composite wastewater will be discharged at an average rate of 111.1 cubic metres per day with a TDS value of 3,867 mg/l, which is considered brackish water (TDS of 1,500 – 5,000 mg/l). This flow will be discharged into the Bowers Gully which has intermittent flows going into the sea. The one year return flow from the gully is estimated at 1.6m^3/s or 141,788m^3/day. This TDS was modelled as salinity in the RMA10 model using the average and fast day conditions to estimate the potential impacts of this flow on the salinity in the nearshore area.

The results of the modelling indicated there will be a marginal decrease of the salinity in the nearshore area due to the introduction of the waste stream from the plant into the Gully. This is so because the gully presently discharges brackish (salinity 0.5 mg/L or more) into the sea. See Figure 6-22.

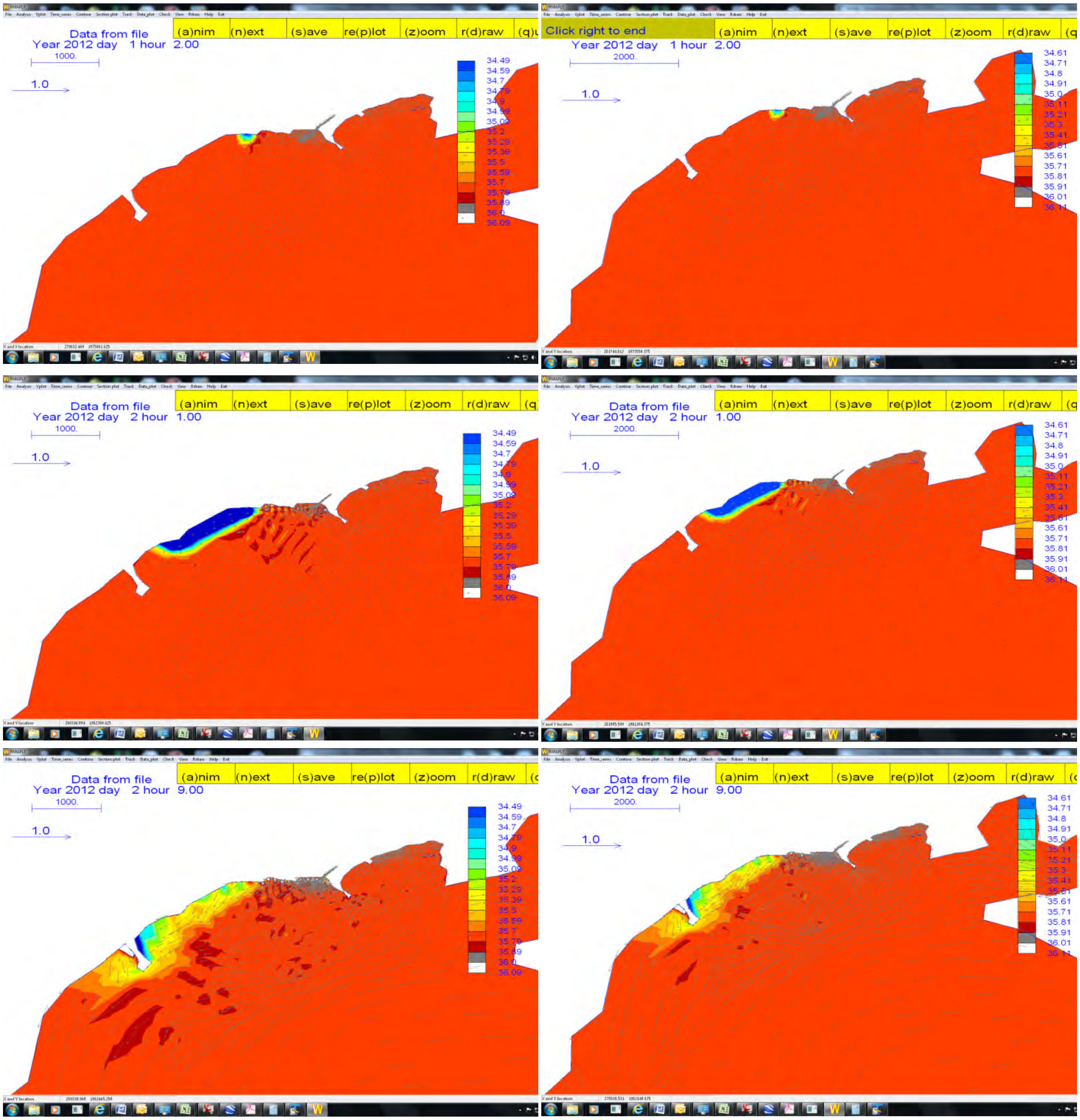


Figure 6-22 - Salinity plots comparing the present nearshore salinity to the post construction salinity

6.2.8 Oily Water Management

Oily water on the site will generally originate from two area, plant floor and car park area. Floor water will originate from a number of activities; these will include wash down operations, maintenance operations, and spills during loading. Oily water in car park area may be as a result of spills from delivery trucks or any other vehicles undergoing mechanical problem or maintenance.

6.2.9 Traffic

There is little potential for an increase in overall traffic as it is expected that there will be the closure of the JPSCo Old Harbour plant, with the opening of the 360 Mw plant. Therefore, it is expected that the traffic that now goes to this plant will be diverted to the 360 MW LNG plant thus no net increase.

6.2.10 Employment

There is the potential for increased employment during the operation phase. It is anticipated that approximately 65 persons will be employed directly. A number of indirect jobs are expected to be created this further benefitting the community.

6.2.11 Aesthetics and Landscaping

The proposed development will have little, if any, visual impact on the aesthetics of the location due to the fact that the power plant is being placed in a location that is industrial and zoned indujstrial.

Plate 6-1 shows the existing JPS power plant which is adjacent to the proposed project site (an example of the industrial structures already in the area)

Plate 6-1 - Photo showing one of the existing JPS power plant adjacent the site

A detailed Landscaping Plan for the proposed project is presented in Section 9 – Recommended Mitigation.

7.0 CUMULATIVE ENVIRONMENTAL IMPACTS

7.1 NOISE

The operation of the proposed 360 MW LNG power plant will result in an increase in the existing noise level (cumulative) (Table 7-1).

The cumulative noise impact takes into account all the existing background noise sources which include the existing Jamaica Public Service Old Harbour power plant, the Jamaica Energy Partners Doctor Bird I and II Barges, Jamaica Ethanol, Operations at Port Esquivel, Hi Pro Feed Mill, and other anthropogenic activities such as night noises. The predicted noise from the new noise source (the proposed 360 MW LNG power plant) is then added to the existing noise levels to determine what if any impact this new development would have on the surrounding community.

7.1.1 Comparison with NEPA Guidelines

Stations 1, 7, 8 and 9 would exceed the NEPA day and Stations 1, 6, 7, 8 and 9 night time guidelines when the cumulative noise levels are calculated. With the exception of Station 1 and Station 6 (night time), the NEPA Guidelines were being exceeded at these locations prior to the addition of the proposed project.

7.1.2 Comparison with World Bank Guidelines

Station 1 exceeded the World Bank guidelines during both the day and night times. Stations 7, 8 and 9 will exceed the World Bank day time guidelines when the cumulative noise levels are calculated. They will comply with the 3dBA rule, thus compliance with World Bank guidelines.

Stations 6, 7, 8 and 9 will exceed the World Bank night time guidelines when the cumulative noise levels are calculated. They will however, be compliant with the 3 dBA rule. The baseline noise levels at these stations were above the guidelines prior to the project.

It should be noted that the baseline noise levels at stations 7, 8, 9, 10 and 11 (day time) and stations 8, 9, 10 and 11 (night time) will not change as a result of the 360 Mw LNG Power Plant.

Table 7-1 - Cumulative noise levels based on results of noise measurements during (7:00 hrs Friday 27th, to 7:00 hrs Monday 30th, April 2012)

		STATION	DAY TIME (7 am. – 10 pm.) (dBA)				NIGHT TIME (10 pm. – 7 am.) (dBA)			
No.	**LOCATION**	**CATEGORY**	**BASELINE**	**CUMM**	**NEPA STD.**	**WORLD BANK GUIDELINE**	**BASELINE**	**CUMM**	**NEPA STD.**	**WORLD BANK GUIDELINE**
1	Northern Property Boundary	Industrial	51.3	**70.6**	75	70	45.1	**70.6**	70	70
2	Eastern Property Boundary	Industrial	53.1	62.2	75	70	51.1	61.6	70	70
3	Southern Property Boundary	Industrial	58.7	60.4	75	70	56.4	59.0	70	70
4	Western Property Boundary	Industrial	50.9	66.9	75	70	53.4	66.9	70	70
5	JPS Guard House	Industrial	61.4	61.4	75	70	54.9	55.6	70	70
6	Informal Settlement	Residential	52.6	54.1	55	55	48.1	**51.4**	50	45
7	Old Harbour Bay Police Station	Residential	59.1	**59.1**	55	55	50.1	**50.8**	50	45
8	New Harbour Village Phase 1	Residential	59.9	**59.9**	55	55	55.8	**55.8**	50	45
9	Church Pen	Residential	59.4	**59.4**	55	55	53.6	**53.6**	50	45
10	Bodles	Commercial	53.5	53.5	65	70	50.6	50.6	60	70
11	Longville Park	Residential	51.7	51.7	55	55	49.9	49.9	50	45

NB: Numbers in red indicate non-compliance with both NEPA and World Bank guidelines, green indicate non-compliance with NEPA guidelines but compliance with World Bank guidelines when the 3 dBA rule is applied.

7.2 AIR QUALITY

As part of the air dispersion modeling analyses, a determination of the impact of the existing sources on the ambient air quality was made, as well as the cumulative impact with the addition of the air pollutant sources associated with the proposed power plant, and the consequent retirement of the existing 220 MW JPS facility with its existing air pollution sources.

Table 7-2 shows the model results for the existing sources (including the ones for the permitted cement manufacturing facility), and the future sources category, where the four sources on the existing 220 JPS power plant will be retired. The results for the existing sources revealed predicted high concentrations that exceed the respective ambient air quality standards for TSP/PM_{10} (24h averaging period), NO_2 (1h), and all averaging periods for SO_2. Similar exceedences were obtained for the modeling of the future sources, but with a reduced impact for all identified pollutants (especially SO_2).

Additionally, upon examining the highest predicted concentrations for the future sources, it was deduced that the proposed power plant will only contribute a small percentage to the overall future air quality impact. Table 7-3 identifies the specific contribution of the proposed power plant and other sources to the future peak modeled short- term concentrations within the air shed.

Table 7-2 - Cumulative Impacts (with Proposed Power Plant using LNG)

Pollutant	Avg. Period	Background ($\mu g/m^3$)	NAAQS ($\mu g/m^3$)	Existing Sources			Future Sources		
				Max Conc ($\mu g/m^3$)	UTME (m)	UTMN (m)	Max Conc ($\mu g/m^3$)	UTME (m)	UTMN (m)
TSP/PM_{10}	24-hr	14	150	**169.2**	272555.2	1983109.91	**167.2**	272555.2	1983109.91
	Annual	20	60	20.8	273390.99	1982514.14	19.9	273390.99	1982514.14
NO_2	1-h	0	400	**638.1**	272159	1986922	**536.0**	272159	1986922
	Annual	0	100	35.7	273314.09	1982514.14	35.4	273314.09	1982514.14
SO_2	1-hr	0	700	**16597.4**	272159	1986922	**2623.0**	272159	1986922
	24-hr	0	280	**1882.3**	272159	1985672	**675.4**	273259	1982322
	Annual	0	60	**116.7**	276453.23	1980815.95	**61.6**	273314.09	1982527.63
CO	1-hr	0	40000	4928.2	272159	1986922	1152.1	273402.45	1982447.36
	8-hr	0	10000	1543.9	272159	1985672	787.2	273402.45	1982447.36

Bold type indicate exceedences above the respective standard

Table 7-3 - Source Contributions to Future Peak Modelled Short-Term Concentrations

Facilities	Concentrations, $\mu g/m^3$						
	TSP/PM_{10} – 24h	NO_2 – 1h	NO_2 – 24h	SO_2 – 1h	SO_2 – 24h	CO – 1h	CO – 8h
360 MW	0.1	52.0	0.00018	6.2	0.00006	0.0005	0.0005
Other Facilities	167.1	484.0	280.599	2616.8	675.399	1152.099	787.199
Totals	**167.2**	**536.0**	**280.6**	**2623**	**675.4**	**1152.1**	**787.2**

8.0 RECOMMENDED MITIGATION

8.1 SITE PREPARATION AND CONSTRUCTION

8.1.1 Vegetation

8.1.1.1 Habitat Fragmentation

- Limit rights-of-passage to areas already showing noticeable signs of habitat degradation. For example areas with open fields and pastureland.
- Develop thorough procedures for the proper disposal of solid waste as well as hazardous and flammable materials. Restrict their disposal into surrounding locales.

8.1.1.2 Accidental or Intentional Removal of Important Plant Species or Plant Communities

- The removal of vegetation should be strictly limited to the development site.
- Altering the orientation or placement of the development's footprint should be considered so that the communities mentioned above are not disturbed.
- A proper plan should be developed concerning transportation routes and storage for equipment and material.
- The proposed post construction or operation road network should be kept simple as well as be used throughout the preparation and construction phases of the project.
- Proper planning regarding access points to the construction site should be established.
- A buffer area should be established and maintained between the project area and the surrounding vegetation.

8.1.1.3 Increased Soil/Substrate Erosion

- If possible, trees with trunks of DBH 20 cm and greater should be left intact.
- Remove trees only as would be necessary. A tree removal protocol should be developed for site preparation prior to project initiation.

8.1.1.4 Storage and Transportation of Raw Materials

- A central area should be designated for the storage of raw materials. This area should be lined in order to prevent the leakage of paints and chemicals into the sediment.
- In terms of transporting equipment, the paths of the planned roadways should be used, rather than creating temporary pathways just for equipment access.

8.1.1.5 Removal of trees and shrubs

- Large trees etc. can be given to locals such as charcoal burners and carvers
- Smaller vegetation can be shredded, stored onsite and used later for landscaping of the site.

8.1.2 Fauna

8.1.2.1 Crocodiles

- The nesting site should be protected from the development.
- The fishermen/locals in the area need to inform about the legal implications of killing crocodiles.
- The personnel on the property should be informed about the crocodile presence in the area for their and the animals safety.
- Some of the infrastructure on the property should be designed with the wildlife in mind such as the drains and the location of the garbage area.
- Proper warning signage and fencing should be erected on and around the construction site.

8.1.2.2 Avifauna

- Trees should be planted to encourage birdlife in the area after the development.

- A few of the temporary ponds in the wetland should be left as is for the wetland birds during the wet season.

8.1.2.3 Invertebrates

- A survey of the area in the wet season is necessary to properly develop a true picture of picture of the fauna of the area.

8.1.3 Stormwater Runoff and Flooding

8.1.3.1 Pollution of Surface Water

In order to limit siltation and debris in drains from construction activities, it is recommended that the contractor adopts the following measures:

- Limits the time that loose material are stored onsite
- Install sediment traps on drains which are susceptible to high silt loading
- Install trash racks/screens on drains leaving the site

It is also recommended that all drains that are susceptible to contamination with oil and grease should have an oily water separator installed.

8.1.4 Storage of Raw Material and Equipment

- Raw materials that generate dust should be covered or wetted frequently to prevent them from becoming air or waterborne.
- 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 berms to contain the volume being stored in case of accidental spillage.

8.1.5 Transportation of Raw Material and Equipment

8.1.5.1 Traffic and Site Access

Construction traffic will be mostly trucks delivering materials to the site as well as removing rubbish; this will vary somewhat for the different stages of construction. For example, site clearance will have predominantly rubbish removal from site, whereas infrastructure construction will have trucks delivering to site. The number of trips per day is not expected to exceed 70 during any of the phases. Construction traffic will be scheduled for off peak hours to avoid or minimise any congestion.

The following precautions must be taken to ensure minimal disruption and potential danger to traffic:

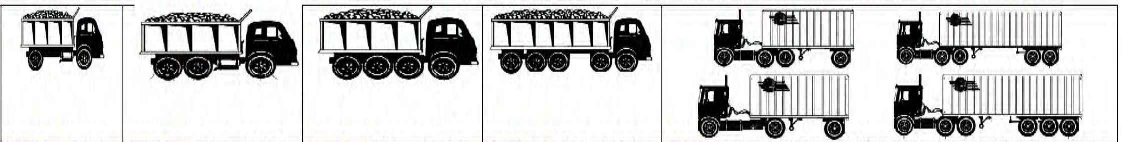
- Construction traffic entering or leaving town may be scheduled for off peak hours to minimize additional congestion and or disruptions in the regular traffic flow; additionally special permits may be had from the Toll authority to allow delivery trucks to use the emergency access to the H2K toll road.
- Heavy equipment should be transported early morning (12 am – 5 am) with proper pilotage.
- Construction activities such as trenching will be scheduled for off peak hours.
- Adequate covering up of the works to minimize danger to passing traffic. 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.
- Appropriate traffic warning signs, informing road users of a construction site entrance ahead and instructing them to reduce speed, should be placed along the main road for the duration of the construction period.
- Flagmen should be employed to control traffic and assist construction vehicles as they enter and exit the project site as well as the intersection.
- Crossing guards will be placed near to schools to assist children in safely crossing Terminal Road.

- The community groups/memebers will be consulted and informed prior to the commencement of this pahse

8.1.5.2 Weight Limits

- The Project Manager should hire a company that already has licensed/ special permit issued for heavy haulage vehicles etc. For over dimension loads (width, height, length etc.) the subcontractor is to submit a letter with the attached specifications and schematics/ drawings of the loaded vehicle to the Director of Island Traffic Authority or the Director of the National Works Agency, and in the case of the Highway, the National Road Operating and Constructing Company (NROCC).
- All trucks are expected to adhere to the National Works Agency standard for the loads per axel they exert on the pavement (Figure 8-1). The Engine for the plant is expected to be one of the most difficult pieces of machinery to transport because of its size and weight. The project manager will need to write to the National Works Agency at least two weeks in advance for a special permit to transport the engine from the Wharf to the site.

SPECIAL PERMIT REQUIREMENTS **vehicles exceeding Permit Column data can be issued ith a Special Permit once the vehicle does not exceed the relevant column etc**



Maximum Allowable	Permit	MAX Limit	Permit	MAX Limit	MAX Limit	Permit	MAX Limit	MAX Limit	Permit	MAX Limit	MAX Limit	Permit	MAX Limit	MAX Limit	MAX Limit	MAX Limit	MAX Limit	MAX Limit	MAX Limit
Overall Height (m)	3.6	4.15	3.6	4.15	4.15	3.6	4.15	4.15	3.6	4.15	4.15	3.6	4.15	4.15	4.15	4.15	4.15	4.15	4.15
Gross Weight (tons)	12.2	15	12.2	20	25	12.2	30	35	12.2	30	35	12.2	25	30	35	40	45	50	55
Length (m)	9.14	12.8	9.14	12.8	12.8	9.14	12.8	12.8	9.14	12.8	12.8	12.8	17.3	17.3	17.3	17.3	17.3	17.3	17.3
Width (m)	2.44	2.70	2.44	2.70	2.70	2.44	2.75	2.75	2.44	2.75	2.75	2.44	2.75	2.75	2.75	2.75	2.75	2.75	2.75
No. of Axles	2	2	3	3	3	4	4	4	5	5	5	3	3	4	4	5	5	6	6
No. of Tires	6	6	8	8	10	12	12	14	16	16	12	10	10	12	14	16	18	20	22

Please note that

1. Maximum allowable dual tire axle load is **10 tonnes** except super singles/ flotation
2. Maximum allowable single tire axle load is **5 tonnes** except super singles/ flotation
3. maximum allowances **must not exceed manufacturer ratings**, specifications for **vehicles and tires** etc
4. Special permits are required for tucks that exceed one or more of the following criteria:

    a. ***Overall Length of 9.14m (rigid) or 12.8 m (articulated/trailer)***

    b. ***Overall width of 2.44 m,***

    c. ***Gross weight of 12,273 kg,***

    d. ***overhang of 50% of wheelbase,***

    e. ***height of 3.6 m from ground***

Figure 8-1 - National Works Agency weight limit requirements for heavy vehicles

8.1.5.3 Roads and Bridges

The parochial road which leads to the present JPS plant is currently in disrepair and has two box culverts. It is recommended that the road and culverts be assessed by engineers and be repaired and or replaced as necessary to facilitate the anticipated construction traffic.

8.1.6 Noise

- Use equipment that has low noise emissions as stated by the manufacturers.
- Use equipment that is properly fitted with noise reduction devices such as mufflers.

- Construction workers operating equipment that generates noise should be equipped with noise protection. Workers operating equipment generating noise of > 80 dBA (decibels) continuously for 8 hours or more should use ear muffs. Workers experiencing prolonged noise levels 70 - 80 dBA should wear earplugs.
- Management controls will be used to mitigate the potential noise impacts along the access route. These are;
    - Trucks and other heavy duty vehicles will be required to travel at 30 km/h along the access route.
    - Truck and heavy duty vehicles should travel along the access route only during day time hours 7 am – 5 pm.
- The avifauna will be marginally affected by changes in the noise environment; the community dynamics and population have already been shaped by elevated noise levels in the project area and zone of influence. Therefore, no mitigation is required.

8.1.7 Air Quality

- Site roads should be dampened every 4-6 hours or within reason to prevent a dust nuisance and on hotter days, this frequency should be increased.
- Minimize cleared areas to those that are needed to be used.
- Cover or wet construction materials such as marl to prevent a dust nuisance.
- Where unavoidable, construction workers working in dusty areas should be provided and fitted with N95 respirators.

8.1.8 Solid Waste Generation

- Skips and bins should be strategically placed within the campsite and construction site.
- The skips and bins at the construction campsite should be adequately designed and covered to prevent access by vermin and minimise odour.
- The skips and bins at the construction site should be adequately covered to prevent a dust nuisance.
- The skips and bins at both the construction campsite and construction site should be emptied regularly to prevent overfilling.

- Disposal of the contents of the skips and bins should be done at an approved disposal site. The Riverton dump in St. Andrew is recommended. Appropriate permission should be sought.

8.1.9 Wastewater Generation and Disposal

Provide portable sanitary conveniences for the construction workers for control of sewage waste. A ratio of approximately 25 workers per chemical toilet should be used. Waste from these portable toilets will be disposed at an approved waste disposal site.

8.1.10 Employment

It is anticipated that approximately 1,270 persons will be employed directly with other persons benefiting indirectly.

JPSCo. Ltd. in partnership with the HEART TRUST has initiated a training and certification programme. This programme consists of four phases:

- Phase 1 – Identify the standards and the training framework
- Phase 2- Recruitment of certified & uncertified residents from the communities within close proximity of the plant
- Phase 3– Levels one and two training and certification for uncertified residents from the communities within close proximity of the plant
- Phase 4– Employment opportunities provided based on qualification and or certification (National Vocational Qualification of Jamaica NVQJ)

The training programmes will provide training to meet the identified needs of the job particulars to execute key objectives of the project. The implementation of HEART (Table 8-1) Intervention for the project will cover the period July 9 through to December 21, 2012.

Table 8-1 Table Showing HEART Implementation Plan

Task	Responsibility	Timeline	Comments
Develop Occupational standards	NCTVET & Stakeholders	July 9 – July 31, 2012	Adjust units to meet project requirements
Recruit persons who meet HEART Trust entry requirements	Career Development Services (CDS) & WS	July 17 – December 21, 2012	Conduct all recruitment session and testing required. Identify and recommend persons for remedial training and upgrade
Train persons from identified neighbouring communities (for specific skill sets)	WS in conjunction with Portmore HEART Academy and HEART Old Harbour VTC, CTI & other HEART Institutions	August 7,2012 to 2013, 2014 & 2015	Level one training available for community programme.
Assess persons trained at level one to determine competency	WS, Portmore HEART Academy and Old Harbour VTC, CTI and other institutions	August 7,2012 to 2013, 2014 & 2015	
Identify through advertisement and other institutions for additional persons for level two training	WS & CDS and other HEART Institutions	September 18 to November 16 2012	
Post implementation evaluation & monitoring of programme		To be decided	

This has the potential to be a significant positive impact. No mitigation is required.

8.1.11 Heritage and Cultural

Watching briefs should be carried out by the JNHT during clearing and excavation stages of the proposed Project.

8.2 OPERATION

8.2.1 Fauna

8.2.1.1 Crocodiles

- The fishermen/locals in the area need to inform about the legal implications of killing crocodiles.
- The personnel on the property should be informed about the crocodile presence in the area for their and the animals safety.
- Proper warning signage and fencing should be erected on and around the power plant site.

8.2.2 Air Quality

The emission rates derived from the manufacturer's emission specification for each individual combustion turbine burning LNG, comply with all stipulated emission standards.

The model predictions for the LNG fired proposed power plant revealed compliance with the CO, TSP/PM_{10}, NO_2 and SO_2 ambient air quality standards and the priority air pollutant guideline concentrations for the requisite averaging periods. The incremental impact of the criteria air pollutants were also less than the established values that would have created a significant air quality impact.

If the substitute fuel of ADO is used, then the model predictions for the proposed power plant would exceed the 24h SO_2 SIC, while only the 1h SO_2 ambient air quality standard is being exceeded. Hence, if ADO is to be combusted, then certain design changes would need to be undertaken to ensure compliance with the 24h SO_2 SIC and the 1h SO_2 JNAAQS.

When combusting LNG, the proposed power plant only has a minor contribution to the overall future peak modeled short term concentrations for CO, TSP/PM_{10}, NO_2 and SO_2.

Since the proposed LNG fired power plant sources demonstrated compliance with the ambient air quality standards and the guideline concentrations, as well as the significant impact incremental values, it is envisaged that approval will be granted for the establishment of the facility that will combust LNG.

8.2.3 Noise

Based on the noise model, the main sources of noise at the receivers that were non – compliant were from the steam turbines, gas turbine and generator and heat recover steam generators (HRSG).

With this information SJPC worked with the equipment manufacturer to sound proof the selected equipment (steam turbines (STG), gas turbine and generator (GTG) and HRSG).

In the first instance the noise emissions from the steam turbines, gas turbine and generator were reduced to 80 dBA. This resulted in a reduction in the area being impacted by night time noise of over 50 dBA. This adjustment is expected to cost an additional US$5,000,000 to the proposed Project.

The reduction in the noise emissions from the STGs and GTGs did not have the desired effect. Therefore the HRSG noise emission was reduced to 80 dBA. This resulted in substantial reduction in the noise climate (Figure 8-3).

This last option is the one that SJPC will employ as a mitigation measure as it relates to the potential noise impact from the proposed Plant. This option is estimated to cost an additional US$8,000,000.

The resultant noise from the proposed plant based on this adjustment is listed in Table 8-2 below.

Table 8-2 – Noise levels at areas immediate to the proposed plant after noise mitigation

LOCATION	NIGHT TIME NOISE (dBA)
N1	63.3
N2	57.5
N3	48.0
N4	61.6
N5	43.3
N6	44.0
Burkesfield Meadows East	48.3
Burkesfield Meadows North	47.5
Burkesfield Meadows South	49.8
Terminal Lane North	49.9
Terminal Lane South	50.9
Terminal Lane West	53.3
Terminal Road West	48.0

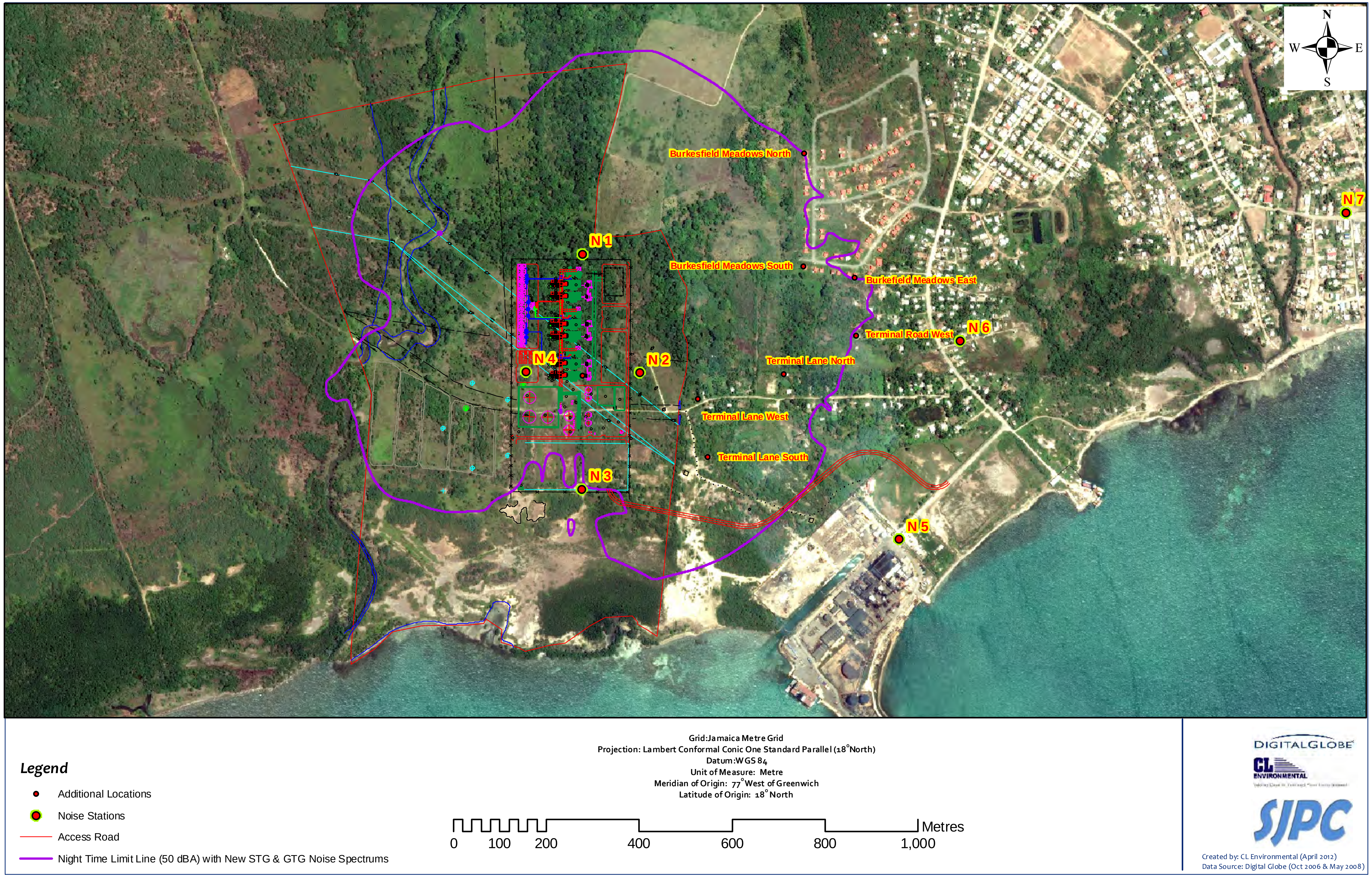


Figure 8-2 – Night time 50 dBA noise limit (purple) with the new steam and gas generators noise spectrums

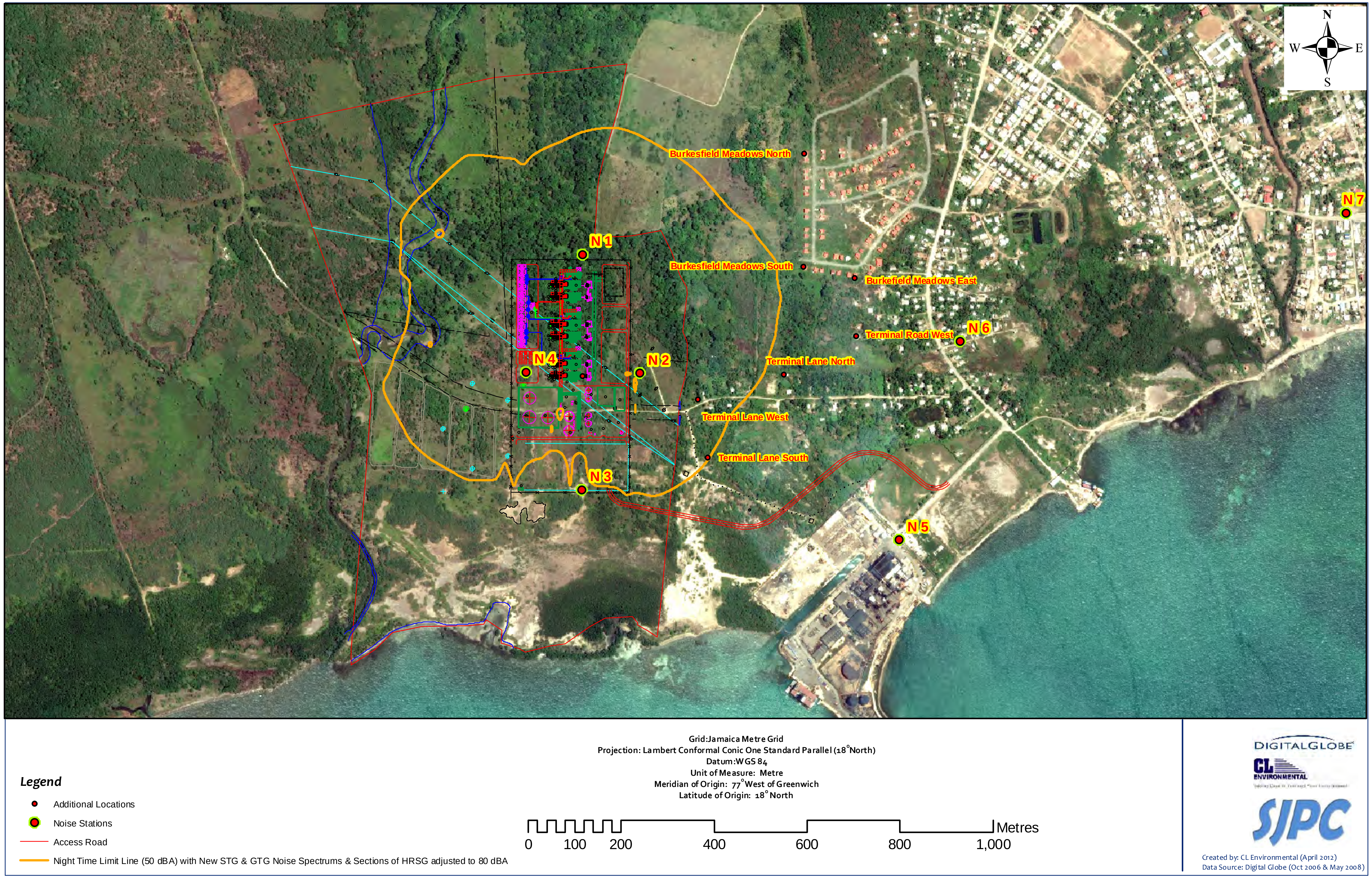


Figure 8-3 - Night time 50 dBA noise limit (orange) with the new steam and gas generators and HRSG noise spectrums

The avifauna will be marginally affected by changes in the noise environment; the community dynamics and population have already been shaped by elevated noise levels in the project area and zone of influence. Therefore, no mitigation is required.

8.2.4 Natural Hazards

- Ensure that the new structures can withstand hurricane and earthquake impacts.
- Ensure that the new structures are designed to withstand a 50 – 100 year flood event.
- Develop an emergency response plan and/or update the existing emergency response plan.

8.2.5 Occupational Health and Safety

- Provision of Personal Protective Equipment (PPE) e.g. noise muffs, plugs, helmets and Personal fall arrest systems (PFAS).
- Establish a hearing conservation programme.
- Ensure adequate ventilation within the work area.
- A programme to monitor the thermal comfort of workers will be implemented.
- Lighting levels (illumination) should be area specific and will be a function of the nature of activity that is being conducted. It should be adequate to enable a safe, comfortable and productive workers environment.
- A confined space policy will be developed and implemented.
- Use the Occupational Safety and Health Administration (OSHA) standard 1910 as a guide to Occupational Health and Safety maters.

8.2.6 Solid Waste Disposal

- Provision of solid waste storage bins and skips.
- Contracting a private contractor to collect solid waste in a timely fashion to prevent a build-up.
- Ensure that the solid waste collected is disposed in an approved dumpsite such as the Riverton dump in Kingston.

8.2.7 Stormwater Runoff and Flooding

8.2.7.1 Increased Runoff to Bowers Gully

Designers should include detention areas to the west of the plant to reduce the peak discharge to the Bowers Gully.

8.2.7.2 Pollution of Surface Water

During operations, a containment bund as well as oil-water separators should be installed for containment and treatment. NEPA requires the following for storage tanks over 4000 litres:

- The bund shall be impermeable with no apertures and should be able to contain 110% of the volume of the capacity of the petroleum storage tank.
- If it is more than one tank, the area for storage should also be impermeable and be able to contain 100% of the capacity of the largest tank plus 10 percent of the capacity of the remaining tanks.

8.2.8 Wastewater Discharge

It is envisaged that these drains will be open floor drains in some areas and therefore susceptible to contamination from other sources. It is therefore recommended that these drains be connected to oil water separators as well as be fitted with bypass gates to allow runoff to be stored and contained for treatment should any spillage of hazardous materials occur.

NEPA Trade Effluent Standards will be maintained for any discharge into the Bowers Gully and the following will be monitored:

- Water quality montoring for various parameters.
- Continuous water quality monitoring system (pH and temperature)
- Regular maintenance of treatment systems
- Biological Monitoring

8.2.9 Oily Water Management

8.2.9.1 Oil Water Separators

Floor water will be directed to floor drains which will terminate at oil water separators and car park runoff will be directed to storm drains which will terminate in oil water separators as well.

Guideline by the Environment Agency for England and Wales recommend Class 1 separators for both circumstances.

These separators are designed to achieve a concentration of less than 5mg/l of oil under standard test conditions, should be used when the separator is required to remove very small oil droplets, such as those arising from car park run-off.

The runoffs in this area will end up in the Portland Bight area which is at very sensitive area. A full retention separator is recommended for this facility. 'Full retention' separators treat the full flow that can be delivered by the drainage system, which is normally equivalent to the flow generated by a rainfall intensity of 50mm/hr. On large sites, some short term flooding may be an acceptable means of limiting the flow rate and hence the size of full retention systems. Additionally a retention area/”bund” adequately sized could be utilized to hold the excess water in the case of accidents or rainfall which may overwhelm the oily water separator.

8.2.9.2 Bund

Bunds are the structures that enclose the oil tanks, effectively isolating them from other areas of the plant. All bunds should be capable of containing the full capacity of the tanks enclosed plus a safety factor of approximately 10 to 20 percent.

The bund walls should be made of reinforced concrete and the insides should be lined with impervious non-slip material such that maintenance works can be carried out without the risk of a worker slipping.

Bunds, tanks and pipe work should be inspected regularly for signs of damage and should be checked at least weekly. Any accumulated rainwater, oil or debris should be removed and any defects to the bund wall or lining should be repaired promptly using the appropriate technique to ensure the bund retains its integrity.

8.2.9.3 Pipe Work

All pipe work should be sited above ground where possible, in order to make inspection and repair easier. The pipe work should also be protected against corrosion; insulated to guard against frost; be effectively supported and safeguarded against damage. Where a pipeline has to be laid underground it should be resistant to corrosion and placed in a protective sleeve or duct with open grating covers for inspection purposes.

The route of underground pipe work will be clearly marked and protected from mechanical damage, excessive surface loading and ground movement or disturbance. Such pipelines will be subjected to regular inspection and periodic pressure tests to check their integrity.

Separate fill pipes will be provided for each tank unless the tanks are interconnected by a balance pipe of greater flow capacity than the fill pipe. The fill pipes should have a 50mm diameter threaded connection and should be clearly marked with the product type, tank capacity and a tank number where more than one tank is involved. They should also be located within the confines of the bund and be fitted with a suitable lockable fill cap with chain and an overfill alarm should be fitted.

Surface drainage from such areas will pass through a suitably sized oil separator of an approved design.

Air vent pipes will, where possible, be positioned so they can be seen easily during delivery. They should not be smaller than the inlet pipe, should be well supported and directed so that any discharge from them (e.g. in the event of the tank being overfilled) passes into the bund.

8.2.10 Employment

It is anticipated that approximately 65 persons will be employed directly with other persons benefiting indirectly. This has the potential to be a significant positive impact. No mitigation is required.

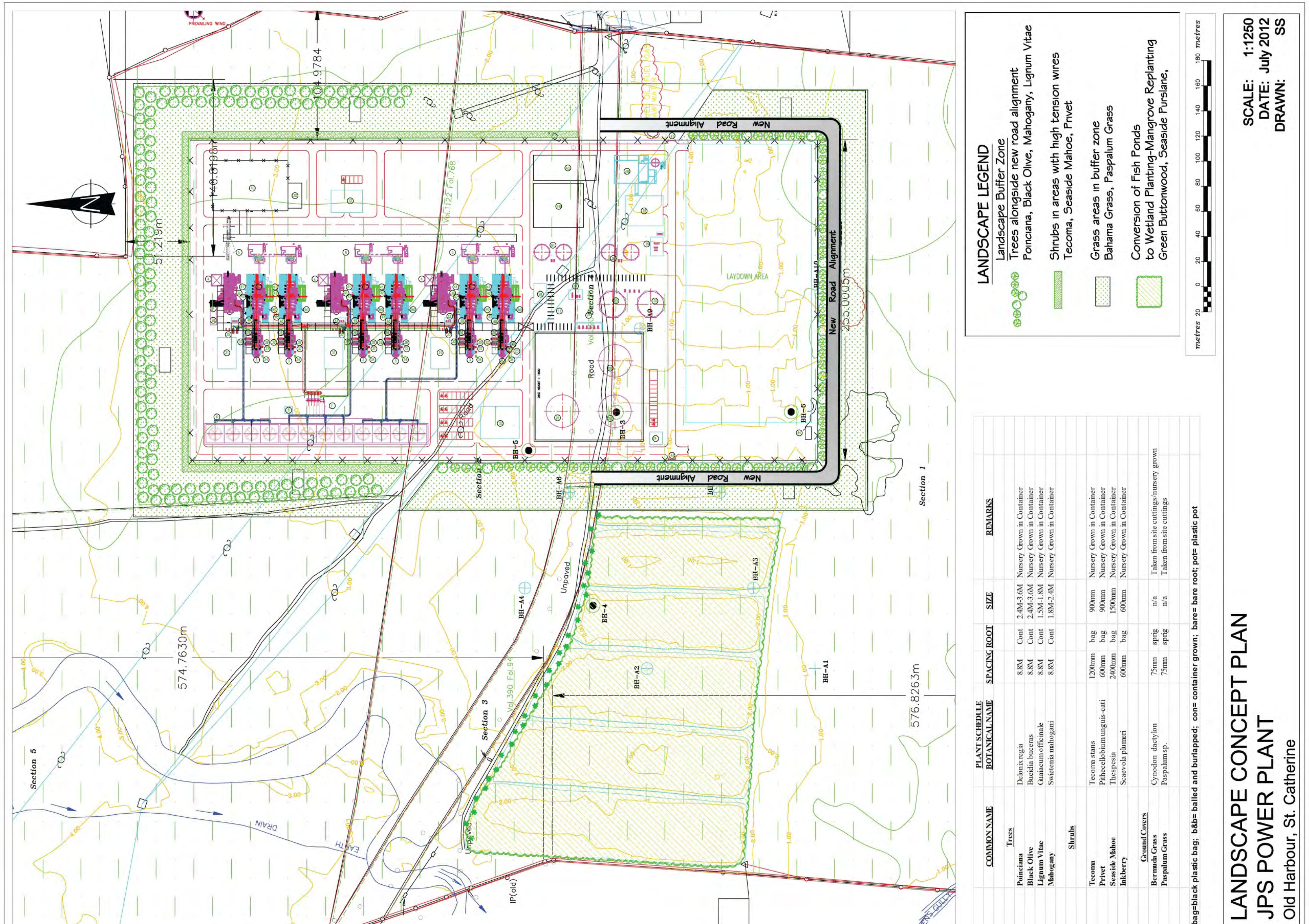
8.2.11 Aesthetics and Landscaping

8.2.11.1 Landscaping Plan

Table 8-3 shows a list of plants to be used in the Landscaping Plan, and Figure 8-4 illustrates the plan.

Table 8-3 List of plants to be used in Landscaping Plan

	PLANT SCHEDULE				
COMMON NAME	BOTANICAL NAME	SPACING	ROOT	SIZE	REMARKS
Trees					
Poinciana	Delonix regia	8.8M	Cont	2.4M-3.6M	Nursery Grown in Container
Black Olive	Bucidia buceras	8.8M	Cont	2.4M-3.6M	Nursery Grown in Container
Lignum Vitae	Guaiacum officinale	8.8M	Cont	1.5M-1.8M	Nursery Grown in Container
Mahogany	Swietenia mahogani	8.8M	Cont	1.8M-2.4M	Nursery Grown in Container
Shrubs					
Tecoma	Tecoma stans	1200mm	bag	900mm	Nursery Grown in Container
Privet	Pithecellobium unguis-cati	600mm	bag	900mm	Nursery Grown in Container
Seaside Mahoe	Thespesia	2400mm	bag	1500mm	Nursery Grown in Container
Inkberry	Scaevola plumeri	600mm	bag	600mm	Nursery Grown in Container
Ground Covers					
Bermuda Grass	Cynodon dactylon	75mm	sprig	n/a	Taken from site cuttings/nursery grown
Paspalum Grass	Paspalum sp.	75mm	sprig	n/a	Taken from site cuttings



PLANT SCHEDULE

COMMON NAME	BOTANICAL NAME	SPACING	ROOT	SIZE	REMARKS
Trees					
Poinciana	Delonix regia	8.8M	Cont	2.4M-3.6M	Nursery Grown in Container
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Inkberry	Scaevola plumeri	600mm	bag	600mm	Nursery Grown in Container
Ground Covers					
Bermuda Grass	Cynodon dactylon	75mm	sprig	n/a	Taken from site cuttings/nursery grown
Paspalum Grass	Paspalum sp.	75mm	sprig	n/a	Taken from site cuttings

Figure 8-4 Landscaping Plan Layout

9.0 EMERGENCY PREPAREDNESS AND RESPONSE

The following points should be taken into consideration with respect to Emergency Response Planning:

- A lead person should be identified and appointed to be responsible for emergencies occurring on the site. This person should be clearly identified to the construction workers.
- The SJPC construction management team should have onsite first aid kits and make arrangements for the nurse and doctor on call for the construction site.
- Make prior arrangements with health care facilities such as the Old Harbour Health Centre, Kingston Public Hospital or the Spanish Town Hospital to accommodate any eventualities.
- Arrange with health practitioners to be on call during the construction period.
- Design and implement an emergency response plan or update the existing plan to reflect the issues of the new power plant.
- Staff should be trained in Cardio Pulmonary Resuscitation (CPR).
- Coordinate with mutual aid organisations/agencies such as with the local fire brigade.
- Material Safety Data Sheets (MSDS) should be stored onsite.
- Conduct emergency response drills.

In addition, it is proposed that SJPC Emergency Response Plan reflect the following issues:

- Earthquake
- Hurricane
- Flooding
- Explosion
- LNG Accidents
- Oil /Hazardous Material Spill
- Community and Outside Liaison
- Unrest and Riots

- Act of Terrorism and Armed Attack
- Bomb Threats and Acts of Sabotage
- Serious or Multiple Injury; and
- Illegal Trespassing

The plan should also include emergency call lists of persons on and offsite, building plans, site maps and evacuation routes.

10.0 EHS MANAGEMENT AND MONITORING PLAN

Daelim has developed a detailed HSE (Health, Safety and Environment) management system for construction, in accordance with ISO 14001 (Environmental Management System) and OHSAS 18001 (Occupational Health and Safety Management System). The Plan is listed in Appendix 12.

11.0 RESIDUAL IMPACTS

Sections 6.0 (Identification and Assessment of Potential Direct and Indirect Impacts) and 8.0 (Recommended Mitigation) described the potential impacts that would occur as a result of different phases of the project and how the proposed mitigation measures would contribute to minimising or eliminating the impacts. Not all impacts can be fully mitigated and therefore residual impacts will be experienced by the environmental and social receptors affected by the project. These are discussed below.

11.1 SITE PREPARATION AND CONSTRUCTION

11.1.1 Noise

The proposed project has the potential to be a noise nuisance during both the construction and the operation phases. Even with the proper mitigative steps, short-term impacts of varying duration such as pile driving, which is a high-noise activity, will be a nuisance to surrounding residential communities.

11.1.2 Air Quality

Fugitive dust has the potential to affect the health of construction workers, the resident population and the surrounding vegetation. Both types of impacts will be of high intensity but of relatively short duration.

11.1.3 Traffic

The construction of the new power plant may introduce traffic delays thereby increasing the travel time. Negative impacts on traffic are expected during the construction stages, including reduced level of service in the areas surrounding Old Harbour and Old Harbour Bay due to increased large/construction vehicle on the roads.

11.1.4 Heritage and Cultural

The proposed project area has very dense vegetation cover. When this vegetation is removed from the proposed site, there is a high probability of finding prehistoric and historic cultural material. However, there is the possibility that they may be destroyed by heavy machinery and equipment during the site clearance process.

11.2 OPERATION

11.2.1 Fauna

11.2.1.1 Avifauna

Even though several trees will be replanted during the Landscaping phase of the proposed project, several of the birds on the property would have already been displaced during the development, and it is not likely that they will return.

11.2.2 Air Quality

The modelled air emissions exceeded the guidelines for SO_2, if the proposed power plant was to run on ADO. These increased emissions have the potential to negatively impact nearby communities.

11.2.3 Wastewater Discharge

The modelled composite wastewater to be discharged will be at an average rate of 111.1 cubic metres per day with a TDS value of 3,867 mg/l, which is considered brackish water (TDS of 1,500 – 5,000 mg/l). Presently, the TDS values within the Bowers Gully adjacent to the proposed site are 29,780 – 30,370 mg/l, which is considered saline water (TDS of >5,000 mg/l). This has the potential to decrease the salinity of the Bowers Gully.

11.2.4 Socio-Economic

11.2.4.1 Lower Energy Costs

Electricity costs are calculated to be lower by 30% when the new LNG power plant comes on line. However, if the backup fuel (ADO) is used instead, then this will not be the case. Therefore, there will be a high residual impact of unmet public expectation if the new plant is not run on LNG.

11.2.4.2 Unmet Employment Expectations

Because of the high unemployment rate in the area and in the island in general, residents in directly affected communities who are unsuccessful in their job application are likely to become frustrated when they do not gain employment on the proposed project. This could create resentment and possibly hostility towards those who are successful in getting jobs, and even towards SJPC. The possibility also exists that there will be resentment towards SJPC arising from perceptions of bias in the recruitment process.

11.2.4.3 Accidents involving community members

The possibility exists that accidents involving community members will occur at some stage during project construction or operation. This could be traffic-related, or other accidents. A residual impact is created in terms of diminishing the standard of living for a person, negatively impacting his or her household.

12.0 IDENTIFICATION AND ANALYSIS OF ALTERNATIVES

The discussion and analysis of alternatives in Environmental Impact Assessments should consider other practicable strategies that will promote the elimination of negative environmental impacts identified. This section is a requirement of the National and Environment and Planning Agency (NEPA), and is critical in consideration of the ideal development with minimal environmental disturbance.

This report has identified the major environmental impacts noted by scientific experts. The SJPC project team and the consulting scientists worked together, utilizing findings of these impacts to analyse possible options for the final development.

The following alternatives have been identified. They are discussed in further detail below:

- The "No-Action" Alternative
- The proposed development as described in the EIA
- The proposed development as described in the EIA but with the orientation of the plant being east to west
- The proposed development as described in the EIA but located north of the current location
- The proposed development as described in the EIA but using automotive diesel oil (ADO) as the primary fuel
- Using nuclear energy or renewable energy resources as alternatives to fossil fuels

12.1 THE NO ACTION ALTERNATIVE

The "no action" alternative is required to ensure the consideration of the original environment without any development. This is necessary for the decision-makers in considering all possibilities.

In light of the existing JPS Old Harbour facility already in the vicinity, and the major infrastructure already in place, the "no action" alternative will have a minimal effect on the physical environment. In terms of the social environment, the "no-action" alternative would result in increased possibilities of power outages for residents of Jamaica, lower job and industrial productivity in the project area, limited economic improvement, and eliminate job creation opportunities nationally.

12.2 THE PROPOSED DEVELOPMENT AS DESCRIBED IN THE EIA

The impacts and mitigation measures for this alternative are discussed in detail throughout this report. The positive impacts have been identified in social and economic benefits for local and national individuals due to lower potential of power outages and increased job creation.

This project has the potential to adversely impact the air quality of the air shed surrounding the proposed development, increase noise pollution and water pollution of the surrounding water body. These impacts will be properly mitigated.

12.3 THE PROPOSED DEVELOPMENT AS DESCRIBED IN THE EIA BUT ALIGNED EAST-WEST

Alternate alignment was investigated for siting the proposed power plant (Figure 12-1). This site proved unacceptable due to the low elevation of the land, soil condition and the wind direction in relation to the air coolers and the combustion turbines. In addition, the EIA team could not identify any significant positive environmental impact of this alternative.

12.4 THE PROPOSED DEVELOPMENT AS DESCRIBED IN THE EIA BUT LOCATED NORTH OF THE CURRENT LOCATION

Locating the proposed power plant north of the current location is not more environmentally sound and it would increase the distance from the proposed liquid natural gas (LNG) facility, thereby increasing the cost of production (Figure 12-2) and will result in the removal of more establish vegetation.

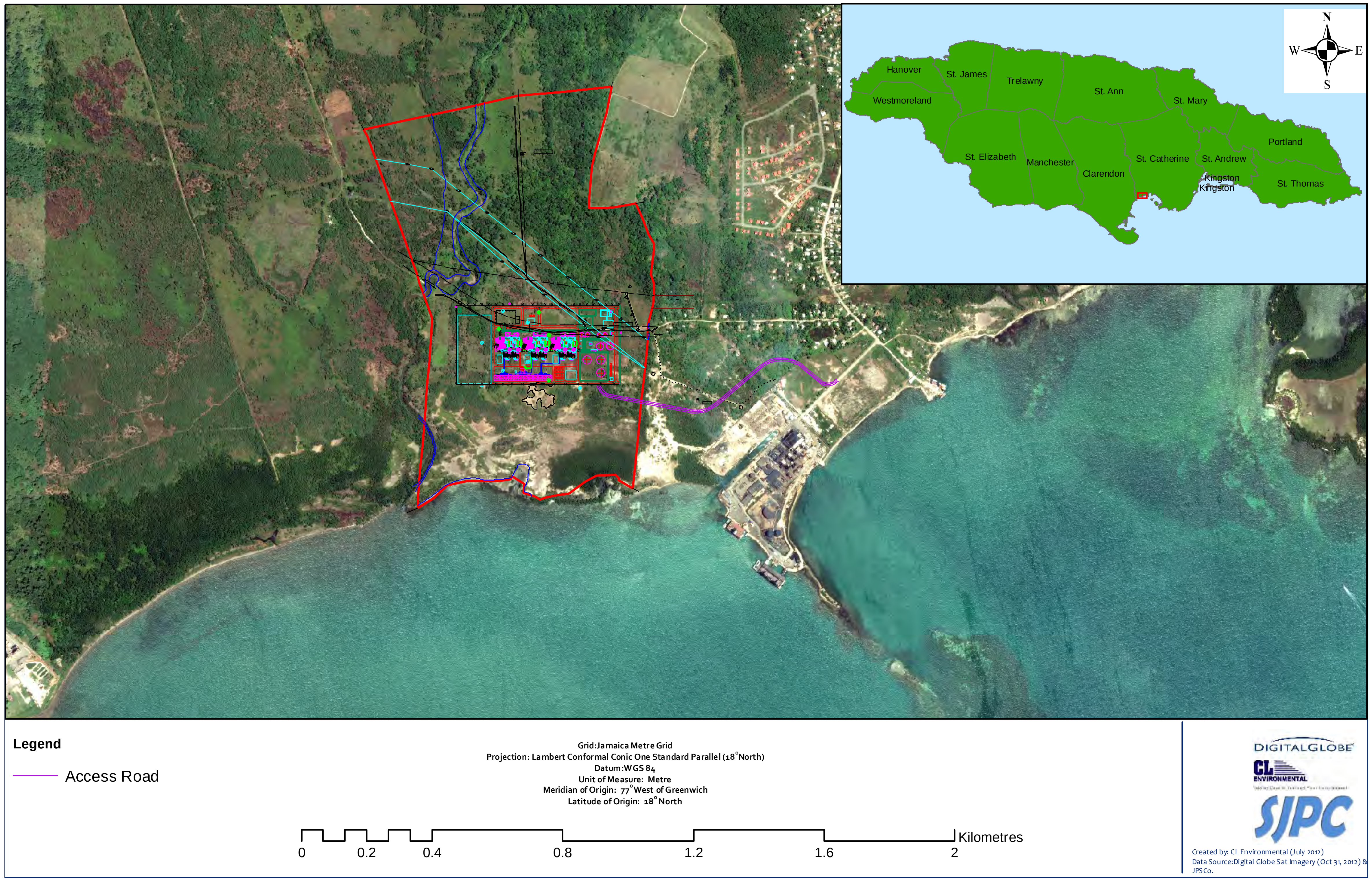

Figure 12-1 - Proposed development as outlined in the EIA but the site is located east to west

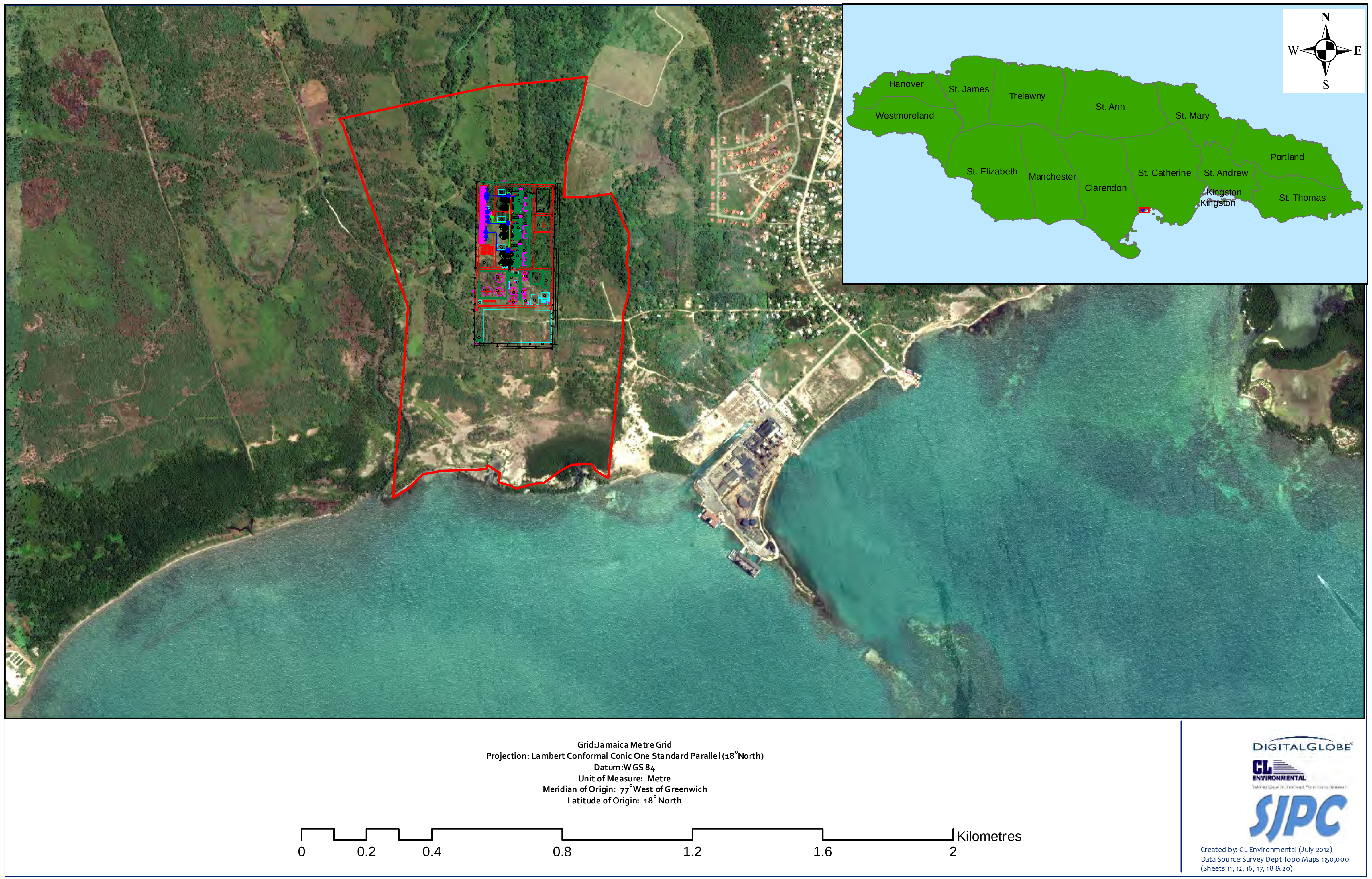

Figure 12-2 - Proposed project at a more northerly location

12.5 THE PROPOSED DEVELOPMENT AS DESCRIBED IN THE EIA BUT USING ADO AS THE PRIMARY FUEL

Using ADO as the primary fuel instead of LNG was investigated; however, LNG produces less air emissions and pollutants than diesel oil. LNG is also more cost effective than ADO.

12.6 USING NUCLEAR ENERGY AS AN ALTERNATIVE TO FOSSIL FUELS

A nuclear energy plant would result in the need for strict security and maintenance. Certain mitigation would also be required for this type of plant. For these reasons the development of such a power plant in Old Harbour is not practical at this time.

12.7 USING RENEWABLE ENERGY RESOURCES AS AN ALTERNATIVE TO FOSSIL FUELS

Wind, solar and hydro energy as renewable energy sources were also considered. Although all three are clean forms of energy there are some limitations.

12.7.1 Wind Energy

Wind turbines would not be able to produce enough energy for this size of plant as the largest turbines to date are producing 3MW. This would require 120 wind turbines to generate the required power. There are two inherent problems with this; the land space required to establish these turbines and the unreliability (fluctuation) in wind doesn't make it suitable to be used for base power.

12.7.2 Solar Energy

The acreage required for solar panels to produce the required energy also make it unsuitable for this area.

12.7.3 Hydro Electricity

The Government of Jamaica has embarked on a study in an effort to determine the feasibility of hydroelectric plants at five locations around the island. Additionally, the Jamaica Public Service Company Limited has enhanced and rehabilitated some of their hydroelectric plants.

The largest hydroelectric plant to date in the island is the Maggotty 6.3 MW hydroelectric plant. This coupled with the fact that most of our rivers are relatively small means that the probability of producing 360 MW of base power from hydroelectricity is low.

12.8 OVERVIEW OF ALTERNATIVE ANALYSIS

Based on the above, the development as proposed in the EIA (Section 13.2) is the most economical option that will result in the provision of the needed power generating capacity with reduced potential impacts which can be mitigated.

13.0 ENVIRONMENTAL MANAGEMENT OF THE PROJECT

13.1 MONITORING DURING SITE PREPARATION FOR THE PROPOSED POWER PLANT

- A noise survey should be undertaken to determine workers exposure and construction equipment noise emission.
  Any organization with the capability to conduct monitoring of the listed parameters should be used to perform this exercise. It is recommended that a report should be given to NEPA at the end of the monitoring exercise.
- The estimated cost for this exercise is **J $126,000**.
- Undertake daily inspections of trucks carrying solid waste generated from site clearance activities to ensure that they are not over laden as this will damage the public thoroughfare.
  Person(s) appointed by SJPC may perform this exercise.
  No additional cost is anticipated for this exercise.
- Daily monitoring of vehicle refuelling and repair should be undertaken to ensure that these exercises are carried out on hardstands. This is to reduce the potential of soil contamination from spills. Spot checks should be conducted by NEPA.
- Person(s) appointed by SJPC may perform this exercise.
- No additional cost is anticipated for this exercise.

13.2 MONITORING DURING THE CONSTRUCTION PHASE OF THE PROPOSED POWER PLANT

- Daily inspection of the power plant construction to ensure they are following the proposed plan and to ensure that site drainage systems are not impacting the coastal environment. Check and balance can be provided by NEPA and the St. Catherine Parish Council

Person(s) appointed by SJPC may perform this exercise.
No additional cost is anticipated for this exercise.

- Undertake monthly water quality monitoring to ensure that the construction works are not negatively impacting the marine environment quality. The parameters that should be monitored are **salinity**, **dissolved oxygen**, **nitrates**, **phosphates**, **turbidity, total suspended solids and faecal coliforms**.
  Any organization with the capability to conduct monitoring of the listed parameters should be used to perform this exercise. It is recommended that a report should be given to NEPA at the end of each monitoring exercise.
  This is estimated to cost approximately **J$71,000** per monitoring exercise.
- Monthly noise surveys should be undertaken to determine workers exposure and construction equipment noise emission.
  Any organization with the capability to conduct monitoring of the listed parameters should be used to perform this exercise. It is recommended that a report should be given to NEPA at the end of the monitoring exercise.
  The noise survey is estimated to cost approximately **J$126,000** per monitoring exercise.
- Daily monitoring to ensure that fugitive dust from cleared areas and raw materials are not being entrained in the wind and creating a dust nuisance.
  Person(s) appointed by SJPC may perform this exercise.
  No additional cost is anticipated for this exercise.
- Undertake daily inspections of trucks carrying raw material to ensure that they are not over laden as this will damage the public thoroughfare.
  Person(s) appointed by SJPC may perform this exercise.
  No additional cost is anticipated for this exercise.
- Undertake daily assessment of the quantity of solid waste generated and keep records of its ultimate disposal. Additionally, solid waste generation at the construction site should also be monitored.
  Person(s) appointed by SJPC may perform this exercise.
  No additional cost is anticipated for this exercise.

- Weekly assessment to determine that there are adequate numbers of portable toilets and that they are in proper working order. This will ensure that sewage disposal will be adequately treated.
  Person(s) appointed by SJPC may perform this exercise.
  No additional cost is anticipated for this exercise.
- Monitor and approve the suppliers and sources of local materials. Inspection of the quarry should be conducted to ensure that they are legal. Copies of these licences should be kept on file.
  Person(s) appointed by SJPC may perform this exercise.
  No additional cost is anticipated for this exercise.
- Daily monitoring of vehicle refuelling and repair should be undertaken to ensure that these exercises are carried out on hardstands. This is to reduce the potential of soil contamination from spills. Spot checks should be conducted by NEPA.
  Person(s) appointed by SJPC may perform this exercise.
  No additional cost is anticipated for this exercise.
- Where possible, construction crews should be sourced from within the study area. This will ensure that the local community will benefit from the investment. The Old Harbour Bay Citizens Association could be used as the watchdog to ensure that this is achieved.
  Person(s) appointed by SJPC may perform this exercise.
  No additional cost is anticipated for this exercise.

13.3 MONITORING DURING THE OPERATIONAL PHASE OF THE PROPOSED POWER PLANT

- Annual noise assessments should be conducted starting with the initial commissioning of the power plant. This should be contracted out by SJPC to a third party company or individual that specializes in performing such tests. The contracted party shall have a proven experience in noise monitoring. All monitoring should be conducted according to generally accepted industry standards and the plant shall conform to the World Bank Ambient Noise Levels and the National Environment and Planning Agency Standards.

The annual noise assessment is estimated to cost approximately **J$300,000** per assessment.

- Undertake monthly inspection of drainage and wastewater systems to ensure that they are in proper working order to negate potential detrimental environmental impacts from malfunctioning infrastructure.
  Person(s) appointed by SJPC may perform this exercise.
  No additional cost is anticipated for this exercise.
- If the power plant is to be run on LNG, then no ambient air quality monitoring stations need to be set up. However, if the plant is to be run on ADO, then ambient air quality monitoring stations which will monitor sulphur dioxides and nitrogen oxides on a continuous basis will need to be set up. These monitors will be located to provide a representative picture of the proposed operations at the power plant.
  Person(s) appointed by SJPC may perform this exercise.

13.4 REPORTING REQUIREMENTS

13.4.1 Noise Assessment

A report shall be prepared by the Contracted Party. This report shall include the following data:

i. Dates, times and places of test.
ii. Test Method used.
iii. Copies of instrument calibration certificates.
iv. Noise level measurements in decibels measured on the A scale (dBA) and wind direction.
v. Noise levels measured in low, mid and high frequency bands (dBL)
vi. A defined map of each location with distance clearly outlined in metric
vii. Assessment done according to varying loads of the facility
viii. Any other relevant operating information (such as unusual local noise source, SJPC loading).
ix. Evaluation of data, discussions and statement giving a professional opinion of the noise impact of the facility.

- The report shall be submitted to Plant Manager or his designate within two weeks after completion of testing.
- The Plant Management shall distribute the report within forty five (45) days of testing being completed.
- In the event that emissions do not meet the required criteria, investigations shall be carried out and corrective actions were necessary taken and a re-test shall be scheduled at the earliest possible time and a new report submitted.
- Reports will be maintained on file at the plant for a minimum of three years.

13.4.2 Water Quality Assessment

A report shall be prepared by the Contacted party. It shall include the following data:

i. Dates, times and places of test.
ii. Weather condition.
iii. A defined map of each location with distance clearly outlined in metric.
iv. Test Method used.
v. Parameters measured
vi. Results
vii. Conclusions

- The report will be submitted to the Plant Manager or his designate within two weeks of the monitoring being completed.
- Plant management shall distribute the report within forty five (45) days of testing being completed.
- In the event that parameters do not meet the required criteria, investigations shall be carried out and corrective actions were necessary taken and a re-test shall be scheduled at the earliest possible time and a new report submitted.
- Reports will be maintained on file at the plant for a minimum of three years.

13.4.3 Air Emissions

If the plant is to be operated on LNG then no ambient air quality stations need to be set up. However; if it is to be operated on ADO, then ambient air quality stations need to be set up. In which a quarterly report will summarize the results of the ambient air quality monitoring stations. This report will provide information relative to SO_2, NO_x, CO and PM_{10} concentrations in the project area.

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15.0 APPENDICES

Appendix 1 - Relevant Sections of the "IFC General EHS Guidelines" and "Thermal Power: Guidelines for New Plants"

Table 1.7.1- Noise Level Guidelines[54]		
	One Hour L_{Aeq} (dBA)	
Receptor	Daytime 07:00 - 22:00	Nighttime 22:00 - 07:00
Residential; institutional; educational[55]	55	45
Industrial; commercial	70	70

Table 2.3.1. Noise Limits for Various Working Environments		
Location /activity	Equivalent level LA_{eq},8h	Maximum LA_{max},fast
Heavy Industry (no demand for oral communication)	85 dB(A)	110 dB(A)
Light industry (decreasing demand for oral communication)	50-65 dB(A)	110 dB(A)
Open offices, control rooms, service counters or similar	45-50 dB(A)	-
Individual offices (no disturbing noise)	40-45 dB(A)	-
Classrooms, lecture halls	35-40 dB(A)	-
Hospitals	30-35 dB(A)	40 dB(A)

Table 6 (B) - Emissions Guidelines (in mg/Nm³ or as indicated) for Combustion Turbine

Note:

- Guidelines are applicable for new facilities.
- EA may justify more stringent or less stringent limits due to ambient environment, technical and economic considerations provided there is compliance with applicable ambient air quality standards and incremental impacts are minimized.
- For projects to rehabilitate existing facilities, case-by-case emission requirements should be established by the EA considering (i) the existing emission levels and impacts on the environment and community health, and (ii) cost and technical feasibility of bringing the existing emission levels to meet these new facilities limits.
- EA should demonstrate that emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards, and more stringent limits may be required.

Combustion Technology / Fuel	Particulate Matter (PM)		Sulfur Dioxide (SO_2)		Nitrogen Oxides (NOx)	Dry Gas, Excess O_2 Content (%)
Combustion Turbine			NDA/DA		NDA/DA	
Natural Gas (all turbine types of Unit > 50MWth)	N/A	N/A	N/A	N/A	51 (25 ppm)	15%
Fuels other than Natural Gas (Unit > > 50MWth)	50	30	Use of 1% or less S fuel	Use of 0.5% or less S fuel	152 (74 ppm)[a]	15%

General notes:

- MWth = Megawatt thermal input on HHV basis; N/A = not applicable; NDA = Non-degraded airshed; DA = Degraded airshed (poor air quality); Airshed should be considered as being degraded if nationally legislated air quality standards are exceeded or, in their absence, if WHO Air Quality Guidelines are exceeded significantly; S = sulfur content (expressed as a percent by mass); Nm³ is at one atmospheric pressure, 0 degree Celsius; MWth category is to apply to single units; Guideline limits apply to facilities operating more than 500 hours per year. Emission levels should be evaluated on a one hour average basis and be achieved 95% of annual operating hours.
- If supplemental firing is used in a combined cycle gas turbine mode, the relevant guideline limits for combustion turbines should be achieved including emissions from those supplemental firing units (e.g., duct burners).
- (a) Technological differences (for example the use of Aeroderivatives) may require different emissions values which should be evaluated on a cases-by-case basis through the EA process but which should not exceed 200 mg/Nm3.

Comparison of the Guideline limits with standards of selected countries / region (as of August 2008):

- Natural Gas-fired Combustion Turbine – NOx
  - Guideline limits: 51 (25 ppm)
  - EU: 50 (24 ppm), 75 (37 ppm) (if combined cycle efficiency > 55%), 50*η / 35 (where η = simple cycle efficiency)
  - US: 25 ppm (> 50 MMBtu/h (≈ 14.6 MWth) and ≤ 850 MMBtu/h (≈ 249MWth)), 15 ppm (> 850 MMBtu/h (≈ 249 MWth))
  - (Note: further reduced NOx ppm in the range of 2 to 9 ppm is typically required through air permit)
- Liquid Fuel-fired Combustion Turbine – NOx
  - Guideline limits: 152 (74 ppm) – Heavy Duty Frame Turbines & LFO/HFO, 300 (146 ppm) – Aeroderivatives & HFO, 200 (97 ppm) – Aeroderivatives & LFO
  - EU: 120 (58 ppm), US: 74 ppm (> 50 MMBtu/h (≈ 14.6 MWth) and ≤ 850 MMBtu/h (≈ 249MWth)), 42 ppm (> 850 MMBtu/h (≈ 249 MWth))
- Liquid Fuel-fired Combustion Turbine – SOx
  - Guideline limits: Use of 1% or less S fuel
  - EU: S content of light fuel oil used in gas turbines below 0.1% / US: S content of about 0.05% (continental area) and 0.4% (non-continental area)

Source: EU (LCP Directive 2001/80/EC October 23 2001), EU (Liquid Fuel Quality Directive 1999/32/EC, 2005/33/EC), US (NSPS for Stationary Combustion Turbines, Final Rule – July 6, 2006)

Table 7 – Typical Air Emission Monitoring Parameters / Frequency for Thermal Power Plants
(Note: Detailed monitoring programs should be determined based on EA)

Combustion Technology / Fuel	Emission Monitoring			Stack Emission Testing				Ambient Air Quality	Noise
	Particulate Matter (PM)	Sulfur Dioxide (SO_2)	Nitrogen Oxides (NOx)	PM	SO_2	NOx	Heavy Metals		
Reciprocating Engine								If incremental impacts predicted by EA >/= 25 % of relevant short-term ambient air quality standards or if the plant >/= 1,200 MWth: - Monitor parameters (e.g., $PM_{10}/PM_{2.5}/SO_2$/NOx to be consistent with the relevant ambient air quality standards) by continuous ambient air quality monitoring system (typically a minimum of 2 systems to cover predicted maximum ground level concentration point / sensitive receptor / background point). If incremental impacts predicted by EA < 25% of relevant short term ambient air quality standards and if the facility < 1,200 MWth but >/= 100 MWth - Monitor parameters either by passive samplers (monthly average) or by seasonal manual sampling (e.g., 1 weeks/season) for parameters consistent with the relevant air quality standards. Effectiveness of the ambient air quality monitoring program should be reviewed regularly. It could be simplified or reduced if alternative program is developed (e.g., local government's monitoring network). Continuation of the program is recommended during the life of the project if there are sensitive receptors or if monitored levels are not far below the relevant ambient air quality standards.	If EA predicts noise levels at residential receptors or other sensitive receptors are close to the relevant ambient noise standards / guidelines, or if there are such receptors close to the plant boundary (e.g., within 100m) then, conduct ambient noise monitoring every year to three years depending on the project circumstances. Elimination of noise monitoring can be considered acceptable if a comprehensive survey showed that there are no receptors affected by the project or affected noise levels are far below the relevant ambient noise standards / guidelines.
Natural Gas (Plant >50 MWth to <300 MWth)	N/A	N/A	Continuous or indicative	N/A	N/A	Annual	N/A		
Natural Gas (Plant >/= 300 MWth)	N/A	N/A	Continuous	N/A	N/A	Annual	N/A		
Liquid (Plant >50 MWth to <300 MWth)	Continuous or indicative	Continuous if FGD is used or monitor by S content.	Continuous or indicative	Annual					
Liquid (Plant >/=300 MWth)	Continuous or indicative		Continuous						
Biomass	Continuous or indicative	N/A	Continuous or indicative	Annual	N/A	Annual	N/A		
Combustion Turbine									
Natural Gas (all turbine types of Unit > 50MWth)	N/A	N/A	Continuous or indicative	N/A	N/A	Annual	N/A		
Fuels other than Natural Gas (Unit > 50MWth)	Continuous or indicative	Continuous if FGD is used or monitor by S content.	Continuous or indicative	Annual					
Boiler									
Natural Gas	N/A	N/A	Continuous or indicative	N/A	N/A	Annual	N/A		
				Annual	Annual	Annual	N/A		
Other Gaseous fuels	Indicative	Indicative	Continuous or indicative	Annual					
Liquid (Plant >50 MWth to <600 MWth)	Continuous or indicative	Continuous if FGD is used or monitor by S content.	Continuous or indicative						
Liquid (Plant >=600 MWth)		Continuous							
Solid (Plant >50 MWth to <600 MWth)		Continuous if FGD is used or monitor by S Content.	Continuous or indicative						
Solid (Plant >/=600 MWth)		Continuous							

Note: Continuous or indicative means "Continuously monitor emissions or continuously monitor indicative parameters". Stack emission testing is to have direct measurement of emission levels to counter check the emission monitoring system.

Table 1.3.1 Indicative Values for Treated Sanitary Sewage Discharges[a]		
Pollutants	Units	Guideline Value
pH	pH	6 – 9
BOD	mg/l	30
COD	mg/l	125
Total nitrogen	mg/l	10
Total phosphorus	mg/l	2
Oil and grease	mg/l	10
Total suspended solids	mg/l	50
Total coliform bacteria	MPN[b] / 100 ml	400[a]

Notes:
[a] Not applicable to centralized, municipal, wastewater treatment systems which are included in EHS Guidelines for Water and Sanitation.
[b] MPN = Most Probable Number

Table 5 - Effluent Guidelines (To be applicable at relevant wastewater stream: e.g., from FGD system, wet ash transport, washing boiler / air preheater and precipitator, boiler acid washing, regeneration of demineralizers and condensate polishers, oil-separated water, site drainage, coal pile runoff, and cooling water)	
Parameter	mg/L, except pH and temp
pH	6 – 9
TSS	50
Oil and grease	10
Total residual chlorine	0.2
Chromium - Total (Cr)	0.5
Copper (Cu)	0.5
Iron (Fe)	1.0
Zinc (Zn)	1.0
Lead (Pb)	0.5
Cadmium (Cd)	0.1
Mercury (Hg)	0.005
Arsenic (As)	0.5
Temperature increase by thermal discharge from cooling system	• Site specific requirement to be established by the EA. • Elevated temperature areas due to discharge of once-through cooling water (e.g., 1 Celsius above, 2 Celsius above, 3 Celsius above ambient water temperature) should be minimized by adjusting intake and outfall design through the project specific EA depending on the sensitive aquatic ecosystems around the discharge point.

Note: Applicability of heavy metals should be determined in the EA. Guideline limits in the Table are from various references of effluent performance by thermal power plants.

Table 2.3.3. Minimum Limits For Workplace Illumination Intensity	
Location / Activity	**Light Intensity**
Emergency light	10 lux
Outdoor non working areas	20 lux
Simple orientation and temporary visits (machine storage, garage, warehouse)	50 lux
Workspace with occasional visual tasks only (corridors, stairways, lobby, elevator, auditorium, etc.)	100 lux
Medium precision work (simple assembly, rough machine works, welding, packing, etc.)	200 lux
Precision work (reading, moderately difficult assembly, sorting, checking, medium bench and machine works, etc.), offices.	500 lux
High precision work (difficult assembly, sewing, color inspection, fine sorting etc.)	1,000 – 3,000 lux

Table 8 - ICNIRP exposure limits for occupational exposure to electric and magnetic fields.		
Frequency	Electric Field (V/m)	Magnetic Field (µT)
50 Hz	10,000	500
60 Hz	8300	415
Source: ICNIRP (1998) : "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)		

Table 2.7.1. Summary of Recommended Personal Protective Equipment According to Hazard

Objective	Workplace Hazards	Suggested PPE
Eye and face protection	Flying particles, molten metal, liquid chemicals, gases or vapors, light radiation.	Safety Glasses with side-shields, protective shades, etc.
Head protection	Falling objects, inadequate height clearance, and overhead power cords.	Plastic Helmets with top and side impact protection.
Hearing protection	Noise, ultra-sound.	Hearing protectors (ear plugs or ear muffs).
Foot protection	Falling or rolling objects, pointed objects. Corrosive or hot liquids.	Safety shoes and boots for protection against moving & falling objects, liquids and chemicals.
Hand protection	Hazardous materials, cuts or lacerations, vibrations, extreme temperatures.	Gloves made of rubber or synthetic materials (Neoprene), leather, steel, insulating materials, etc.
Respiratory protection	Dust, fogs, fumes, mists, gases, smokes, vapors.	Facemasks with appropriate filters for dust removal and air purification (chemicals, mists, vapors and gases). Single or multi-gas personal monitors, if available.
	Oxygen deficiency	Portable or supplied air (fixed lines). On-site rescue equipment.
Body/leg protection	Extreme temperatures, hazardous materials, biological agents, cutting and laceration.	Insulating clothing, body suits, aprons etc. of appropriate materials.

Appendix 2 – Terms of Reference

TERMS OF REFERENCE ENVIRONMENTAL IMPACT ASSESSMENT FOR PROPOSAL TO BUILD OWN AND OPERATE

360 MW POWER GENERATION PROJECT IN JAMAICA

Combined Cycle Plant

The Office of Utilities Regulation (OUR) invited proposals for the Supply of up to 480 MW of Base-Load Generating Capacity on a Build, Own and Operate (BOO) Basis to increase the generating capacity on the island. This development will be undertaken over the next five years from 2011 to 2016 in two tranches. The first tranche (360MW) is proposed for completion in 2014 and the second tranche in 2016. This new capacity will be base-load and is intended for the replacement of approximately 292 MW of inefficient heavy fuel oil burning aged plants with the remainder to provide for load growth. Jamaica Public Service Company Limited (JPS) was awarded the right to go forward with the project – 360 MW Combined Cycle Plant.

Proposed Project Location and Siting

The Old Harbour 360 MW combined cycle power plant is to be located approximately 75.6 kilometres (47 miles) from the city of Kingston near the community of Old Harbour on the south coast. The proposed is near to JPS' existing Old Harbour facility, which currently has 220 MW of generation and houses major transmission and distribution operation along with a privately owned diesel power plant. The project site consists of 81 hectares (200 acres) of contiguous piece of real estate owned by JPS.

The community of Old Harbour Bay, located on the southwestern coast of Jamaica in the parish of St. Catherine, was estimated to have a total population of 8,537 in 2009. Located approximately 5km from the town of Old Harbour, the Old Harbour Bay community consists of twenty-four (24) small communities, which include Blackwood Gardens, Kelly Pen, Thompson Pen, Bay Bottom, Terminal, Dagger Bay, More Pen Lane, Peter's Land, Sal Gully, Cross Road and Panton Town. Bordered by the Colbeck Castle community to the east and Bourkesfield to the southeast, the Old Harbour Bay community is one of many residential fishing villages found along the coast in Jamaica, and is considered the largest fishing village on the island. The other industries and sources of employment include mining, manufacturing, small retail shops and subsistence farming.

This proposed development is located within the boundaries of the Portland Bight Protected Area (PBPA) (Figure 2). It is Jamaica's largest protected area and has been in existence since April 1999. The area covers approximately 1,876 km2 of terrestrial and marine environment

The proposed project site is bounded on its northern and western boundaries by industrial lands, to the south by salinas and mangroves and to the east by industrial lands and informal settlements. The proposed site is largely flat area with clay type soils and poor drainage with site elevation varying from approximately 1.5 meters to 3.0 meters (5 to 10 ft) above mean sea level.

The proposed site is located in an Intermediate Acacia Forest ecosystem. This ecosystem is comprised mainly of Acacia sp. trees and stands. The Intermediate is distinguished from the Secondary Acacia Forest ecosystem in three main ways: (i) the under storey vegetation tends to be more pioneer, monocotyledonous, vegetation (i.e. grass, etc.), (ii) the canopy is more open, and (iii) the trees are more low-profile (i.e. only a couple of meters high). Typical bird species within this zone of vegetation are warblers.

The Intermediate Acacia Forest ecosystem is less significant/ecologically important than the Mangrove Ecosystem and Salina Ecosystem. Although the relative species diversity and abundance of avifauna tends to be average for this type of ecosystem, avifauna species tend to be more robust than their marine/salina counterparts and they, therefore, have more habitat options to migrate to, during development and construction within this vegetation zone. C.L. Environmental, 2007

The proposed site showed significant evidence of anthropogenic disturbance due to the presence of an air quality monitoring station, well water transfer pipes and the Parish Council roadway that runs through the site. In the past the area also had fish ponds.

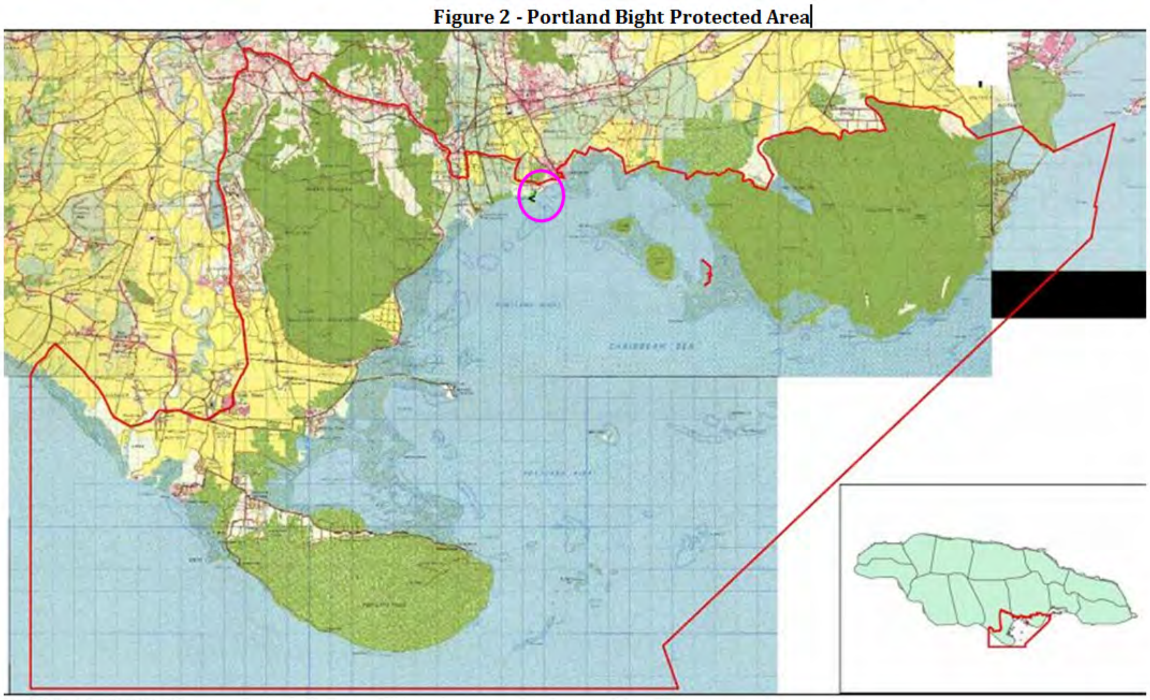
Figure 3 shows a map outlining the boundaries of the existing Old Harbour Power Plant and the proposed 360 MW NGCC Plant.

Utilities and Infrastructure

The area in which the proposed site is situated has all major infrastructure including roads; water supplied by the National Water Commission, power and telecommunication systems with landline and cell services. A Police Station and a Clinic are located within the town.

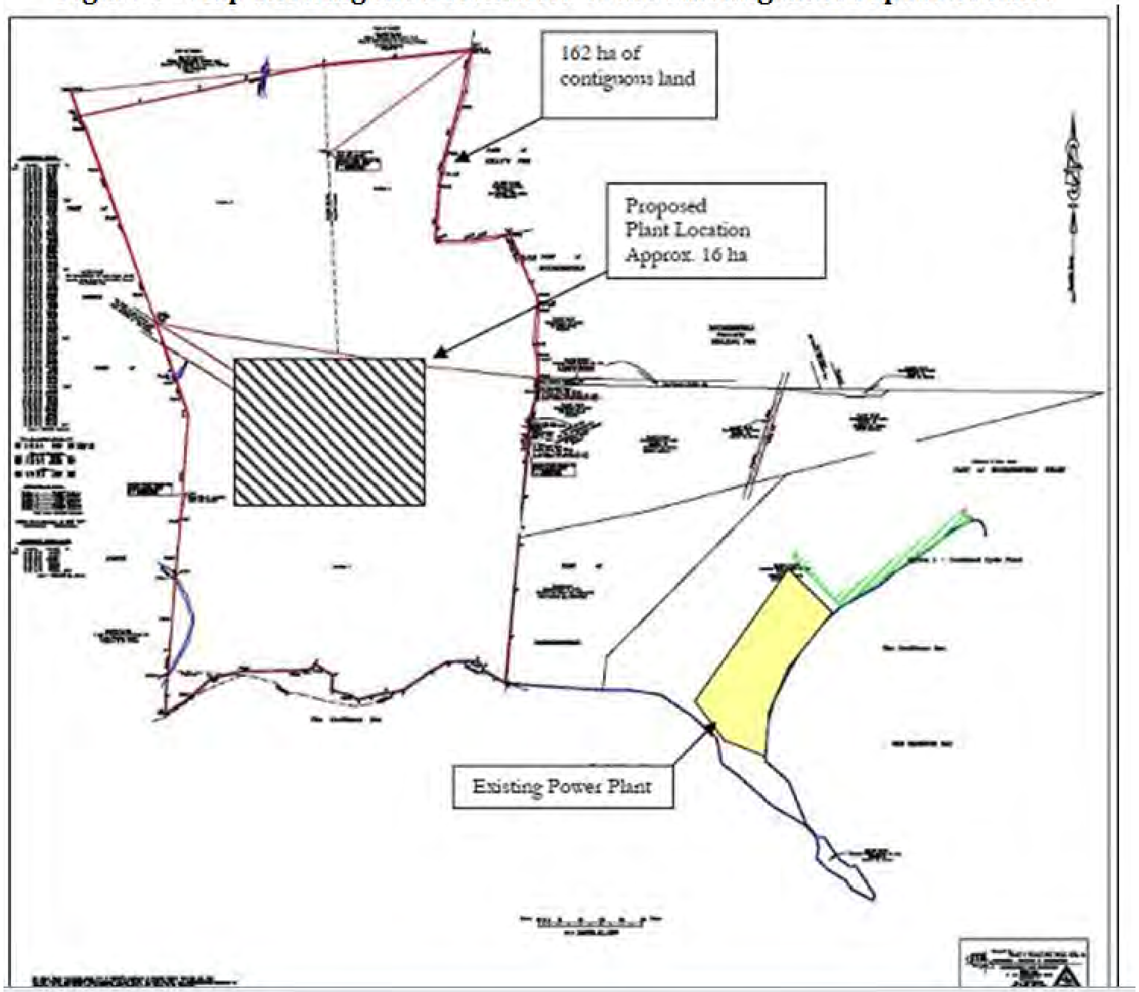
Google Map showing the location of the proposed site

Figure 2 - Portland Bight Protected Area



Created On: November 25, 2004

Figure 3 - Map Showing the Boundaries of the Existing and Proposed Plants



Proposed Plant Technical Specifications

The new plant proposed herein will consist of three (3) blocks of nominal 120MW combined cycle plant. Each block consists of 2x2x1 configuration and uses a multi shaft design for gas turbine and steam turbine generators:

- two gas turbines,
- two heat recovery steam generator (HRSG)
- one steam turbine

The combustion turbines will be dual fuel capable, with natural gas as the primary fuel and automotive diesel oil (ADO) as the back-up fuel.

These gas turbine units are each 40 MW class, providing nominal 120 MW block sizes in the 2 x 1 combined cycle configuration. This provides for the best combination of economies of scale while also complying with the OUR requirement that no single event can result in the loss of more than 120 MW to the grid. Each 120 MW nominal block will be designed to operate independently of one another, further enhancing reliability of supply.

The exhaust gas from the gas turbine is led to the associated heat recovery steam HRSG for generating the steam which in turn will be fed to a common steam turbine generator. The HRSGs will be dual pressure, non-reheat type in order to obtain optimum exhaust gas energy utilization based on thermo-economic considerations.

The plant is designed for both base load and cycling duty (two shift operation) in order to be able to comply with all instructions from the system load dispatcher. The plant will operate with a 92% average annual equivalent availability factor (EAF) for the life time of the plant. This reliability is based on the inherent reliability of the Siemens turbine packages, the unique features of the Siemens gas turbines that allow for optimum maintenance schedules, a robust balance of plant (BOP) design, all coupled with a competent operations and maintenance staff that will be provided. In addition, the company intends to enter into a long term service agreement (LTSA) with the original equipment manufacturer for scheduled maintenance on the gas turbines. This will ensure that maintenance is done in accordance with OEM requirements, with genuine OEM parts and service, and in an expeditious manner.

The metering system is used in order to measure net energy output from the plant, and to monitor and co-ordinate operation of the facility. The location of the metering system will be in 138 kV substation control building and potential transformers for the metering system will be located on 138 kV side of each generator transformer feeders in 138 kV switchyard to measure net electrical energy outputs.

Continuous emissions monitoring (CEM) port will be provided for the measurement of air emission levels in the exhaust stack of each HRSG.

Plant waste water and all effluents will be treated to comply with the effluent discharge limit criteria and discharged to Old Harbour Bay. The GPS locations for the discharge points will be determined following the finalization of the technical specifications and maps.

The plant will be designed to meet the regulatory standards and is designed for an operating life of at least 30 years.

TERMS OF REFERENCE

The Terms of Reference (TOR) for conducting the EIA are based on the General Guidelines for Conducting EIAs (NEPA revised 2007) for prescribed categories under the NRCA Act.

The Environmental Impact Assessment will include but not necessarily be limited to:

Cover Page

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14.6. Photographs & Maps
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14.9. Instruments used in Community Survey

Additional Requirements

The EIA study should also take into consideration the Transmission line requirements and easement and the sphere of influence of their impact on the development of adjoining/surrounding properties.

The proposed zoning of the site in the Highway 2000 corridor Portmore to Clarendon Park Development Plan must be stated and discussed.

The EIA should seek to propose mechanisms for the reduction of discharges from the plant.

Landscaping of the site is recommended by NEPA. Therefore consideration should be given to the development of a Landscape Plan which should include but not limited to:

- A list of the species (both common and scientific names) to be used in landscaping
- The sources of the vegetation to be used during landscaping, especially large trees, and
- A landscaping map

To ensure that a thorough environmental impact assessment is carried out, it is expected that the following tasks be undertaken:

Task # 1 - Description of the Project

Provide a comprehensive description of the project and the surrounding environment specifying any information necessary to identify and assess the environmental effects of the project. This should include project objectives and information on, rationale for the project and background, the nature, location/existing setting, timing, duration, frequency, general layout including construction of any additional power lines and their impacts on the surroundings communities, as well as the impact of the turbines on the power supply and carbon footprint of the energy sector are to also be discussed, pre-construction activities, construction methods, works and duration, and post construction plans. A description of raw material inputs, technology and processes to be used as well as products and by-products generated, should be provided. Note areas to be reserved for construction and areas to be preserved in their existing state as well as activities and features which will introduce risks or generate impact (negative and positive) on the environment.

Task # 2 - Description of the Environment/Baseline Studies Data Collection and Interpretation

Baseline data will be generated in order to give an overall evaluation of the existing environmental conditions, including a historical meteorological evaluation to include but not be limited to wind characteristics and analysis, values and functions of the area, as follows:

i.) physical environment
ii.) biological environment
iii.) socio-economic and cultural constraints

It is expected that methodologies employed to obtain baseline and other data be clearly detailed. Baseline data will include:

Physical

i.) A description of the existing soil and geology, landscape, aesthetic values and hydrology. Special emphasis should be placed on storm water run-off, drainage patterns, and aquifer characteristics. Any slope stability issues that could arise should be thoroughly explored. Any slope stability issues that could arise should be thoroughly explored.

ii.) The current air quality of the physical environment. The area of influence as it pertains to air quality should be determined. Factors such as wind speed and direction, precipitation, relative humidity and ambient temperatures should be assessed pre construction and monitored during post construction.

iii.) Water quality of any existing wells, gullies, rivers, ponds, streams or coastal waters in the vicinity of the development.

iv.) The water quality of the coastal water in the vicinity of any discharge points/sites in Old Harbour Bay and the potential cumulative impact of such discharges on the environment.

v.) The likely constituents of any discharge.

vi.) Noise levels of undeveloped site and the ambient noise in the area of influence

vii.) Sources of existing pollution and extent of contamination

The Physical Impacts should also be classified based on:

- Land Impacts
    - Onsite impacts
    - Offsite impacts

- Water Impacts
    - Pollution of water bodies
    -
- Air Impacts
    - Changes to the micro climate of the area

Biological

Present a detailed description of the flora and fauna (terrestrial and aquatic if applicable) of the area, with special emphasis on rare, threatened, endemic, protected and endangered species. Migratory species and habitat loss and fragmentation due to construction and operation should also be considered and assessed.

i.) Coastal and Marine ecosystem, including but not limited to any wetlands including mangroves, seagrass and coral community with indication of its function and value in the project area.

ii.) The intermediate Acacia Forest should be surveyed and assessed.

Socio-economic & cultural

Present and proposed land use; transportation of heavy equipment, road widening and associated traffic considerations particularly in the construction phase of the project, planned development activities; issues relating to squatting and relocation; public health and safety. The historical importance (heritage, archaeological sites and feature) and other material assets of the area should also be examined. While this analysis is being conducted, it is expected that an assessment of public perception of the proposed development be conducted. This assessment may vary with community structure and may take multiple forms such as public meetings and/or questionnaires/surveys.

i.) Availability of solid waste management facilities

Task #3 - Policy, Legislative and Regulatory Considerations

Outline the pertinent regulations and standards governing environmental quality, safety and health, protection of sensitive areas, protection of endangered species, siting and land use control at the national and local levels. The examination of the legislation should include at minimum, legislation such as the NRCA Act, the Public Health Act, the Town and Country Planning Act and the appropriate international convention/protocol/treaty where applicable.

Examine the Government National Energy Policy and renewable projects. Discuss briefly the 360 MW in relation to the National Energy Policy.

Task # 4 - Identification and Assessment/Analysis of Potential Impacts

Examine and identify the major potential environmental and public health issues of concern and indicate their relative importance to the development project. These should include the occupational exposure, health and safety measures and population exposure in the appropriate study area(s) and changes and or enhancement in emergency response plan. Identify potential impacts as they relate to, (but are not restricted by) the following:

- change in drainage patterns
- flooding potential if necessary
- landscape impacts of excavation and construction
- loss of and damage to geological and palaeontological features
- loss of species and natural features
- habitat loss and/or fragmentation
- biodiversity/ecosystem functions including impacts of bird and bat mortality
- pollution of potable, surface or ground water
- air pollution
- socio-economic and cultural impacts
- impact of flooding, loss of natural features, excavation and construction on the historic landscape, architecture and archaeology of the site
- risk assessment
- noise and vibration, EMF
- solid waste disposal
- soil
- change in land use
- visual impacts – aesthetics

- impact on traffic associated with road widening and the transportation of heavy equipment to the site
- Pollution of potable, surface or ground water should be explored to include the marine environment
- Sewage and trade effluent treatment systems and discharge. The cooling water source and implications inclusive of existing demands and any effluents that may be likely as a consequence. The cooling water discharge and its impact must also be addressed.
- Natural hazard risks – Risk assessment of the plant in relation to tsunamis, hurricanes, tropical storm, flooding must be undertaken. In light of the concentration of significant power generation capacity at Old Harbour Bay, a risk analysis of the threat to the supply of power to the national grid from the proposed plan during emergencies should be assessed.

Distinguish between significant positive and negative impacts, direct and indirect, long term and immediate impacts to include discussion on site restoration and residual impacts and the proposed mitigation measures. Identify avoidable as well as irreversible impacts. Cumulative impacts of this and other proposed and/or existing developments will be explored.

Characterize the extent and quality of the available data, 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 will be represented in matrix form.

Task #5 - Drainage Assessment

An assessment of Storm Water Drainage should be conducted. The EIA Report will cover but not be limited to where necessary:

i.) Drainage for the site during construction to include mitigation for sedimentation to the aquatic including marine environment

ii.) Drainage for the site during operation, to include mitigation for sedimentation to the aquatic and marine environment

iii.) Drainage control for crossings of rivers and/or gullies, to include impacts that drainage control features could have on aesthetics, water quality and sedimentation of rivers and/or gullies.

iv.) Storm water runoff should be assessed based on existing situation and the impact that the proposed plant is expected to have.

v.) Drainage assessment should also include impact of the development on the hydrodynamics of the general area. Of note is that the Old Harbour Bay, which is 5 kilometres from the site, is impacted by flooding.

vi.) All possible efforts should be made to retain all of the surface drainage/storm water runoff on the site. The natural drainage should not be impacted.

Task # 6 - Mitigation & Emergency Preparedness and Response

Prepare guidelines for avoiding or reducing (e.g. restoration and rehabilitation), as far as possible, any adverse impacts due to proposed usage of the site and utilising of existing environmental attributes for optimum development. The potential impacts on aircrafts in the area should be addressed. Quantify and assign financial and economic values to mitigating methods.

Indicate the emergency preparedness and response plans for dealing with risks and hazards identified at Task 4.

Task # 7 - EHS Management and Monitoring Plan

Design a plan for the management of the natural, historical and archaeological environments of the project to monitor implementation of mitigatory or compensatory measures and project impacts during construction and occupation/operation of the units/facility. Preparation of an EHS Management Plan and Historic Preservation Plan (if necessary) for the long-term operations of the site.

An outline of a monitoring programme (if necessary) should be included in the EIA, and a detailed version submitted to NEPA for approval after the granting of the permit and prior to the commencement of the development. At the minimum the monitoring programme and report should include:

- An introduction outlining the need for a monitoring programme and the relevant specific provisions of the permit and/or licence(s) granted.
- Raw data collected
- Discussion of results with respect to the development in progress, highlighting any parameter (s) which exceeds the expected standard (s).
- The activity being monitored and the parameters chosen to effectively carry out the exercise.

- Project maintenance and decommissioning
- The methodology to be employed and the frequency of monitoring.
- The sites being monitored. These may in instances, be pre-determined by the local authority and should incorporate a control site where no impact from the development is expected.
- Frequency of reporting to NEPA
- Tables and graphs are to be used where appropriate

Task # 8 - Project Alternatives

Examine alternatives to the project including an assessment of the impacts of all the alternatives examined and the no-action alternative. This examination of project alternatives should incorporate the use history of the overall area in which the site is located and previous uses of the site itself.

Project alternatives should be discussed in the EIA

Task #9 - Public Participation/Consultation Programme

Conduct public presentation(s) on the findings of the EIA to inform, solicit and discuss comments from the public on the proposed development if necessary.

- Document the public participation programme for the project.
- Describe the public participation methods, timing, type of information to be provided to the public, and stakeholder target groups.
- Summarise the issues identified during the public participation process
- Discuss public input that has been incorporated into the proposed project design; and environmental management systems

Task #10

Commence the preparation of a Health Impact Assessment (HIA) within the environs of the proposed plant according to the Ministry of Health's (MOH) Requirements.

The HIA should be prepared in accordance with the MOH format. Attached

THE EIA REPORT

All Findings will be presented in the EIA report. The report will contain an introduction explaining the need for, and context of the project. The report should, at a minimum, cover the following basic aspects:

Cover Page

Table of Contents

1. Executive Summary
2. Introduction
3. Policy, Legal and Administrative Framework
4. Public Participation and Consultation
5. Comprehensive Description of the Proposed Project
   - 5.1. The Proponent
   - 5.2. Project Concept & Description
   - 5.3. Project Infrastructure
   - 5.4. Project Operations and Maintenance
6. Description of the Existing Environment
   - 6.1. Physical
   - 6.2. Natural hazards
   - 6.3. Biological
   - 6.4. Heritage
   - 6.5. Human Social
7. Identification and Assessment of Potential Direct and Indirect Impacts
   - 7.1. Physical
   - 7.2. Natural Hazards
   - 7.3. Manmade Hazards
   - 7.4. Biological
   - 7.5. Heritage
   - 7.6. Human/Social
   - 7.7. Carrying Capacity
8. Cumulative Environmental Impacts
9. Recommended Mitigation
10. Residual Impacts
11. Identification and Analysis of Alternatives
12. Environmental Management of the Project
13. References
14. Appendices
    - 14.1. EIA Terms of Reference
    - 14.2. Glossary of Technical Terms
    - 14.3. Reference Documents
    - 14.4. Specific Technical Studies/Reports

14.5. Data Tables
14.6. Photographs & Maps
14.7. Composition of the Research Team (including names, qualification and roles
14.8. Notes of Public Consultation Sessions
14.9. Instruments used in Community Survey

Fourteen hard copies and an electronic copy of the report will be required for submission to the National Environment and Planning Agency.

Appendix 3 – EIA Study Team

• Carlton Campbell, M.Phil, CIEC	Project Coordinator, Noise Assessment, Noise Modelling, Vibration, Electro Magnetic Frequency
• Professor Dale Webber	Vegetation
• Dr. Philip Rose,	Vegetation
• Matthew Lee, M.Sc	Air Quality, Vibration, Water Quality
• Rachel D'Silva, B.Sc.	Water Quality, Sediments, Benthic Assessment
• Kristoffer Lue, M.Phil	Water Quality, Sediments, Benthic Assessment
• Tamia Harker, M.Phil	Policy, Legal and Administrative Framework
• Glen Patrick	Technical Assistant (Noise and Air Quality)
• Errol Harrison	Technical Assistant (Noise and Air Quality)
• Janette Manning, M.Phil	Human and Socio-economic
• Christopher Burgess, M.Sc. Eng, PE	Hydrodynamic Modelling, Hydrology and Flooding
• Carlnenus Johnson, B.Sc. Eng	Topography, Climate, Bathymetry, Wave Climate, Shoreline Sediments /Vulnerability
• Dr. Eric Garraway,	Faunal Studies
• Dr. Catherine Murphy,	Faunal Studies
• Dr. Eric Hyslop	Freshwater Study
• Dr. Sacha Todd	Freshwater Study
• Professor Edward Robinson	Seismicity, Hazards, Soils and Geology
• Dr. Shakira Khan,	Seismicity, Hazards, Soils and Geology
• Stephen Haughton, M.Sc. Eng	Air Dispersion Modelling
• Suzan Spence, M.Arch	Landscaping
• Jamaica National Heritage Trust	Heritage and Cultural

Appendix 4 – NEPA Guidelines for Public Participation

NATURAL RESOURCES CONSERVATION AUTHORITY

GUIDELINES FOR CONDUCTING PUBLIC PRESENTATIONS

1997-01-08

Section 1: General Guidelines

1.1 Introduction

There are usually two forms of public involvement in the environmental impact assessment (EIA) process. The first is direct involvement of the affected public or community in public consultations during EIA study. These consultations allow the developer to provide information to the public about the project and to determine what issues the public wishes to see addressed. The extent and results of these consultations are included in the documented EIA report.

The second level of involvement takes place after the EIA report and addendum, if any, have been prepared after the applicant has provided the information needed for adequate review by NRCA and the public.

Public involvement in the review process is in keeping with Principle 7 of the United Nations Environment Programme (UNEP) decision published as Goals and Principles of Environmental Impact Assessment [Decision 14/25 of the Governing Council of UNEP, of 17, June, 1987]

1.2 Purpose

These guidelines are prepared for the use of the developer/project proponent, the consultants who did the EIA study and prepared the EIA report and the public.

Section 2: Specific Guidelines for Public Presentations/Meeting

2.1 Requirements

When a decision is taken by the Authority that a pubic presentation is required, the developer and consultant will be notified by the NRCA. [See Appendix A below] On receipt of the notification arrangements must be made for the public presentation in consultation with the NRCA in respect of date, time, venue and participants.

2.2 Public Notification

The developer/consultants must in addition to specific invitation letters, put a notice in the press advertising the event. Specific notice to relevant local NGOs should be made by the developer/consultants. The notice should indicate where the EIA report is available.

2. 3 Responsibility of Developer/Consultant Team

The consultant is responsible for distribution of copes of the EIA report to ensure that they are available to the public in good time for the meeting. A summary of the project components and the findings of the EIA in non-technical language should be prepared for distribution also in good time for the meeting. Three (3) to four (4) weeks in advance of the meeting is recommended. Copies should be placed in the Local Parish Library and the Parish Council office as well as at the nearest NRCA Regional Coordinator's office and other locations in the community.

The consultant is also responsible for making the arrangements to document the proceedings of the meeting. A permanent record of the meeting is required and one can consider tape recording from which a written record can be made.

2.4 Conduct of the Meeting

With respect to the conduct of the meeting, the NRCA will advise on the selection of a Chairman and will make arrangements to document the concerns of the audience for its own records. The Chairman should be "neutral", that is, not have a direct interest in the project. NRCA staff may on occasion be responsible to chair the meeting.

The technical presentation by the proponent and the consulting team should be simple, concise and comprehensive. The main findings of the EIA with respect to impacts identified and analysed should be presented both adverse and beneficial.

The mitigation measures and costs associated with these measures should be presented. The presentation should inform the public on how they will get access to monitoring results during construction and operational phases of the project (if it is approved) bearing in mind that the public and NGO groups are expected to be involved in post-approval monitoring. Graphic and pictorial documentation should support the technical presentation.

Presenters are advised to keep the technical presentation simple and within a time limit of 20-30 minutes depending on the complexity of the project and to allow up to 30-60 minutes for questions.

Please note that the public will be given a period of thirty (30) days after the meeting to send in written comments.

APPENDIX A

Date

Name of Organization Submitting EIA

Address of the Organization

Attention: Responsible Party

Dear

Subject: Notification of Requirement of Public Presentation/Meeting

The Natural Resources Conservation Authority (NRCA) has determined that a public meeting is required to adequately assess the potential environmental impacts associated with the following proposed activity:

____

____

____

NRCA guidelines for conducting public meetings are attached. As noted in the guidelines, a Notification of Public Meeting must be issued by you once the date, time, venue and programme has been established in consultation with the NRCA. Please note that further processing of your application will halt until the public meeting be carried out by the developer and consulting team and that the public will be allowed a period of thirty (30) days after the meeting to send in written comments.

Questions regarding the public presentation process should be directed to:

____

____

Signature__________________________

Name_____________________________

Title______________________________

Date______________________________

cc: other government agencies

Appendix 5 – National Land Agency Letter

NATIONAL LAND AGENCY
20 North Street, Kingston, Jamaica
Tel: (876) 750-5263/946-5263 • Fax (876) 948-9382
Website: www.nla.gov.jm

Ref. No. SZ/553 Vol 2

April 26, 2012

The Manager
Jamaica Public Service Company Limited
6 Knutsford Boulevard
Kingston 5

Attention: Mr. David Cook

Re: Transfer of Interest in Bodles Rosehall Well and Bodles Experimental Well Land part of Bodles, St. Catherine – Registered at Volume 1432 Folio 276 (part)

Reference is made to your letter dated April 18, 2012 regarding the captioned matter and Memorandum of Understanding dated February 28, 2000, between the Jamaica Public Service Company Limited (JPS) the Commissioner of Lands (COL) and the Water Resources Authority (WRA).

Pursuant to the MOU and subject to the Honourable Minister's Approval, the COL has no objection to the following:

1. the transfer of the interests in the captioned Wells to JPS for use in the development and operation of a 360 MW Power Plant to be constructed in Old Harbour, St. Catherine;
2. the grant of an easement allowing access to both Well sites; and
3. the grant of an easement for the pipelines to be installed on the Bodles Rosehall Well site.

Kindly submit a Preliminary Survey Plan outlining the Well sites, access route and the area for the easement for both Well sites as well as the route and area of the pipelines to be installed.

It must be noted that only the Wells will be transferred to JPS and as such the area surrounding the Wells which will be necessary for the erection of a pump house etc. will be leased.

Yours faithfully,

....
Donovan M. Hayden
Director, Estate Management
for Commissioner of Lands

DH/nc

Appendix 6 – Water Resources Authority Letter

WATER RESOURCES AUTHORITY

ESTABLISHED BY THE WATER RESOURCES ACT, 1995

HOPE GARDENS, P.O. BOX 91, KINGSTON 7, JAMAICA
TEL: (876) 927-0077, 927-0293, 927-0189, 927-0302
FAX: (876) 977-0179, 702-3937

REF: A2004/37-38

2012 April 19

Mr. David Cook
Unit Leader Logistics
Jamaica Public Service Co., Ltd
6 Knutsford Boulevard
Kingston 5

Dear Mr. Cook

Re: Bodles Rosehall and Bodles Experimental Wells – St. Catherine

The water rights to the **Bodles Rosehall** and **Experimental Wells** were transferred from the **National Irrigation Commission/Ministry of Agriculture** via the *Memorandum of Understanding (MOU)* in which JPSCo would develop and install a new irrigation supply at **Colbeck, St. Catherine**.

The terms and conditions of the MOU having been fulfilled as certified by the National Irrigation Commission's letter of February 2012 the wells and sites can now be transferred to JPSCo.

The **Water Resources Authority (WRA)** has reserved the water rights to these wells and in *November 2004* issued licences to JPSCo – **A2004/37** and **A2000/38** to abstract and use *1,000m³/d* and *11,000m³/d* from the Bodles Experimental and the Bodles Rosehall Wells respectively. These licences expired as no abstraction was undertaken within one (1) year of issue as the construction of the new generating plant at Old Harbour Bay was yet underway.

Now that the new plant is to be started and the water is needed the Water Resources Authority will issue new licences to JPSCo upon submission of the requisite application forms for licences to abstract and use water. There has been no change of circumstances that would prevent the licences being reissued for the previous allocation of *1,000m³/d* and *11,000m³/d* from the Bodles Experimental and Rosehall Wells respectively.

Yours sincerely
WATER RESOURCES AUTHORITY

Basil P. Fernandez OD, JP
MANAGING DIRECTOR

*BPF*cmj*

Jamaica's Hydrologic Agency

Appendix 7 – Hydrolab DS-5 Calibration Certificate

HACH®

Hydromet

Certificate of Instrument Performance

Agency Name: CL ENVIRONMENTAL

Certification for Job# 672064

Part/Model Number: DATASONDE 5	Serial Number: 100100048757

RECEIVED CONDITION: *(One must be checked)*

X Within Tolerance
Within Tolerance but Limited *(*see service report)*
Out of Tolerance *(*see service report)*

RETURNED CONDITION: *(One must be checked)*

X Within Tolerance
Within Tolerance but Limited *(*see service report)*

Test Equipment Used, (ID#): ASTM – N.I.S.T traceable glass thermometer (Thermo-Fisher Scientific, Serial ***1781)*** and a Cole-Parmer "*PolyStat*" Constant Temperature Circulator

Environmental Conditions:

Actual Temperature: ***10*** °C	Instrument Reading:	10.03°C	Error .03°C
20 °C		20.02°C	.02°C
30 °C		30.00°C	.00°C

Hach Company does hereby certify that the above listed equipment meets or exceeds all Manufacturers' Service Specifications (unless limited conditions apply). Test equipment used for performance verification are calibrated using standards traceable to the National Institute of Standards and Technology (NIST). Where such standards do not exist, the basis for calibration is documented. The proper operation of the above instrument was established at the time of certificate issuance. To insure continued performance, user must adhere to all requirements listed in the instrument manual.

Certified by: David W Simonini   Title: Instrument Service Technician

Certification Date: 02-28-2012

5600 Lindbergh Drive • Loveland, CO 80538
(800) 227-4224 / FAX (970) 461-3924

Doc# 19773-01
Rev. 3

Appendix 8 –Detailed Water Quality Results

Physico-Chemical (Table 1)

Run	Stn	Depth (m)	Temp. (◦C)	SpC (mS/cm)	Sal (ppt)	pH	ORP	PAR ($\mu E/cm^2/s$)	DO (mg/l)	Turb (NTU)	TDS (g/l)
1	1	0	29.19	46.47	30.24	7.66	498		6.95	45.5	29.78
2	1	0	32.34	46.11	29.96	7.58	492		6.81	20.6	29.5
3	1	0	29.95	47.49	30.98	7.8	373		6.26	31.9	30.37
1	2	0	29.39	54.31	36.01	7.88	286	370	6.08	0.4	34.76
2	2	0	30.45	53.93	35.73	7.86	280	1764	5.64	104.7	34.58
3	2	0	30.63	54.26	35.97	7.89	435	1059	5.12	52.7	34.74
1	3	0	30.72	54.12	35.93	7.84	299	435	5.83	1.2	34.77
2	3	0	30.27	54.04	35.75	7.86	259	1898	5.86	5.3	34.57
3	3	0	28.55	54.43	36.1	7.96	446	930	5.77	10.5	34.82
1	4	0	29.08	54.25	35.96	7.92	352	1633	6.08	0	34.72
2	4	0	29.25	53.95	35.73	7.99	292	1060	5.95	1.2	34.52
3	4	0	28.48	54.32	36.01	8.02	374	446	5.45	7	34.76
1	5	0	28.57	54.21	35.92	7.88	409	608	5.86	0	34.67
2	5	0	29.27	53.61	35.49	7.94	355	787	5.71	6.5	34.28
3	5	0	28.18	53.63	35.5	7.93	433	143	5.3	12.4	34.35
1	6	0	29.08	54.24	35.96	7.92	363	511	5.92	0	34.72
2	6	0	29.05	54.09	35.84	7.94	295	1203	4.91	0.3	34.61
3	6	0	28.4	54.29	36	8.03	392	1370	5.92	2.8	34.74
1	7	0	28.49	54.19	35.92	7.88	366	710	6	1.5	34.69
2	7	0	29.08	54.1	35.85	7.96	321	1086	6.15	2.6	34.62
3	7	0	28.36	54.25	35.96	8.02	402	3327	5.98	5.3	34.71
1	8	0	28.63	54.13	35.87	7.88	370	486	5.79	1.3	34.64
2	8	0	29.21	54.18	35.91	7.95	313	1468	5.7	13.5	34.67
3	8	0	28.76	54.37	36.05	7.99	397	1345	5.7	10.8	34.78

Run	Stn	Depth (m)	Temp. (◦C)	SpC (mS/cm)	Sal (ppt)	pH	ORP	PAR (μE/cm^2/s)	DO (mg/l)	Turb (NTU)	TDS (g/l)
1	9	0	29.06	53.99	35.79	7.86	305	979	5.73	213	34.54
2	9	0	29.97	54.2	35.94	7.97	312	2606	6.11	312	34.69
3	9	0	28.89	53.92	35.71	8.02	417	973	5.96	13.2	34.5
1	10	0	28.97	54.2	35.92	7.85	311	829	5.9	0	34.68
2	10	0	29.97	54.07	35.81	7.91	277	1728	6.04	1.4	34.57
3	10	0	28.68	54.42	36.12	8.01	440	642	5.77	13.4	34.86
1	11	0	29.09	54.25	35.96	7.81	326	800	5.05	2.8	34.73
2	11	0	29.8	54.21	35.92	7.97	279	1795	6.09	4.6	34.71
3	11	0	28.79	53.06	35.08	7.99	429	394	5.76	19.9	33.96
1	12	0	28.19	1.163	0.61	7.18	825		6.75	0	0.7446
2	12	0	29.34	1.232	0.65	6.92	788			0	0.7873
3	12	0	29.01	1.416	0.75	7.65	566		5.67	148.1	0.9012
1	13	0	36.65	54.13	35.23	7.87	339	589	6.08	6.5	34.51
2	13	0	33.31	53.79	35.62	7.81	290	2519	5.83	5	34.44
3	13	0	36.04	53.72	35.49	7.85	396	1507	5.32	31.7	34.37
1	2	0.75	29.4	54.31	36	7.89	298	310	6.07	12.2	34.76
2	2	0.75	30.01	54.03	35.8	7.89	287	1074	5.83	90.6	34.58
3	2	0.75	30.64	54.27	35.97	7.87	432	272	5.03	58.2	34.71
1	3	1	29.36	54.23	35.93	7.87	306	294	5.94	0.7	34.67
2	3	1	29.81	54.12	35.86	7.91	272	1173	6.08	4.7	34.63
3	3	1	28.56	54.39	36.06	7.97	444	370	5.74	10.5	34.82
1	4	1	29.09	54.24	35.96	7.92	352	801	6.11	0	34.71
2	4	1	29.27	53.94	35.73	7.98	298	676	5.94	1.3	34.52
3	4	1	28.6	54.29	35.99	8.02	373	197	5.41	7.8	34.76
1	5	1	28.65	54.24	35.95	7.91	405	600	5.84	0.4	34.72
2	5	1	29.23	53.72	35.59	7.94	350	196	5.61	5.7	34.45
3	5	1	28.25	53.81	35.69	7.95	428	9	5.3	108	34.42
1	6	1	29.06	54.26	35.96	7.91	363	274	5.86	0	34.7

Run	Stn	Depth (m)	Temp. (◦C)	SpC (mS/cm)	Sal (ppt)	pH	ORP	PAR (µE/cm^2/s)	DO (mg/l)	Turb (NTU)	TDS (g/l)
2	6	1	29.04	54.07	35.83	7.93	298	948	4.85	0.2	34.61
3	6	1	28.44	54.26	35.98	8.03	390	812	5.95	3	34.74
1	7	1	28.49	54.21	35.93	7.88	367	530	5.98	2.9	34.7
2	7	1	29.08	54.1	35.85	7.97	323	832	6.17	1.4	34.63
3	7	1	28.38	54.25	35.96	8.02	402	955	5.88	4.9	34.72
1	8	1	28.63	54.12	35.87	7.88	370	458	5.77	1	34.64
2	8	1	29.21	54.16	35.9	7.94	319	954	5.7	10.6	34.66
3	8	1	28.76	54.34	36.03	8	396	245	5.66	9.6	34.78
1	9	1	29.09	54.03	35.79	7.88	312	889	5.82	115.5	34.58
2	9	1	29.95	54.2	35.92	7.97	315	1105	6.44	376.1	34.69
3	9	1	28.9	53.91	35.71	8.02	416	196	5.95	12.4	34.5
1	10	1	28.98	54.18	35.9	7.86	316	594	5.92	0	34.67
2	10	1	29.83	54.03	35.84	7.95	285	1294	6.08	2.9	34.63
3	10	1	28.72	54.45	36.1	8.01	437	223	5.76	12.6	34.85
1	11	1	29.09	54.27	35.97	7.81	328	490	5.01	2.8	34.73
2	11	1	29.77	54.2	35.92	7.97	287	1171	6.12	4.7	34.6
3	11	1	28.8	53.04	35.07	7.98	426	98	5.62	19.9	33.94
1	13	1	30.4	54.21	35.95	7.88	341	306	6.44	6.3	34.72
2	13	1	32.89	53.81	35.63	7.83	298	1873	6.03	4.2	34.46
3	13	1	30.63	55.6	36.07	7.87	397	266	5.23	30	35.6
1	3	2	28.99	54.17	35.9	7.87	310	181	5.88	0.9	34.62
2	3	2	29.72	54.11	35.86	7.91	284	740	5.76	5.7	34.64
3	3	2	28.53	54.39	36.06	7.97	441	114	5.72	10.5	34.8
1	4	2	29.08	54.23	35.95	7.92	353	466	6.1	0	34.71
2	4	2	29.26	53.95	35.73	7.98	301	304	5.96	1.5	34.51
3	4	2	28.6	54.28	35.98	8.02	372	70	5.4	8.1	34.75
1	5	2	28.64	54.23	35.93	7.92	401	453	5.84	0.3	34.71
2	5	2	29.27	53.83	35.65	7.95	273	135	5.51	6.7	34.53

Run	Stn	Depth (m)	Temp. (◦C)	SpC (mS/cm)	Sal (ppt)	pH	ORP	PAR ($\mu E/cm^2/s$)	DO (mg/l)	Turb (NTU)	TDS (g/l)
3	5	2	28.4	53.8	35.65	7.95	417	1	5.25	66.3	34.45
1	6	2	28.9	54.15	35.9	7.87	364	227	5.22	0	34.68
2	6	2	29.04	54.07	35.83	7.93	301	713	4.86	0.2	34.6
3	6	2	28.44	54.27	35.98	8.03	390	456	5.92	3.2	34.73
1	7	2	28.49	54.2	35.93	7.88	367	298	5.98	3.9	34.69
2	7	2	29.08	54.1	35.85	7.97	324	741	6.16	1.1	34.62
3	7	2	28.37	54.25	35.95	8.02	400	531	5.91	5	34.71
1	8	2	28.63	54.12	35.86	7.88	370	398	5.78	0.4	34.64
2	8	2	29.21	54.16	35.9	7.94	321	741	5.7	8.7	34.65
3	8	2	28.76	54.34	36.04	8	395	128	5.68	9.1	34.77
1	9	2	29.09	54.09	35.84	7.89	318	597	5.99	60.8	34.62
2	9	2	29.94	54.19	35.92	7.97	318	581	6.42	215.2	34.68
3	9	2	28.89	53.9	35.7	8.02	415	120	5.93	11.6	34.48
1	10	2	28.96	54.18	35.9	7.87	220	419	5.94	0	34.67
2	10	2	29.7	54.1	35.86	7.95	290	794	6.14	2.1	34.63
3	10	2	28.72	54.44	36.1	8.01	435	98	5.73	12	34.84
1	11	2	28.94	54.22	35.94	7.82	330	322	5.01	7.9	34.7
2	11	2	29.71	54.19	35.93	7.96	293	805	6.08	4.9	34.67
3	11	2	28.82	53.05	35.07	7.98	425	24	5.59	42.3	34.26
1	5	2.5	28.64	54.24	35.96	7.92	395	181	5.8	1.6	34.7
1	3	3	28.91	54.18	35.92	7.87	313	112	5.79	1.2	34.69
2	3	3	29.55	54.05	35.82	7.91	292	388	5.61	6.3	34.59
3	3	3	28.53	54.39	36.06	7.98	439	43	5.75	10.2	34.8
1	4	3	28.99	54.22	35.93	7.92	354	213	6.09	0	34.71
2	4	3	29.24	53.94	35.73	7.98	303	164	5.92	1.7	34.53
3	4	3	28.59	54.28	35.99	8.01	371	24	5.4	7.9	34.74
2	5	3									
3	5	3									

Run	Stn	Depth (m)	Temp. (◦C)	SpC (mS/cm)	Sal (ppt)	pH	ORP	PAR (μE/cm^2/s)	DO (mg/l)	Turb (NTU)	TDS (g/l)
1	6	3	28.6	54.2	35.93	7.83	364	199	4.34	0	34.69
2	6	3	29.03	54.06	35.82	7.93	304	434	4.85	0.2	34.59
3	6	3	28.44	54.27	35.98	8.03	389	330	5.94	3.4	34.72
1	7	3	28.48	54.2	35.94	7.88	367	210	5.96	4.7	34.69
2	7	3	29.08	54.1	35.85	7.97	326	468	6.17	0.8	34.62
3	7	3	28.37	54.23	35.94	8.02	398	396	5.86	4.4	34.71
1	8	3	28.62	54.11	35.87	7.88	370	348	5.76	0	34.63
2	8	3	29.19	54.16	35.9	7.94	323	515	5.67	5.2	34.66
3	8	3	28.76	54.33	36.02	8	395	52	5.67	9	34.77
1	9	3	29.07	54.11	35.87	7.9	321	344	6.05	35.5	34.64
2	9	3	29.93	54.19	35.92	7.97	321	307	6.37	182.1	34.68
3	9	3	28.9	53.92	35.71	8.02	413	42	5.93	11.1	34.52
1	10	3	28.92	54.17	35.9	7.88	323	293	5.94	0	34.67
2	10	3	29.66	54.09	35.88	7.96	295	514	6.11	1.7	34.63
3	10	3	28.73	54.43	36.1	8.01	433	29	5.73	11.7	34.84
1	3	4	28.83	54.2	35.93	7.86	316	74	5.62	2.8	34.69
2	3	4	29.48	54.02	35.78	7.92	292	14	5.75	11	34.57
3	3	4	28.5	54.37	36.05	7.98	437	20	5.72	9.7	34.8
1	4	4	28.84	54.22	35.94	7.9	355	149	5.88	1.1	34.7
2	4	4	29.22	53.94	35.73	7.97	306	93	5.86	1.5	35.52
3	4	4	28.6	54.28	35.98	8.01	370	9	5.37	7.5	34.74
1	6	4	28.57	54.22	35.96	7.8	364	159	3.79	0	34.72
2	6	4	29.02	54.06	35.82	7.92	307	324	4.87	0.2	34.59
3	6	4	28.44	54.27	35.98	8.03	388	233	5.94	3.2	34.72
1	7	4	28.48	54.2	35.93	7.89	368	126	5.96	4.4	34.69
2	7	4	29.08	54.1	35.84	7.97	327	374	6.16	0.8	34.62
3	7	4	28.37	54.23	35.94	8.02	397	262	5.9	4.4	34.7
1	8	4	28.62	54.12	35.86	7.87	371	278	5.7	0	34.64

Run	Stn	Depth (m)	Temp. (◦C)	SpC (mS/cm)	Sal (ppt)	pH	ORP	PAR (μE/cm^2/s)	DO (mg/l)	Turb (NTU)	TDS (g/l)
2	8	4	29.2	54.15	35.89	7.94	324	460	5.68	3.5	34.66
3	8	4	28.75	54.33	36.01	8	394	36	5.64	8.9	34.77
1	9	4	29.02	54.1	35.85	7.9	324	171	6.09	15.8	34.62
2	9	4	29.88	54.17	35.9	7.97	323	158	6.3	129.2	34.68
3	9	4	28.89	53.93	35.73	8.02	412	18	5.88	11.4	34.54
1	10	4	28.88	54.14	35.88	7.88	325	217	6.03	0	34.65
2	10	4	29.59	54.12	35.86	7.96	299	340	6.09	1.7	34.63
3	10	4	28.72	54.43	36.1	8.01	432	10	5.72	11.9	34.84
2	6	5	29	54.17	35.91	7.95	309	232	5.19	1.1	34.69
1	7	5	28.48	54.18	35.91	7.89	368	80	6.03	3.8	34.68
2	7	5	29.07	54.1	35.85	7.97	329	322	6.17	0.9	34.63
3	7	5	28.37	54.21	35.93	8.02	397	169	5.92	4.6	34.7
1	8	5	28.61	54.1	35.85	7.87	371	224	5.66	0	34.62
2	8	5	29.17	54.14	35.89	7.94	328	409	5.64	0	34.65
3	8	5	28.75	54.33	36.02	8	394	19	5.65	9.1	34.77
1	9	5	28.98	54.1	35.85	7.9	327	142	6.01	16.1	34.62
2	9	5	29.79	54.18	35.91	7.95	326	130	5.85	87.3	34.67
3	9	5	28.8	54.13	35.88	7.99	411	6	5.57	22	34.63
1	10	5	28.83	54.14	35.87	7.88	328	161	6.08	0.3	34.63
2	10	5	29.51	54.12	35.87	7.95	303	236	5.97	5.7	34.65
3	10	5	28.73	54.42	36.09	8.01	430	5	5.73	14.3	34.83
2	6	6	28.98	54.2	35.93	7.97	312	205	5.81	2.1	34.69
1	7	6	28.49	54.18	35.92	7.89	368	41	5.96	4.4	34.69
2	7	6	29	54.24	35.96	7.96	330	251	6.07	1.5	34.71
3	7	6	28.37	54.22	35.93	8.02	396	114	5.9	4.6	34.7
1	8	6	28.61	54.11	35.84	7.88	371	198	5.67	0	34.63
2	8	6									
3	8	6									

Run	Stn	Depth (m)	Temp. (◦C)	SpC (mS/cm)	Sal (ppt)	pH	ORP	PAR (μE/cm²/s)	DO (mg/l)	Turb (NTU)	TDS (g/l)
1	10	6	28.83	54.12	35.85	7.89	330	117	6.06	89.4	34.63
2	10	6	29.48	54.12	35.87	7.95	307	202	5.78	14.9	3464
3	10	6									
1	7	7	28.48	54.2	35.92	7.89	368	25	5.96	7.5	34.7
2	7	7	28.98	54.27	35.96	7.96	332	195	6	2.3	34.72
3	7	7	28.37	54.2	35.93	8.02	396	74	5.89	5.2	34.7
1	8	7	28.69	54.22	35.91	7.86	371	146	5.58	1.2	34.66
2	8	7									
3	8	7									
1	7	8	28.47	54.22	35.93	7.89	369	12	5.91	5.2	34.7
2	7	8	28.99	54.26	35.97	7.96	333	151	5.95	2.8	34.74
3	7	8	28.36	54.21	35.92	8.02	395	49	5.9	5	34.69
1	8	8	28.77	54.32	36.01	7.84	372	101	5.17	7	34.77
2	8	8									
3	8	8									
1	7	9	28.47	54.2	35.93	7.89	369	5	5.92	9.9	34.7
2	7	9	28.99	54.26	35.97	7.96	334	111	5.85	3.5	34.73
3	7	9	28.37	54.22	35.93	8.02	395	26	5.88	4.7	34.69
1	7	10	28.46	54.21	35.93	7.89	369	2	5.9	8.1	34.69
2	7	10	28.99	54.26	35.97	7.95	335	68	5.78	7.3	34.7
3	7	10	28.37	54.2	35.92	8.02	394	17	5.89	4.4	34.69
1											
1											

Chemical Lab Results (Table 2)

Run	Stn	BOD (mg/l)	TSS (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	FOG (mg/l)	F. Coliform (mpn/100ml)	Tot. hardness (%CaCO3)	Iron (mg/l)	Zinc (mg/l)	DRO (mg/l)	GRO (mg/l)

Run	Stn	BOD (mg/l)	TSS (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	FOG (mg/l)	F. Coliform (mpn/100ml)	Tot. hardness (%CaCO3)	Iron (mg/l)	Zinc (mg/l)	DRO (mg/l)	GRO (mg/l)
1	JPS1	12	46	0.6	0.09	42.57	240	0.7	0.86	0.024	ND	ND
2	JPS1	7	27	0.2	0.23	13.71	100	0.5	1.01	0.023	ND	ND
3	JPS1	15	61	0.1	0.08	7.43	250	0.57	0.89	0.025	ND	ND
1	JPS10	8	3	0.7	0.01	13.71	<11	0.68	0.24	0.041	ND	ND
2	JPS10	10	4	0.8	0.02	4.86	<11	0.65	0.24	0.032	ND	ND
3	JPS10	9	13	0.7	0.06	5.14	<11	0.66	0.36	0.026	ND	ND
1	JPS11	8	3	0.5	0.01	72.86	120	0.64	0.28	0.026	ND	ND
2	JPS11	10	4	0.9	0.02	32	1500	0.67	0.63	0.025	ND	ND
3	JPS11	18	19	0.6	0.02	3.14	78	0.63	0.6	0.03	ND	ND
1	JPS2	5	3	0.7	0.01	63.71	<11	0.69	0.21	0.016	ND	ND
2	JPS2	11	3	0.9	0.24	10.29	<11	0.66	0.28	0.036	ND	ND
3	JPS2	17	53	0.8	0.05	5.71	<11	0.66	1.2	0.022	ND	ND
1	JPS3	8	5	0.7	0.01	4.29	<11	0.67	0.22	0.024	ND	ND
2	JPS3	10	5	0.7	0.05	12	2400	0.65	1.53	0.034	1.5	ND
3	JPS3	17	10	0.6	0.05	15.14	210	0.66	0.36	0.039	ND	ND
1	JPS4	13	2	0.7	0.02	2.29	<11	0.72	0.54	0.02	ND	ND
2	JPS4	23	5	0.7	0.09	10.57	<11	0.64	0.18	0.023	ND	ND
3	JPS4	18	14	0.7	0.07	20.57	<11	0.66	0.38	0.027	ND	ND
1	JPS5	8	3	0.5	0.02	3.43	<11	0.69	0.2	0.019	ND	ND
2	JPS5	21	7	0.8	0.02	4.43	<11	0.65	0.7	0.025	ND	ND
3	JPS5	8	43	0.7	0.01	2	69	0.66	1.12	0.033	ND	ND
1	JPS6	7	1	0.6	0.15	2.29	<11	0.69	0.18	0.022	ND	ND
2	JPS6	9	6	0.9	0.15	5.71	<11	0.65	0.1	0.023	ND	ND
3	JPS6	19	11	0.8	0.01	5.14	22	0.66	0.19	0.029	ND	ND
1	JPS7	8	3	0.7	0.01	15.14	<11	0.68	0.21	0.024	ND	ND
2	JPS7	8	2	0.8	0.21	9.14	<11	0.67	0.24	0.021	ND	ND
3	JPS7	27	20	0.8	0.03	9.14	<11	0.66	0.22	0.028	ND	ND
1	JPS8	7	1	0.6	0.06	8	<11	0.66	0.27	0.031	ND	ND

Run	Stn	BOD (mg/l)	TSS (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	FOG (mg/l)	F. Coliform (mpn/100ml)	Tot. hardness (%CaCO3)	Iron (mg/l)	Zinc (mg/l)	DRO (mg/l)	GRO (mg/l)
2	JPS8	9	5	1	0.26	6.29	<11	0.65	0.19	0.034	ND	ND
3	JPS8	17	10	0.8	0.06	8	<11	0.66	0.33	0.026	ND	ND
1	JPS9	8	5	0.7	0.02	130.29	<11	0.69	0.24	0.029	ND	ND
2	JPS9	8	5	0.9	0.02	12.86	<11	0.65	0.16	0.017	ND	ND
3	JPS9	18	16	0.3	0.01	4.57	<11	0.66	0.41	0.029	ND	ND

Potable Water

Run	Stn	Arsenic (mg/l)	Barium (mg/l)	Boron (mg/l)	Cadmium (mg/l)	Chromium (mg/l)	Copper (mg/l)	Lead (mg/l)	Manganese (mg/l)	Nickel (mg/l)	Selenium (mg/l)	Mercury (mg/l)	Tot. Cyanide (mg/l)	Fluoride (mg/l)	Residual Chlorine (mg/l)
1	JPS12	ND	0.073	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.18	0.57
2	JPS12	ND	0.082	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.16	0.21
3	JPS12	ND	0.12	0.17	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.13	0.19

Soil

Run	Stn	Arsenic (mg/kg)	Cadmium (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	GRO (mg/kg)	DRO (mg/kg)
1	JPSoil 1	7.5	ND	14	0.044	ND	53
2	JPSoil 1	7.6	ND	12	ND	ND	110
3	JPSoil 1	6.6	ND	11	ND	ND	43
1	JPSoil 2	9.3	ND	12	0.047	ND	ND
2	JPSoil 2	8.3	ND	10	0.043	ND	11
3	JPSoil 2	8.3	ND	11	0.028	ND	ND
1	JPSoil 3	6.6	ND	11	0.054	ND	ND
2	JPSoil 3	7.6	ND	12	0.059	ND	13
3	JPSoil 3	7	ND	12	0.042	ND	ND

Run	Stn	Arsenic (mg/kg)	Cadmium (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	GRO (mg/kg)	DRO (mg/kg)
1	JPSoil 4	4.6	ND	9.4	ND	ND	ND
2	JPSoil 4	8.4	ND	9.9	0.039	ND	ND
3	JPSoil 4	6.5	ND	10	0.04	ND	ND
1	JPSoil 5	7.8	ND	14	0.065	ND	ND
2	JPSoil 5	9.8	ND	13	0.029	ND	ND
3	JPSoil 5	8.4	ND	13	0.052	ND	ND

Appendix 9 – Noise Calibration Certification (Quest QC)

3M Occupational Health and Environmental Safety Division

Quest Technologies
1060 Corporate Center Drive
Oconomowoc, WI 53066-4828
www.questtechnologies.com
262 567 9157 800 245 0779
262 567 6149 Fax

3M

QUEST TECHNOLOGIES now part of 3M
An ISO 9001 Registered Company

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Certificate of Calibration

Certificate No:1084042QII050083

Submitted By: IEES SUB. PROV. DE RIESGOS DE

Serial Number:	QII050083	Date Received:	6/28/2011
Customer ID:		Date Issued:	7/5/2011
Model:	QC-10 CALIBRATOR	Valid Until:	7/5/2012
Test Conditions:		**Model Conditions:**	
Temperature:	18°C to 29°C	As Found:	IN TOLERANCE
Humidity:	20% to 80%	As Left:	IN TOLERANCE
Barometric Pressure:	890 mbar to 1050 mbar		

SubAssemblies:

Description: **Serial Number:**

Calibrated per Procedure: 56V981

Reference Standard(s):

I.D. Number	Device	Last Calibration Date	Calibration Due
ET0000556	B&K ENSEMBLE	7/21/2010	7/21/2011
T00230	FLUKE 45 MULTIMETER	2/3/2010	2/3/2012

Measurement Uncertainty:

+/- 1.1% ACOUSTIC (0.1DB) +/- 1.4% VAC +/- 0.012% HZ
Estimated at 95% Confidence Level (k=2)

Calibrated By: S. V-Z 7/5/2011
SHAWN VANHEMERT **Service Technician**

This report certifies that all calibration equipment used in the test is traceable to NIST, and applies only to the unit identified under equipment above. This report must not be reproduced except in its entirety without the written approval of Quest Technologies.

098-393 Rev. B

Appendix 10 – Vegetation Survey

Scientific name	Common name	Growth form	DAFOR Ranking
Abrus precatorius	Crab Eyes	Climbers/Twiners	R
Antigonon leptopus	Coralita		R
Cissus sicyoides	Soldier Withe, Snake Withe, Pudding Withe		F-A
Cryptostegia grandiflora	Indian Rubber Vine		O
***Ipomoea* sp.**			F
Ipomoea triloba			O
Mikania micrantha	Guaco		O
Momordica balsamina	Cerasee		R
Passiflora ?triflora			R
Passiflora maliformis	Sweet Cup		O
Phaseolus vulgaris	Red Peas		R
Pithecoctenium echinatum	Monkey Comb		O-F
Selenicereus grandiflorus	Queen-of-the-Night		O
Trichostigma octandra	Basket Withe		F
Urechites lutea	Nightshade, Nightsage		O-F
Achyranthes indica	Devil's Horse-whip	Herbs	A
Adropogon sp.			F-A
Asclepias curassavica	Red Top, Redhead		R
Batis maritima	Jamaican Sapphire		O
Bidens pilosa	Spanish Needle		O
Bromelia penguin	Pingwing		R
Commelina diffusa	Water Grass		R
Cynodon dactylon	Bermuda Grass, Bahama Grass		F
***Cyperus* sp.**			O
***Eleocharis* sp.**			O
Emilia javanica	Cupid's Shaving Brush		O
***Gomphrena* sp.**			O
Heliotropium angiospermum	Dog's Tail		R
Leonotis nepetifolia	Christmas Candlestick		R
Mimosa pudica	Shame-o-lady		O
Musa sapientum	Banana		R
Oeceoclades maculata	Monk Orchid/Ground Orchid		O
Panicum maximum	Guinea Grass		A
Paspalum sp.			O
Rhynchospora nervosa	Star Grass		F
Rivina humilis	Bloodberry		F
Sesuvium portulacastrum	Seaside Purslane		O

Scientific name	Common name	Growth form	DAFOR Ranking
Sporobolus indica			F-A
Sporobolus jacquemontii			A
Sporobolus virginicus			R
Stemodia maritima			R
Talinum traingulare			R
Typha domingensis	Reedmace		O
Vernonia cinerea			O
Allamanda cathartica	Yellow Allamanda	Shrubs	O
Allamanda violacea	Purple Allamanda		O
Capparis baducca			R
Chromalaena (Eupatorium) odoratum	Christmas Bush		R
Lantana camara	White Sage, Wild Sage		R
***Malpighia* sp.**			R
Pisonia aculeata	Cockspur		O
Pithecellobium unguis-cati	Privet		R
Pluchea carolinensis	Wild Tobacco		R
***Plumbago* sp.**			R
Randia aculeata	Box Briar, Indigo Berry, Ink Berry		R
Ricinus communis	Castor Oil Plant, Oil Nut		R
Sida acuta	Broomweed		A
Stenocereus hystrix	Dildo Pear		R
Harrisia gracilis	Torchwood Dildo	Shrubby Herbs	R
Urena lobata	Ballard Bush, Bur Mallow		F
Acacia tortuosa	Wild Poponax	Trees	A
Avicennia germinans	Black Mangrove		R
Caesalpinia bonduc	Grey Nickal/Grey Nicker		R
Cassia emarginata	Senna Tree, Yellow Candle Wood		R
Cocus nucifera	Coconut		R
Comocladia pinnatifolia	Maiden Plum		R
***Cordia* sp.**			R
Guazuma ulmifolia	Bastard Cedar		A
Haematoxylum campechianum	Logwood		O
***Nectandra* sp.**			R
Samanea saman	Guango		F
Tecoma stans			O

Appendix 11 – Old Harbour Bay CDA Stakeholder Meeting Attendees

Meeting 13.8.12

Name	Organisation
Camille Cheese	C.D.A. (Secretary)
Murelda Folkes	CDA V.P.
Peter Davis	Councillor
Rolando Reynolds	OHBFFC.
Charles Moodie	O.H.B Coop
Rev. Sondra Membhord	OHB CDA PRO
Patrick Ethson	OHB Primary and AW Centre
Karren Dixon	C.D.A. Treasurer
Dorrett Heath	C.D.A (Ass. Secretary)
Errol Coborne	CDA President
Ricardo Fearon	C.D.A P.R.O
Henley Bent	O.H.B.FFC / O.H.B. F. Co-op
Dinal Simpson	C.D.A. PRO
KRISTOFFER LUE	CL ENVIRONMENTAL
RACHEL D'SILVA	CL ENVIRONMENTAL
CARLTON CAMPBELL	CL ENVIRONMENTAL

Appendix 12 – Health, Safety and Environment Management System (Daelim)

Appendix 12 – Health, Safety and Environment Management System (Daelim)

SECTION 6.0 CONSTRUCTION EXECUTION PLAN

6.8. Safety & Environment (HSE) Program

6.8.1 Safety Aspects

All of HSE Procedure will be developed on the basis of the Company and Jamaica's regulations at the early construction stage.

Daelim will conduct the systematic assessment of all health, safety, environmental and security matters for key construction and pre-commissioning activities, e.g. civil, building, mechanical, electrical, instrumentation, painting, insulation and flushing work prior to the contract award with Subcontractors. Daelim thereby will be able to identify and verify Subcontractors' loss potential (in terms of capability, experiences, frequency and severity).

The findings of this assessment, together with risk assessments submitted by Subcontractors will form the inventory of tasks from which the additional method statements and work practices will be developed more efficiently by Subcontractors in conjunction with Daelim, the Company as well as Jamaica HSE regulations. All output of these assessments will be submitted to the relevant discipline manager at least 3 days prior to intended execution of the works, and will also form the basic content of the pre-task Instructions. The significant assessments, particularly those requiring method statements will be required to submit more than 3 days in advance.

Besides for example, the HSE leader who is in charge of the pre-commissioning, with the construction manager, will review all pre-commissioning activities prior to commencement, to analyze any risks involved, in order to approach the activity in accordance with the predefined criteria by Daelim.

The identified hazards and controls shall be communicated to the work team via daily work team meetings such as Task/Craft Special Talks, Tool Box Meeting, HSE Meeting and HSE Committee

6.8.2 An overview of Health, Safety & Environment (HSE) Program

The Project shall be subject to Daelim's HSE management system. Daelim has developed an integrated management system; HSE (Health, Safety and Environment) management system in accordance with ISO 14001 (Environmental Management System) and OHSAS 18001 (Occupational Health and Safety Management System) that increases the effectiveness and efficiency of health, safety and environment control.

This system pursues the Daelim's Zero-Lost Time accident philosophy and is designed to prevent accidents by effective control of hazards identified through risk assessments following the principle of PDCA (Plan, Do, Check and Action) cycle and therefore provide a clean and safe work site.

Our HSE goals are;

- Zero injury, No illness, No lost time and Zero fatalities to people
- No damage, No harm and No accidents to property and facilities
- No contaminate, No pollution and No damage to environment

Health and safety hazards are identified prior to project activities. Health and Safety objectives for the Project are to be established, being based on the HSE policy, the results of risk assessment and current applicable legal and other requirements.

Construction management team prepares action plans to achieve Health and Safety objectives with measures to reduce the risks. All employees of Daelim and Subcontractors shall take part in the Health and Safety Training before they commence the work.

Daelim's Subcontractor and partner are asked to adopt Daelim's HSE commitment to their work. Every activity will be carried out in accordance with Health and Safety procedures developed in order to support safe working. Non-conformance found during the implementation and operation phases will be corrected and prevented immediately by taking appropriate actions in accordance with relevant procedures. Daelim assesses the effectiveness of the HSE management system on a regular basis through monitoring and auditing.

Planning

Hazards and Risks will be identified prior to the commencement of work and necessary measures to reduce hazards and risks will be implemented in accordance with Project/Site HSE plan. Daelim's construction management team will also identify all current applicable local laws and legislation to be complied with Jamaica HSE regulation. HSE objectives will be set based on the consideration of legal and other requirements, hazards and risks, technological options, financial, operational and business requirements, and the views of clients.

HSE management programs will also be established to achieve these objectives.

- Hazard identification, Risk assessment and Risk control
- Legal and Other Requirements
- HSE Objectives
- HSE Management Program

Implementation and Operation

Daelim's construction management team will give the appropriate HSE trainings to its employees at each relevant function and level to ensure that they are competent to perform tasks.

HSE information will be communicated to and from employees, Subcontractors and other interested parties. By established documentation measures, Daelim's construction management team will control HSE documents and data. Plans and procedures will be developed that respond to emergency situations to prevent further incidents. Daelim will identify those operations and activities that are associated with hazards and risks and necessary control measures will be applied on those operations and activities.

- Organization Structure and Responsibilities
- HSE Training
- Consultation and Communication
- HSE Documentation
- Document and Data Control
- Operational Control
- Emergency Preparedness and Response

Checking and Corrective Action

On a regular basis, Daelim's construction management team will monitor HSE performance. Periodic internal audits will be carried out by Head Office HSE (Health, Safety and Environment) team to make sure that planned arrangements are working effectively. Relevant records will be maintained in accordance with relevant procedures. All incidents and accidents will be investigated and prompt actions will be taken. Daelim's construction management team will eliminate the cause of non-conformance by taking corrective or preventive actions.

- Performance measurement and monitoring
- Accidents, incidents, non-conformances and corrective and preventive action
- Records control

Management Review

Daelim's construction management team will review the overall HSE performance at regular intervals to ensure its continuing suitability, adequacy and effectiveness

HSE Plan

The HSE plan applies to all employees and activities of the site carried out by Daelim. This HSE plan is designed to describe how Daelim intends to satisfy all of its obligations to manage and co-ordinate project's operations and the operations of Daelim's Subcontractors in overseas projects. In order to comply with any additional HSE requirements in Jamaica, the plan will be augmented. As work progresses, this HSE plan will be amended as necessary and further developed to include the relevant sections from Daelim detailed HSE procedures.

This HSE Plan consists of the following major subjects;

- Health, Safety and Environmental Plan

- HSE Policy
- Purpose
- Scope
- Responsibilities
- Definitions

SECTION 6.0 CONSTRUCTION EXECUTION PLAN

- HSE Policy Statements
- HSE Objectives
- HSES training
- HSE Organization
- Construction Contractual Obligations
- Hazard Identification, Task Analysis and Risk Control
- HSE Management of Subcontractors / Vendors
- HSE Committee
- HSE Training
- Communication and Reporting
- Environment Management
- HSE Inspection
- Emergency Preparedness and Response
- HSE Audit
- Incident / Accident Reporting and Investigation
- HSE Notice for Corrective Actions
- Traffic Safety
- Alcohol and/or Controlled drugs
- Smoking.
- HSE Signs
- Holographic Equipment and Radios
- Work after Regular Hours
- Temporary Facilities
- Personal Protective Equipment
- Signs, Signals and Barricades
- Fire Protection
- Tools (Hand or Power)
- Cranes and Lifting Equipment

- Excavation and Trenching
- Concrete Forms and Shoring
- Floor and Wall Openings, and Stairways
- Scaffolding and Ladders
- Structural Steel Erection
- Welding and Cutting
- Electrical Work
- Abrasive Blasting
- Pressure Testing
- Vessel and Confined Space (VCS)
- Hot Tapping and Tie-in to Active Equipment
- Handling of Chemicals
- Material Safety Data Sheet (MSDS)
- Road Closures
- Work Permit System
- Waste Control
- Noise and Vibration Control
- Chemicals
- Water Quality Control
- Contamination Control (Air and Soil)
- Dust Control
- Discharge of Hazardous Material
- Cleaning Site
- Site Security Plan

More detailed and specified project/site HSE Plan will be developed to manage the work, associated risks and adverse environmental impacts after award.

HSE Manual and Procedure

All activities that are not covered by this plan shall be carried out in accordance with Daelim Corporate HSE Manual and HSE procedures.

Daelim has the HSE manual and procedures which is intended to comprehensively define and control HSE aspects relating to the majority of the Construction and Commissioning operation within the scope of the Daelim.

6.9. Inspection/QA/QC

The following sections describe Daelim's QA/QC system in brief.

6.9.1 Quality

6.9.1.1 Quality Assurance Program

Daelim is committed to providing quality products and services and maximising the delivered value to the Company. This is achieved through the implementation of a quality assurance program. The quality assurance program implemented by Daelim complies with internationally recognised standards and is based on proven practices and processes for the execution of construction activities.

6.9.1.2 Quality Control at Site

1) General

The Quality control at the site will be an integral part of the overall QC system for this Project. The plan is intended to specify the methods to be applied in order to achieve the quality objective of completing the construction in accordance with the Project specifications.

The procedure will be established for the monitoring and verification of the work as it progresses. The procedures will be based on relevant specifications, the Company standards and good construction practice and will be subject to the Company's approval. The control of documentation and non-conformances will define the set-up and organization to handle these functions.

The Quality control at the site will address applicable requirements of the Project quality plan and contain the following;

SECTION 7.0

SAFETY PLAN

< CONTENTS >

SECTION 7.0 SAFETY PLAN

◆ CORPORATE HSE POLICY ◆

Health, Safety and Environmental Policy

Since (founded in) 1939, we, Daelim Industrial Co., Ltd., have won a great confidence from the clients and the society at home and abroad through successful completion of various projects under the corporate motto of "**Creator of Prosperous and Comfortable Lives**"

With this confidence in mind, we, all officers and employees, deeply recognize the importance of the health and safety working environment and natural environment preservation and improvement of living environment, establish the HSE Management System, and in order to implement it continually, we hereby declare as follows.

- ◆ We will hold "Humanism" as the top priority in all business activities with respect for human beings.
- ◆ We will strictly comply with current applicable legislation and regulations of Korea and the overseas countries to which our clients subscribe and will actively accept the opinion of interested parties.
- ◆ We will carefully plan and design all the business activities, products and services to minimize adverse environmental impacts, and do our best to reduce resources consumption, maximize resources recycling and avoid environmental pollution.
- ◆ We will make ourselves trained in order to effectively take part in the HSE Management System, and have all subcontractor's personnel awake the importance of HSE and encourage them to actively participate in the HSE control activities.
- ◆ We will try our best efforts to research, develop, and maintain state-of-the-art technologies related to Health, Safety, and preservation of Environment.

This Health, Safety, and Environmental Policy shall be publicly announced to all personnel and interested parties and communicated at every level of the organization. The HSE Management System shall be improved continually by setting up HSE objectives, establishing HSE management program and reviewing its implementation periodically.

March 12, 2007

President Jong In, Kim
Daelim Industrial Co., Ltd.

DAELIM

SECTION 7.0 SAFETY PLAN

7.1 Purpose.

Daelim Industrial Co., Ltd. (hereinafter called as "Contractor"), places a great deal of emphasis on maintaining the standard procedures of Health, Safety and Environment (HSE) protection.

This HSE Plan describes the necessary instructions and guidelines to be applied to the Construction of 360MW Combined Cycle Power Plant Project, Old Harbour Bay in the parish of St. Catherine, Jamaica Construction Site for development and implementation of a site-specific HSE program.

This HSE Plan will also govern the job conditions and work practices for all employees throughout the duration of this construction.

As outlined within the HSE Policy, the elimination of accidents within our work force will be the number one priority.

The purpose of this document is to provide clear guidelines to all members of the Construction of 360MW Combined Cycle Power Plant Project, Old Harbour Bay in the parish of St. Catherine, Jamaica Construction Site on the HSE criteria to be applied during the execution of the Construction of 360MW Combined Cycle Power Plant Project Construction Work.

7.2 Scope.

This HSE Plan is applied to the Construction of 360MW Combined Cycle Power Plant Project, Old Harbour Bay in the parish of St. Catherine, Jamaica Construction Site carried out by Contractor.

This HSE Plan is designed to describe how Contractor's Construction Management intends to satisfy all of its obligations to manage and co-ordinate their operations and the operations of their sub-contractors at the site, during the construction and commissioning activities at the Construction of 360MW Combined Cycle Power Plant Project Construction Site.

7.3 Responsibilities.

7.3.1 Project Manager.

1) Is Contractor Representative for the project and has the overall responsibility with respect to HSE matters during the execution of project.

2) Provide essential resources for the implementation, control and improvement of the project HSE management system to the construction

site.

7.3.2 Site Manager.

1) Has the prime responsibility for ensuring the site HSE activities.

2) Establish a realistic HSE policy and HSE targets for the site.

3) Promote the setting up of site HSE procedure, regulations and rules and of site HSE training plan, etc.

4) Direct each vendor's / sub-contractor's Site Manager, site HSE manager and other managers in carrying out their duties and responsibilities.

7.3.3 Site HSE Manager.

1) Ensure the development and implementation at construction site described in this plan.

2) Managing the implementation of Contractor HSE procedure throughout all phases of the construction.

3) Assist the Site Manager in all HSE related matters.

4) Ensure that all activities regarding HSE related matters are carried out in accordance with this HSE plan for construction and commissioning.

5) Ensuring that Contractor HSE manual and procedures / plans are distributed to each individual sub-contractor or vendor at construction site and supplying the necessary information and advice.

6) Over viewing vendor or sub-contractors activities as far as compliance with the related HSE law and regulations and other relevant requirements.

7) Managing the accident, incident investigations and maintaining the records of the site HSE statistics.

8) Issuing the site HSE committee meetings program and organizing site HSE meetings during the execution of construction work.

9) Organize and preside over overall site HSE meeting.

10) Submit a HSE program including HSE measures prior to commencement of the work.

11) Be responsible for all HSE activities, including fire prevention during the construction period.

12) Conduct independent audits to assure conformance with the established HSE program and determine the effectiveness of individual elements of the program.

13) Coordinate the HSE activities between the Client and Contractor.

14) Co-operating with Project HSE representatives for discussing and resolving site HSE issues related to the execution of construction.

15) Liaisons with Project Team / Contractor Head Office Plant HSE Team.

7.3.4 Site HSE Supervisor.

1) Initiate the site HSE plan.

2) Conduct weekly HSE meetings with craft employees and submitting a weekly report to the Client documenting HSE activities.

3) Conduct periodic HSE inspection / audit to ensure that the established HSE program is implemented in a proper manner for construction work.

4) Conduct daily safety tour and report to site HSE manager.

5) Conduct a HSE program under the direction of Site Manager and/or site HSE manager.

6) Patrol the work site periodically to verify that the work is carried out under safe and healthy conditions, with no violations of HSE requirements.

7) Advise promptly his field supervisors and works of the corrective action when any unsafe condition or violations are observed.

8) Check each work procedure from the safety point of view and advise his field supervisors before commencement of work and/or while working.

9) Maintain the published HSE literature, HSE regulations, codes and other communications. Advise manager of compliance and conditions requiring

attention.

10) Make thorough analysis of the statistical data through inspection, delineate problem areas, and make recommendations for solutions.

11) Check on the use of all types of personal protective equipment, evaluate effectiveness and suggest improvements.

12) Control / implement all HSE activities for employees inside / outside of site area together with field supervisors / foremen as assistants.

13) Supervise and direct the foremen and ensure that they carry out their daily routine jobs as well as report any environmental matters observed.

14) Maintain contacts with respective government authorities on environmental control measures.

15) Establish and update procedures to examine and evaluate the effect of activities on the environment (waste, noise, air pollutants, sewage, etc.).

16) Monitor environmental impacts regularly.

17) Liaisons with the Client's Loss Prevention Division whenever demanded by the Client's sponsoring Department.

7.3.5 Security Officer.

1) Supervise and direct the security guards and ensure that they carry out their daily routine jobs as well as report any security matters observed.

2) Make every security guard fully aware of any orders or instructions given by the site HSE manager or HSE supervisors and ensure an efficient performance by every security guard.

3) Conduct a patrol, at least twice a day, to check on the activities of the security guards.

4) Reports daily to the site HSE manager on topics and status of security and submit a daily report to him for review.

5) Enforce prohibitions (drinking, drug, etc.).

6) Maintain security records and update security regulations.

7) Implement security checks and drills.

8) Administrate area restrictions.

7.3.6 Medical Staff.

1) Develop operation plan of the medical facility.

2) Request the purchase of the medical equipment, facilities and medicine, as necessary.

3) Perform periodically inspection about facility and place related public health.

4) Make arrangements for the provision of adequate first aid at selected areas on site and in the camp.

7.3.7 Sub-contractor's Construction Manager.

1) Organize work in accordance with the required standards with minimum risk to employees, other sub-contractors, public, and the plant.

2) Comply with the local legislation, other relevant legislation and any other requirements imposed by Contractor.

3) Submit the site HSE plan to site HSE manager including HSE measures with his review prior to commencement of the work.

4) Establish, implement and maintain the HSE program through his HSE manager, supervisor and workers.

5) Conduct independent audits to assure conformance with the established HSE program and determine the effectiveness of individual elements of the program.

7.3.8 Sub-contractor's HSE Manager.

1) Conduct daily safety tour and report to Contractor.

2) Conduct a HSE program under the direction of Contractor's site HSE manager.

3) Patrol the work site regularly to verify that the work is carried out under safe and healthy conditions, with no violations of HSE requirements.

4) Advise promptly the field supervisors and workers of the corrective action when any unsafe and unhealthy conditions or violations are observed.

5) Check each work procedure from the HSE point of view and advise the field supervisors before commencement of work and while working.

6) Submit accident report to Contractor's site HSE manager.

7) Maintain the published HSE literature, HSE regulations, codes and other communications and advise management of compliance and conditions requiring attention.

8) Make thorough analysis of the statistical data through inspection, delineate problem areas, and make recommendations for solutions.

7.3.9 Sub-contractor's Supervisor / Foreman.

1) Organize the workplace so that the work can be carried out in accordance with the HSE standards required for the minimum risk to employees and property.

2) Know the HSE requirements stipulated in the HSE program.

3) Give precise instructions as to the requirements for correct work method.

4) Coordinate with his supervisor / superintendent to avoid any confusion about areas of responsibility.

5) Make sure that suitable personal protective equipment is available and in use.

6) Ensure that new employees are properly instructed in and fully understand the precautions to be taken before they are allowed to start work.

7) Report to include inspections, tool-box meeting and near miss reports. These reports should be given to the Site HSE Supervisor.

8) To ensure work places are kept clean during and at the end of the work.

9) To conduct a daily tool-box talk for group prior to the start of work.

10) To carry out team talks prior to every job, inform the working crew of the requirements of the Permit to Work Certificates & Risk Assessments.

7.3.10 Sub-contractor, Vendors and Suppliers.

1) Ensure that all employees conform to HSE rules and regulations.

2) Supply employees with appropriate equipment and appliances.

3) Attend HSE committee meeting when called upon.

4) Ensure good housekeeping.

5) Report all accidents to Contractor's site HSE manager immediately.

7.3.11 Sub-contractor's Workers.

1) Be directly responsible for this own personal safety and health.

2) Do nothing against this site HSE plan.

3) Do nothing to endanger him or co-workers.

4) Use correct tools and equipment for the job.

5) Do not use plant or equipment for job if you are neither trained nor experienced.

6) Keep his work place clean and tidy as part of his assigned duty.

7) Keep tools in good condition.

8) To immediately report all 'Near Miss' and any injury that results from an incident at work.

9) Report any damage to plant or equipment.

7.4 Definitions.

7.4.1 Accident.
Undesired event giving rise to death, ill health, injury, damage or other loss.

7.4.2 Danger.
A person is in danger when they are exposed to a risk. The degree of danger is dependent on the hazard or risk.

7.4.3 Environment.
Surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelation.

7.4.4 Environmental Impact.
Any change to the environment, whether adverse or any beneficial, wholly or partially resulting from an organization's activities, products or services.

7.4.5 Hazard.
Source of situation with a potential for harm in terms of injury or ill health, damage to property, damage to the workplace environment, or a combination of these.

7.4.6 Hazard Identification.
Process of recognizing that a hazard (see 7.4.5) exists and defining its characteristics.

7.4.7 HSE Policy.
Statement by the organization of its intentions and principles in relation to its overall HSE performance that provides a framework for action and for the setting of its HSE objectives and targets.

7.4.8 Incident.
Event that gave rise to an accident or had the potential to lead to an accident.

<Note> An incident where no ill heath, injury, damage, or other loss occurs is also referred to as a "near-miss" The term "incident" includes "near-miss".

7.4.9 HSE Management System.
The part of the overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing

and maintaining the HSE policy.

7.4.10 Manual.

A document that gives guidance and contains explanations of rationale for the way a particular aspect is to be approached, and where the resultant practice or method is outlined.

7.4.11 Non-Conformance.

Any deviation from work standards, practices, procedure, regulations, management system performance etc. that could either directly or indirectly lead to injury or illness, property damage, damage to the workplace environment, or a combination of these.

7.4.12 Occupational Health and Safety.

Conditions and factors that affect the well-being of employees, temporary workers, contractor personnel, visitors and any other person in the workplace.

7.4.13 Practicable.

Practicable means that it is capable of being done, even though it may be difficult, inconvenient or expensive.

7.4.14 Prevention of Pollution.

Use of processes, practices, materials or products that avoid, reduce or control pollution, which may include recycling, treatment, process changes, control mechanism, efficient use of resources and material substitution.

<Note> The potential benefits of prevention of pollution include the reduction of adverse environmental impacts, improved efficiency and reduced costs.

7.4.15 Procedure.

Document describing the purpose and scope of an activity and the specific way the activity is to be performed to achieve a satisfactory result. An auditable series of steps defining roles, responsibilities and tasks that transform a defined input into a defined output.

7.4.16 Risk.

Combination of the likelihood and consequence(s) of a specified hazardous event occurring.

7.4.17 Risk Assessment.

Overall process of estimating the magnitude of risk and deciding whether or not the risk is tolerable.

7.4.18 Safety.

Freedom from unacceptable risk of harm.

7.4.19 Zero Accident Philosophy.

The philosophy based on the principle that zero is the only acceptable target to be established for any organization or project, and that accidents are unacceptable events, for which every reasonably practicable effort towards prevention will be made. This philosophy emphasis that it is unacceptable for even one person to be injured or suffer occupational health problems whilst working at Site.

7.4.20 Construction HSE Instructions.

7.4.21 HSE Policy Statements.

1) Site HSE Policy Statement.

   a) Site Manager will issue and bring to the attention of all construction personnel a written Site HSE Policy Statement at the site.

2) Drug and Alcohol Policy Statement.

   The following Site HSE Policy relating to Substance Abuse will be approved by Site Manager and implemented at construction site controlled by Contractor.

   - The transportation, use, possession, promotion or sale of Prohibited Substances, such as alcohol, drugs and other intoxicating substances, in all work-places, which are under the direct or indirect control of Contractor, is strictly forbidden.
   - Any person found in possession, or under the influence of any alcohol, drug or other intoxicating substances should be subject to Disciplinary Procedures.

7.4.22 HSE Objectives.

1) To comply with all applicable Health, Safety and Environment regulations, relevant to the local regulations and employer's standards as required by Contract, supplemented by Contractor's operational experience.

2) Identify all potential hazards associated with the execution of construction work, and to develop prevention, control and mitigation measures to eliminate or minimize harm to people, damage to plant or equipment, or adverse impact on the environment.

3) Encourage the adoption of a positive, proactive, committed HSE culture throughout all phases of the construction and commissioning.

4) Site HSE objectives are reached by:

- Defining and maintaining effective organization, plans and working procedures to manage the risks to all personnel involved (both from Contractor and sub-contractors / vendors).
- Setting HSE targets and monitoring HSE performance through statistical indicators.
- Motivating personnel at all levels on HSE issues and communicating clear commitments.
- The following construction HSE objectives for site personnel and workforce (including sub-contractors and vendors) during construction and commissioning are as follows:

  ✓ Zero Major Injuries and Zero Fires.
  ✓ Zero Fatalities.
  ✓ Zero Illness.
  ✓ No Damage.
  ✓ No Harm.
  ✓ No Contamination.
  ✓ No Pollution.

7.4.23 HSE Organization.

1) The HSE Management System ensures that the site Health, Safety and Environmental objectives are met through implementation of technical activities and procedures, the construction HSE part will be appointed to perform all the technical activities included in this HSE plan.

2) Contractor's Head Office Plant HSE Team based in Seoul–Korea, supports the construction HSE part with specialist advice, consultation, inspection, auditing and directions for the execution of construction work.

3) The construction management team interfaces with Contractor's project management team, also with sub-contractors and vendors, to establish that all activities comply with the construction HSE objectives.

4) The organization of the construction HSE function is shown in the Appendix 3. Site HSE Organization Structure.

7.4.24 Construction Contractual Obligations.

1) The construction management team fully appreciates its responsibilities to comply with the contractual HSE requirements.

7.4.25 Hazard Identification, Task Analysis and Risk Control.

1) All work activities performed at the site will be executed in a safe and controlled manner. To accomplish this, hazard identification, task analysis and risk control systems will be introduced where necessary for the type of work to be carried out.

2) Task Planning / Risk Assessment

   a) The construction management team, when considered necessary, will implement arrangements to assess the risks of the construction activities, which are likely to result in injury or ill health to persons at work or to members of the public.

   b) The purpose of these assessments is to identify the degree of risk associated with the construction activity and to determine the preventative or protective controls required. Details of the risk assessments will be recorded and used to formulate HSE construction instructions for undertaking the work.

   c) All risk assessments will be continuously reviewed and where circumstances change to such an extent as to render the original assessment invalid, a new assessment will be carried out.

   d) Each task, where task planning is required, will be the subject of a study. The Superintendents or Supervisors will undertake this in charge of the work. The study will incorporate all recognized the degree of hazards and risk associated with them

   e) Site HSE manager or assigned site HSE supervisors in the construction site will review the study and provide additional instructions or requirements as necessary. They will carry out Hazard Identification and the hazards identified will be graded according to their degree of risk:

      - Those that have the potential to cause death or permanent disability to people, or permanent damage to plant, equipment or structures.
      - Those that have the potential to cause serious injury or illness to people or major downtime in the use of plant, equipment or structures.
      - Those that have the potential to cause minor injury or illness to people or minor damage to plant, equipment or structures.

   f) The Risk Assessments will then be formatted for each identified hazard, risks will graded similarly:

- Those with high probability of occurring.
- Those with a medium probability of occurring.
- Those with a low probability of occurring.

g) Where jobs are identified as high risk, a written risk assessment will be prepared and approved by the Client.

h) Included in the Risk Assessments will be the requirement for Personal Protective Equipment.

i) Where reasonably practicable, risks will be reduced by a change of design, work methods and where possible engineering control.

j) The Risk Assessment will state the task to be performed, the identified hazards, the risks associated and methods to be employed in order to reduce the risks.

k) The final part of the assessment will state the line of communication and emergency assistance available if necessary.

l) Prior to work commencing information on the contents of the Risk Assessment will be passed onto the workforce via toolbox talks and stand up meetings.

m) It is likely that the same risk will be performed in a number of locations or on a number of occasions.

n) Where this is the case, one assessment may be valid for many instances, with only minor alterations and change of location.

7.4.26 HSE Management of Sub-Contractors / Vendors.

1) Sub-contractors to be controlled by Contractor at site will only be selected to consistently achieve high levels of HSE Risk Assessments if they can prove that they are able to execute their work in a safe and healthy manner.

2) Contractor will check the arrangements that Sub-contractors / Vendors have in place for managing the Health, Safety and Environment of their employees and protection of other persons not involved in their activities.

3) Sub-contractors to establish their HSE competency include:

- Copies of sub-contractors HSE policy and employers liability Insurance.
- Accident frequency rates for the past three years.
- Method statements for high-risk activities.
- Assessment for control of hazardous substances.

4) Contractor imposes the same level of standards to works by sub-contractors / vendors who are expected to perform to the satisfaction of Contractor in respect of HSE matters. They will be subject to the same monitoring and assurance systems as works carried out directly by Contractor.

5) The relationship between Contractor, sub-contractor and vendors will be no different from the relationship between the employer and Contractor, therefore, the sub-contract agreement requires the sub-contracting party fulfill all HSE obligations, which are undertaken by Contractor in the agreement.

6) Each sub-contractor / vendor will be issued with a copy of the construction HSE procedure together with HSE procedures applicable to their activities.

7) HSE procedures will be discussed at site HSE meetings.

8) Construction management will constantly liaise with sub-contractors / vendors to establish the site HSE requirements of their work and make arrangements for them to work in a safe and healthy manner.

9) Sub-contractors / vendors who do not perform to the satisfaction of Contractor will be subject to penalties and risk removal from the construction site.

7.4.27 HSE Committee.

1) Site HSE committee will be established to monitor the implementation of the construction HSE plan in line with the contractual HSE requirements.

2) Site HSE manager will be the chairman of the site HSE committee meeting and assigned staffs to the construction site will be invited to attend these monthly meetings.

3) Attendees at these meetings will include the Site Manager and other persons from the construction site nominated by the Site Manager and site HSE manager.

4) The function and terms of reference of the site HSE committee are:

- To monitor the adequacy of the HSE plan and ensure its implementation.
- To review emergency and response procedures.
- To promote the contractual HSE requirements at construction site.
- To review results of HSE inspections.
- To determine that required follow up actions have been implemented.

5) Minutes of the HSE committee meeting will be circulated to all concerned parts within 2 day from the meeting date.

6) Site HSE manager will, if necessary, via the Site Manager arrange an extraordinary meeting to discuss any urgent site HSE matters.

7.4.28 HSE Training.

1) Site Manager will ensure that all section parties throughout the construction adopt a suitably structured schedule of site HSE training.

2) Site HSE manager will ensure that suitable ongoing programs for the site HSE training courses are implemented to the construction site, including sub–contractors / vendors.

3) All construction personnel will undergo initial HSE induction training before they commence work at the construction site.

4) Additional training may be necessary as site conditions change or new HSE procedures are introduced.

5) Comprehensive and up to date records of all kind of site HSE training will be kept.

6) Site Manager will be provided with detailed reports of site HSE training carried out on a monthly basis.

7) Site HSE manager will require sub-contractors / vendors to implement site HSE training programs.

7.4.29 Communication and Reporting.

1) Site Manager acknowledges the importance of establishing effective communication procedures on HSE matters throughout the organizational structure of the construction site.

2) Toolbox talk will be conducted weekly by supervisors prior to the start of work. It will include and not limited to, the monthly safety topic, safety advice, safety non-compliances, and incidents occurred along with learning points.

3) Team talks will be conducted prior to starting each task by supervisors. There will be a short discussion with the party about the tasks to be carried out and should include the following:

   - Details of the task and hazards that may arise.
   - Details of risk assessment where applicable.
   - Permit conditions.
   - Work methodology.

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- Personal Protective Equipment requirement.
- Equipment and tools to be used.
- Feedback from the working crew about the method of work.
- Feedback from any safety learning points.

4) Weekly site HSE coordination meetings will be held between the Site Manager, site HSE manager, site superintendent, and section superintendents including sub-contractors / vendors.

5) HSE letters will be circulated to all employees reporting/highlighting any health or safety topic for educational purposes.

6) HSE posters will be designed, produced by Contractor and displayed regularly around the work site in an attempt to increase safety awareness.

7) All employees are encouraged to make HSE suggestions. A form will be made available for this purpose.

8) Site HSE manager will provide a monthly report to the Site Manager the following items will form the base of this report.

- HSE promotion and training undertaken.
- HSE committee and details from other HSE meetings.
- HSE instructions and corrective actions.
- HSE performance of sub-contractors / vendors.

SECTION 7.0 **SAFETY PLAN**

7.4.30 Health, Safety and Environmental Management.

1) Construction site will be subject to Contractor's Health & Safety Management System which acquired certification of OHSAS 18001:2007 (Lloyd's Register Quality Assurance Ltd. January 13th 2009 – January 12th 2012) as follow;

CERTIFICATE OF APPROVAL

This is to certify that the Occupational Health & Safety Management System of:

Daelim Industrial Co., Ltd.
Jongno-gu, Seoul
Korea

has been approved by Lloyd's Register Quality Assurance to the following specification:

OHSAS 18001:2007

The Occupational Health & Safety Management System is applicable to:

Project management, R&D, engineering, design, procurement, supervision, consulting, construction, commissioning and operation, construction management, maintenance and after-servicing for civil, building, housing, plant, electrical, telecommunication, fire fighting, landscaping, dredging, reclamation and structural steel works including site activities on domestic and overseas construction fields.

Approval
Certificate No: SEO 6005437

Original Approval: 13 January 2009

Current Certificate: 13 January 2009

Certificate Expiry: 12 January 2012

Sangkeun Yoo

Issued by: LRQA (Korea) Ltd. for and on behalf of Lloyd's Register Quality Assurance Limited

UKAS
Health and Safety
001

This document is subject to the provision on the reverse
17th Floor, Singsong Bldg. 425 4, Yeouido-dong, Yeongdeungpo-gu, Seoul, 150-010, Korea

SECTION 7.0 SAFETY PLAN

SECTION 7.0 SAFETY PLAN

2) Construction site will be subject to Contractor's Environmental Management System which acquired certification of ISO 14001:2004 (Lloyd's Register Quality Assurance Ltd. October 1st 2008 – September 30th 2011) on November 12th 2003 as follow;

CERTIFICATE OF APPROVAL

This is to certify that the Environmental Management System of

Daelim Industrial Co., Ltd.
Jongno-gu, Seoul
Korea

has been approved by Lloyd's Register Quality Assurance
to the following Environmental Management System Standard

ISO 14001:2004 BS EN ISO 14001:2004 KS A 14001:2004

The Environmental Management System is applicable to

Project management, R&D, engineering, design, procurement, supervision, consulting, construction, commissioning and operation, construction management, maintenance and after-servicing for civil, building, housing, plant, electrical, telecommunication, fire fighting, landscaping, dredging, reclamation and structural steel works including site activities on domestic and overseas construction fields.

Approval
Certificate No. SEO 0032017

Original Approval 12 November 2003
Current Certificate 1 October 2008
Certificate Expiry 30 September 2011

Issued by LRQA (Korea) Ltd. for and on behalf of
Lloyd's Register Quality Assurance Limited

UKAS

3) Also, Contractor will comply with the Client's Environmental Management System(EMS) and Occupational Health and Safety Management System based on ISO 14001 and OHSAS 18001 International Standards. This includes adherence to the Client's Health, Safety and Environmental Policy, Planning, Operation and Implementation, Checking and Corrective Action and Management Review.

7.4.31 HSE Inspection.

1) All construction site personnel are required to carry out continual Health, Safety and Environmental surveillance's as they go about their daily job.

2) Site HSE manager will plan the site HSE inspections. The inspections will be in line with the Client's site inspections procedure & forms.

3) HSE inspections will be carried out using the HSE inspection report form that will be completed by a comprehensive checklist as soon as possible after the inspection. A copy of the inspection results will be distributed to the construction site section parts and sub-contractors / vendors within 24 hours of the inspection.

4) All site HSE checklists / inspection reports will incorporate a follow–up procedure to ensure that any recorded HSE violations have been promptly attended to in a satisfactory manner.

7.4.32 Emergency Preparedness and Response.

1) Any emergency occurring at construction site or a camp may cause serious injuries, loss of life, and extensive damage to property or the environment. These situations may demand adequate rescue and relief measure to handle such events quickly and effectively.

2) The objective of this procedure is to reduce the severity of loss and handle the situation in the best possible ways. It must be clearly understood that it is not a substitute for maintaining good standards of Health, Safety and Environmental requirements.

3) Every person working at construction site must be familiar with the emergency and evacuation procedures. In the event of emergency, such as fire, chemical spillage, land slide, scaffolding collapse, structure collapse or other industrial disaster, worker should be prepared to tackle the emergency and be able to leave their work place in a safe and orderly manner as quickly as possible.

4) Emergency Classification.

- Fire and/or explosion.
- Bomb threat.
- Loss of utilities (water, sewerage services, power, etc.).
- Health epidemic.
- Extreme weather (wind storms, sand storms, tornadoes, etc.).

- Release of hazardous materials.
- Major injuries and large numbers of injured persons.
- Missing persons.

5) Emergency Preparedness.

The basic and essential features of any emergency preparedness are to analyses and plan for the potential risk. This includes:

- Establishing and maintaining effective communications.
- Liaison with local emergency services and authorities.
- Action procedures.
- Appoint of key personnel and specifying their duties and responsibility.
- Emergency response drills.

6) Emergency Response Drills.

Effectiveness and comprehensiveness of emergency procedures must be tested on a routine basis. Drills that reflect the conditions induced from the more likely emergency occurrences must be conducted.

- Plan, coordinate and execute emergency drills that effectively test existing emergency response procedures for all site environments.
- Draw upon the Client support and resources as necessary for effective drills.
- Encourage the Client participation in drills when feasible.
- Basic drills for fire evacuation from site support facilities and offices will be conducted.
- Specific emergency drills (confined space rescue, weather, rescue-the-drowned) will be conducted according to the schedule prepared.
- All emergency drills, exercises and responses to actual incidents will be fully documented and followed by a complete review and when necessary, procedure revision process.
- Initiate any required procedural changes, and initiate the dissemination of any lessons learned through the site HSE program communication system.

7.4.33 HSE Audit.

1) The Plant Q-HSE Team will conduct 12 monthly-based site HSE audits to make it aware, hazards inherent in the construction site activities and to evaluate those hazards.

2) An audit checklist will subject each discipline of the construction HSE

activities to a systematic and critical analysis.

3) A copy of the construction site HSE audit will be sent to the Site Manager.

4) The Plant HSE Team based in Seoul-Korea, will plan and organize site HSE audits to monitor correct implementation of the construction HSE procedure, and compliance with the contractual HSE requirements.

7.4.34 Incident / Accident Reporting and Investigation.

An effective system for the reporting and investigation of incidents / accidents and follow-up to preventive recurrence is one of the importance issues in the site HSE system.

1) 'Incident / Accident Reporting.

All incidents / accidents must be immediately reported to Site Manager, site HSE manager and the Client's Safety officers, when they have the potential for or lead to:

- Fires, explosions.
- Injuries.
- Damage to property.
- Uncontrolled emissions.
- Near Miss.

A report should, after immediate verbal notice, be prepared by the responsible supervisor and reported in writing on the prescribed form to Contractor's line management and to the Client's Loss Prevention Division within twenty-four (24) hours of the occurrence of the incident. The report will serve as a source for the education of the employee to prevent recurrence of similar incident / accident.

2) Incident / Accident Investigation.

All incidents / accidents must be reviewed and analyzed to establish root causes and type of injury, trends and practices.

Investigation will begin promptly after the occurrence of the incidents / accidents. The completed incidents / accidents investigation report will be submitted to the Site Manager within 7 days after the occurrence.

3) Follow-Up.

All incidents / accidents, including investigation results and recommendations, will be discussed with sub-contractor in the site HSE meeting and educated the employees in toolbox meetings.

4) Sanctions.

All personnel working at the construction site both direct employees and sub-contractors are required to follow statutory and the safety requirements at all time. In the event of a person(s) failing to comply with HSE requirements disciplinary action may be taken.

7.4.35 HSE Notice for Corrective Actions.

If the sub-contractor fails or refuses to fulfill his HSE responsibility or to correct unsafe conditions or inadequate practices, he will be ordered by Contractor's site HSE section part to take the necessary corrective action.

When any negligence of HSE and/or inadequate practices is detected, Contractor site HSE section part will immediately advise or instruct the sub-contractor to correct them.

If the sub-contractor fails to heed the instruction or advice or neglects fire precautions described in the work permit, Contractor site HSE section part will issue the letter of instruction for corrective action to the sub-contractor. Unsafe work will be stopped. The work will not be commenced again until corrective actions have been taken.

Sub-contractor's HSE manager who will record and submit one copy of the daily checklist to Contractor's site HSE manager will make daily HSE tour.

7.5 Construction HSE Working Procedure.

7.5.1 Traffic Safety.

1) Employees will comply with all HSE rules and signs regarding traffic and vehicle use including the requirements traffic safety. Vehicles must be parked only in areas approved by the Client.

2) Vehicles/equipment to be driven/operated only by the authorized drivers/operators who have a valid driving license.

3) Transportation of personnel utilizing pick-ups beds are prohibited unless seating with cages is provided for that purpose.

4) Drivers to ensure that any material extending more than one meter beyond the front or rear of the vehicle will have a red flag, fastened at the

end of the load.

5) When parking or leaving the vehicle outside the approved parking areas, the engine will be shut off, the parking break engaged and the key will be left in the car.

6) Permit to work will be obtained prior to entry of Internal Combustion Engines to process areas.

7) Speed limit within the plant is controlled according to site and road condition, but must not exceed maximum 30 Km/hr.

8) All equipment, machinery and tools for use at the job site must be checked, and will be subject to initial and periodic inspection by Contractor. Any equipment, machinery and tools that have not been checked will be removed from the site. Inspection records will be kept by Contractor's and/or sub-contractor's site HSE supervisor.

9) Contractor will schedule and co-ordinate with the Client all heavy traffic to and from the construction location, such that all access ways will be open for emergency vehicles (minimum 3 meters wide clear access). If the above requirement cannot be met, Contractor will contact the Client 72 hours prior to movement of the heavy traffic.

10) The engines of all vehicles and equipment should be stopped during refuelling.

7.5.2 Alcohol and/or Controlled drugs.

1) Alcoholic drinks and/or controlled drugs are prohibited at all times.

2) Anyone found under the influence of, or in possession of, alcohol or drugs will be immediately removed from the site and refused future access.

7.5.3 Smoking.

1) Smoking is not permitted except in specified areas and also smoking inside vehicles on the site is not permitted.

2) Strike anywhere matches and lighters are not allowed in the plant. Cigarette butts should be discarded only in proper receptacles.

3) Smokers should ensure that cigarette butts are extinguished properly before leaving their designated smoking areas.

4) Contractor will post "No Smoking" signs in all non-approved smoking areas.

5) Smoking is not permitted in any buildings.

7.5.4 HSE Signs.

1) All personnel will observe the requirements of all HSE signs at the site.

2) No one will remove safety chain, barrier, and tag or sign unless so directed by the proper authority.

7.5.5 Holographic Equipment and Radios.

1) Holographic equipment (camera, video and etc.) is not permitted on the site without prior approval in writing from the Client.

2) The use of transistor radios, two-way radios, mobile telephones and pack link system inside the plant is not permitted until approved by Contractor and the Client.

7.5.6 Work after Regular Hours.

1) When sub-contractor wishes to work before or after regular hours or on Saturday, Sunday or public holidays, he must have authorization from Contractor.

7.5.7 Temporary Facilities.

1) Contractor will be responsible for the safe operation, upkeep and maintenance of all temporary facilities at the construction site including removal of rubbish and debris and all other services deemed necessary.

7.5.8 Personal Protective Equipment (PPE).

1) General Requirements.

a) Each sub-contractor is totally responsible for providing personal protective equipment for the protection of his employees as needed or requested at site.

b) Safety helmet, safety shoes, and long sleeve shirt/coverall are mandatory.

c) It is also the sub-contractor's responsibility to ensure that his employees are well trained and use properly the personal protective equipment.

d) Work permit will define an additional PPE according to the nature of work and area involved.

e) All PPE items will be of good quality and will be approved by the Client.

2) Head Protection.

a) Safety hats or helmets are rigid headgear made of various materials and designed to protect the head from impact, flying particles, electric shock, or any combination of the three. Each helmet has two parts, a shell and a suspension cradle.

b) Any modification of the safety helmet, especially punching holes in shell, is prohibited.

3) Eye and Face Protection.

a) Protection of the eyes and face by physical or chemical agents is of prime importance in an industrial environment.

b) To select the type of protection will depend on the properties of possibly imposed hazard, but it should be borne in mind that all eye protection and most face protection devices must be considered as optical instruments. They must be selected, fitted, and used with regard to both the type of hazard and the optical condition of the user.

c) Industrial grade safety glasses (with shield) required during working hours in shop or in construction site for following works:

- Welding and cutting.
- Excavation.
- Driving nails.
- Grinding.
- Drilling.
- Sandblasting.
- Painting.

- Safety goggles are to be provided for protection against injuries light rays.

4) Hand Protection.

a) The kind of gloves used depends primarily upon the material or equipment being handled.

b) Gloves should not be used near rotating machinery as they can be caught and trap the hand.

c) Suitable gloves should be worn on most construction work.

5) Foot Protection.

a) The safety shoes or boots are fitted with a metal toe protection and will be worn at all times while working. The toe protection is capable of withstanding both compression and impact loads.

b) Non-slip or studded boots will be worn because of the risk of slipping on grease surfaces. All studs should be non-sparking.

6) Safety harness, Lifelines and Lanyards.

a) Safety harness, lifelines and lanyards should be worn while working elevation is 2 m high from ground or platform level.

b) Lifelines, safety harness and lanyards will be used only for worker safeguarding. Any lifeline, safety harness or lanyard actually subjected to in-service loading, as distinguished from static load testing, will be immediately removed from service and will not be used again for worker safeguarding.

c) Lifelines will be secured above the point of operation to an anchorage or structural member.

7) Safety Nets.

a) When workplaces are more than 7.5 meters above the ground or water surface or other surface and ladders, scaffolds, catch platforms, temporary floors, safety lines or safety harness are not being used, safety nets must be hung with sufficient clearance to prevent contact with the surfaces or structures below.

b) Nets must extend 2.5 meters beyond the edge of the work surface where employees are exposed and must be installed as close under the work surface as practical but in no case more than 7.5 meters below such work surfaces.

8) Respiratory Protection.

a) Where industrial processes create atmospheric contaminant, which may be hazardous to the health of employees, the first consideration always should be the application measures to control the release of the contaminants.

b) In some cases, engineering control measures are not practical and the worker should therefore be supplied with personal respiratory protective equipment.

c) Ventilators, fans, air movers, dust mask or a combination of these should be used in dusty atmospheres.

d) Users of dust masks, breathing air masks and respirators must be fit-tested and trained in their use.

9) Hearing Protection.

a) Protective hearing equipment is to be provided and used in designated areas or for high noise hazard jobs.

b) Devices include disposable earplugs, permanent re-usable earplug, and headbands with rubber inserts and ear protectors.

c) Hearing protection requirement as follows:

Sound Level	Hearing Protection Requirement	Remarks
Below 85 dB (A)	No protection required	
85 ~ 89 dB (A) (Continuous)	Required for work in area that may last more than 4 hours a day	
90 dB (A) (Continuous)	Required for all personnel in area	
90 dB (A) (Intermittent)	Required for person using equipment that creates the excessive noise	

7.5.9 Signs, Signals and Barricades.

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1) Accident Prevention Signs and Tags.

When hazardous work is to be performed, the appropriate signs and symbols must be posted prior to starting work and must be removed or covered promptly when the hazards no longer exist.

a) Danger signs must be used where a hazard exists.

b) Caution signs must be used only to warn against potential hazards or to caution against unsafe practices.

2) Warning Barricades.

a) Warning barricades must be erected and maintained at least two (2) meters from the edge of an excavation or opening.

b) Warning barricades will immediately be removed once the hazard is eliminated.

7.5.10 Fire Protection.

1) General Requirements.

a) All employees will be shown where fire extinguishers are and how to use them.

b) Flammable will be stored in properly labeled containers.

c) Accumulation of trash, oily rags, combustible materials and similar fire hazards of any nature will not be permitted.

d) All welding and cutting torches must be equipped with flame valve.

e) All alleyways, driveways, roads, stairway, ladder and transformers will be kept clear of hazardous material and equipment.

f) Refueling of petrol and diesel equipment will be done only in prescribed areas and with approved equipment. Employees will take all measures to minimize spills and to clean up immediately any spills, which may accidentally occur. Refueling equipment with the engine running is prohibited.

g) The sub-contractor will supply and maintain fire extinguisher and fire fighting equipment, which will be available all times at the construction site and site office. Also will keep up-to-date records of all said equipment.

h) There must be a fire extinguisher, water hose or other fire control equipment easily accessible for welding, cutting, burning or other such operation.

i) Burning of rubbish or any other material at site is strictly prohibited.

j) Do not use fire hydrants or fire hoses/equipment except for fire fighting purpose.

k) During any hot work operation, a pressurized fire hose and fire extinguisher, filled in 10 lb dry chemical powder, must be provided at place of hot work. All of Contractor and sub-contractor's personnel will be properly trained and know how to use such extinguishers and fire hose.

2) Fire Watcher / Stand-by Man Requirement.

a) Fire watcher / stand-by man will be assigned at any work place where any heating, welding, spark and flame producing is involved.

b) The role of a fire watcher / stand by man is an integral part of performing any heating, welding, spark producing activity safely from fire.

c) Each supervisor / foreman is responsible to assign one of his workers with written instruction which shows detail steps he has to take in case of fire.

- How to act by himself.
- How to report.
- Where to report.

d) All workers will be fully oriented with this role when they have an initial safety orientation on their first day work and will be reminded at every toolbox meeting.

e) Site HSE supervisor is responsible to confirm whether this exercise is being well performed. In case of violation, he will stop the work until corrective action takes place.

3) Fire Extinguisher Training Program.

a) All individuals will have a demonstration for how to use fire extinguisher at the initial orientation on his first day of work.
b) Each sub-contractor's HSE supervisor at site will provide additional training to all workers every month.
c) Site HSE supervisor will witness this training session and keep the record.

4) Fire Protection Equipment and Maintenance.

a) Initial Inspection.

All fire protection equipment including fire engine car will be checked by site HSE organization before moving into site. Site HSE supervisor will provide control numbers and will keep record. All fire extinguishers must carry valid sticker (fire extinguisher record) that will be supplied by manufacturer or authorized refill agency.

b) Maintenance and Periodical Inspection.

Site HSE supervisor and sub-contractor's HSE supervisor are responsible to maintain their own fire extinguisher in operational condition. All fire extinguishers will be checked every month and confirmed on each sticker. Site HSE supervisor will check this sticker every three-month and record will be kept. Any extinguisher once used and refilled will be inspected by site HSE supervisor same as initial inspection.

7.5.11 Prevention of Falling Objects.

1) The hand tools should be tied with a cord and attached with belt of the technician.
2) Bins or bags should be provided for storage of nuts, bolts and other small items.
3) A sheet should be laid to cover all gaps and openings, if working above platform having grating on it.
4) Tools. Materials.....etc. should not be thrown from the heights but will be brought down by a rope or crane.
5) The area should be cordon off and no one would be allowed to cross during lifting.
6) Ropes/slings should be inspected each time before use.
7) Suitable arrangement will be made for the people above and below elevations in one location.

7.5.12 Tools (Hand or Power).

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1) General Requirements.

   a) All items placed in tool containers will be properly stored to avoid accidents.
   b) Inspect and ensure that tools are in good condition before use.
   c) All electrical tools and equipment must be properly maintained in good working condition.
   d) Always carry tools in bags/boxes when ascending or descending ladders.
   e) Ensure cable plug sockets and/or connectors are in good condition before use.
   f) Do not try to repair tools if not authorized.
   g) Equipment power switch must be in off position before plugging into power source.
   h) Before using any electric tool, make sure that you are using the correct power supply.
   i) Never stand on wet surface when using electrical equipment.
   j) Keep electrical equipment dry and clean.
   k) Disconnect power from equipment when it is not in use.
   l) Electric power tools should be regularly inspected and maintained by competent electrician.
   m) More check to be carried out if the equipment's are to be used in the wet area.
   n) MARAFIQ Electrical Safety Regulations Procedure will be followed.

2) Pneumatic Tools.

   a) Compressed air should not be used to clean the working space.

   b) Tools must not be modified or the labels and inscriptions defaced or removed. Competent persons must carry out maintenance of pneumatically operated equipment at regular intervals.

3) Tools Guarding.

   a) When power operated tools are designed to accommodate guards, they will be equipped with such guards when in use.

   b) Belts, gears, shafts, pulleys, sprockets, spindles, drums, fly wheels, chains, or other reciprocating, rotating or moving parts of equipment must be guarded if such are exposed to contact by employees.

   c) Each worker must satisfy himself that all tools and equipment to be used by him are in good condition and appropriate for the job, which they are to be used on.

7.5.13 Cranes and Lifting Equipment.

1) General Requirements.

a) All cranes and lifting equipment will be maintained and inspected with manufacturer's recommendation, the Client's requirement and applicable regulation by the law.

b) To maintain and inspect cranes and lifting equipment to ensure their safe condition is heavy equipment superintendent / related section superintendent responsibility with the assistance of HSE supervisor at each level (Contractor and sub-contractor).

c) Based on certain criteria under the Client's Lifting Equipment Procedure (SP # 04), a lifting plan will be reviewed/approved by the Client.

d) Any lifting equipment like cranes, forklifts, loose lifting tackles – slings, shackles, chain pulley blocks, etc. will not be used without being tested and certified by a recognized third party.

e) A guide rope (tag line) will be used to control objects while lifting.

f) Working/lifting area will be barricaded.

g) Supervisor is aware of the scope.

h) Permit to work certificate will be obtained prior to start the job.

2) Inspection.

a) Initial Inspection.

When any crane or lifting equipment is mobilized to site it will be checked and inspected by Contractor's heavy equipment superintendent / related section superintendent in witness of site HSE supervisor.

b) Daily Checking by Operator.

Operator for each crane and lifting equipment will check his equipment prior to start work using prearranged checklist and maintain the record with his equipment.

c) Monthly Inspection.

Contractor's heavy equipment superintendent / related section superintendent will inspect all equipment on a monthly basis with the assistance of the Client and keep the record.

d) Maintenance.

e) Heavy equipment superintendent / related section superintendent is responsible for maintenance of cranes and lifting equipment.

f) Heavy equipment superintendent / related section superintendent will keep maintenance record for all equipment.

3) Operator.

a) All operators for cranes and lifting equipment will have a valid operator license and will be fully competent to the particular type of crane to which he is assigned.

b) Heavy equipment superintendent / related section superintendent will ensure that all operators are physically fit and mentally sound with assistance of each supervisor. If any operator shows any sign of illness, he will be removed from crane and/or lifting equipment.

c) A crane operator can operate the crane that he has been authorized to operate by Heavy equipment superintendent / related section superintendent.

d) List of crane operators with relevant information will be maintained and will be provided to the Client's supervisor every month.

4) Crane Safety Device.

a) All mobile crane and lifting equipment will be in compliance with manufacturer's recommended safety device.

b) All mobile cranes will be fitted with the manufacturer's loading chart inside the cab where it can be easily found.

7.5.14 Excavation and Trenching.

1) Excavations such as ditches, trenches or holes will be sloped sufficiently to prevent cave-in or slide. If sloping is impractical, shoring will be used whenever the vertical dimension exceeds 1.2 meters.

2) Worker removing shoring after completion of work will not be in the bottom of the excavation. Shoring will be removed in a manner to prevent cave-in on worker.

3) Barricades, handrails, signals or other appropriate warning devices to protect worker from any hazardous operation or excavation will be provided. Open trenches, excavations, etc., will be covered when handrails or barricades do not provide adequate protection.

4) Grade lines, ropes, chains, and other tripping hazards will be sufficiently marked to be clearly visible in the day or night.

5) Excavation by powered equipment is prohibited closer than 1.2 meters to any underground cable. Tiles covering electric cables will not be removed without prior approval.

6) Obstacles, cables and piping located underground will be marked, i.e. physically identified, in the field and will be updated on drawings of underground.

7) Ground water will be removed from and kept out of the bottoms of all trenches and excavations.

8) Access / egress will be provided such that no greater than 8 meters is required for coming out from the excavated trench when working inside trench.

7.5.15 Concrete Forms and Shoring.

1) Form work and shoring will be designed, erected, supported, braced and maintained so that it will safely support all vertical and lateral loads that may be imposed upon it during placement of concrete.

2) Stripped forms and shoring will be removed and stockpiled promptly after stripping, in all areas in which persons are required to work or pass. Protruding nails, wire ties, and other form accessories not necessary to subsequent work will be pulled and cut or other means taken to eliminate the hazard.

3) Imposition of any construction loads on the partially completed structure will not be permitted unless such loading has been considered in the design and approved by the field supervisor.

7.5.16 Floor and Wall Openings, and Stairways.

1) Floor and Wall Openings.

a) All floor, grating or roof openings will be covered with planks so as to carry safe load which may be required to be supported thereon, or will be fenced in all sides by a standard railing and toe board.

2) Guarding of Open-sided Floor and Platforms.

a) Standard guardrails and toe boards must guard every open-sided floor or platform 1.8 meters or more above adjacent floor or ground level.

b) Regardless of height, open-sided floors, walkways, platforms, or runways above or adjacent to dangerous equipment, pickling or galvanizing tanks, degreasing units and similar hazards must be guarded with a standard railing and toe board.

3) Guardrails, Stair, Railings and Toe Boards.

a) A standard railing will consist of top rail, intermediate rail, toe board, and posts, and will have a vertical height of approximately 1 meter from upper surface of top rail to floor, platform, runway, or ramp level. The top rail will be smooth surfaced throughout the length of the railing. The intermediate rail will be halfway between the top rail and the floor, platform, runway, or ramp. Minimum requirements for standard railing under various types of construction are as follows;

b) Stairs and Stairways.

- On all structures, two or more floors (6 meters or over) in height, stairways, ladders, or ramps, will be provided for employees during the construction period.
- Debris, slippery and other loose materials will not be allowed on or under stairways.
- Stairs will be installed at angles to the horizontal of between 30 and 50.
- Rise height and tread width will be uniform throughout any flight of stairs including any foundation structure used as one or more treads of the stairs.
- Stairways having one or both open sides will have a stair railing along the open side or sides.

7.5.17 Scaffolding and Ladders.

1) Scaffolding.

a) All scaffolds will be erected and inspected in strict conformity with the Specification, Code and the Client's procedure, and the appropriate records maintained.

b) Inspect scaffolding prior to use. Use only scaffolding that is certified for use with a green tag.

c) Do not overload scaffold and distribute the load.

d) All overhead scaffolds and suspended loads must be properly secured and scaffold boards and/or cat ladder must be used when working on roofs.

e) Aluminium alloy scaffolding and ladders may not be used. Metal tube scaffolding is required.

f) Any scaffolding erection exceeding 40 meters in height requires professional engineer's design.

g) Sufficient base plates will be provided for all scaffolds erected on filled or otherwise soft ground.

h) Scaffolds will be plumb and level at all times.

i) Scaffold will not be used as material hoist towers, for mounting derricks or to support pipe or equipment.

j) Regular inspection for the scaffold will be conducted prior to using.

k) The frequency of inspection will be seven (7) days as per the Client's procedure.

l) Scaffolding will be modified only by qualified scaffolders.

2) Mobile and Tower Scaffolds.

a) Mobile scaffold's height greater than the times the minimum base dimension will be guyed or tied off while being used.

b) Mobile scaffold will be used on flat level surface and have four (4) wheels locked to ensure the stability of the scaffolds.

c) Caster brakes will be locked when not in motion.

d) Tower will be free of workers, material and equipment before being moved.

e) Surface over which tower scaffolding is being moved will be cleaned of rubble of material that could cause the tower to tip over.

3) Suspended Scaffolding.

a) The suspended support will be electrically insulated when welding is to be performed to guard against arcing and subsequent failure.

b) Worker on suspended scaffolds work platforms must use independent safety lines and safety harness/ lanyards.

c) Scaffold fittings (i.e. joints, pipes....etc) will be lowered by hands or rope safely.

4) Ladders.

a) All ladders will be made of the proper material and be in good condition.

b) Inspect ladders before use and report any defects. Do not use defective ladders.

c) Make sure that ladders are tied near the top or arrangement must be made to prevent the ladder from slipping outwards or sideways.

d) The foot of the ladder should be supported on a firm level surface and should not rest on a drum or a box or any unsteady base to get extra height.

e) Place the ladder at a suitable angle (75°) to minimize the risk of it slipping outwards (one meter out for every four (4) meters in height).

f) Rest the top of the ladder against a solid surface.

g) Use both hands when ascending or descending a ladder, use tool bags for lifting tools.

h) Do not over reach from a ladder, always move it.

i) Ensure firm grip of hands and feet before moving on to the next step to avoid slipping.

j) Area around top and base of the ladder must be free from tripping hazard.

k) The ladder is of suitable quality for industrial use.

5) Step Ladders.

a) Always open fully, set level on all four feet, and lock spreaders in place. Do not use like a straight ladder.

b) Do not place tools or material on steps or platform.

c) Get specific approval before using two-man stepladders.

d) Must be tied off under certain conditions.

7.5.18 Structural Steel Erection.

1) Personal Protection.

a) In all structures, all employees exposed to hazard more than 2 m high will wear safety harnesses. When the use of safety harness is not appropriate due to the hazard of being pinched or struck by incoming steel, connectors will be only permitted to unhook their safety harness during the actual receiving and positioning of structural members.

b) Safety nets are only an acceptable substitute for safety harness when the use of safety harness is impractical. When safety nets are used, they will generally be used on the interior of the structure only. Lifeline will be installed along the perimeter and within the structure whenever employees are exposed.

c) For the protection of other crafts, signs and barricades will be installed at the area where the erection of steel is in progress.

2) Rigging.

a) A competent worker prior to initial use at the site will inspect rigging equipment and monthly thereafter to ensure that it is safe.

b) Damaged rigging equipment will be removed from service immediately.

c) Riggers must be qualified to rig and signal.

7.5.19 Welding and Cutting.

1) Welding or cutting torches and hoses will not be connected to cylinders when stored in any enclosure or building. When work is shut down and hoses disconnected all valves at the gas and oxygen cylinders must be closed.

2) Permit to work will be obtained prior to start the hot work.

3) The initial cut on the pipes, etc. will be done in the presence of the area operator.

4) Ensure that personnel executing the work are wearing PPE according to job requirement.

5) Ensure that welding machines must be inspected and in good working condition.

6) Gas cylinders will be equipped with flash back arrestor between regulator and hoses and check valve between torch & hose.

7) Ensure that regulators are used properly and gauges are checked and calibrated.

8) Keep hoses clear from traffic lanes.

9) Open the valve slowly and check for leaks before commencement of work.

10) Gas and oxygen cylinders will be handled with care, properly supported in an upright position away from any source of heat or flames and securely tied-off. All cylinders not in use will have the protective valve cap in place, will be vertically secured, and be stored outside the work area.

11) Oxygen cylinders in storage and not in use will be separated from gas cylinders by a fire retardant partition or a minimum distance of 6 meters.

12) When gas and oxygen cylinders are lifted, hoisting equipment a basket cradle or similar handling device will be used.

13) When oxygen or gas cylinders are transported, protective valve caps will be in place and valves will be closed.

14) Special care (use of welding blankets) will be taken during overhead cutting and welding operations to safeguard the worker and prevent falling sparks from starting a fire or causing damage. Warning signs will be posted around and at each level below the area of overhead welding or burning operation. Fire extinguishers will be ready and available, and the plant approved fire hoses must be attached to firewater hydrants ready for use.

15) Fire watcher / stand-by man, fire watchers are established when welding, burning, cutting, grinding or other spark-producing activities are planned in an area where flammable materials may be present, or where there is the possibility of flammable materials being released.

16) Gas and oxygen cylinders will be used only when secured on a cylinder carrier. Loose cylinders will never be used.

17) Ensure that all cylinders are labelled with its correct contents.

18) Gas cylinders never to be vented into the atmosphere.

19) Protect cylinders from heat, chemicals, flammable liquids or fumes, or corrosive materials.

20) Oxygen cylinders and equipment will be kept free from oil or grease.

21) Gas and oxygen cylinders will not be taken into confined spaces.

22) Gas and oxygen cylinders will be provided with turn-off wrench during use.

23) Must check that regulator is well fitted to cylinder.

24) Do not use matches or cigarettes to light a torch.

25) Do not use compressed gas to clean your clothing, blow out cinch anchor holes or otherwise clean your working area.

26) Gas cylinders will be handled with care and will not be dropped.

27) Gas cylinders will not be misused as rollers, support or for any other

similar purpose.

28) Oxygen and gas cylinders must be transferred to a designated location away from operating units and tank farms after working hours.

29) Welding cables and oxygen gas hoses will be inspected regularly. The hoses will be fitted by means of tight hose clamps.

30) The ground cable will be attached as close as possible to the work piece by means of a clamp. The ground cable will not be attached to an existing installation or apparatus. Welding of the ground cable is forbidden.

31) Welder and his helpers must use adequate eye and face protection while welding. Welding shields (curtains) must be used to protect the eyes of nearby workers from flash-burn exposure.

32) When not in use, diesel welding machines, generators, and transformers must be turned off. When in use they must be protected by suitable covers for general protection. Refueling will be done with machines turned off.

33) When employees are working with welding and cutting equipment, adequate ventilation has to be furnished.

34) All combustible material in the vicinity of the welding or cutting operation must be removed, or if this is not possible be covered by fire resistant materials.

35) The work area must be kept clean and all wooden, combustible material must be removed.

36) Electric welding will never be performed from a metal ladder.

7.5.20 Electrical Work.

1) Qualified and experienced workers will perform all electrical works. And equipment will be locked or secured to prevent starting by unauthorized person.

2) A padlock will be used to hold an electrical switch or handle in the de-energized position.

3) A tag ("**Danger – Do Not Operate This Switch**") will be attached to each lock for prevention from careless touch.

4) Warning signs or posters, such as "**Danger**", "**No Entry**", "**Do Not Touch**", etc., will be posted at dangerous places, such as substations, switch boxes, and overhead or underground cable.

5) Electrical parts to be used will be in good condition, including cords for connection. The extension and outlets to connect tools have to be polarized.

6) Transformer banks or high voltage equipment will be barricaded with a fence. The entrance will be locked.

7) Circuit Breakers will be provided for all electrical equipment, to prevent worker from being injured by electrical shock.

8) Temporary switch boxes will be installed in the space provided with a waterproof roof and door, which can be locked. Switch boxes will be grounded with vinyl-insulated copper wire.

9) Before welding machines are used, insulation will be tested and certified to be in safe operating conditions. Automatic anti-electric discharge devices will be provided for all welding machines. All exposed terminals will be covered safely with insulation tape. Welding machine will be grounded.

10) To prevent a short circuit or electric discharge, special precautions, such as grounding, will be taken for wiring work where metal scaffolds or steel structures are erected. Grounding will be secured by connecting the wire to on earth and buried firmly in the ground.

7.5.21 Abrasive Blasting.

1) Abrasives are shattered and pulverized during blasting operations and the dust formed will contain particles of respiratory size. Therefore, the concentration of respiratory dust in the breathing zone of the abrasive blasting operator or any other workers must be kept below toxic levels. Testing will determine the required respiratory protection.

2) Aisles and walkways must be kept clear of steel shot or similar abrasive, which may create a slipping hazard. Dust from abrasive operations will not be permitted to accumulate on floors and will be cleaned up promptly.

3) Sand or shot blasting areas, when possible, are to be prepared to minimize dust hazards to other workers.

4) Blasters will be equipped with heavy canvas or leather gloves and aprons or equivalent protection to protect them from the impact of abrasives.

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5) Equipment for protection of the eyes and face will be supplied to the operator when the respirator design does not provide such protection, and to any other workers working in the vicinity of the abrasive blasting operations.

7.5.22 Pressure Testing.

1) It is essential that safe practices are observed during testing since this can be a hazardous procedure. Stresses are high in the item being tested; there is the danger of air pockets with the subsequent risk of explosion.

2) The person in charge of testing should have read the test procedure and instruction prepared in site office. All persons who will work on the test must be informed of the hazards and the necessary precautions.

3) No one should be allowed near equipment under test when the pressure is near the yield strength or when test pressures of over 35 kg/cm^2 are being applied.

4) The rate of pressure increase must not exceed 7 kg/cm^2 per minute.

5) Smoking and other sources of ignition should not be permitted in the immediate area when testing with a flammable liquid.

6) When draining test fluid, the vessel should be vented slowly to avoid excessive vacuum.

7) Oxygen lines must be flushed of all traces of hydrocarbons before introducing oxygen.

7.5.23 Confined Space Entry.

1) The environment within the Confined Space will be checked for adequate oxygen levels each day before persons are allowed to enter.

2) Any work inside a confined space will be carried out according to the Client's Confined Space Entry Procedure (SP # 07).

3) No one is allowed to enter a confined space, unless permit to work certificates are issued and all safety requirements mentioned in the safety permit have been met.

4) Only appointed workers are allowed to enter confined space.

5) Ensure all personnel protective equipment are inspected and is in good working condition.

6) Ensure the entry attendant and the watchman is fully aware of their responsibilities.

7) Ensure that permit to work certificates is valid and displayed at job location.

8) If work is stopped for any reason and the confined space is vacated, "NO ENTRY" sign will be displayed on the entrance of the confined space, i.e. Column, Vessel, Tank, etc.

9) Stand-by man will be trained and certified by the Client.

10) Gas cylinders are not allowed inside the confined space.

11) Whenever safety glasses are required, clear lenses will be used inside the confined space.

12) For welding activities inside the confined space, local or forced-air ventilation will be used.

7.5.24 Hot Tapping and Tie-in to Active Equipment.

1) This is the process of cutting and tying-in a coupon in a pipe, tanks or vessel wall while that equipment is in service or operation, so it is very high-risk and sophisticated job in an operating area.

2) Later these hot tapping and tie-in procedures will be developed and fixed at job site through discussion with the Client and Contractor.

7.5.25 Handling of Chemicals.

There may not be any specific chemicals to be handled by Contractor and sub-contractors but in case of handling maximum care will be exercised and MSDS (Material Safety Data Sheet) will be maintained by site HSE supervisor with a copy to the Client.

1) Before handling any chemicals, it is essential to know its properties and follow the proper precaution / procedure.

2) All chemicals will be stored in appropriate containers with proper labels.

3) Hazardous chemicals must be effectively isolated to avoid contamination.

Incompatible materials must not be stored in the same area.

4) All employees must be aware that many of these chemicals are potential fire, explosion hazards and/or health hazards.

7.5.26 Material Safety Data Sheet (MSDS).

1) When any hazardous substance is procured, used, stored, or disposed, MSDS for the substances will be available. Supplier will provide MSDS.

2) Information contained in the MSDS will be incorporated in the hazard analyses for the activities in which the material will be used and will be followed in the use, storage, and disposal of the material and the selection of hazard control and emergency response measures.

3) All employees using, storing, or disposing of hazardous substances will receive training in the information contained in the MSDS for the substance and any general occupational health and safety instruction required understanding this instruction.

7.5.27 Road Closures.

1) General.

The purpose of this plan is to cover the occasions, when it may become necessary to temporarily close any road during construction. Discretion and other reasonable alternative must be considered before exercising this activity.

2) Objective.

a) To ensure the safety and security of the personnel and equipment are maintained during periods of a road closure.

b) To provide mechanisms to inform appropriate organization of a road closure including the Client.

c) To provide a consistent method of obtaining road closure concurrence from designated personnel / section departments.

d) To provide the availability to overview and coordinate to the Client and security department in the event of multiple road closure requests.

3) Procedures.

a) Planning and scheduling.

A concerted planning and scheduling effort by site HSE supervisor and the related Superintendent must be made to ensure that the elapsed time of closing road is held to a minimum.

b) Barricades and signs.

The temporary installation of barricades, flashing lights, detour signs, etc. to identify the road closure area should be considered and installed under direction of site HSE supervisor with support by each superintendent as required.

c) Communication to other organization.

For a road closure Contractor's Site Manager must communicate to the Client's Site Representative in writing with follows.

- Reason of road closure.
- Precautionary measures to be taken.
- A drawing is required to identify the location of road closure and alternate routes. Routing of emergency equipment, ambulance and fire truck is of prime consideration.
- Location of road closure.
- Date(s) and time(s) of road closure and opening of the roadway.

7.5.28 Work Permit System.

1) General Requirements.

a) Contractor will initiate and maintain work permits and system as may be necessary to comply with requirements set forth by the appropriate occupational safety and health agency and any other local, provincial and national regulation.

b) Contractor will provide all permits prior to commencement of work at the site. If safety and health permits are not required to perform work, a letter will be submitted to the Client prior to commencement of work at the site stating that no permits are required.

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c) Each supervisor / foreman is responsible for getting a valid work permit for his own work.

d) Management is responsible to provide enough numbers of work permit receiver to allow each supervisor / foreman to proceed his work smoothly.

e) No work will be allowed without a valid work permit.

2) Definition.

a) Work Permit.

A written document authorizing a person or a group to perform an identified work subject to specific conditions and precautions.

b) 'Safety Work (Cold Work).

Safety work is any work which is not hazardous in nature, will not generate heat that can cause ignition or flammable, and will not involve personnel exposure to hazardous or toxic substances or any other hazardous conditions.

c) Hazardous Work.

Hazardous work is any work that is hazardous in nature, can generate heat that can cause ignition of flammables, and can involve personnel exposure to hazardous or toxic substances or any other hazardous conditions.

d) Hot Work.

Hot work is any work that involves open flames sparks or can generate sufficient heat or energy to act as source of ignition.

3) Procedures.

a) Authorization.

All work performed by Contractor and sub-contractor will require in advance a work authorization by the Client in charge of the respective area. The work authorization will be one of the following;

i) Verbal Authorization.

Verbal authorization will be given only for work, which is external in scope to the process equipment and does not involve any hazard or - exposure to personnel.

- Observation of Equipment.
- Taking Measurements
- Obtaining Reading "Temperature, Pressure, etc."

ii) Safe Work Permit (Cold Work Permit).

A safe work permit will be required for all safe work and a safe work permit may require equipment to be electrically locked or mechanically isolated.

- Adjusting instrument.
- Using Basic Hand Tools or Hand Impact Tools.
- Inspection.

iii) Hazardous Work Permit.

Hazardous work permit will be required for any work not classified as safe work. Examples of hazardous work are ;

- Hot work (welding, cutting, open flames, operation of internal combustion engines, opening of explosion proof enclosures, etc.).
- 'Confined space entry.
- 'Other work involving exposure to high temperature, high pressures, rotating or moving equipment, toxic or hazardous substances, and work in hazardous areas such as over water or extreme heights, etc.
- Work involving the use of, or possible exposure to, radioactive sources.

b) Issuance of Work Permits.

i) Work Permits will be issued and controlled by the Client's operating department responsible for the unit or area. Each work permit identifies areas and job title of control for issuance of work permits. Anyone desiring to perform work within a given area will obtain the proper permit from authorized personnel of the respective area.

ii) Only one work permit will be issued for each job. Work performed on single equipment involving more than one work group can be considered as one job if it can be covered with one work permit and that all safety requirements for all work groups are the same or can be covered with one work permit. Different locations or equipment will require different work permits. In cases where more than one workman (from the same work group) is working on the equipment, one authorized representative will be responsible for accepting and signing off the safe work permit on behalf of his co-workers. In cases where more than one work group is working on the equipment, one authorized representative from the groups will be responsible for accepting and signing off the safe work permit on behalf of all work groups.

4) Accepting the Work Permit.

Work Permits will be accepted only by the authorized Contractor or sub-contractor personnel who have successfully completed the Client training program on work permit system. It is the responsibility of the authorized person accepting the permit to do the following:

a) Review with issuing personnel the hazards associated with the job and any special instructions or precautions listed on the work permit dealing with the type of work to be done. Verify the safeguards are observed during the course of the work.

b) Abide by the pre-set conditions on the work permit.

c) Remain in the area so that he is readily available to the issuer and the workmen on the job. If the acceptor leaves the area, another authorized acceptor must endorse the permit, or the permit becomes invalid.

d) Immediately notify issuing personnel of any noted changes in work site conditions that would make the permit invalid and stop work.

e) Clean up the work area and notify issuing personnel when work has been completed. The acceptor must visit the job site with issuer to sign off the work permit.

f) Ensure that work starts at the job site within two hours from the time the work permit is issued. If work does not start within two hours, work permit becomes invalid and a new work permit is required to start the job.

g) Special care covering all aspects of safety for a restricted area or a part of the plant facilities will be necessary when hydrocarbons and energy / utilities are introduced into part of the plant. It is up to Contractor to install a system of written work permits and safety wise supervised activities.

5) Posting of Work Permit.

Once a work permit is issued, the rigid hard copy will be posted in visible location at the immediate work site and will remain posted at the work site until work is completed, the permit expires or the permit has been revoked, whichever comes first. The original will be posted in the control room or designated area until the work is completed.

6) Time Keeping.

When sub-contractor wishes to work before or after regular hours or on Saturday, Sunday or Public Holidays, he must have authorization from Contractor.

7.5.29 First Aid.

1) When the Client does not provide first aid facilities or when Contractor and sub-contractor are not allowed to use the Client facilities, Contractor and sub-contractors will provide their own first aid facilities.

2) The paramedical facilities for first aid purposes, supplied and maintained by Contractor on the construction site, will be equipped and maintained to the standards required by applicable legislation.

3) The sub-contractor on the construction site must have at least one member of his employees full qualified as a first aid helper. This person must be present on the site at all times the Sub-contractor has employees working on the site.

4) If the Sub-contractors have only a very limited number of employees working on site, they may at the discretion of Site Manager of Contractor, agree with another firm at the site to combine their first aid program.

5) In the event that immediately medical aid is required, call the Central First Aid Centre and indicate clearly location and nature of accident and protect the injured against any further injury.

6) No person without First Aid training will treat the injured person.

7.5.30 Environmental Management.

1) General Requirements.

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Contractor is responsible for all levels of HSE Management Control to conduct operations in accordance with applicable laws and regulations, including those relating to the health of employees, the environment, and the use of toxic or hazardous substances.

a) Contractor will manage the environment according to Contractor's Environmental Management System which acquired certification of ISO 14001:2004 (Lloyd's Register Quality Assurance Ltd. November 12th 2003 – September 30th 2011) on November 12th 2003.

b) Contractor will develop an Environmental Management plan for the implementation phase to ensure proper disposal of water, (in particular test water used for hydraulic testing of piping systems and tanks,) soil, waste and scrap material is undertaken.

c) Sub-contractor will arrange for cleaning and sanitation of their workplace and will daily clear all waste. Sub-contractor is responsible for the quality of the separation of waste.

d) Sub-contractor will arrange disposal of waste through qualified companies and provide Contractor with the required information for registration.

e) Contractor will provide hygienic facilities for food consumption.

2) Waste Control.

The Site Waste Control will include a strategy for managing waste based on the principles of "**Reduction - Reuse - Recycle – Recover**". The storage, transportation and disposal measures to avoid or minimize potential adverse impacts associated with waste arising from the construction of the facility.

Site HSE supervisor will ensure the followings:

- Handling and storage of waste in accordance with the applicable procedures and Local legislation.
- All debris will be transported in an enclosed truck to the sanitary landfill.
- Stored waste is not accessible to unauthorized persons.
- ' Sub-contractor will maintain a register of toxic or hazardous substances.
- Waste registration includes the type, quantity, composition, source of origin, location of destination, and method of transport as a minimum.
- 'Sub-contractor will provide a sufficient number of metal containers to store trash and debris resulting from their operations.

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3) Noise and Vibration Control.

Noise emissions from construction sites can be minimized through good site practice, selecting quiet plant and quiet working methods and through the use of temporary barriers. To reduce impact of noise to the residential area from operation of vehicles and equipment for site, the speed of vehicles and other equipment will be limited and noise from operation of the equipment will be minimized.

Site HSE supervisor will ensure the followings:

- Sub-contractor will only use routes prescribed by Contractor.
- Piling will only be performed during day shift on regular workdays.
- Noise levels will not exceed the legal acceptable level.
- Engines and other equipment will be run for strictly necessary period.
- Noise operations exceeding normal working hours are restricted and require written approval of Site Manager.
- In general, noise barriers located between noisy construction activities and noise sensitive receivers can provide noise reduction form screening. Movable noise barriers can be located close to noisy plant or between noisy construction activities and noise sensitive receivers in order to achieve a certain level of noise reduction.
- Explosion works produce noise and vibration. The preventive measure will be taken. Selection of proper grade of explosives and limit of using amount will be assured. When blasting, it is good practice to give local residence advanced warning of blasting periods, and use screen, curtains and/or mats whenever possible.

4) Chemicals.

For the process that generates chemical waste, it may be possible to find alternatives that generate reduced quantities or even no chemical waste, or less dangerous types of chemical waste. The management of chemical waste causes number of problems in practice.

Site HSE supervisor will be advised about all chemicals to be used during the construction.

All applicable specifications and/or MSDS for Chemicals will be handed over to site HSE supervisor.

- The chemicals will be properly packed and labeled.
- Safety and sound transport and storage will be guaranteed.
- When working with chemical substances, protective clothing and equipment will be used as specified in the MSDS.

- The removal and processing of process waste is tied to regulations and legislation.
- Small dangerous waste materials such as batteries, carbon cartridges etc. are considered as environmental damaging materials. Sub-contractor will collect dangerous waste separately and dispose in accordance with the applicable procedures and local legislation.

5) Water Quality Control.

Contractor will, at its expense, provide suitable facilities to prevent the introduction of any substances or materials into any steam, lake or other body of water, which may pollute the water or injure marine or aquatic life.

- Qualified sub-contractors employees will supervise the handling of scavengers and inhibitors during make-up of the water for hydro-testing purposes constantly.
- ' Site Manager will only allow disposal of water containing additives.
- Mitigation measures may include the use of sediment traps, wheel washing facilities for vehicles leaving the site, adequate maintenance of drainage systems to prevent flooding and overflow sewage collection and treatment.

6) Contamination Control (Air and Soil).

a) Contractor will perform its work as not to discharge into the atmosphere from any source smoke, dust, or other air contaminants in violation of the Laws, rules and regulations of the governmental entities having jurisdiction.

b) Sub-contractor is obliged to avoid all contamination of soil and/or air due to product such as fuels, gases, lube oil, paints etc. which cause pollution of the environment.

c) Sub-contractor will take all possible precautions and will handle and store all chemicals in the most suitable way with regard to the environmental aspects.

d) Contamination of soil or water or air will be immediately reported to Site Manager. Sub-contractor will stop and minimize the emission and take corrective measures in accordance with the applicable rules, regulations and legislation.

7) Dust Control.

a) Contractor, for duration of the construction stage, will maintain all excavations, embankments, haul roads, plant sites, waste disposal areas, borrow areas, and all other work areas free from dust, as determined by the Client.

b) Industry-accepted methods of dust control suitable for the area involved, such as sprinkling, chemical treatment, light bituminous treatment or similar methods will be permitted. There will be no cost to the Client for dust control required of Contractor.

8) Discharge of Hazardous Material.

a) Contractor will not, under any circumstances, cause or permit, in connection with the work to be performed hereunder, the discharge, emission or release of any hazardous material.

b) Contractor will comply with all legal regulatory requirements applicable to the work. Contractor will submit to the Client Material Safety Data Sheets (MSDS) as required by applicable Law.

c) Contractor warrants full compliance and that it will adhere to all applicable Hazardous Material procedures, if necessary, and obtain or arrange for at its expense all identification numbers, permits, applications and other things required in connection with the relevant activities under the Contact.

d) Contractor may report to the appropriate Governmental Authorities all discharges, releases and spills of hazardous substances and/or wastes required to be reported by Law and to immediately notify the Client of the same.

9) Cleaning Site.

a) Contractor will at all times keep the site free from accumulation of waste, including sanitary waste, demolition debris, construction debris, office waste and wastes related to the construction, testing and pre-commissioning of the facility and equipment. All paved areas will be broom-swept at least once every workday.

b) Upon completion of the work, Contractor will promptly arrange unused materials and remove the surplus materials from the site to lay-down area and the vicinity clean, safe and ready for use.

c) Housekeeping inspection will be carried out on regular basis.

7.5.31 Site Security Plan.

1) General.

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a) Contractor will provide security and surveillance services at the site, and will be solely responsible for any theft, loss or vandalism that occurs at the site and/or lay-down area and any consequent delay as a result thereof. Such will not be considered a Force Majeure Excused Event.

b) Site Manager will arrange for site security and effective plant protection and will carry out regular reviews with all personnel of the construction management team on the effectiveness of the security arrangements.

c) The major fires and stolen materials on construction sites not only require replacing with the additional associated costs but will also have a severe affect on construction schedule.

d) Effective 24-hour security with regular patrols will assist in preventing major fires and theft of plant, materials and associated equipment.

e) No unauthorized persons will have access to the construction site at any time.

f) Contractor will be solely and entirely responsible for the safety and security of the work from the commencement date until the date of substantial completion. Upon the date of substantial completion, the Client will take over the responsibility for safety and security except for Contractor's temporary facilities and any Contractor's assistance required by the Client.

2) Plant Protection.

For effective plant protection the followings are to be done as a minimum:

a) Warehouse, storage of equipment, waste-tipping areas is to be arranged.

b) Vehicle route, especially emergency vehicles, and vehicle parking are to be established.

c) Site speed limit with relevant signs is to be introduced at site.

3) Traffic and Pedestrian Control.

a) Site Admittance.

SECTION 7.0 SAFETY PLAN

- Erection of temporary fences to enclose restricted areas and to separate existing operational facilities.
- Erection of fencing will conform to the Company's requirement accordingly.
- No one will be allowed to enter site and camp areas without valid identification or properly badge.
- All visitors will be issued temporary badges.

b) Personnel Control.

i) The security officer will issue the identification badges to all site personnel and each personnel must wear upon their clothing, showing:

- Personal Photograph.
- Name of the individual, and assigned number.
- Name of Employer.

ii) The security officer must maintain the control records. The record includes followings as a minimum:

- The badge number.
- The name of person.
- The date of issued.
- Valid period.
- Induction course record.

c) Visitor Control.

i) All visitors must report to the Security Station.

ii) The guard will proceed as follows:

- Request identification.
- Request the purpose of visit and the name of the person that the visitor
  wishes to visit.
- Notify the person to determine whether the person meet the visitor or not.
- Request visitor's signature in the Visitor's Register.
- Check the visitor listing to determine if the visitor will be allowed on the site 'without escort. If visitor is to be escorted, he must wait at the security station 'until escort arrives.

- Issue the visitor's badge and safety helmet, as required.

iii) When the visitor returns to the security station to leave, the guard will proceed as follows:

- Log the time-out on the Visitor's Register.
- Recover the visitor's badge.
- Recover the safety helmet if issued.

iv) At the end of the normal working hours, the guard will check the Visitor Register if any visitor is still on the site. If the guard is not able to find the visitor's location, he should notify the security officer.

d) Vehicle Control.

i) 'All vehicles entry / exit must report to the Security Station.

ii) 'The Vehicle entry / exit log includes followings:

- Vehicle Registration Number.
- Client name.
- Number of persons in the vehicle.
- Shipping materials and brief description of the load.
- Consigned person or department.
- Time in and out.
- Material gate pass number for material leaving the site.
- Security guards signature.

e) Security System.

i) Prohibition of photography except appointed person who has a valid permission.
ii) Information to all sub-contractors on the security systems.
iii) Information to all persons about the consequence of violating the security arrangements.
iv) Immediate notification to the Client of all theft and security violations.

7.6 Appendices

SECTION 7.0 SAFETY PLAN

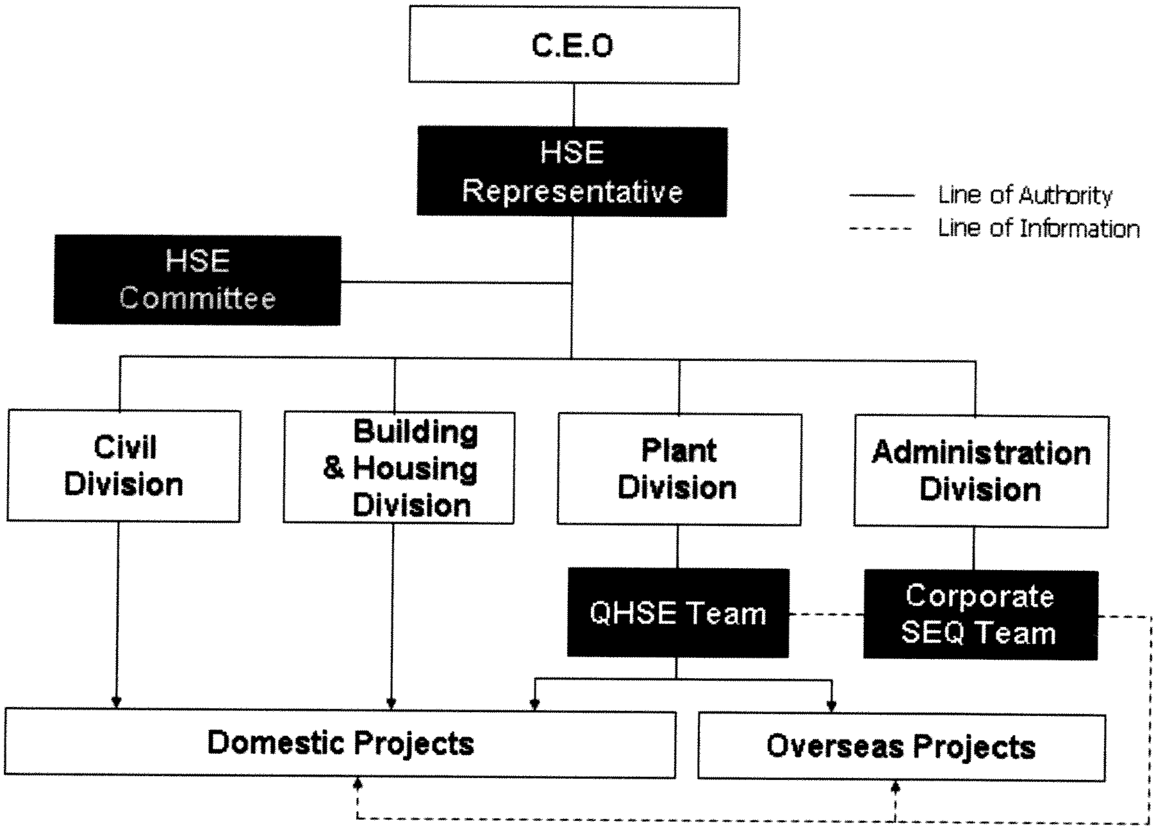
Appendix 1. HSE Organization Structure.

Appendix 2. Site HSE Organization Structure.

Appendix 3. Safety Incentive Program.

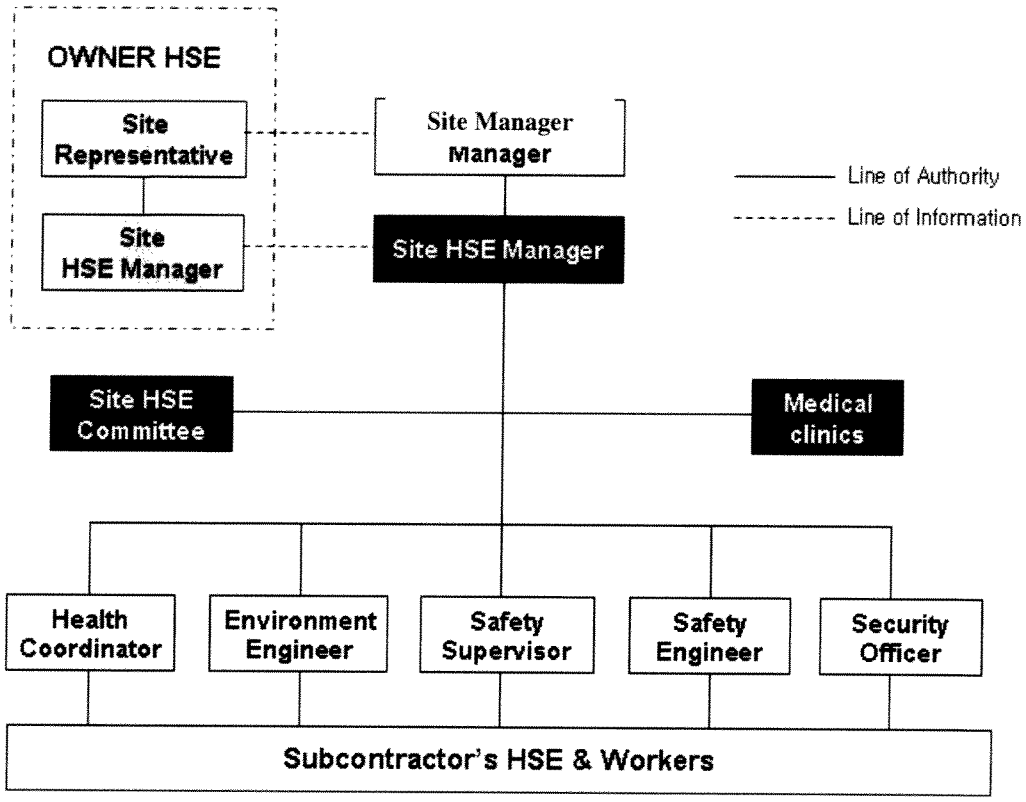
SECTION 7.0 **SAFETY PLAN**

Appendix 1. HSE Organization Structure.



SECTION 7.0 SAFETY PLAN

Appendix 2. Site HSE Organization Structure.



SECTION 7.0 SAFETY PLAN

Appendix 3. Safety Incentive Program

Introduction

Loss prevention is a paramount consideration in a construction job site especially where an operating plant exists. The goal of this program is to encourage all individuals on site to observe this procedures and safety plan to maintain safe working condition.

■ To achieve successful completion of project without any injury or damage to any person or facilities:

- Ensure that all personnel at job site have to have loss prevention and safety awareness and concern for a safe job site.
- Improve the ability and productivity of each person involved.
- Cultivate in each Sub-contractor loss prevention and safety awareness.
- Cost saving and minimizing construction period as a result of loss prevention and safety.

■ Safety Hour Achievement and Reward

Once any Sub-contractor is mobilized, target safe hours will be set in consideration of estimated man-hours, record will be maintained to assess the achievement, and the record will be presented to Contractor / Subcontractor's HSE Committee.

- Target Hour

Class	150,000 Safe hours	300,000 Safe hours	500,000 Safe hours	750,000 Safe hours	1,000,000 Safe hours
A	1st Phase	2nd Phase	3rd Phase	4th Phase	5th Phase
B		1st Phase	2nd Phase	3rd Phase	4th Phase

Note: 1) A Class Sub-contractor: Below 200 workers/day
2) B Class Sub-contractor: Above 200 workers/day

- Class Classification

Each Sub-contractor will be classified according to his estimated manpower mobilization schedule.

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- Reward to Sub-contractors

Achievement of	Rewards	Remark
1st Phase Test	Medal with gift	Value of gift will be decided later at the HSE committee.
2nd Phase Target	Medal with gift	
3rd Phase Target		
4th Phase Target		
5th Phase Target		

- Calculation of safe hour
  = (Number of workers x Actual working hour) will be used.