Jamaica Broilers Ethanol Dehydration Plant
Wastewater Treatment Facility
Port Esquivel, St. Catherine, Jamaica

Waste Treatment and Disposal Options
Preliminary Analysis
and
Discussion of Effluent Water Quality Standard
Requirement by NEPA/NRCA

FLUID SYSTEMS ENGINEERING LIMITED
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1. Introduction

The Jamaica Broilers Group, Jamaica's pioneer commercial producer of broiler meat, has a fully integrated poultry operation and has also diversified into feed milling, cattle rearing, beef production and fish farming, along with the development and marketing of other value-added products for both local consumption and export.

The Jamaica Broilers Group has also devoted significant resources to developing affiliated services that support the varied agricultural operations. These include veterinary and nutritional services, the wholesale and retail of a full range of farm products and the premixing of feed ingredients and concentrate.

The Jamaica Broilers Group recently announced that it would be investing U$14,000,000 to establish an ethanol dehydration plant capable of producing 60 million gallons per year of fuel grade ethanol.

Fluid Systems Engineering Limited, Consulting Engineers was requested to determine the sewage treatment requirement for the waste stream that is expected from this facility. This determination in the first instance is to form the basis of a submission to the National Environmental and Planning Authority NEPA (Jamaica) for a construction permit of the proposed wastewater treatment plant and a license to discharge trade effluent.

Limited information was provided as to the projected quantity and nature of the waste streams for the various components for the dehydration plant. It will therefore only be possible at this stage to prepare outline designs of the treatment options for the expected composite waste stream so that a preferred treatment approach can be selected.

With the selection of the preferred approach, a preliminary design and plant layout will be required for submission to the regulatory agency.

2. Data provided by Jamaica Broilers

The following data was provided by the Client. The information is limited and clearly there are implications relating to the operation of the dehydration plant and the source and nature of the hydrous feed stock that will ultimately influence the final waste treatment requirements.

Dehydration Plant

4,000 liters per hour (contains MAX 0.03% alcohol by volume)
{Assume 24/7 Operations}

Typical characteristics are below.

Sr. No.	Analytical Parameter	Unit	Value
1	Ethanol Content	ppm	500 max.
2	Appearance		Colourless
3	BOD	ppm	150 – 200
4	COD	ppm	300 – 400
5	Other Chemicals	ppm	Nil
6	pH		4 - 5

Boiler

Typical blow-down from 40,000 PPH boiler. Will contain Calcium Carbonates and Sulphates.
{Assume 24/7 Operations}

Cooling Tower

Similar characteristics as Boiler – volumes at MAXIMUM of 5,000 liters per hour.
{Assume 24/7 Operations}

Human Wastes

Budget for 50 persons maximum.

The engineers for the dehydration plant provided a preliminary P and ID chart which is attached separately as a PDF file.

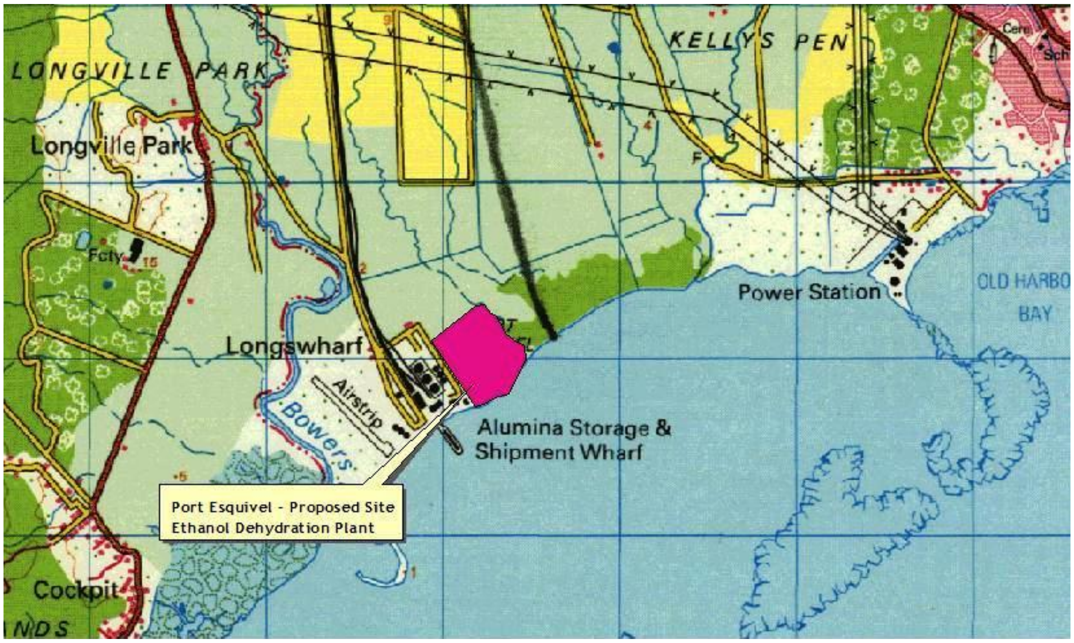

Figure 1: Topographic Map of Site with Planimetric features

The proposed site for the sewage treatment is located on the Portland Bight, a jealously protected coastal zone with rich ecological and natural history features.

Figure 2: Oblique aerial photo of site with total project area delineated in red

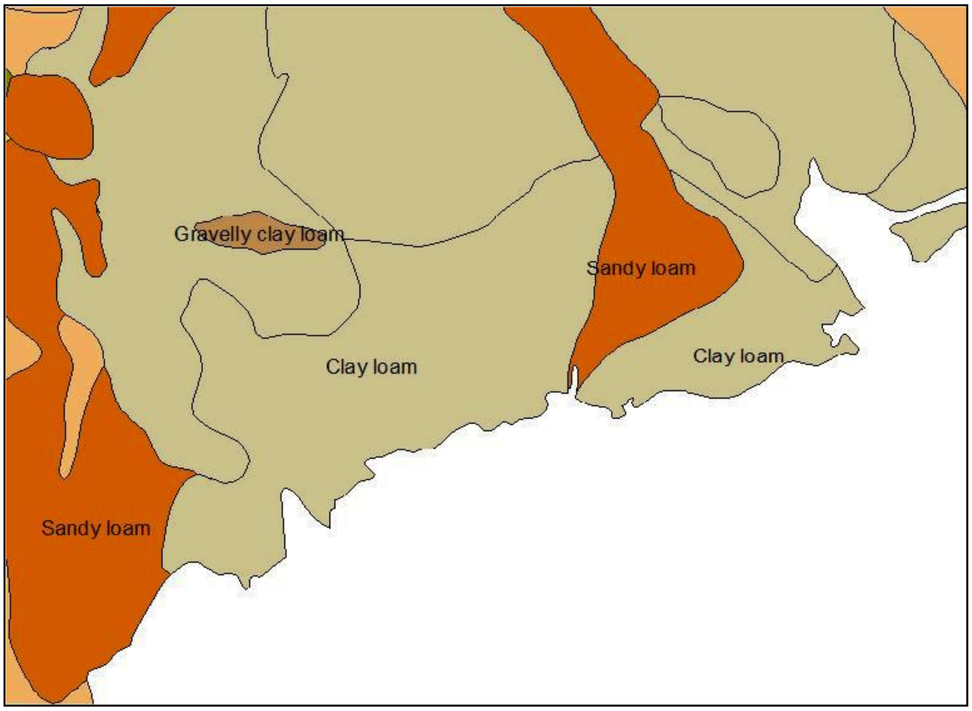

Figure 3: Soils within the proposed development site and general vicinity

Figure 4: Aerial view of site and coastal lagoon area

3. Summary of waste stream data provided and estimated

The following data was provided by the Client or estimated by Fluid Systems where no data was provided.

Dehydration Plant - Binary waste stream

Plant Parameter	Parameters Provided	Estimated Parameters	Units	Total Daily Load	Total Daily Load Estimated	Units
Flow (4000l/hr)	96	96	m³/d			
BOD5	200	300	mg/l	1.9	28.8	Kg/d
TSS	50	100	mg/l	0.5	9.6	Kg/d
Total Nitrogen	0	30	mg/l	0.0	2.9	Kg/d
Total Phosphates	0	0	mg/l	0.0	0.0	Kg/d
COD	350	350	mg/l	3.4	33.6	Kg/d

Cooling Tower waste stream

Plant Parameter	Parameters Provided	Estimated Parameters	Units	Total Daily Load	Total Daily Load Estimated	Units
Flow (5000l/hr)	120	120	m³/d			
BOD5		40	mg/l		4.8	Kg/d
TSS		100	mg/l		12.0	Kg/d
Total Nitrogen		50	mg/l		6.0	Kg/d
Total Phosphates		5	mg/l		0.6	Kg/d
COD		100	mg/l		12.0	Kg/d

Boiler waste stream

Plant Parameter	Parameters Provided	Estimated Parameters	Units	Total Daily Load	Total Daily Load Estimated	Units
Flow		20	m³/d			
BOD5		100	mg/l		2.0	Kg/d
TSS		100	mg/l		2.0	Kg/d
Total Nitrogen		0	mg/l		0.0	Kg/d
Total Phosphates		0	mg/l		0.0	Kg/d
COD		150	mg/l		3.0	Kg/d

Domestic waste stream

Plant Parameter	Parameters Provided	Estimated Parameters	Units	Total Daily Load	Total Daily Load Estimated	Units
Flow (158l/hr)		3.8	m³/d			
BOD5		200	mg/l		0.8	Kg/d
TSS		175	mg/l		0.7	Kg/d
Total Nitrogen		45	mg/l		0.2	Kg/d
Total Phosphates		15	mg/l		0.1	Kg/d
COD		300	mg/l		1.1	Kg/d

Table 1: Summary of waste stream data

Based on the above, the initial estimate of the composite waste stream is set out below.

4. Sewage Organic and Nutrient Load Estimate

The untreated waste stream is taken as the weighted composite of the individual contributions i.e.,

Flow + Mass Balance - TOTAL waste stream

Plant Parameter	Parameters Provided	Estimated Parameters	Units	Total Daily Load	Total Daily Load Estimated	Units
Flow	216	240	m^3/d			
BOD5		152	mg/l		36.4	Kg/d
TSS		101	mg/l		24.3	Kg/d
Total Nitrogen		38	mg/l		9.1	Kg/d
Total Phosphates		3	mg/l		0.7	Kg/d
COD		207	mg/l		49.7	Kg/d

Table 2: Composite waste stream projection

PARAMETER	RAW SEWAGE QUALITY
FLOW	240 m^3/day
BOD_5	150 mg/l
COD	200 mg/l
TSS	100 mg/l
Total Nitrogen	40 mg/l
Total Phosphates	3 mg/l
Faecal Coliform	1 x 10^7 MPN/100ml

Table 3: Untreated Waste Stream Characteristics

4.1. Discussion of Regulatory Framework

Based on discussions with the NEPA, the proposed treatment plant would normally be required to meet the NRCA's Trade Effluent Standards applicable to new plants. This effluent standard requires the following;

DRAFT DRAFT DRAFT

Schedules

Schedule 1 Trade Effluent Standards

PARAMETER	TRADE EFFLUENT STANDARD
Ammonia/ammonium measured as NH_4	1.0 mg/l
Barium	5.0 mg/l
Beryllium	0.5 mg/l
Biological oxygen demand (BOD)	<30 mg/l
Boron	5.0
Calcium	No standard
Chemical Oxygen Demand (COD)	100 mg/l or 0.1 kg/1000 kg product
Chloride	300 mg/l
Colour	100 TCU
Cyanide (free) Cyanide (Total as CN)	0.1 0.2
Detergent	15 mg/l
Dissolved oxygen (DO)	>4 mg/l
Faecal Coliform	<100 MPN/100 ml
Fluoride	3.0 mg/l
Iron	3.0 mg/l
Magnesium	No standard
Manganese	1.0 mg/l
Nitrate as NO_3	10 mg/l
Oil and grease	10mg/l or < 0.01 kg/1000 kg product
pH	6.5 – 8.5
Phenols	5.0 mg/l
Phosphate as PO_4	5 mg/l
Sodium	100 mg/l
Sulphate	250 mg/l
Sulphide	0.2 mg/l
Temperature	±2° of ambient
Total Coliform	<500 MPN/100 ml
Total dissolved solids (TDS)	1000 mg/l
Total organic carbon (TOC)	100 mg/l
Total suspended solids (TSS) (maximum monthly average)	50 mg/l
Total suspended solids (TSS) maximum daily average	<150 mg/l
Trace Metals: Zinc Lead Cadmium Arsenic Chromium Copper Mercury Nickel	 1.5 mg/l 0.1 mg/l 0.1 mg/l 0.5 mg/l 1.0 mg/l 0.1 mg/l 0.02 mg/l 1.0 mg/l

Drafting Instructions
Trade Effluent & Industrial Sludge Regulations 29 Drafting InstructionsNEPACSD.doc
March 2004

PARAMETER	EFFLUENT LIMIT
BOD_5	30 mg/l
TSS	50 mg/l
Nitrogen as NO_3	10 mg/l
Phosphates as PO_4	05 mg/l
COD	100 mg/l
Residual Chlorine	1.5 mg/l
Faecal Coliform	100 MPN/100ml

Table 4: NEPA Trade Effluent Requirement

Based on the above schedules, it will be necessary to remove substantial components of the carbonaceous and nitrogen based pollutants in the raw waste stream.

Disinfection will be necessary for the effluent from the plant to meet the set bacteriological standards.

5. Sewage Treatment Options

Generally, the sewage treatment options considered can be classified into four main groups based on the secondary treatment process utilized. For tertiary treatment, common options will be shared. The main groups are;

Suspended Growth Systems:

- Activated Sludge
  - Aeration options: Diffused Air, Surface Aeration, Hybrid
  - Mixing options: Propeller mixers
  - BNR: Various proprietary configurations
  - CNR: Precipitation of phosphates with alum
  - Disinfection: Chlorine, UV
  - Sludge Treatment: Aerobic Stabilization, dewatering drying beds.

- Activated Sludge (Ditch Systems)
  - Aeration options: Surface Aeration, Hybrid
  - Mixing options: Propeller mixers
  - BNR: Various proprietary configurations
  - CNR: Precipitation of phosphates with alum
  - Disinfection: Chlorine, UV
  - Sludge Treatment: Aerobic Stabilization, dewatering drying beds.

Fixed Growth Systems:

- Rotating Biological Contactors
  - Aeration options: Proprietary entrainment
  - Mixing options:
  - BNR: Nitrogen capable only in extended configuration
  - CNR: Precipitation of phosphates with alum
  - Disinfection: Chlorine, UV
  - Sludge Treatment: Aerobic Stabilization, dewatering drying beds.

Hybrid Systems (Fixed and Suspended):

- STM-Aerotor™ process.
  - Aeration options: Proprietary entrainment
  - Mixing options: Proprietary
  - BNR: Nitrogen capable, limited Phosphorus
  - CNR: Precipitation of phosphates with alum
  - Disinfection: Chlorine, UV
  - Sludge Treatment: Aerobic Stabilization, dewatering drying beds.

Natural Based Treatment Systems:

Stabilization Ponds, Advanced Ponds Systems, Reed-bed, Rock Filters

Aeration options: Photosynthesis, re-circulation

Mixing options: wind, re-circulation

BNR: Nitrogen capable, Phosphorus (50% ponds, reed-beds, filters)

CNR: N/A

Disinfection: Natural disinfection

Sludge Treatment: Digestion, stabilization integrated

5.1. Treatment Option Matrix

1 - Good, 2 - Acceptable, 3 - Poor, 4 - Unacceptable	A/S, BNR	A/S, BNR-N, CNR-P	A/S, Ditch, BNR	Fixed, RBC, CNR-P	Hybrid, STM-Aerotor™	Stabilization Ponds, FM	Ponds, AFM	Ponds, AFM Re-cir
Capital Cost	1	3	1	3	2	2	1	1
Land Requirement	1	1	2	2	1	4	3	3
Energy Requirement	3	3	2	1	1	1	1	1
Operational Cost	2	3	2	3	1	1	1	1
Maintenance Cost	2	3	2	3	2	1	1	1
Operational Complexity	2	3	2	3	2	1	1	1
Treatment Robustness	2	2	1	3	1	2	1	1
Treatment Flexibility	2	2	1	3	2	2	1	1
Treatment Reliability	2	2	1	2	1	2	1	1
Local Technology Capacity	3	4	2	4	2	1	1	1
Effluent Disposal Issues								
Issues for Phased								
Reuse Issues	2	2	2	3	2	1	1	1
Implementation Issues	2	3	2	3	2	1	1	1
Maintenance Issues	3	4	2	4	2	2	2	1
Treatment Contingency	3	3	2	4	3	1	1	2
TOTAL (Lowest Best)	30	38	24	41	24	22	17	17
Rank	4	5	3	6	3	2	1	1

Table 5: Treatment Options Matrix

A preliminary analysis of sewage treatment options, considered appropriate for the proposed development suggest that sewage treatment methodologies utilizing low energy input and simple technology for process operation and maintenance should be given the greatest consideration.

Sewage stabilization ponds, configured with anaerobic, facultative, maturation units and recirculation arrangements, presented a robust treatment option. The large land space requirement for the ponds and for the necessary setback in many situations, exclude these solutions.

High rate sewage treatment options based on the activated sludge process, where nutrient removal is available, generally leads to the use of the oxidation ditch process in Jamaica. It provides the best option when energy use and simplicity of operations is considered. The BNR configurations of these systems require increased complexity not appropriate for relatively small sewage flows.

Several proprietary and hybrid high rate suspended and fixed growth treatment systems are available in the marketplace.

Systems with any feature graded un-acceptable will not be considered.

6. Treatment System Recommendations

Based on the outcome of the treatment matrix analysis and the general discussion, the following options for sewage treatment for the proposed Jamaica Broilers Ethanol Processing Plant have been reviewed.

1. Stabilization Ponds lined (AFM), if a suitable site adjacent to the development area can be found. Land area required 0.3 ha.

2. Recirculation enhanced stabilization pond system (AFM^3r) with appropriate lining, if a suitable site adjacent to the development area can be found. Land area required 0.22 ha.

7. Stabilization Pond Treatment and its variants

Generally for the treatment requirements necessary, a stabilization pond system is highly recommended.

Stabilization ponds wastewater treatment systems have several different configurations.

- The most basic is the use of facultative ponds and maturation ponds (FM^3). This configuration also has the highest demand for land.

- By incorporating an anaerobic pond as a pre-treatment system, the land area of the basic system can be reduced by about 15% (AFM^3). Odours associated with poorly designed anaerobic ponds have given them a bad ‘rap’ and their use has been generally avoided. Improved design technology has addressed the issues and these systems are now gaining significant acceptance.

- The robust nature of the ponds systems and their wide acceptance has in recent times led to the development of more advanced applications. The (AFM^3r) recirculation enhanced pond system is a variant that includes the provision for re-circulation, allowing a high rate of loading of the main treatment pond. This reduces land area requirement but more importantly, gives much needed operational flexibility especially for small systems.

Pond systems are highly integrated biological, physical and chemical ecologic balances. They can get upset and during such times (change of climate, long overcast periods etc.) they do need some help. The (AFM^3r) recirculation enhanced pond system is best suited to address such situations.

8. Design of Recommended Treatment Facility

8.1. Septic Tank / Anaerobic Pond Option - Description and System capacity

The anaerobic section of the treatment plant will be provided either with the use of a 0.75 day retention septic tank or covered anaerobic lagoon. In the case of a covered lagoon, a de-sludge facility will be provided. The anaerobic section of the plant will allow for the removal of suspended solids and some homogenizing of the waste stream. The sludge load will also be reduced by digestion. The basic dimensions of the septic tank will be 3m deep x 15m long x 4 m wide.

For the covered anaerobic tank option, the basic dimensions will be 2.5m deep x 16m long x 4.5 m wide adjusted to maintain the prescribed volume within provision of the side slopes.

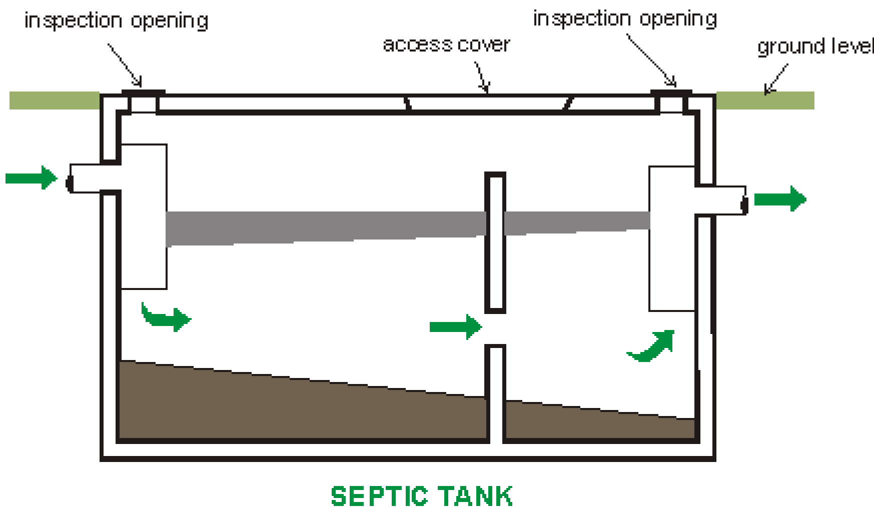

Figure 5: **Septic Tank typical detail**

System fouling due to accumulation of grease and solids - blockage

- The septic tank system is robust and will operate efficiently and without attention for nine to twelve (9 - 12) months. Septic tanks are troubled primarily by hydraulic overload, the disposal of excess grease to the septic tank and the disposal of non-degradable solids. Also, the breakdown of degradable organic solids that are settled out of the sewage by anaerobic digestion can be affected by the disposal of aggressive chemicals in the sewers.

8.2. Septic Tank - Mitigation of operational risks

- Industrial waste septic tanks must be cleaned of accumulated sludge every nine to twelve months or as often as inspections indicate that clearing is necessary.
- The septic tanks should be inspected every three months.
- Large volumes of disinfectant, strong caustic or acidic solutions should not be disposed of in the collection system discharging to the treatment plant.

8.3. Stabilization Ponds - Description and System capacity

The stabilization ponds proposed for secondary treatment of the waste stream is shown below in Figure 6. It will consist of four ponds the first being a facultative pond and the other three maturation ponds. The treatment facility will feature a simple recirculation system that when required, will facilitate the pumping of water from the maturation pond having high levels of dissolved oxygen back to the facultative pond where the main process of oxidation occurs.

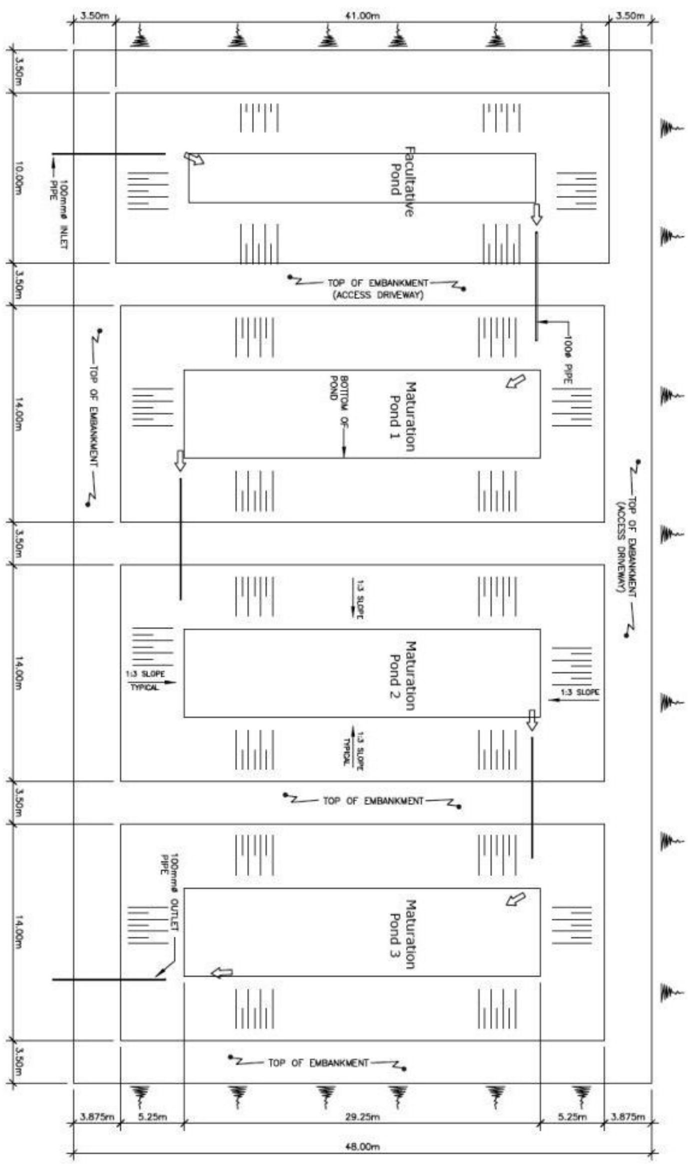

Figure 6: General arrangement of the treatment ponds

The design of the stabilization pond treatment facility is presented in the following three tables.

Design of Anaerobic, Facultative & Maturation Ponds

Jamaica Broilers Ethanol Plant - Process Outline

Design Parameters	Areal Loading Design			Imperial		S.I.	
Influent Bacterial Conc. FC/100ml				1.00E+08	MPN/100ml	1.00E+08	MPN/100ml
Mean Min. monthly temp. °C				25	°C	25	°C
Effluent Standard Req'd BOD				30	mg/l	30	mg/l
Effluent Standard Req'd FC/100ml				<200	MPN/100ml	<200	MPN/100ml
No. of pond series				1		1	
Design Hydraulic Load						**240**	**m^3/day**
Sewage flow to each series	0.0632	Mgd (US)		**0.0527**	**Migd**	**240**	**m^3/day**
Total organic load	80	lbs/d		**80**	**lbs./d**	**36**	**kg/d**
Influent BOD conc.				**152**	**mg/l**	**152**	**mg/l**
Anaerobic Pond Design	for < 500 mg SO4/l .... Check!						
Volumetric Loading Rate - (Mara)	for T > 20' Lv= 300 g/m3/d			0.51	**lb/yd^3/d**	300.00	g/m^3/d
Pond volume	Va=LiQ/Lv			1,305	ft.^{3}	121	m^3
Retention, ... ta	ta=Va/Q			0.51	days	0.51	days
BOD Removal	for T > 20' BOD% = 60%			60%		60%	
Anaerobic Pond Depth	2 - 5 m			8.20	ft	2.50	m
Length to width ratio	L > 3b ...1: n			3	ft/ft	3	m/m
Internal side slope	1:3 .... 1: s			3	ft/ft	3	m/m
Anaerobic Pond Width				30	ft	9.0	m
Anaerobic Pond Length				89	ft	27	m
Anaerobic Pond Surface Area				2,626	ft^2	244	m^2
Facultative Pond Design							
Allowable Loading Rate - (Mara global)	λ_s =350(1.107-0.002T)^(T-25)			312.3	lb BOD/ac.d	350.0	kg BOD/ha.d
Pond mid depth area	Af=(10*Li*Q)/Ls			4,475	ft^2	416	m^2
Depth of pond				4.92	ft	1.50	m
Evapouration rate	e			0.24	inches/d	6.00	mm/d
Retention, ... tf1	Rt=2Af*D/(2Q-0.001Afe)			2.62	days	2.62	days
Flow Pond_1 effluent	Qe=Qi-0.001*Af*e			**0.05**	**Migd**	**237**	**m^3/day**
BOD removal rate - #1 (McGarry & Pescod)	Lr=0.725Ls + 10.75			76%		76%	
Effluent BOD - facultative pond				**14.84**	**mg/l**	**14.84**	**mg/l**
Pond volume				22,025	ft.^{3}	624	m^3
Pond Side slopes, internal				3	ft/ft	3	m/m
Pond Side slopes, external				1.5	ft/ft	1.5	m/m
Maturation Pond Design							
Coliform removal rate kinetics - (Marais)	K(t)=2.6(1.19)^(T-20)			6.20	d^{-1}	6.20	d^{-1}
FC reduction.... /100ml - (Marais)	Ne=Ni/(1+K(t)*θf)(1+K(t).θm)^n						
Influent Bacterial Conc. FC/100ml				1.00E+08	MPN/100ml	1.00E+08	MPN/100ml
Effluent Bacterial Conc. FC/100ml				2.00E+02	MPN/100ml	2.00E+02	MPN/100ml
Retention for n = 1..tm=((Ni/Ne(1+K(t)tf)(1+K(t)tf))^1/n-1)/K(t)		1		1129.1	days	1129.1	days
Retention for n = 2		2		13.3	days	13.3	days
Retention for n = 3		3		2.9	days	2.9	days
For θm>θf reject combinations		#	days				
	not this	2	13.3	26.7	days	26.7	days
No. and (θm) of each maturation pond	use this	3	3.0	9.0	days	9.0	days
Depth of Maturation Ponds				4.10	ft.	1.25	m

Table 6: Ponds Design - Sheet 1

Design of Anaerobic, Facultative & Maturation Ponds							
Jamaica Broilers Ethanol Plant - Process Outline							
Based on the assumption that 70% BOD is removed before 1st maturation pond, check surface loading, apply lower							
Surface loading ->(70% load removed)	Lsm1=10*0.3*Li*D/(θm1)					227.8	kg BOD/ha.d
Surface loading of 1st Maturation pond @ 75% of facultative pond						262.5	kg BOD/ha.d
Sizing of Maturation Pond No.1	10LiD/Lsm1	1	3.0	3.0		3.0	days
Retention for 1 addn.		1		57.4		57.4	days
Retention for 2 addn.		2		2.9		2.9	days
Retention for 3 addn.		3		1.0		1.0	days
Minimum θ_f = 3.0		#	days				
For θm>θf reject combinations	not this	1	57.4	57.4	days	57.4	days
		2	3.0	6.0	days	6.0	days
No. and (θm) of each maturation pond		3	3.0	9.0	days	9.0	days
Area maturation 1				6,081	ft²	565	m²
Effluent flow maturation 1				**0.05**	**Migd**	233.7	cu. m/d
Area maturation 2				5,994	ft²	557	m²
Effluent flow maturation 2				**0.05**	**Migd**	230.4	cu. m/d
SUMMARY FOR POND SERIES OF	2 x (1A x 1F x 2M)						
Anaerobic Pond Area				2,626	ft²	244	m²
Pond length				90	ft.	27	m
Pond Width	Ratio	3.085		29	ft.	9	m
Anaerobic Pond Retention				0.5	days	0.5	days
Anaerobic Pond Effluent BOD				60.7	mg/l	60.7	mg/l
Anaerobic Pond Effluent FC/100ml				2.4E+07	MPN/100ml	2.4E+07	MPN/100ml
Facultative Pond Area				4,475	ft²	416	m²
Pond length				135	ft.	41	m
Pond Width	Ratio	4.072		33	ft.	10	m
Facultative Pond Retention				2.6	days	2.6	days
Facultative Pond Effluent BOD				14.8	mg/l	14.8	mg/l
Facultative Pond Effluent FC/100ml				1.4E+06	MPN/100ml	1.4E+06	MPN/100ml
Maturation # 1 Area				6,081	ft²	565	m²
Pond length				135	ft.	41	m
Pond Width	Ratio	2.997		45	ft.	14	m
Maturation # 1 Retention				3.0	days	3.0	days
Maturation # 1 Effluent BOD				3.7	mg/l	3.7	mg/l
Maturation # 1 Effluent FC/100ml				7.1E+04	MPN/100ml	7.1E+04	MPN/100ml
Maturation # 2 Area				5,994	ft²	557	m²
Pond length				135	ft.	41	m
Pond Width	Ratio	3.04		44	ft.	14	m
Maturation # 2 Retention				3.0	days	3.0	days
Maturation # 2 Effluent BOD				2.8	mg/l	2.8	mg/l
Maturation # 2 Effluent FC/100ml				3.6E+03	MPN/100ml	3.64E+03	MPN/100ml
Maturation # 3 Area				5,909	ft²	549	m²
Pond length				135	ft.	41	m
Pond Width	Ratio	3.084		44	ft.	13	m
Maturation # 3 Retention				3.0	days	3.0	days
Maturation # 3 Effluent BOD				2.1	mg/l	2.1	mg/l
Maturation # 3 Effluent FC/100ml				1.9E+02	MPN/100ml	1.9E+02	MPN/100ml
Total Pond Area				**22,460**	**ft²**	**0.209**	**ha**
Total Retention Time				**11.6**	**days**	**11.6**	**days**
Total Area Required				**26951**	**ft²**	**0.250**	**ha**

Table 7: Ponds Design - Sheet 2

Design of Anaerobic, Facultative & Maturation Ponds							
Jamaica Broilers Ethanol Plant - Process Outline							
Total Nitrogen Removal							
Influent TN - facultative pond				38.00	mg/l	38.00	mg/l
Influent A - $CaCo_3$/l - facultative pond				175.00	mg/l	175.00	mg/l
Facultative Pond pH - 7.3e(0.0005A)				7.97		7.97	
Effluent TN - facultative pond				19.59	mg/l	19.59	mg/l
Influent TN - maturation1 pond				19.59	mg/l	19.59	mg/l
Influent A - CaCo3/l - maturation1 pond				154.94	mg/l	154.94	mg/l
maturation1 Pond pH - 7.3e(0.0005A)				8.61		8.61	
Effluent TN - maturation1 pond				7.45	mg/l	7.45	mg/l
Influent TN - maturation2 pond				7.45	mg/l	7.45	mg/l
Influent A - CaCo3/l - maturation2 pond				141.70	mg/l	141.70	mg/l
maturation2 Pond pH - 7.3e(0.0005A)				9.24		9.24	
Effluent TN - maturation2 pond				2.11	mg/l	2.11	mg/l

Table 8: **Ponds Design - Sheet 3**

8.4. Stabilization Ponds - Operational Risks and Mitigation

System distress due to extended period of cloud cover

Pond systems represent highly integrated chemical, biological and physical and ecologic balances. They are known to be robust and can operate successfully without intervention for several weeks. They can get upset from time to time and during such periods (change of climate, long overcast periods etc.) they do need some help.

Risk mitigation

- Risks associated with pond failure due to ecologic imbalances are addressed primarily in the design of the facilities and the monitoring and maintenance provided. During periods of extended cloud cover, it might be necessary to operate the recirculation system. This will ensure that oxygen rich water from the secondary ponds is made available to the primary pond to meet the high oxygen demand related to stabilization of the incoming organic waste.

System distress due to biological upset

Although this tends to occur quite infrequently, ponds do experience biological upset at times.

Risk mitigation

- The recirculation of water from the secondary ponds will re-establish the required biological balance within a period of a day or two and return the system to stability. Odors if they occur at all, will be detectable in the immediate vicinity of the ponds during such period but it must be stressed that such situation are not expected more frequently that once or less per year.

Damage to pond structure due to hurricane storm surge or run-up wave

During the passage of hurricane, high sea water levels associated with storm surge and wave run-up can damage coastal structures.

Risk mitigation

- This risk is addressed primarily in the locating and design of the ponds. The pond embankments will be protected from wave action with the use of a geo-textile cover and stone armour.

9. Location of Proposed Sewage Treatment Ponds

Figure 7 below shows the proposed location of the sewage treatment ponds to the south of the dehydration plant.

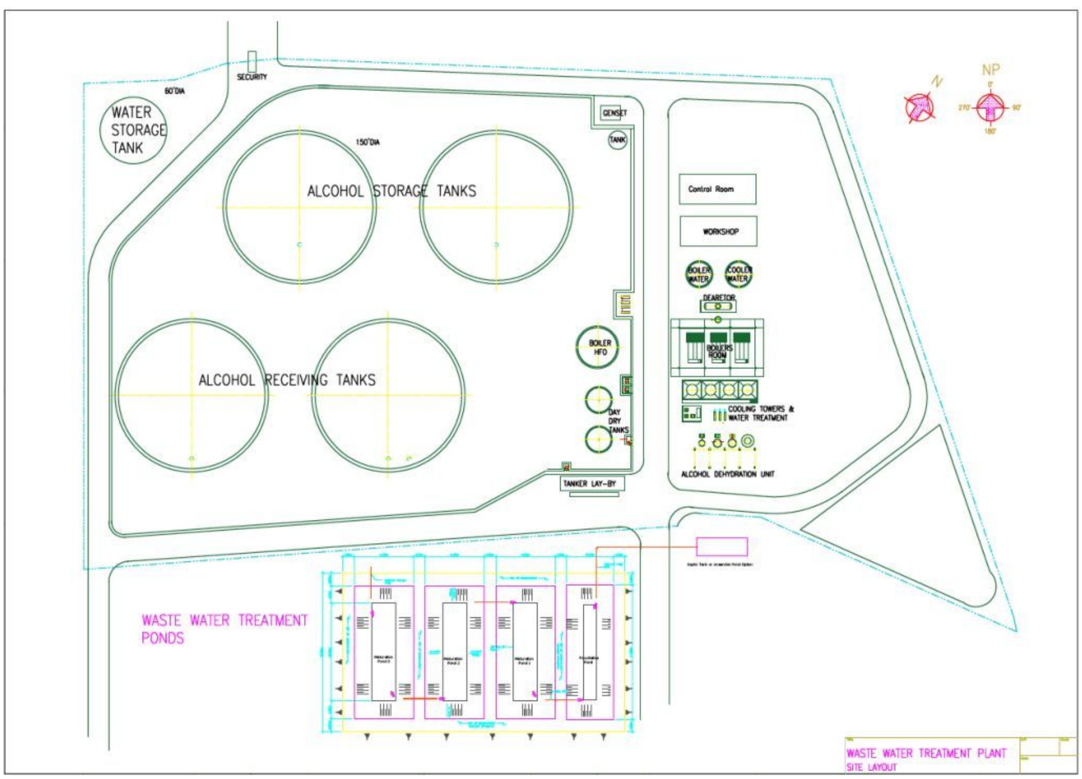

Figure 7: Location of waste water treatment plant relative to dehydration plant