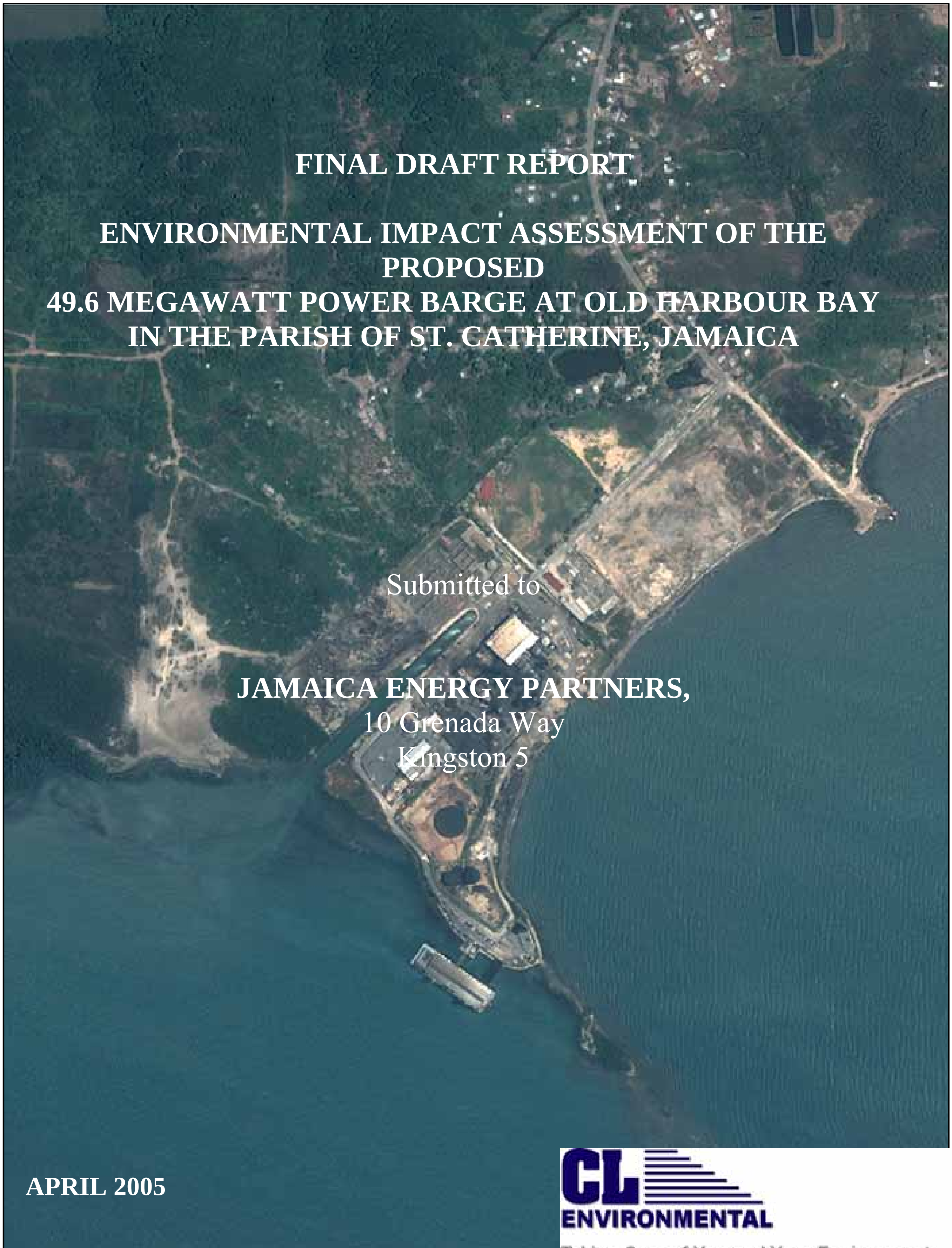

FINAL DRAFT REPORT

ENVIRONMENTAL IMPACT ASSESSMENT OF THE PROPOSED 49.6 MEGAWATT POWER BARGE AT OLD HARBOUR BAY IN THE PARISH OF ST. CATHERINE, JAMAICA

Submitted to

JAMAICA ENERGY PARTNERS,
10 Grenada Way
Kingston 5

APRIL 2005

CL ENVIRONMENTAL
Taking Care of You and Your Environment.

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APRIL 2005

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1.0 EXECUTIVE SUMMARY

The Jamaica Energy Partners (JEP) which owns and operates a 74.16 MW (net) electricity-generating facility (The Doctor Bird Power Barge), plans to increase its generating capacity by installing a second but smaller barge. This will increase JEP's capacity by 49.5 MW, which would result in the company having a total net installed capacity of 123.63 MW. The site for the second barge is adjacent to the existing barge and places a the three electricity- generating facilities in close proximity to each other, the third being the Jamaica Public Service Company (JPS) Power plant in Old Harbour Bay, St. Catherine. The JEP Power Barge has been in operation since 1995.

Features of the European constructed barge by Wärtsilä include a double hull to reduce the risk of oil spills, fuel warning alarms, fire resistant walls and roof on the deck house and automated system from a central control room. The site identified for the barge is on average approximately 2m deep will be dredged to approximately 5.5m to create an adequate basin to accommodate the proposed barge and allow cooling water intake without sediment.

Operation will see a 25 person capacity sewage treatment facility and a permanent boom encircling the barge to contain any unlikely spill. In addition there are existing Oil Spill Contingency Plans, which include using additional booms, skimmers, absorbents and mops. With respect to project siting and natural disasters (seismic zone risks and hurricane periodicity) considering the seismic history and hurricane events of Jamaica these factors must be considered as acceptable risks.

The water quality in the proposed location is considered as poor due to high temperatures, high resuspension of fine particle sediment resulting in low light penetration and low dissolved oxygen. Biochemical Oxygen Demand however indicates no signature of sewage as a marine contaminant. The waters of the bay at the proposed site are primarily influenced by the thermal discharge from existing two electricity generating facilities as well as daily wind regimes. Overall, the effects of the wind appear to be more dominant in comparison to the effect of tides as little tidal influence could be inferred from the drogue trajectories and speeds. Elevated temperatures from the existing Jamaica Public Service Co. Ltd. and Doctor Bird barge thermal discharges are the dominant water quality feature of the bay in the project area. The thermal discharges create surface water temperatures 3 to 8 ^{o}C higher than ambient, depending on proximity to discharge points The 3 degree above ambient contour appeared to end some 800 to 1,000 metres from the JPS cooling canal. The plume also appeared to be attached to the shoreline where one could reasonably expect slower moving currents.

Sediment Heavy metal analysis yielded results with no significant elevated values. In fact all metals analysed (Cadmium, Mercury, Lead, Arsenic and Copper) returned trace values or values below the detection limit. Risks from metal contamination are therefore minimal. Seagrasses where present not luxuriant in growth and their in places and proliferation in patches confirm the site is moderately stressed in specific areas. Absence of benthic floral communities at sites appears to be driven by poor light penetration in some areas and increased temperature in shallow areas. Not surprisingly there were no coral reef communities within the bay although fringing reef systems were observed some distance offshore (≈ 1km). Dredging will not be conducted in the area of coral reefs, but approximately 4,000 m^2 of seagrass in varying state of health will be removed during the dredging operation. The process of dredging and the disposal of dredge “spoils” will inevitably lead to soil particles being put into suspension in the water column. Depending on the direction and velocity of the prevailing sea-currents, the potential for aquatic resources down drift of the dredge and the dredge disposal sites being adversely impacted by being smothered by sediments exists. Appropriate spoil suspension mitigation and possible replanting of portions of the removed seagrasses are possibilities for further discussion, although health status and replant sites may deem this unfeasible.

Prevailing current direction takes the thermal plume along the coast away from these offshore reef systems. Furthermore, resuspended fine sediments are also kept away from the fringing reefs reducing the impact of smothering.

Adjacent coastal and terrestrial ecological communities were surveyed. In general, a total of 17 species were observed, which were not significantly important, ecologically or commercially, and the areas displayed signs of stress either from anthropogenic or hurricane impact but should not be affected significantly by the installation of operation of the barge. Fourteen (14) species of birds representing ten (10) families and totalling thirty-six (36) individuals were observed over a one hour period but few were nesting or using the area as habitat. The list of birds consisted of two (2) endemic species; the Jamaican Mango and the Jamaican Euphonia. The low species diversity and numbers of birds seen are testament of the disturbed nature of the area and its relative insignificance as a habitat for birds. In general, the Old Harbour area is known for crocodile incidences and sightings and is reported by NEPA to have turtles and manatees as well. This information, along with the other marine organisms observed during this investigation, indicate the area as one used by a number of animal species for feeding and as nursery grounds for juvenile development. The site under consideration represents >1% of the Portland Bight Protection Area, Portland Bight which has the largest remaining mangrove system in Jamaica (The Great Salt Pond, Galleon Harbour, West Harbour, the Goat Islands and almost all areas between), which, together with extensive sea-grass beds and coral reefs, provide probably the largest nursery area for fish, crustaceans and molluscs on the island. The proposed location is outside of the major fish nurseries and fishing grounds in the area and as such will have no or very little impact on fisheries in the area. The sightings of protected species are in locations that are away (except for a crocodile) from the proposed project site and are not expected to be impact by the proposed development

The 1991 population data showed that there were approximately 12,800 persons within the 5km radius of the proposed barge (Social Impact Area). From this population it was estimated that the actual growth within the SIA was approximately 1.72% per annum, which is less than that of the parish. Furthermore, it was clearly seen that population increases mainly north and northeast of the proposed barge were associated with increased informal settlers ("squatters"). Fortunately only 24% of the working age population were unemployed and a high proportion of the population in proximity to the proposed Barge location have attained a secondary education suggesting 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. It is estimated that approximately 60 man months of professional/technical, 180 man months of skilled workers and

60 man months of unskilled/casual employment will be required for site and engineering works which will be a major benefit to the SIA.

Approximately sixty five percent (65.7%) of respondents interviewed said that the existing facility (JPS/JEP) did not impact on their lifestyle in anyway. Thirty one percent (31%) indicated that the present facility impacted on their lifestyle positively by providing employment and negatively at times generating noise, vibration and oil spills. Consultations with NGO and community groups indicated that in principle there were no objections to the proposed project and in fact supported the project especially if it created jobs for locals. However, they listed the increased potential for thermal water pollution, oil spills, especially at oil reception mooring facility, and noise as their major concerns. Additionally, the chemicals used for the treatment of the cooling water lines were also a concern.

This project has the potential to adversely impact the air quality of the air shed surrounding the proposed development, increase noise pollution and thermal pollution of the surrounding water body. These impacts will be properly mitigated.

The air quality of both the proposed project (standalone) and cumulatively (JPS, Dr. Barge and JEP 2) shows compliance with NEPA standards and World Bank Guidelines for SO_2, NOx, PM10, TSP and CO. The cumulative noise impact which takes into account all the existing background noise sources (including the Jamaica Public Service power plant, the existing Jamaica Energy Partners barge and the proposed new barge) predicts an increase in noise to the surrounding community. However, the noise would not result in a three decibel increase to background noise therefore the noise increase in the surrounding community would comply with the World Bank guidelines under the 3 dB criterion.

An outfall with a discharge of 0.8 cubic metres per second and surface temperature of 35.8 degrees Celsius was considered. A location in approximately 3.0 metres water depth and some 100 metres away from the existing JEP outfall in a SW direction was considered. In addition, a location further offshore was considered so as to limit the interaction with the other outfalls (existing JEP and JPS) and to prevent the plume from touching the shoreline. Thermal modelling results indicate that the outfall will produce a plume that will be compliant within a very short distance from where it surfaces. A core temperature of about 33.5 degrees Celsius with a radius of about 20 to 30 metres is expected to be produced. The outfall is therefore expected to be compliant.

While alternative locations and fuel types were investigated, the most environmentally sound and economical alternative is the development as proposed in the EIA. This option will result in the shortest possible time for the provision of the required additional generating capacity, with impacts which can be mitigated. The project will result in a more reliable and constant supply of electricity to the national power grid, which, will increase worker productivity and economic growth for the island of Jamaica.

2.0 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

2.1 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.
- 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.

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

2.2 JAMAICAN ENVIRONMENTAL REGULATORY STRUCTURE

EIAs are not only recommended in project design, but also required by Jamaican legislation. The following is a review of Jamaican environmental policy and laws that are relevant to the Jamaica Energy Partners (JEP) barge expansion project.

2.2.1 National Environment and Planning Agency (NEPA)

NEPA is the government executive agency and represents a recent merger of the Natural Resources Conservation Authority (NRCA), the Town Planning Department (TPD) and the Land Development and Utilisation Commission (LDUC).

Among the reasons for this merger was the streamlining of the planning application process in Jamaica. The Agency is moving towards one application to NEPA for new developments and new modifications that will review and approve environmental aspects as well as planning, building control and zoning considerations.

It is this agency that will review the Environmental Impact Assessment.

<u>Natural Resources Conservation Authority (NRCA) Act</u>

The NRCA Act is 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.

The Act has established the Natural Resources Conservation Authority (NRCA), which has a number of powers including,

- issuing of permits to persons responsible for undertaking any construction, enterprise or development of a prescribed category in a prescribed area, including power generation facilities;
- requesting an Environmental Impact Assessment (EIA) from an applicant for a permit or the person responsible for undertaking any construction, enterprise or development; and

- ♦ revocation or suspension of permits.

The Act also gave power of enforcement of the following environmental laws to the NRCA:

- ♦ The Beach Control Act
  - ⇨ Establishes Crown (Government) ownership and management responsibility for the foreshore, floor of the sea, and overlying water (regulates activities within 25 metres of the shoreline, including control over construction of sheds and huts on beaches.)
  - ⇨ Prohibits commercial use of these areas without license from the NRCA, with renewal provided that (as per regulations under Section 18):
    - ▪ all fees or other sums due under the licence to the Authority have been paid;
    - ▪ the conditions of the said licence have been observed and no breach exists at the time of the application for renewal; and
    - ▪ renewal is not contrary to the best interests of the public and of the Island.
  - ⇨ Requires NRCA permit and payment of fees for any structure on or attachment to the foreshore, including seawalls, piers, jetties, mooring buoys, and artificial reefs.
  - ⇨ Requires NRCA approval of beach development plans (developments up to 1 mile inland) and inspection of beaches to ensure adherence to safety and cleanliness standards.

- ♦ 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.

Town and Country Planning Authority (TCPA)

The Town and Planning Act, as amended (1987), establishes the Town and Country Planning Authority, which is responsible for land use zoning and planning regulations as described in their local Development Orders.

St. Catherine Development Order

The local planning authority for the development is the St. Catherine Parish Council. Its functions include granting permission to develop land (based on the Development Order and subject to approval by TCPA), maintaining a public register on land development applications, and enforcing planning controls.

Continued proactive communication with the Parish Council is recommended in order to keep them informed and in dialogue on the activity in their jurisdiction. This will also be the approach of the environmental consulting team in deliberating environmental aspects of the planning and approval process.

2.2.2 NRCA's EIA Process

Under Section 9 of the NRCA Act, all activities associated with power generating facilities, such as the JEP expansion 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 JEP 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 1 gives the approved TORs for the proposed barge development.
- The EIA is then prepared by a multi-disciplinary team of professionals (Appendix 2 for the team used in this assessment). 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.
    - ⇨ 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).

- Eight copies of the finalised draft are then submitted to NRCA, two to the client, and the consultant keeps one (11 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) etc.) 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 Minister of Land and the Environment.

Public Participation in EIAs

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, have been prepared and after the applicant has provided the information needed for adequate review by NRCA and the public.

The JEP barge expansion development lies in the Portland Bight Protection Area (PBPA). The PBPA is managed by Caribbean Coastal Area Management Programme (CCAMP), a local community Environmental Non-Governmental Organisation (ENGO). The consultant has contacted the major environmental stakeholders in the development area including NGOs, Community Based Organisations (CBOs) and Academic Experts. Based on the questions and concerns raised in these discussions, the Consultant will adjust the EIA to address the concerns. 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 3 for the NRCA reference document entitled "Guidelines for Public Participation" in EIAs.

2.2.3 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.

2.3 WORLD BANK GUIDELINES

2.3.1 National Regulatory Requirements

As a World Bank venture, this project is also subject to World Bank Environmental Guidelines, updated in 1998. It should be noted that the Jamaican EIA process was strongly influenced by the original World Bank guidance on EIAs. The EIA report, however, has been reviewed for compliance with World Bank Guidelines and meets all requirements for the Project from design to implementation.

2.3.2 Overview of World Bank Requirements

This EIA is, as required, "commensurate with the project's potential impacts" and contains the items required in the World Bank Operational Procedures (OP 4.01;), including:

- 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 (See Appendix 4 Relevant sections of the Pollution Prevention and Abatement Handbook – Thermal Power: Guidelines for New Plants):

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

This power plant is less than 50 MW.

3.0 PROJECT DESCRIPTION

The Jamaica Energy Partners (JEP) owns a 74.16 MW (net) electricity-generating facility (Doctor Bird Power Barge) located adjacent to the Jamaica Public Service Company (JPS) Power plant in Old Harbour Bay, St. Catherine. The Doctor Bird Power Barge has been in operation since 1995.

3.1 PROPOSED PROJECT

The proposed project will also be a floating barge smaller than the existing "Dr. Bird" facility. It will be transported to Jamaica on a semi-submersible vessel, where it will be off-loaded in deep waters. Tugboats will be used to put it in its proposed location, and the route taken to access the Bay will be the same as that used by the existing Doctor Bird Power Barge. As described further in the sections below, the Proposed Plant will be docked near the shore. To accommodate the barge near shore dredging activity will have to be undertaken.

The barge will supply power from three (3) Wärtsilä 18V46 Medium Speed Diesel generating sets. This will increase JEP's capacity by 49.5 MW, which would result in the company having a total net installed capacity of 123.63 MW. The Dimensions of the barge are as follows:

- Overall Length = 66.5 metres (m)
- Breadth (molded) = 30.4m
- Draught Design Waterline (DWL) = Approx. 4.5m
- Height to top of stacks (3 stacks) = 35m

The proposed facility will be designed for base load power generation and is intended to be used in parallel with the existing Dr. Bird barge. The electricity will be produced at 11 kilo-volts (kV) and converted to 138 kV before interconnecting to the JPS transmission network (Figure 1).

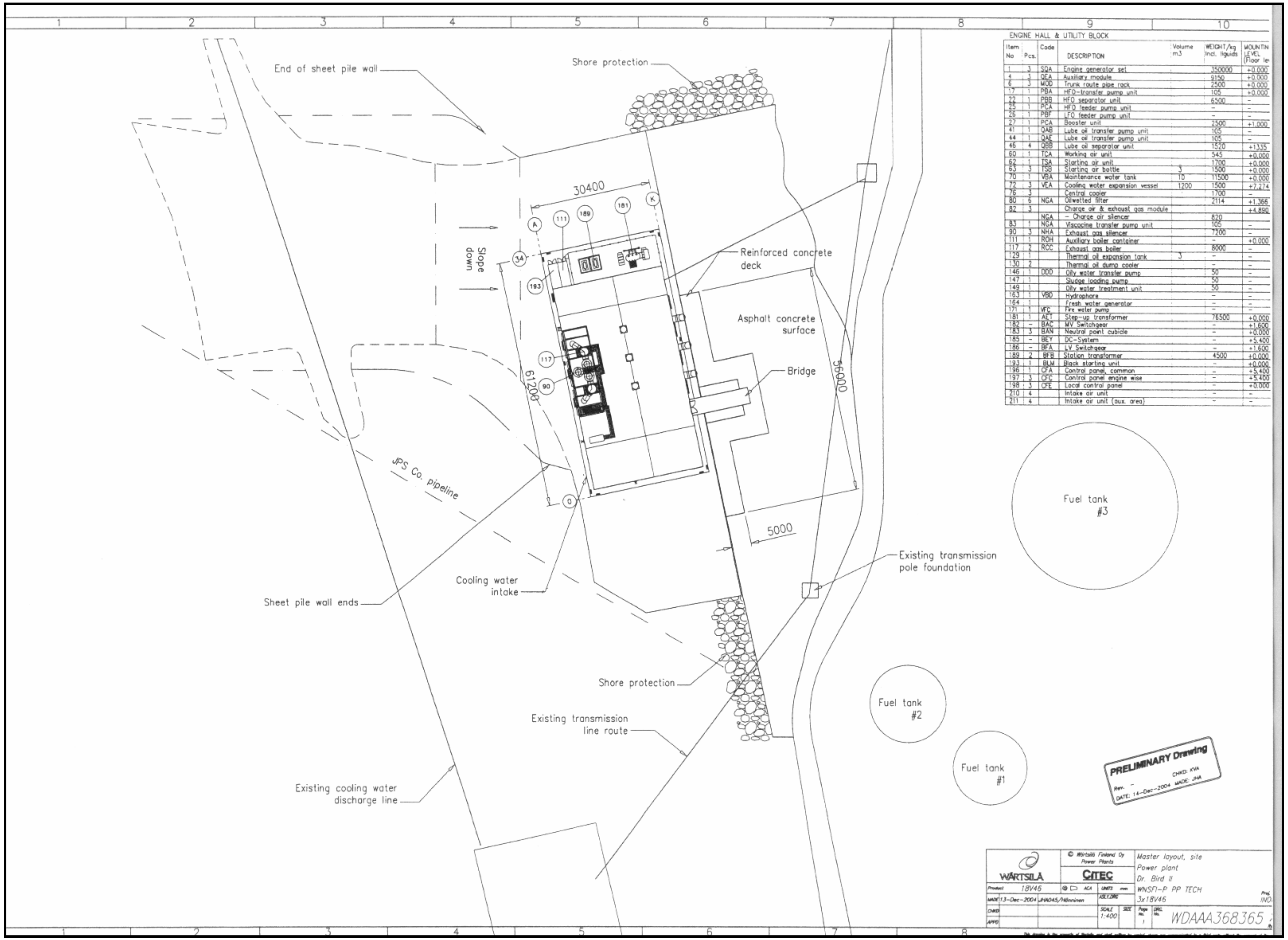
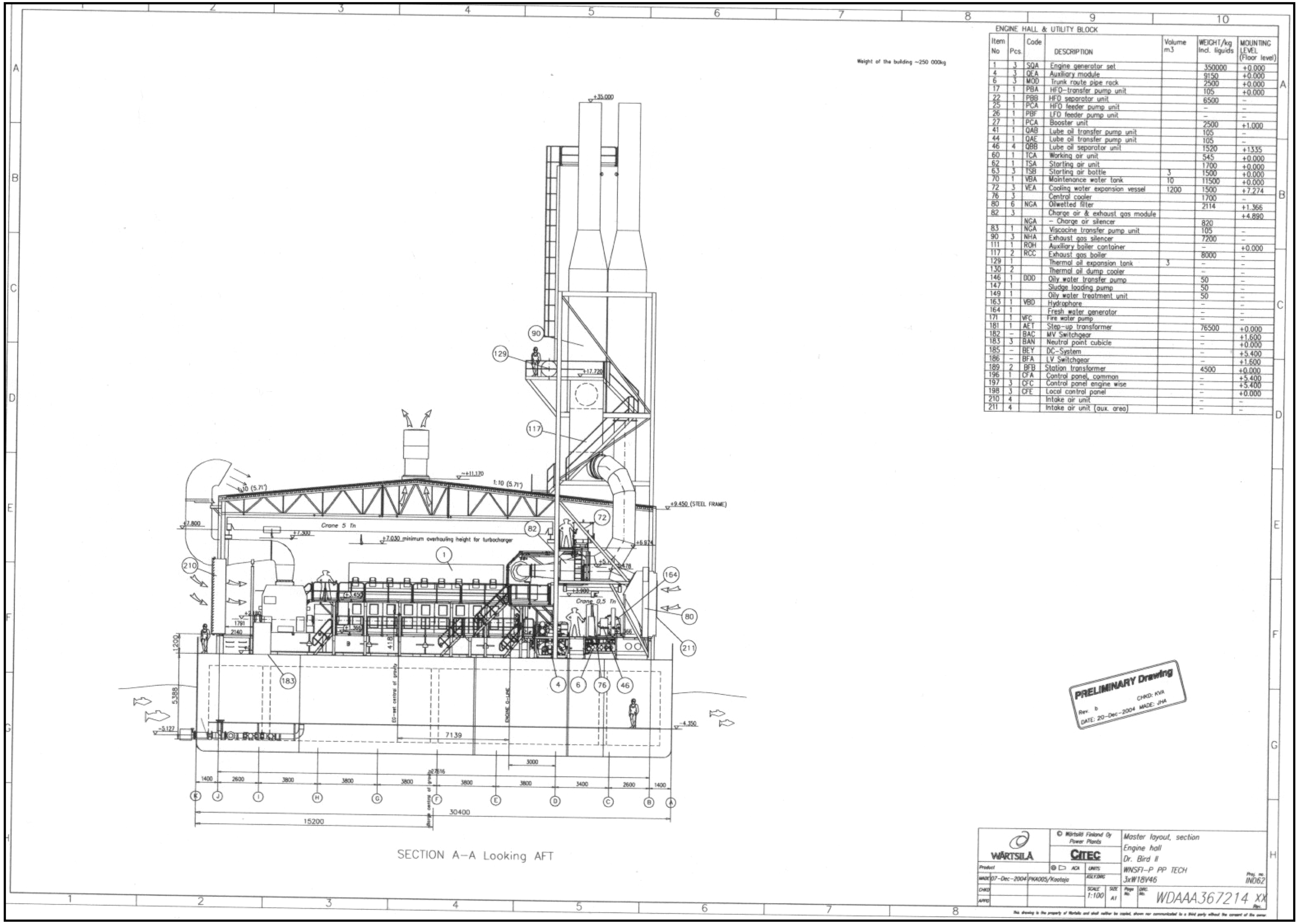


Figure 1 Schematics illustrating the proposed barge



ENGINE HALL & UTILITY BLOCK

Item No	Pcs.	Code	DESCRIPTION	Volume m3	WEIGHT/kg Incl. liquids	MOUNTING LEVEL (Floor level)
1	3	SQA	Engine generator set		350000	+0.000
4	3	QEA	Auxiliary module		9150	+0.000
6	3	MOD	Trunk route pipe rack		2500	+0.000
17	1	PBA	HFO–transfer pump unit		105	+0.000
22	1	PBB	HFO separator unit		6500	–
25	1	PCA	HFO feeder pump unit		–	–
26	1	PBF	LFO feeder pump unit		–	–
27	1	PCA	Booster unit		2500	+1.000
41	1	QAB	Lube oil transfer pump unit		105	–
44	1	QAE	Lube oil transfer pump unit		105	–
46	4	QBB	Lube oil separator unit		1520	+1335
60	1	TCA	Working air unit		545	+0.000
62	1	TSA	Starting air unit		1700	+0.000
63	3	TSB	Starting air bottle	3	1500	+0.000
70	1	VBA	Maintenance water tank	10	11500	+0.000
72	3	VEA	Cooling water expansion vessel	1200	1500	+7.274
76	3		Central cooler		1700	–
80	6	NGA	Oilwetted filter		2114	+1.366
82	3		Charge air & exhaust gas module			+4.890
		NGA	– Charge air silencer		820	
83	1	NGA	Viscocine transfer pump unit		105	–
90	3	NHA	Exhaust gas silencer		7200	–
111	1	ROH	Auxiliary boiler container		–	+0.000
117	2	RCC	Exhaust gas boiler		8000	–
129	1		Thermal oil expansion tank	3	–	–
130	2		Thermal oil dump cooler		–	–
146	1	DDD	Oily water transfer pump		50	–
147	1		Sludge loading pump		50	–
149	1		Oily water treatment unit		50	–
163	1	VBD	Hydrophore		–	–
164	1		Fresh water generator		–	–
171	1	VFC	Fire water pump		–	–
181	1	AET	Step–up transformer		76500	+0.000
182	–	BAC	MV Switchgear		–	+1.600
183	3	BAN	Neutral point cubicle		–	+0.000
185	–	BEY	DC–System		–	+5.400
186	–	BFA	LV Switchgear		–	+1.600
189	2	BFB	Station transformer		4500	+0.000
196	1	CFA	Control panel, common		–	+5.400
197	3	CFC	Control panel engine wise		–	+5.400
198	3	CFE	Local control panel		–	+0.000
210	4		Intake air unit		–	–
211	4		Intake air unit (aux. area)		–	–

Figure 2 Aft view of the proposed barge

3.2 PROJECT LOCATION

The proposed site is located approximately 5 km (≈ 3 miles) south of the town of Old Harbour and approximately 48 km (≈ 30 miles) west of Kingston, the capital of Jamaica. The site is bordered by the JPS plant to the north northeast and the Caribbean Sea to the south, west and east (Figure 2). The present Dr. Bird plant is approximately 90m to the east of the proposed site. The nearest community is an informal settlement approximately 500m north of the proposed site.

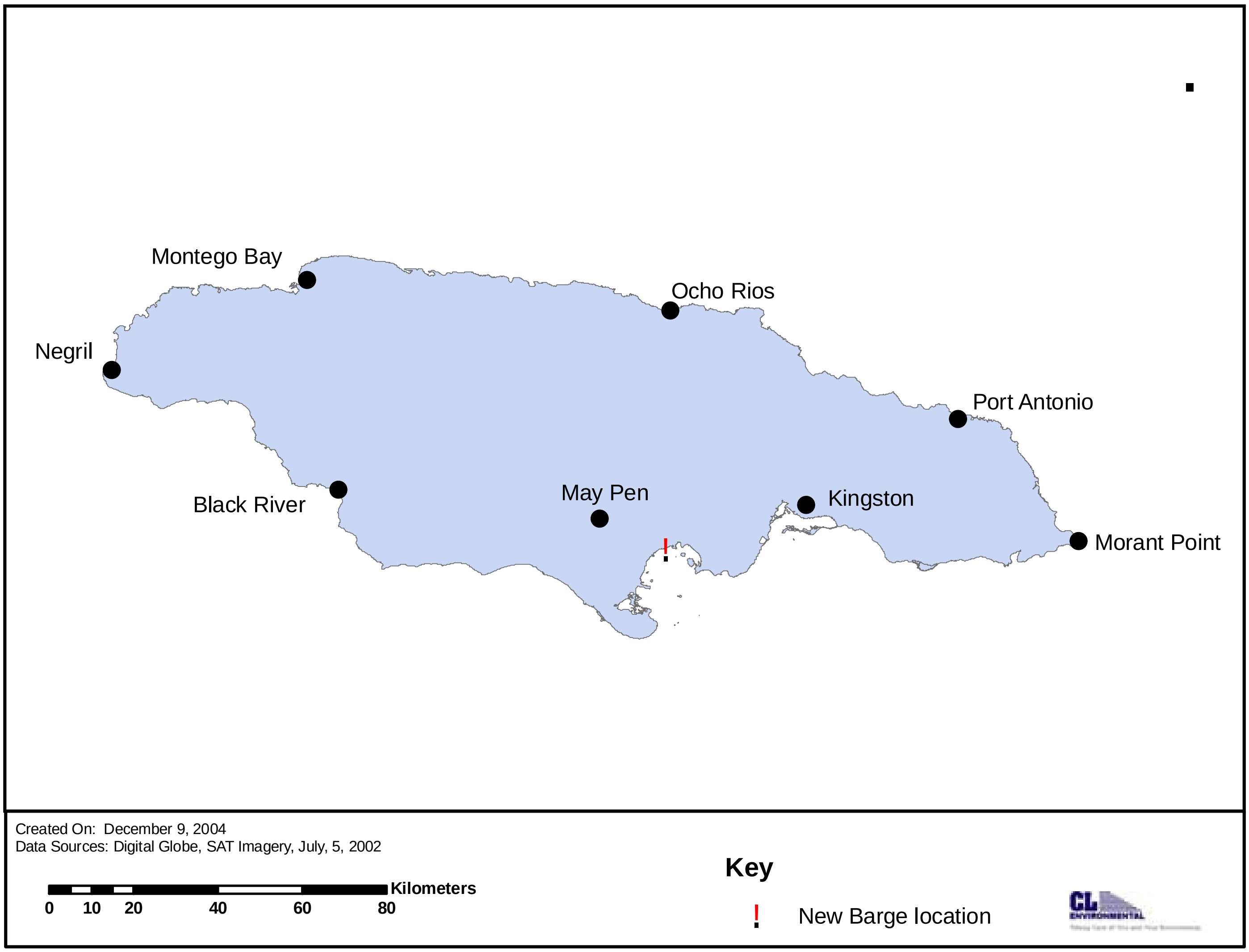


Figure 3 Location map of the proposed JEP barge

3.3 PROJECT FEATURES

The Power plant will be constructed by Wärtsilä in Europe and the Barge will be assembled in Asia using relevant international industrial standards (including International Organization for Standardization (ISO), European Standards (EN), Det Norske Veritas (DNV). It will contain several specialised features of note, including:

- Storage for 30,000 barrels of Heavy Fuel Oil
  - Tank Facilities

LFO Day Tank:	503 cubic metres
HFO buffer Tank (Day):	565 cubic metres
Fresh Lube Oil Storage:	65 cubic metres
Used Lube Oil Storage:	20 cubic metres
Intermediate Lube Oil Storage:	16 cubic metres
Maintenance Water:	25 cubic metres
Oily Water Buffer Tank:	50 cubic metres
Sludge:	50 cubic metres

- A double hull design to create an extra barrier with the marine environment in the unlikely event of a leak or spill. .
- A 20 cubic meter storage tank for used oil. In addition, oily water from the facility is treated on the barge, which is equipped with oil/water separators. The oily water is collected and transported by private contractors to Petrojam.
- The facility can operate with Light or Heavy Fuel Oil. The Light (back-up) and Heavy (main) Fuel Oil Tanks will be equipped with valves; level indicators and alarms for high and low fuel levels.
- The walls and roof of the Power and Deck House on the barge will be insulated with Rock Wool for fire proofing. This puts the roof in the Fire Resistance Category A, or fire-proof. In addition, fire alarms and an on-board fire extinguishing system with the following will be provided with the barge:
  - 2 pumps, 10 hoses, 2 hydrants, 3 foam units, 6 portable CO_2 extinguishers, 12 dry powder extinguishers and 3 sets of fireman's protective outfits with breathing apparatus

- An automation system allows centralized operation of the plant from a control room. Alarms and important measurements from auxiliary units are connected to the automation system. Local independent access to critical aspects of the system is built in if required. The control room contains a PLC (Programmable Logic Controllers) based control and monitoring system which controls the generators and substation. Sensors are strategically located on the engines and auxiliaries send information from the entire operation to the PLC and computers which control the engines and substation.
- Impurities and water are removed from the bunker fuel oil by heating and centrifuging before it enters the engine. Each engine is equipped with a lubricating oil centrifuge, which purifies the oil and extends oil change intervals.
- The main generating equipment consists of three Wärtsilä 18V46 engines working at 500 revolutions per minute (rpm). These are coupled to 3-phase synchronous generators producing 11kV at a frequency of 50hertz (Hz). The outboard substation will transform the electricity to 138 kV to be connected to the land-based JPS substation.
- Each of the 3 engines will have its own exhaust stack. However, rather than having 3 individual stack exiting the barge, one truss structure will be designed to support the individual engine stacks.
- One emergency diesel generator set with a minimum capacity of 500 kW, rated 625kVA, 400 V.
- The barge will contain a packaged sewage treatment unit and is designed for a 25-person capacity.

3.3.1 ONSITE CONSTRUCTION

This activity will involve the construction of a jetty with reinforced concrete deck and a section will be covered with asphaltic concrete. There will be a bridge that connects this to the proposed barge (access ramp).

The existing area which is on average approximately 2m deep will be dredged to approximately 5.5m to create an adequate basin to accommodate the proposed barge. At this depth sufficient allowance is made for the laden barge (fuel) with a draught of approximately 4.5m. This means that the clearance between the bottom of the barge's sea –chest and the bottom of the barge basin is approximately 1m. This should be sufficient to eliminate the possibility of significant amount of sediments being sucked up in the cooling water.

It is estimated that it will be necessary to remove approximately 18,500- 20,000 cubic metres of material from the foreshore area at the proposed site in order to provide suitable conditions for the installation and operation of the barge.

3.3.2 OPERATION

The start of operations of the facility will mark the beginning of the Environmental Monitoring, Management and Mitigation Plan for the facility. This will include the monitoring of the following parameters:

- water quality 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

In addition, JEP will be proactive in addressing any issues raised by the neighbouring communities and local authorities.

3.3.3 DECOMMISSIONING

As part of the Environmental Monitoring and Mitigation Plan for the proposed facility, JEP will provide a decommissioning plan that will consider the most environmentally sound and cost effective means of disposal for the barge and its major parts. This will be presented to NEPA and the World Bank within 2 years of commissioning the facility. The expected life span of the barge is 25 years.

4.0 BASELINE DESCRIPTION

4.1 CLIMATOLOGY, METEOROLOGY AND AIR QUALITY

4.1.1 CLIMATOLOGY AND METEOROLOGY

Jamaica has a maritime climate that is largely controlled by warm equatorial ocean currents creating a hot and humid climate. The temperature variations in Jamaica are minor. Minimum daily temperatures vary between 12.4 and 18.8°C. Maximum daily temperatures vary between 31.1 and 31.6°C. The mean annual temperature on the southern coastal plains is 24 ^{o}C. The mean monthly temperatures are lowest in January and February (23.6 ^{o}C) and highest in August and September (26.6 ^{o}C). The mean monthly relative humidity ranges between 76.8 and 80 percent. Relative humidity is lower in the afternoon and higher in the evenings (FAO, 1974).

The prevailing trade winds bring moist air from the east so higher rainfall is at the eastern end of the island (FAO, 1974). The main dry season lasts from December through April. Maximum rain generally occurs in October with a secondary maximum in May. Sixty-nine percent of the rainfall occurs in May, June, October, and November. The monthly evapotranspiration ranges between 77 – 158 millimetres (mm). Evapotranspiration rates are often higher than rainfall levels, causing drought conditions in some areas. Annual rainfall ranges between 1,400 – 2,200 mm. Rainfall in the south coastal plains of Clarendon and St. Catherine Parishes is generally less than 1,500 millimetres per year (Underground Water Authority, 1990).

Figure 4 shows an annual wind rose for the Old Harbour area from July 1999 through July 2000. The predominant wind direction is from the south southeast and southeast with a secondary maximum from the north northeast.

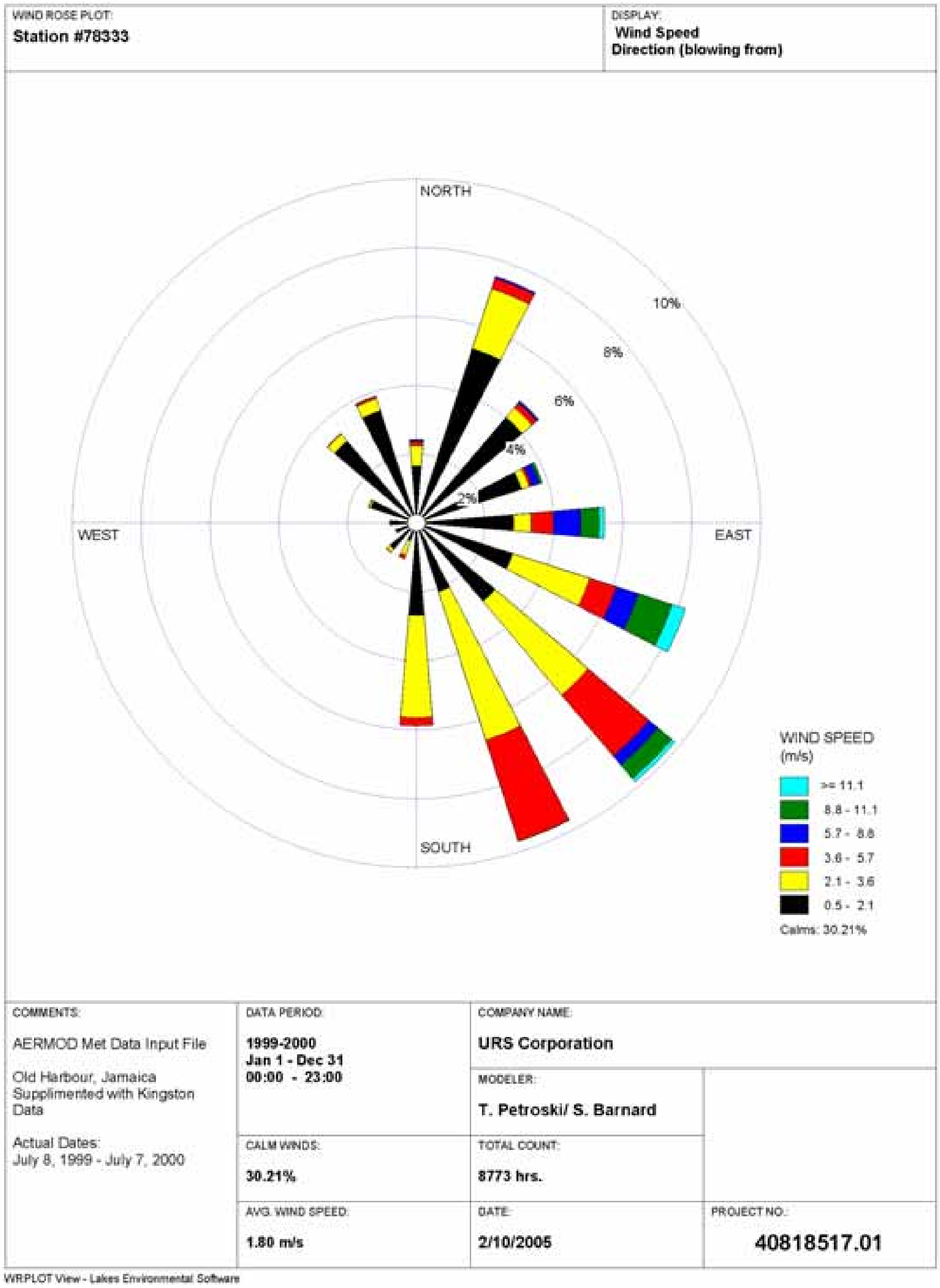


Figure 4 Old Harbour, Jamaica Windrose (July 1999 through July 2000) Orientation: Blowing From" Windspeed: meters per second

4.1.2 AIR QUALITY

There has been an ambient air quality monitor in operation near the JEP/JPS plant location since February 2004. This monitor is not in a location to record a maximum concentration from the combined operations of both plants, but these data would be indicative of the general ambient air quality levels in the project area. Table1 provides a summary of the valid data from this monitor.

Table 1 Ambient air quality monitoring data, Old Harbour

Pollutant	Maximum Concentration Measured During Each Month, ug/m^3 or parts per billion										
	Feb 04	Mar 04	Apr 04	May 04	June 04	July 04	Aug 04	Sep 04	Oct 04	Nov 04	Dec 04	Jan 05
PM_{10} (average in ug/m^3)	34.35	32.61	33.06	-	-	53.32	44.98	25.8	-	-	-	27.23
24-hour (Max in ug/m^3.)	82.65	51.05	42.84	-	-	86.60	84.95	23.12	-	-	-	37.99
Annual	37.35 (based on approximately six months data)											
TSP (average in ug/m^3)	-	-	-	34.94	66.52	-	-	-	34.16	25.90	28.80	-
24-hour (Max in ug/m^3.)	-	-	-	53.11	114.83	-	-	-	91.92	35.61	42.83	-
Annual	38.06 (based on approximately five months data)											
NO_x												
1-hour	216.1	33.9	22.8	42.5				39.4	43.5	36.4	36.2	36.6
24-hour	12.1	12.7	8.8	11.1				11.9	10.5	15	10.1	11.7
Annual	15.7											
SO_2												
1-hour	397.8	279.7	247.7	278.0				-	-	-	-	-
24-hour	74.1	34.6	43.5	91.2				-	-	-	-	-
Annual	15.9											
CO												
1-hour	1937.5	2512.5	-	-	-	-	937.5	1037.5	2925	837.5	1400	1100
8-hour	1025	1750	-	-	-	-	762.5	475	1275	462.5	662.5	550

- Indicates missing data

<u>Notes:</u>

1. The Annual averages are not actually annual averages since the Station has been in operation for a little over 11 months. Hence the values stated for annual averages are extrapolated.
2. Bad data was removed in calculating the mean monthly values for PM10 and TSP.
3. The highest daily values recorded for each month is recorded in Table 1 as the 24-hour Max (in ug/m^3).

4.2 PHYSIOGRAPHY, GEOLOGY AND STRUCTURE

4.2.1 Physiography

The site and its environs are situated on the southwestern flank of the Rio Cobre fan/ alluvial plain complex (Figure 5). The coastline in this area is low-lying, characterized by sand flats, salt marsh/ pans and mangrove backing the beaches. No height in the region of the site exceeds 2 metres and heights at the site itself are less than 1 metre above sea level (asl). Evidence from historical maps and aerial photographs suggests that the coastline has changed its position over the past 60 years (Figure 6). The site of the power station is on artificially reclaimed land, and/ or land produced by progradation of the coastline. The site of the power station is bounded to the west by the seasonal Bowers Gully and to the east by the township of Old Harbour Bay.

4.2.2 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). The present beach sediments consist mainly of non-carbonate grains (Wood, 1976).

The project site is located in Portland Bight in south central Jamaica adjacent to the St. Catherine coastal plain. The coastal plains are comprised of quaternary alluviums of generally moderate permeability. Coefficient of permeability is expected to be low to very low and should range from 10^{-5} to 10^{-10} meters per second. The alluvial plain results largely from the build up of essentially non-limestone deposits derived by rivers from the largely volcanic rocks of the island's interior, and consists of coarse gravel, sand and clay (Harris and Williams, 1999). Well log data for alluvium in the Dorothy's plain indicate that clay, and clay with variations of sand and gravel are dominant in the upper 23 meters (Harris and Williams, 1999). The alluvium varies in thickness from a few feet near contact with the surrounding limestone hills to several hundred feet on the central plain area (Harris and Williams, 1999).

In coastal areas there are two main alluvial soil series: the recent Agualta sandy loam and Caymanas clay loam. The older alluvials are Church Pen clay and Bodles Clay loam (e.g. found in Clarendon).

In 2002 JPS installed three monitoring wells at the proposed project site. The following table lists the soil descriptions obtained during well installation.

Table 2 Monitoring Wells –Soil Description

Well	Depth Interval (ft-bgs)	Soil Description
MW-1	5-6	Silty clay (ML) dark brown, dry, slightly poorly graded
	10-11.5	Dark brown silty clay, trace gravel (CL) dry, slightly plastic
	15-17.5	Dark brown silty sand (SM) with trace gravel, wet
	20-21.5	Dark brown silty clay, trace gravel, lenses of gray clay distributed evenly throughout, (CL),dry, stiff
MW-2	5-6	Dark brown silty sand (SM) loose, moist, poorly graded
	10-11.5	Dark brown medium sand (SP), poorly graded, wet, loose
	15-16.5	Dark brown medium sand (SP) poorly graded, wet, loose
MW-3	5-6	Dark brown silty sand (SM) moist, loose poorly graded
	10-11.5	Dark brown silty sand (SM) moist, loose poorly graded
	15-16.5	Dark brown medium sand (SP) wet, loose, poorly graded

Source: MACTEC formerly Harding ESE

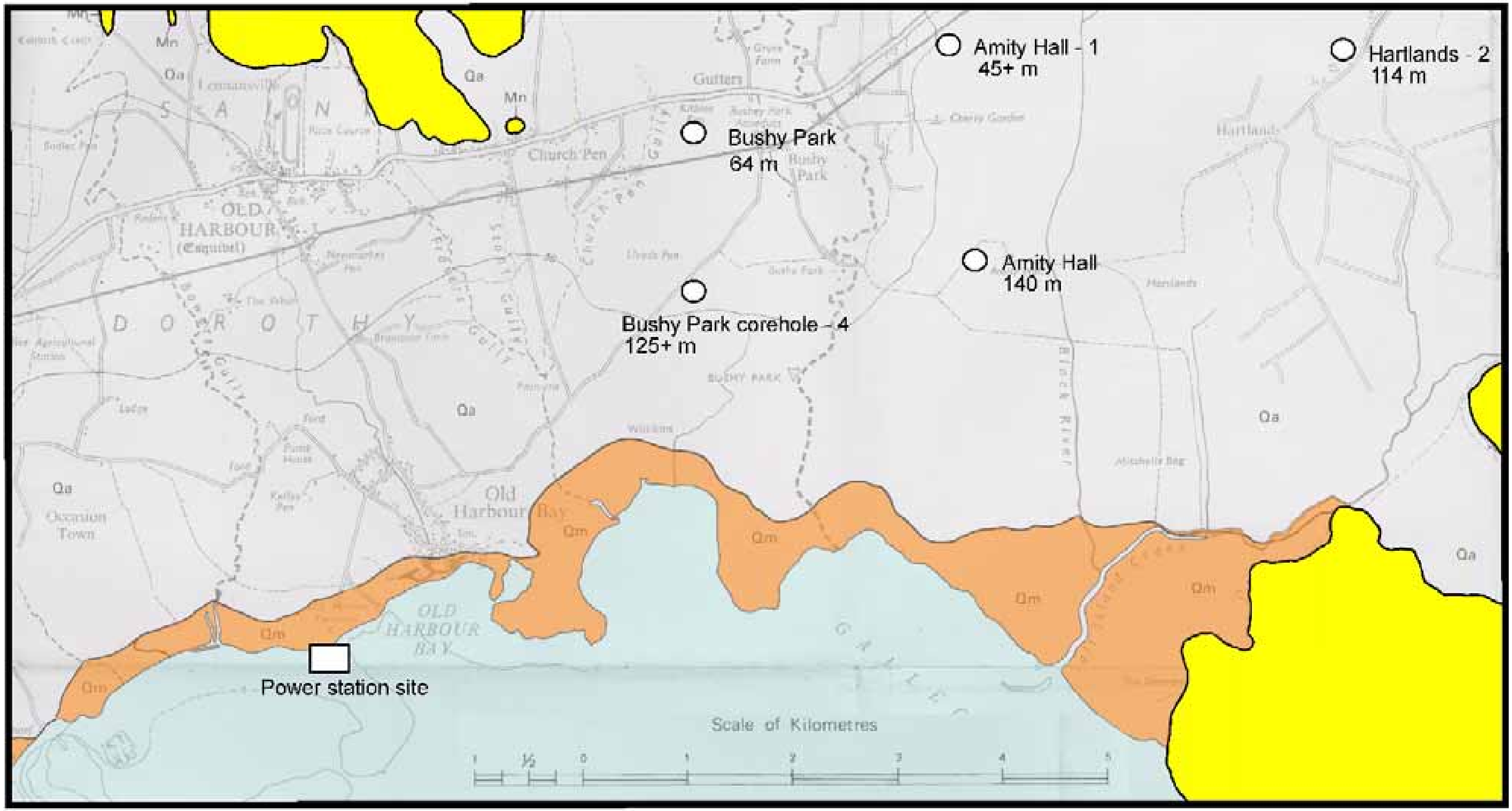


Figure 5 **Geological map of Old Harbour Bay area. Qa(grey), Quaternary alluvium; Qm (brown), sediments of the coastline; yellow, White Limestone Group; white circles, sites of wells, depth to White Limestone bedrock indicated. White rectangle, site of JEP power station.**

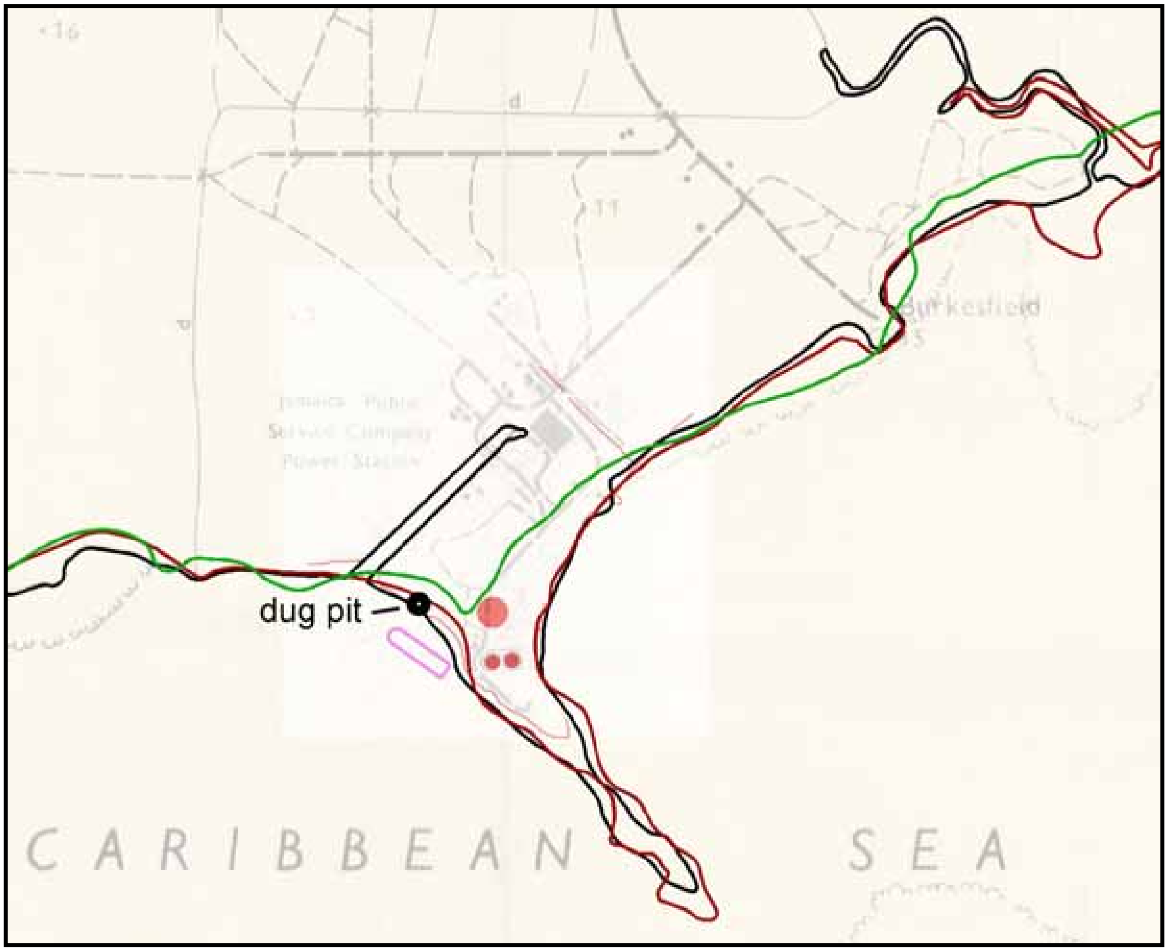


Figure 6 Changes of the Old Harbour Bay coastline over the past 60 years.

Green Line – coastline derived from photographs taken in January 1942; Black Line - coastline derived from photographs taken in 1968; Red Line – coastline derived from photographs taken in 1953; purple rectangle is proposed site for the barge. Thin red line indicates shoreline indicated on the JEP installation survey. Scale bar is 500 m**.**

Unconsolidated or semi-consolidated deposits of Holocene age probably extend to a depth exceeding 200 metres (Figure 5; data from Porter and Bateson, 1974, and Fernandez, 1983; Halcrow, 1998). 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) is present at Old Harbour Bay (Porter and Bateson, 1974).

4.2.3 Structure

There is no evidence of structural complications within the superficial sediments of the area. However 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.

4.2.4 Seismicity

As indicated above, evidence of fault movements affecting the White Limestone bedrock (ten million years and older) in the Old Harbour Bay region is provided by data from water supply wells and geophysical studies (Fernandez, 1983). In other parts of the island rocks of the Coastal Group (1-5 million years old) are faulted. However, as noted above, faulting affecting more recent unconsolidated or semi-consolidated sediments may frequently be difficult to identify, and is certainly not evident in the field at Old Harbour Bay. Figure 8, 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 occur per century.

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 best 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.

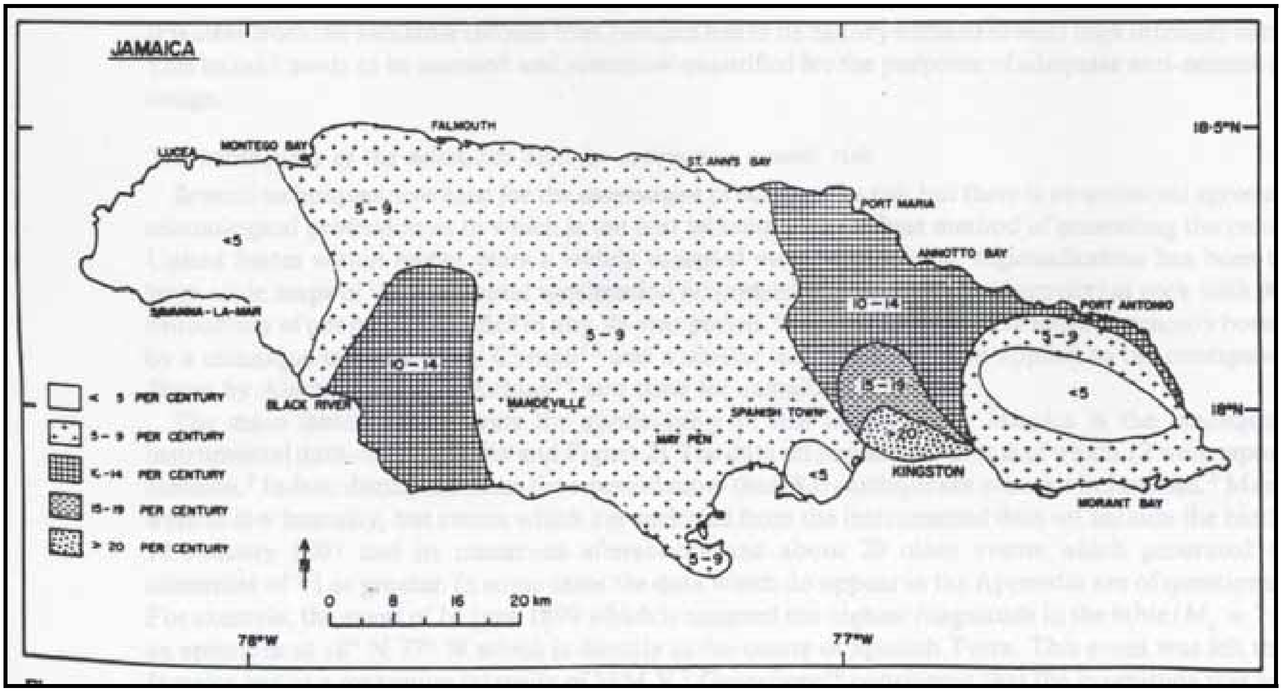


Figure 7 **Map showing number of times per century that intensities of MM VI or greater have been reported, 1880-1960 (from Shepherd & Aspinall, 1980)**

Most of the large earthquakes (M 6.0 or greater) over the past 100 years have occurred offshore, while the smaller seismic events were generated beneath the mainland (Harris and Williams, 1999). Modelling of the Crawl River-Rio Minho fault system that passes within 30 kilometres of the project site has worst case slip rate of 5 millimetres per year and a best case rate of 1 millimetre per year (Harris and Williams, 1999). For the project site, ground shaking at the site will likely last between 0.5 and 3.0 seconds. Peak ground acceleration of 0.245g with a 10-percent probability of exceedance in 50 years was estimated (Harris and Williams, 1999). With respect to project siting and seismic zone risks, Geomatrix, Ja.,Ltd (1991b) stated that given the seismic history of Jamaica that this factor must be considered an acceptable risk.

4.3 NATURAL HAZARDS

The natural and anthropogenic hazards include;

i. Hurricane Waves, Winds and Storm Surge
ii. Tsunami
iii. Long term sea level rise
iv. Oil Spills
v. Fire

Hurricane Waves

A database of hurricanes, dating back to 1886, was searched for storms that passed within a 500km radius from the site. The results of the search from the database for hurricanes that came within 500 km of the site are shown in Table 3.

Table 3 Hurricanes and storms that have come within 500 km of the JEP site, Portland Bight, Jamaica

	Storm No.	Name	Date	SS Cat		Storm No.	Name	Date	SS Cat		Storm No.	Name	Date	SS Cat		Storm No.	Name	Date	SS Cate
1	10	NOTNAMED	1852	2-	31	360	NOTNAMED	1901	1-	61	550	NOTNAMED	1932	3-	91	886	INEZ	1966	4-
2	38	NOTNAMED	1857	2-	32	375	NOTNAMED	1903	3-	62	553	NOTNAMED	1932	4-	92	890	BEULAH	1967	5-
3	50	NOTNAMED	1859	3-	33	383	NOTNAMED	1904	1-	63	556	NOTNAMED	1933	2-	93	910	FRANCELIA	1969	3-
4	83	NOTNAMED	1864	1-	34	391	NOTNAMED	1905	2-	64	557	NOTNAMED	1933	1-	94	936	CHLOE	1971	1-
5	89	NOTNAMED	1865	3-	35	400	NOTNAMED	1906	4-	65	560	NOTNAMED	1933	1-	95	938	EDITH	1971	5-
6	94	NOTNAMED	1866	3-	36	403	NOTNAMED	1906	1-	66	569	NOTNAMED	1933	2-	96	966	CARMEN	1974	4-
7	127	NOTNAMED	1870	2-	37	418	NOTNAMED	1909	4-	67	570	NOTNAMED	1933	1-	97	969	FIFI	1974	2-
8	150	NOTNAMED	1873	3-	38	419	NOTNAMED	1909	1-	68	572	NOTNAMED	1933	4-	98	1004	GRETA	1978	4-
9	157	NOTNAMED	1874	2-	39	420	NOTNAMED	1909	3-	69	573	NOTNAMED	1933	2-	99	1018	ALLEN	1980	5-
10	160	NOTNAMED	1875	3-	40	422	NOTNAMED	1909	4-	70	585	NOTNAMED	1934	1-	100	1025	HERMINE	1980	1-
11	172	NOTNAMED	1877	3-	41	424	NOTNAMED	1909	3-	71	590	NOTNAMED	1935	3-	101	1078	DANIELLE	1986	1-
12	178	NOTNAMED	1878	1-	42	425	NOTNAMED	1909	1-	72	591	NOTNAMED	1935	1-	102	1095	GILBERT	1988	5-
13	183	NOTNAMED	1878	4-	43	426	NOTNAMED	1910	1-	73	619	NOTNAMED	1938	2-	103	1099	KEITH	1988	2-
14	188	NOTNAMED	1878	1-	44	427	NOTNAMED	1910	3-	74	620	NOTNAMED	1938	2-	104	1111	ARTHUR	1990	1-
15	194	NOTNAMED	1879	1-	45	432	NOTNAMED	1911	2-	75	642	NOTNAMED	1941	3-	105	1186	MARCO	1996	1-
16	198	NOTNAMED	1880	4-	46	439	NOTNAMED	1912	4-	76	646	NOTNAMED	1942	3-	106	1207	MITCH	1998	5-
17	199	NOTNAMED	1880	1-	47	446	NOTNAMED	1915	4-	77	648	NOTNAMED	1942	1-	107	1220	LENNY	1999	4-
18	227	NOTNAMED	1884	2-	48	448	NOTNAMED	1915	2-	78	666	NOTNAMED	1944	1-	108	1228	HELENE	2000	1-
19	240	NOTNAMED	1886	2-	49	449	NOTNAMED	1915	4-	79	668	NOTNAMED	1944	3-	109	1238	CHANTAL	2001	1-
20	241	NOTNAMED	1886	2-	50	453	NOTNAMED	1916	3-	80	739	CHARLIE	1951	4-	110	1244	IRIS	2001	4-
21	242	NOTNAMED	1886	3-	51	455	NOTNAMED	1916	3-	81	740	DOG	1951	3-	111	1259	ISIDORE	2002	3-
22	247	NOTNAMED	1887	2-	52	462	NOTNAMED	1916	3-	82	761	FLORENCE	1953	3-	112	1262	LILI	2002	4-
23	248	NOTNAMED	1887	1-	53	466	NOTNAMED	1917	3-	83	776	HAZEL	1954	4-					
24	252	NOTNAMED	1887	2-	54	467	NOTNAMED	1918	2-	84	788	JANET	1955	5-					
25	277	NOTNAMED	1889	2-	55	468	NOTNAMED	1918	2-	85	790	KATIE	1955	3-					
26	321	NOTNAMED	1895	2-	56	503	NOTNAMED	1924	2-	86	811	ELLA	1958	3-					
27	324	NOTNAMED	1895	3-	57	525	NOTNAMED	1928	1-	87	829	ABBY	1960	2-					
28	329	NOTNAMED	1896	3-	58	526	NOTNAMED	1928	1-	88	835	ANNA	1961	3-					
29	344	NOTNAMED	1898	1-	59	537	NOTNAMED	1931	1-	89	857	FLORA	1963	4-					
30	345	NOTNAMED	1898	1-	60	539	NOTNAMED	1931	3-	90	864	CLEO	1964	4-					

Tsunami

Although tsunamis (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.

Long term sea level rise

Data from the Arctic Climate Impact Assessment report, released in mid-November, 2004, indicates 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 70 centimetres to one metre by the end of the century. This rise will be gradual, but the consequences of such a rise must be taken into consideration in any construction of the new plant.

Oil Spills

With the onboard storage of approximately 30,000 barrels of fuel oil (Bunker C), there is potential for oil spill. However the double hulled design around the fuel storage area of the proposed barge reduces the potential. If, in the unlikely eventuality of both layers being ruptured, there is leakage to the outside environment (sea), then there is a permanent oil boom surrounding the barge, which would contain the spill locally (Plate 1). If this fails then there are contingencies outlined in the existing Oil Spill Contingency Plan, which will be updated to include the proposed barge. These include using additional booms, skimmers, absorbents and mops. The plan also categorizes the spill level, who to be contacted in the event of a spill, and the names, roles and responsibilities of the individuals.

The spill level are categorized as follows;

i. Level 1 – the spill is dealt with in house
ii. Level 2 – mutual aid is sought from other local entities such as West Indies Alumina Company (WINDALCO) and the Jamaican Coast Guard.
iii. Level 3 – overseas assistance is sought.

Plate 1 Picture showing the boom around the existing barge "Dr. Bird"

Fire

With the operation of such a facility there is always the risk of a fire. The fire may originate from the operation or from activities surrounding it. Fortunately, the proposed barge will be surrounded mainly by the waters of Portland Bight and the main threat as it relates to fires, are the existing barge and the JPS plant and junk yard (Figure 8).

Figure 8 Potential areas of risk as it relates to fires

4.4 PHYSICAL AND CHEMICAL OCEANOGRAPHY: Bathymetry, Currents and Water Quality

The marine environment of the entire Old Harbour Bay ranges from pristine clear waters offshore with a calcareous dominated substrate to sediment, nutrient and thermally affected waters along the shoreline.

4.4.1 Bathymetry

Bathymetric data were acquired by field measurements using a depth sounder and Global Positioning System. These data were augmented with existing information from three geo-referenced bathymetric charts of Port Esquivel, Portland Bight and Eastern Jamaica. These were as follows:

1. BA 457
2. BA 255
3. BA 257

The WGS 84 datum in a UTM projection was assumed for all of the geo referencing work. See Figures 9 and 10 for plots of the bathymetry for the overall project area.

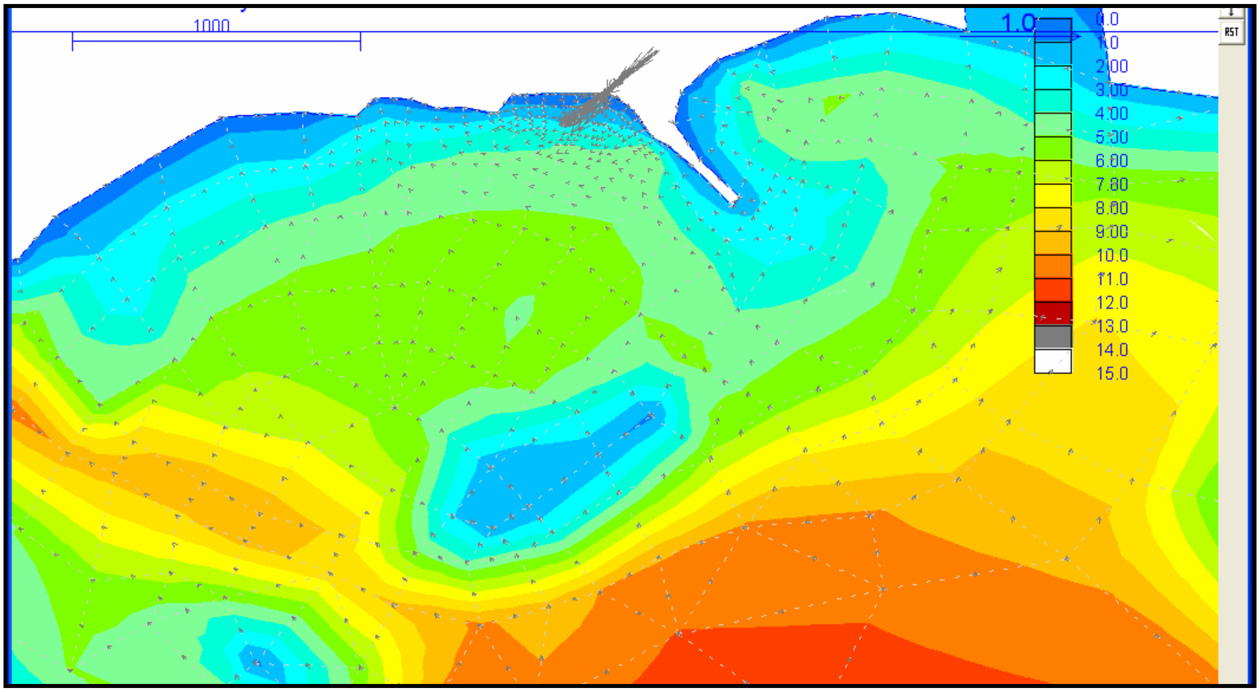


Figure 9 Bathymetry of the entire hydrodynamic mesh, from Portland Bight, Jamaica

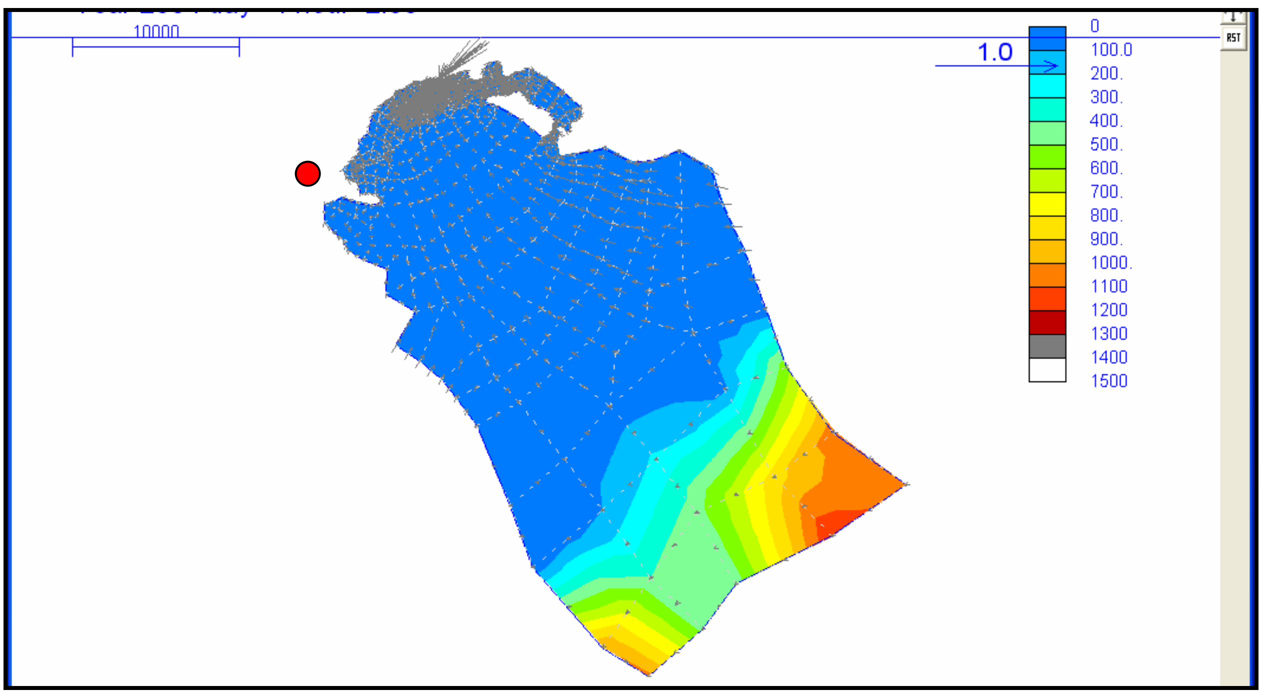


Figure 10 Bathymetry of the project area (JEP), in Portland Bight

4.4.2 Currents

Baseline current data in the project area were investigated using surface and sub-surface drogues. A total of five sessions (two on October 30, 2004 and three on January 3-4, 2005) were carried out for this project. The objective of this current monitoring program was to gather sufficient information on the currents in the area so as to facilitate the calibration of the hydrodynamic model (which was used to assess impacts of a thermal plume discharge in Section 5.0).

First Monitoring Mission (30th of October, 2004)

Currents were monitored during two sessions on the 30th of October, 2004 during the rising and falling tides for that day. The currents were monitored using drogues with sails set at surface and 2 m water depths. The prevailing wind speeds and directions during that day are shown in Figure 11 for Norman Manley Airport. The data provided by JEP for the site appeared suspect with low wind speeds and inaccurate directions (in comparison to those directions observed in the field).

The drogue trajectories and speeds (Figures 12 and 13) indicate that the currents in the area monitored were predominantly affected by winds. Lower wind speeds of 10 to 15 knots resulted in surface and sub-surface current speeds of 2 to 3 centimetres per second (cm/sec). Higher wind speeds of 15 to 20 knots result in current speeds of 6 to 8 cm/sec in the same general direction of the wind.

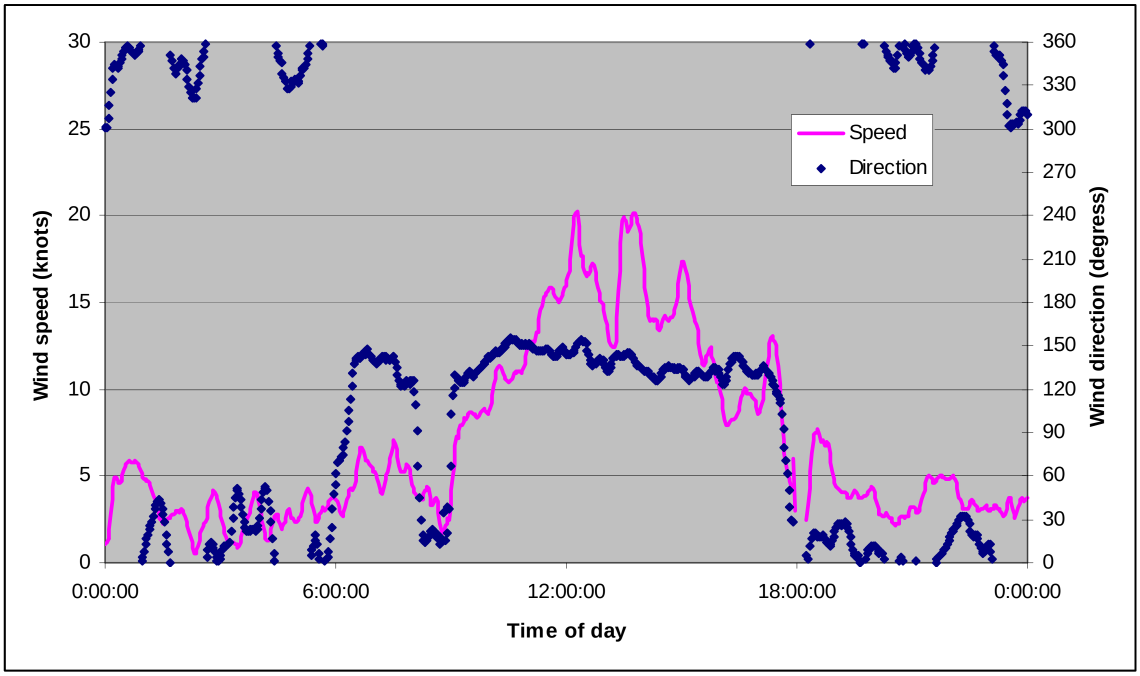


Figure 11 **Wind data for Norman Manley International Airport (Kingston, Jamaica) for 30th of October, 2004**

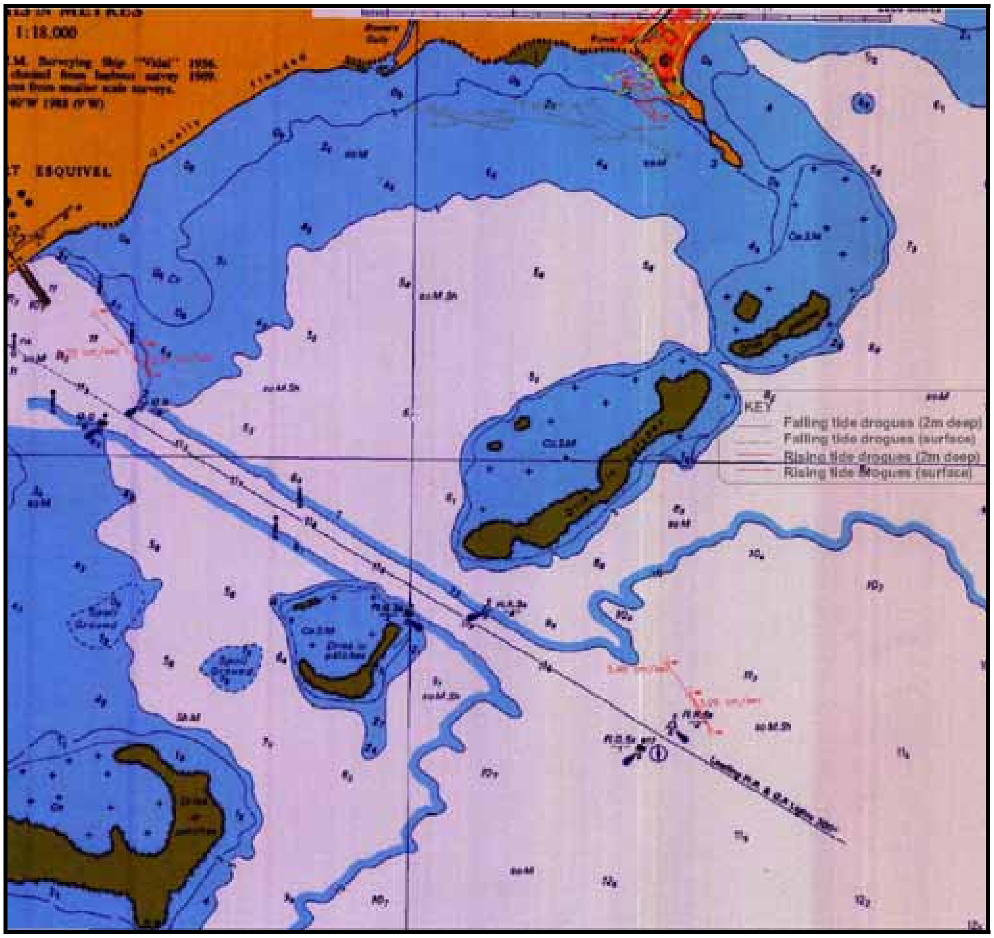


Figure 12 Both rising and falling tide surface and 2 m deep drogues with estimated current speeds for October 30th, 2004

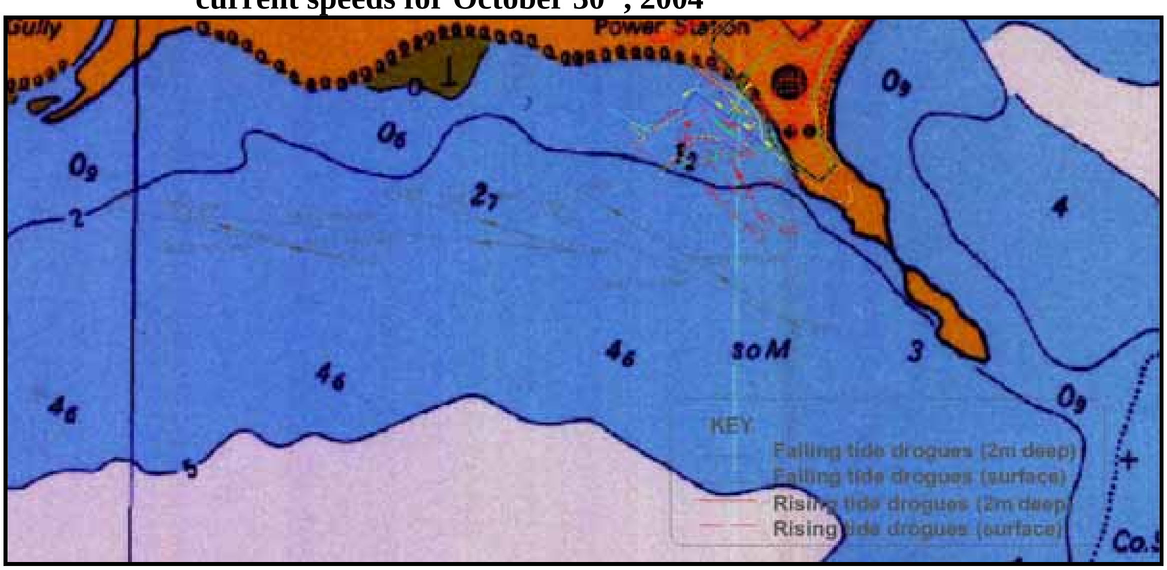


Figure 13 Both rising and falling tide surface and 2 m deep drogues with estimated current speeds for October 30th, 2004, close to the JEP complex

Second Monitoring Mission (3rd and 4th of January, 2005)

A second monitoring mission was undertaken in keeping with NEPA personnel concerns about the possible variations in currents during night time hours when currents could be moving south-easterly, due to northerly mountain winds in the area. Such currents could possibly result in a thermal recycling of the effluent to the intake.

Three sessions were undertaken between 5:00 pm on the 3rd of January, 2005 to 12:00 pm on the 4th of January, 2005. The first two sessions occurred during the night time hours predominantly, with light (i.e. <10 knots) NE winds. The late morning session on the 4th of January, 2005 was undertaken under slightly higher winds estimated to be about 15 knots from an ENE direction.

The drogue trajectories and speeds (Figures 14, 15 and 16) indicate that the currents in the area were predominantly affected by winds. Lower wind speeds of less than 10 knots resulted in surface current speeds of 6 to 10 cm/sec. Higher wind speeds of 15 to 20 knots result in current speeds of 10 to 13 cm/sec in the same general direction of the wind. Overall, the effects of the wind appears to be more dominant in comparison to the effect of tides as little tidal influence could be inferred from the drogue trajectories and speeds.

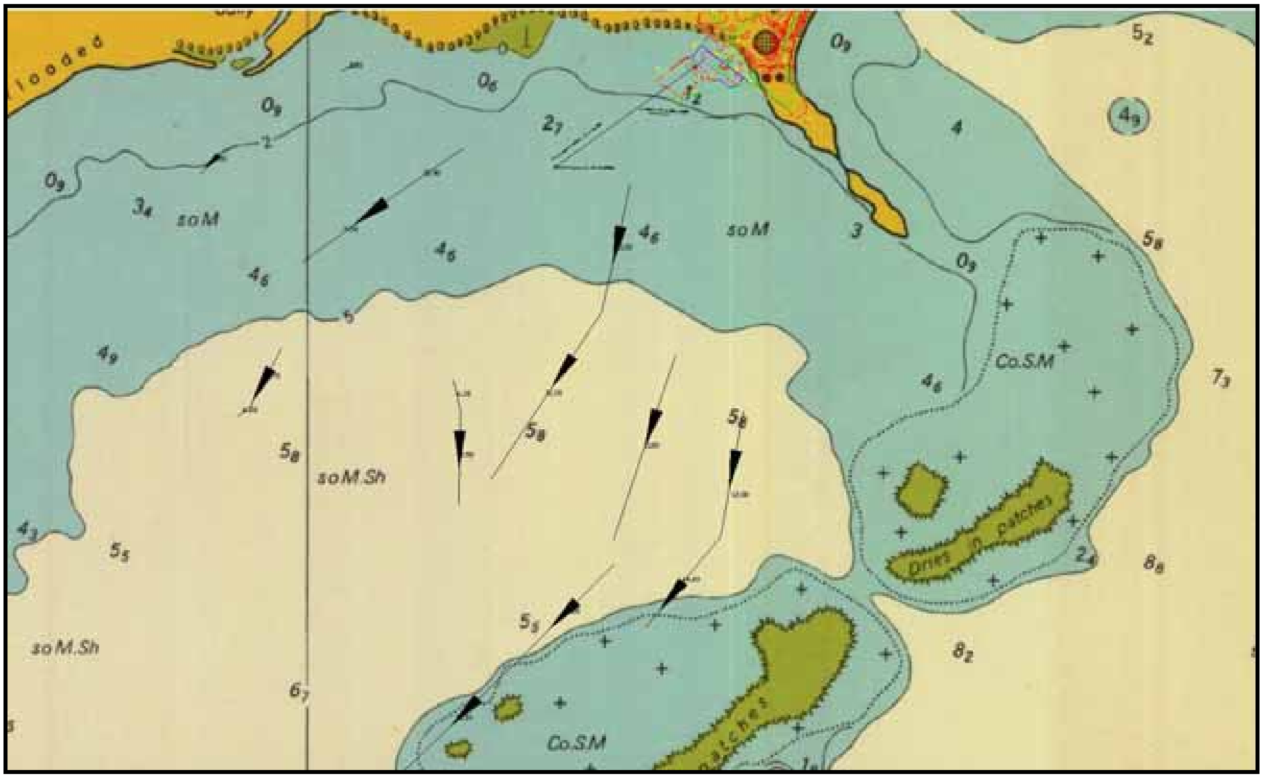


Figure 14 **Falling tide surface drogues with estimated current speeds for January 3rd, 2005 close to the JEP complex**

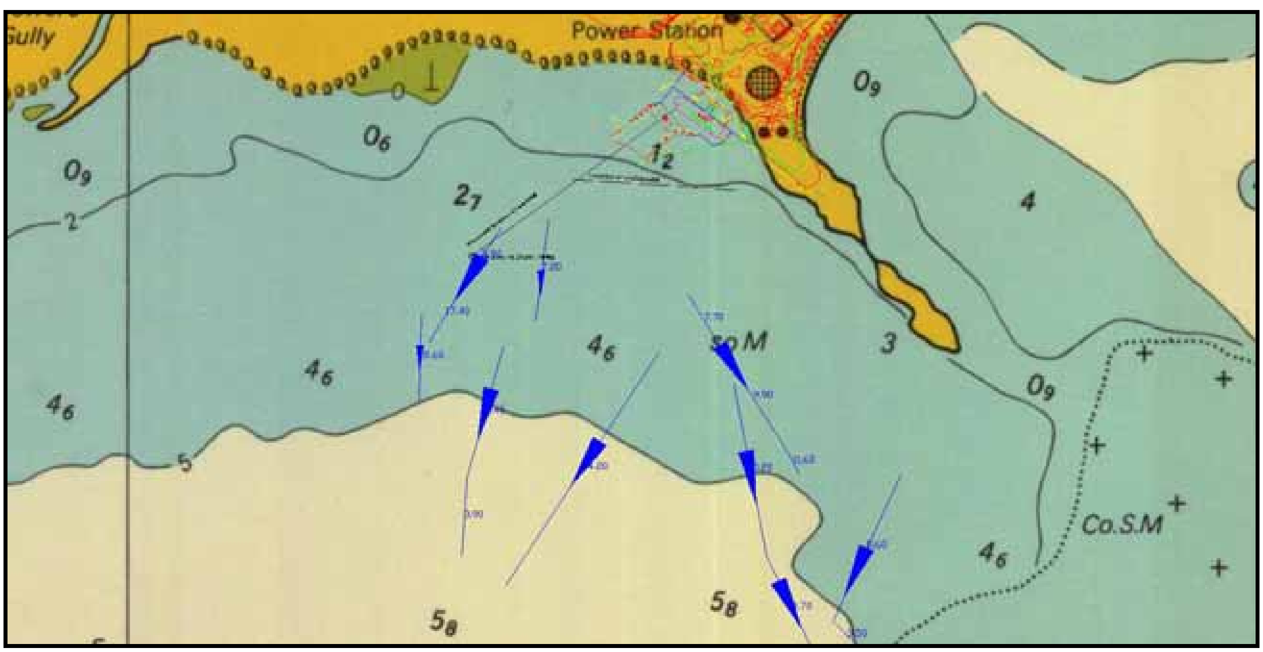


Figure 15 **Rising tide surface drogues with estimated current speeds for January 4th, 2005 close to the JEP complex**

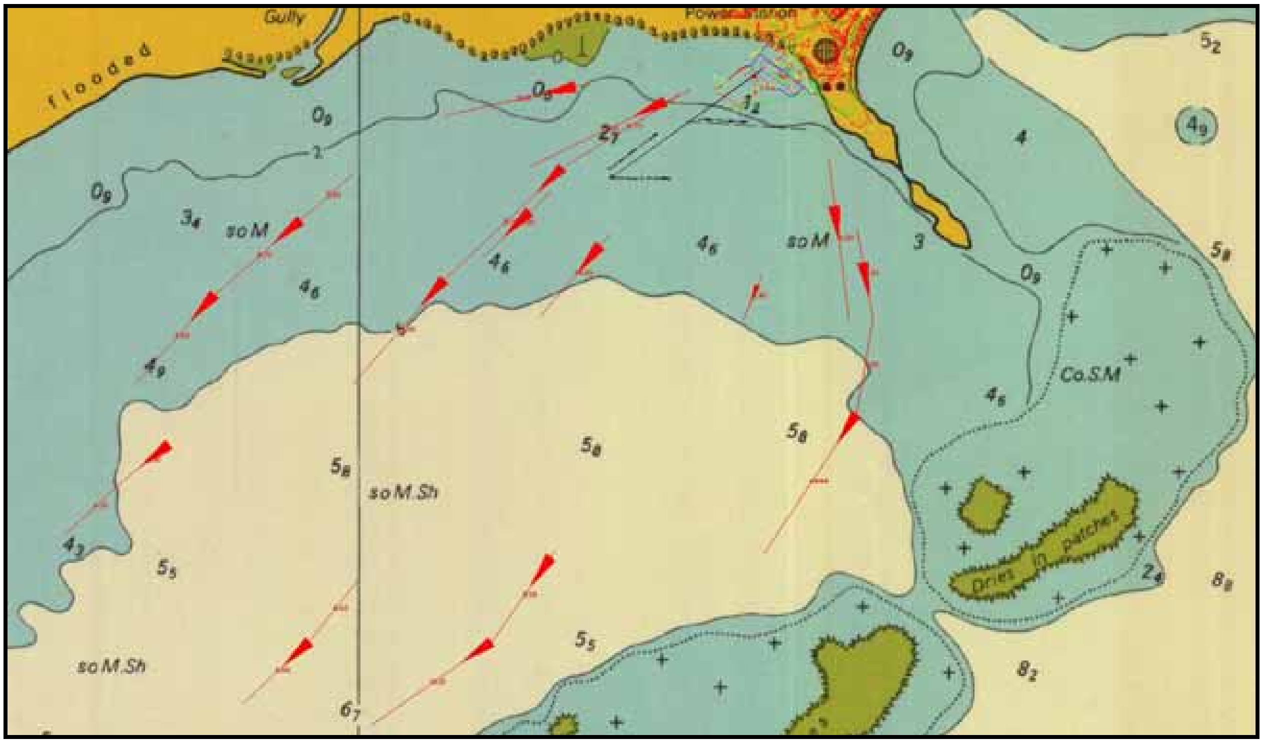


Figure 16 Falling tide surface drogues with estimated current speeds for January 4th, 2005 close to the JEP complex

4.4.3 Water quality

The Dr. Bird barge plant has been measuring certain chemical parameters in the cooling water discharge and the temperature profiles near the barge. Tables 4 and 5 provide summaries of these chemical and temperature measurements respectively.

Table 4 shows a summary of the historical data concerning the cooling water discharge for the current barge operations.

Table 4 Historical data cooling water discharge existing barge plant

DATE	COPPER (mg/l)	IRON (mg/l)	ZINC (mg/l)	TOTAL HEAVY METALS (mg/l)	pH	TSS (mg/l)
7/96	0.49	0.209	0.219	NA	8.20	10

DATE	COPPER (mg/l)	IRON (mg/l)	ZINC (mg/l)	TOTAL HEAVY METALS (mg/l)	pH	TSS (mg/l)
12/96	0.13	0.410	0.170	NA	8.32	16
7/97	0.059	0.300	0.056	NA	8.20	40
12/97	40	340	30	NA	7.20	985
7/98	0.024	0.410	0.062	NA	8.57	0
9/98	0.026	0.532	0.048	NA	NA	NA
10/98	0.08	0.51	0.05	NA	8.3	28
4,5/99	0.068	0.44	0.44	NA	8.97	14.3
12/99	0.01	0.02	0.48	NA	8.57	86.8
5/00	0.03	0.203	0.012	NA	8.32	3.5
9/02	<0.005	<0.100	<0.005	NA	7.97	NA
1/03	0.041	0.125	0.01	0.241	7.85	NA
12/03	0.06	0.17	0.04	NA	7.28	103.8

NA-Not available (either not recorded or not tested)

The parameters of chloride, oil and grease, and total heavy metals have not been routinely monitored, so there are little or no data on these constituents. Also, the data for December 1997 are suspect, and these data will not be used for any comparison purposes.

Table 5 provides data from 2002 and 2003 for various temperature measurements concerning the existing Doctor Bird barge inlet cooling water temperature (aft of barge) and various measurement points after discharge of cooling water.

Table 5 Temperature measurements for cooling water system existing barge plant

Point of Measurement	Temperature ^{O}C	Change in Temperature ^{o}C(from aft of barge to any other location)
9/17/02		
Aft of barge	30.62	-0.52 to +3.5
At discharge pipe(surface to 5m depth)	30.12-32.05	
1 m from discharge pipe(surface to 5 m depth)	30.14-31.06	
3 m from discharge pipe(surface to 5 m depth)	30.22-31.73	
5 m from discharge pipe(surface to 5 m depth)	30.1-34.12	

Point of Measurement	Temperature ^{O}C	Change in Temperature ^{o}C(from aft of barge to any other location)
1/24/02		
Aft of barge	27.59	-0.29 to +8.08
At discharge pipe(surface to 5 m depth)	29.42-35.67	
15 m from discharge pipe(surface to 5 m depth)	27.34-31.22	
25 m from discharge pipe(surface to 5 m depth)	27.3-30.56	
12/22/03		
Aft of barge	26.74	-0.12 to +5.01
At discharge pipe(surface to 5 m depth)	26.62-27.84	
15 m from discharge pipe(surface to 5 m depth)	26.7-31.75	
25 m from discharge pipe(surface to 5 m depth)	31.7-31.75	

Elevated temperatures from the existing Jamaica Public Service Co. Ltd. and Doctor Bird barge thermal discharges are a dominant water quality feature of the bay in the project area. The thermal discharges create surface water temperatures 3 to 8 ^{o}C higher than ambient, depending on proximity to discharge points. Salinity, pH and conductivity are relatively constant throughout the bay and describe the standards expected for a marine environment. However Dissolved Oxygen (DO) and to a lesser extent redox potential (ORP) indicate a marine environment under some stress. While the DO values over the proposed dredge site for barge location were lowest (>4.0 mg L-1) redox values were highest (143mV) throughout the bay but still considered very low by coastal water quality standards (C.L. Environmental, 2004). Increased depth with distance from shore only marginally improved subsurface water quality within the present thermal plume and increased distance outside of plume influence results in a cooler, but still affected, water column. These indicators, along with poor light penetration, render this section of the Old Harbour Bay as degraded and non-recoverable without significant relocation and remediation.

In July 2004 additional sea water temperature measurements were obtained near the existing barge. Figure 17 shows the locations monitored and the resulting temperatures. Station 3 is the location of the discharge point.

A comparison of the temperature readings for this period showed approximately a 1.47^{o}C increase in the surface temperature at the discharge pipe (Station 3) when compared to the water temperature at the aft of the barge (Station 1). Readings were taken approximately 87m (285 ft) southwest and northwest, 125m (410 ft) southeast and approximately 140m northeast of the discharge pipe. The results showed that there was a decrease in temperature at the southwest (Station 4) and southeast stations (Station B). There were however, an increase of 3.98^{o}C at the northwest station (Station A) and a 5.77^{o}C increase at the northeast station (Station 5).

The increase in temperature may be a result of currents and wind direction or influence from the JPS cooling canal.

Figure 17 July 2004 surface water temperature (^oC)

Thermal and physio-chemical water quality data for the site were collected concurrently with drogue tracking information. The data were collected *in situ* using a Hydrolab H_2O multiprobe data logger with sensors to measure: temperature; DO; pH; TDS and Conductivity.

Thermal discharges from the combined JEP and JPS operations create surface water temperatures 3 to 8 ^{o}C higher than ambient depending on proximity to discharge points. Observations during the first mission on the 30th of October, 2004 revealed that wind dispersion is the primary driving force for the thermal plume. Ambient temperatures at that time were 29.5 degrees Celsius. The 3 degree above ambient contour appeared to end some 800 to 1,000 metres from the JPS cooling canal. The plume also appeared to be attached to the shoreline where one could reasonably expect slower moving currents (Figures 18 to 21).

The second sampling mission on the 3rd and 4th of January, 2005 revealed that under offshore wind conditions that the plume moves, as expected, offshore in the direction of the wind. The overall dimension of the plume was between 300 to 400 metres for that portion of the plume three degrees Celsius above ambient (Figures 22 to 25).

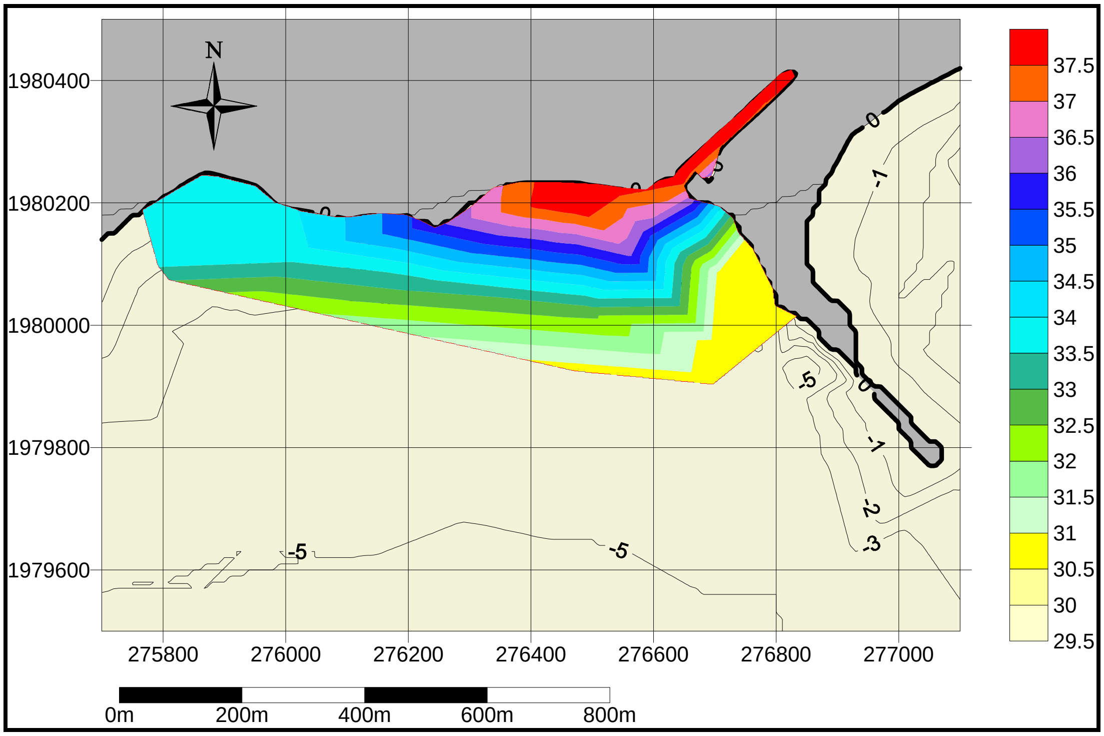


Figure 18 **Afternoon surface temperatures, at JEP on the 30th of October, 2004(1st session in morning)**

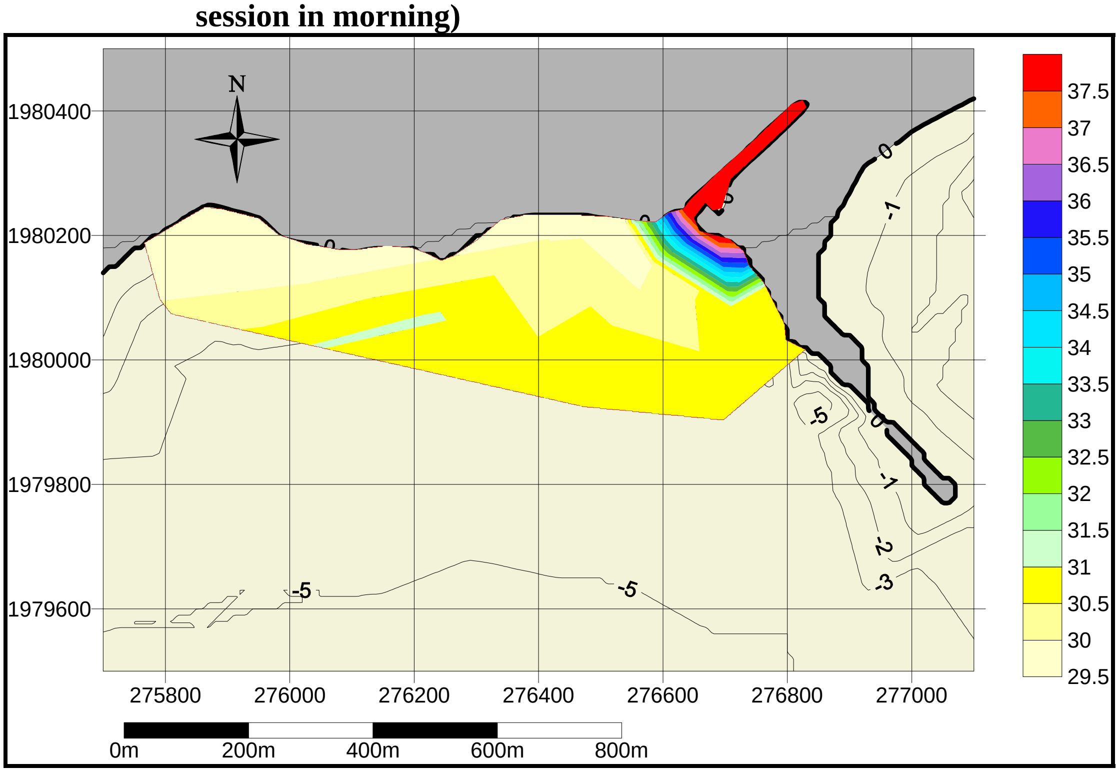


Figure 19 **Afternoon temperature at a 1m depth, at JEP on the 30th of October, 2004(1st session in morning)**

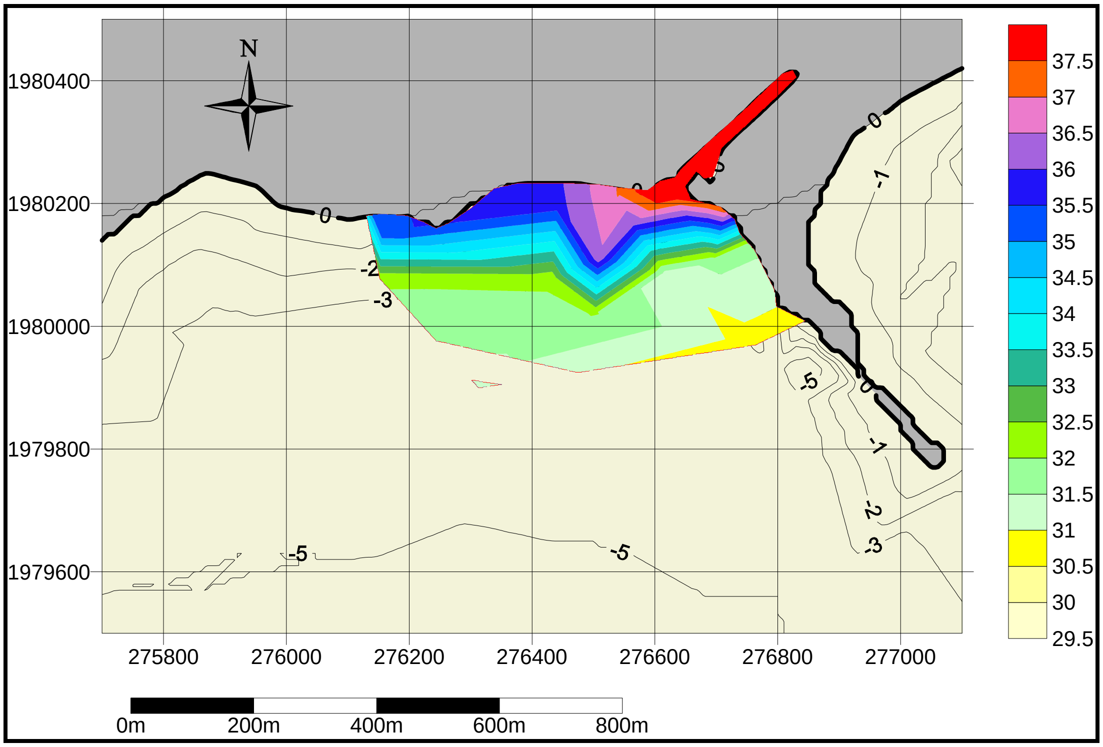


Figure 20 Morning surface temperatures, at JEP on the 30th of October, 2004 (2nd session in afternoon)

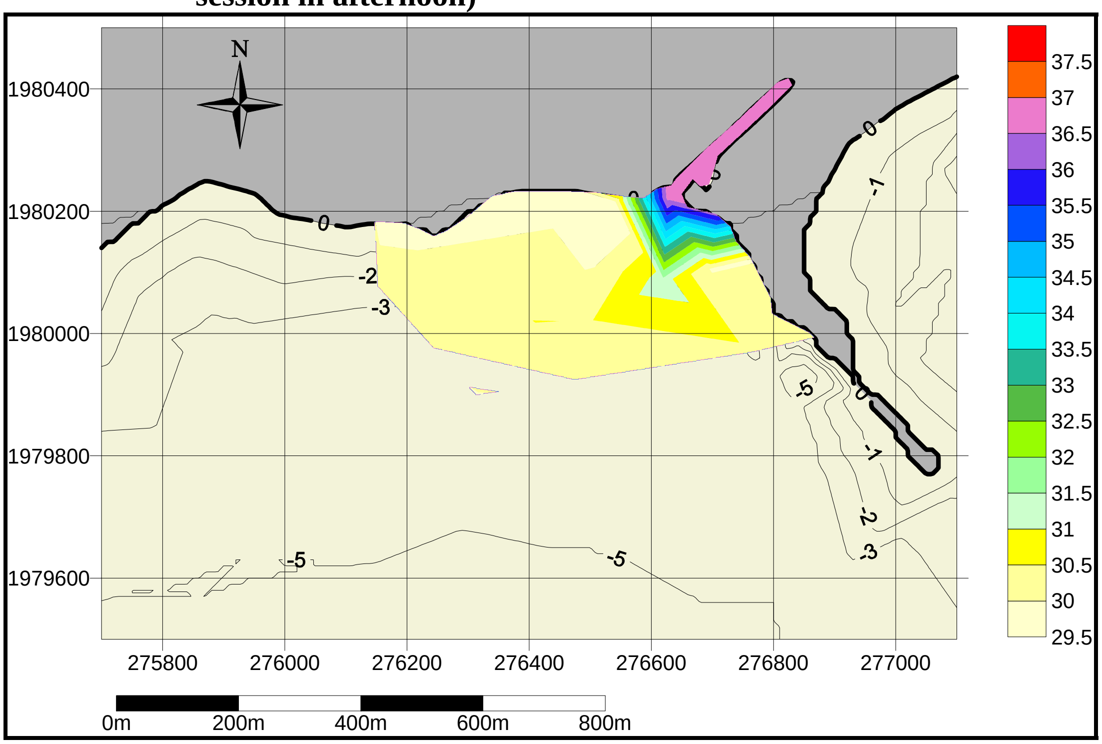


Figure 21 - Morning temperature at a 1m depth, at JEP on the 30th of October, 2004(2nd session in afternoon)

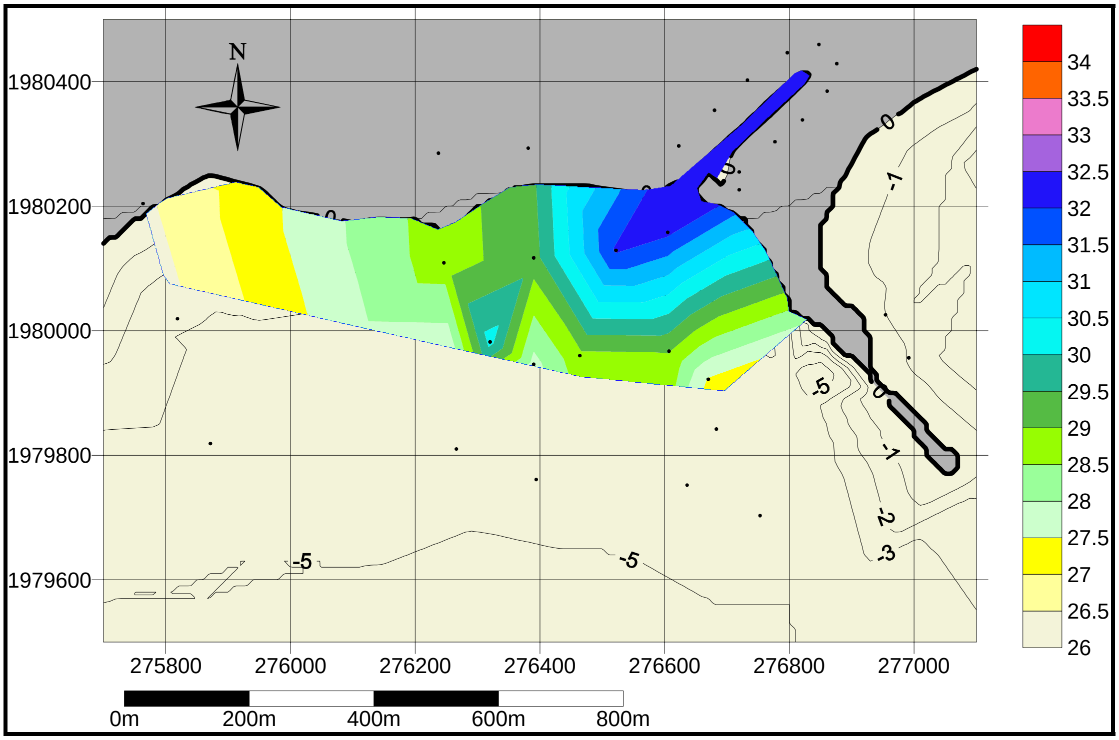


Figure 22 **Surface temperatures during Rising Tide, at JEP on the 3rd of January, 2005 (1st session in night)**

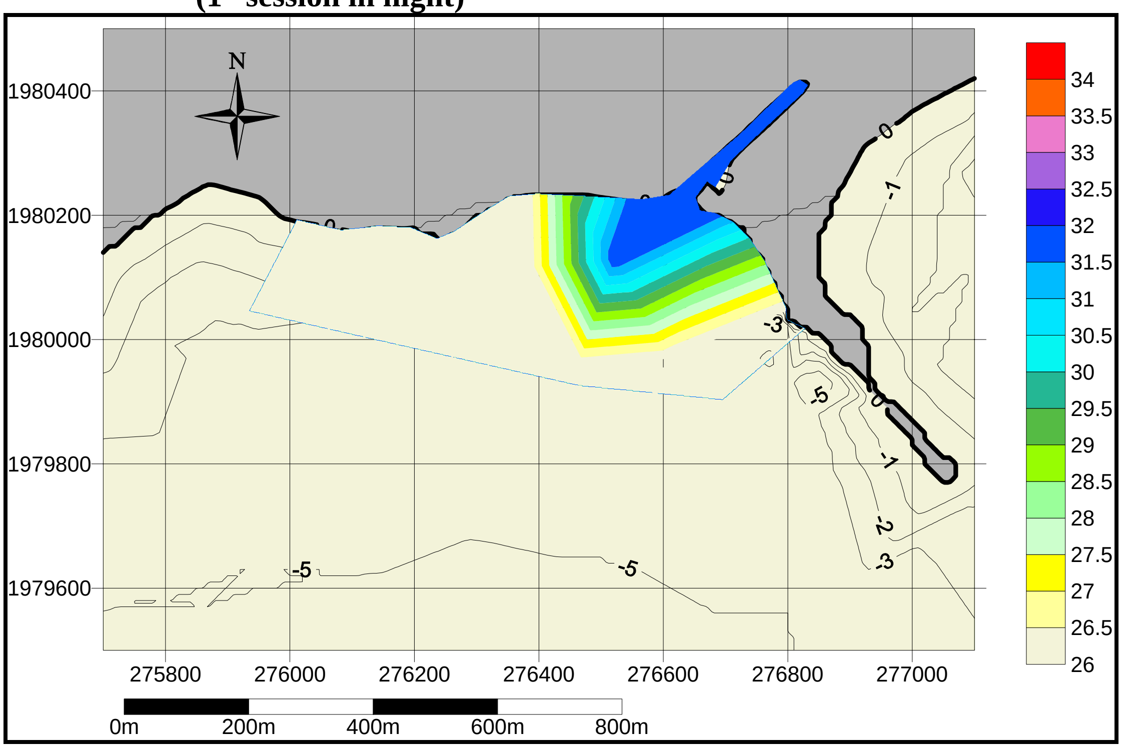


Figure 23 **Water temperature at 1m depth during rising tide, at JEP on the 3rd of January, 2005 (1st session in night)**

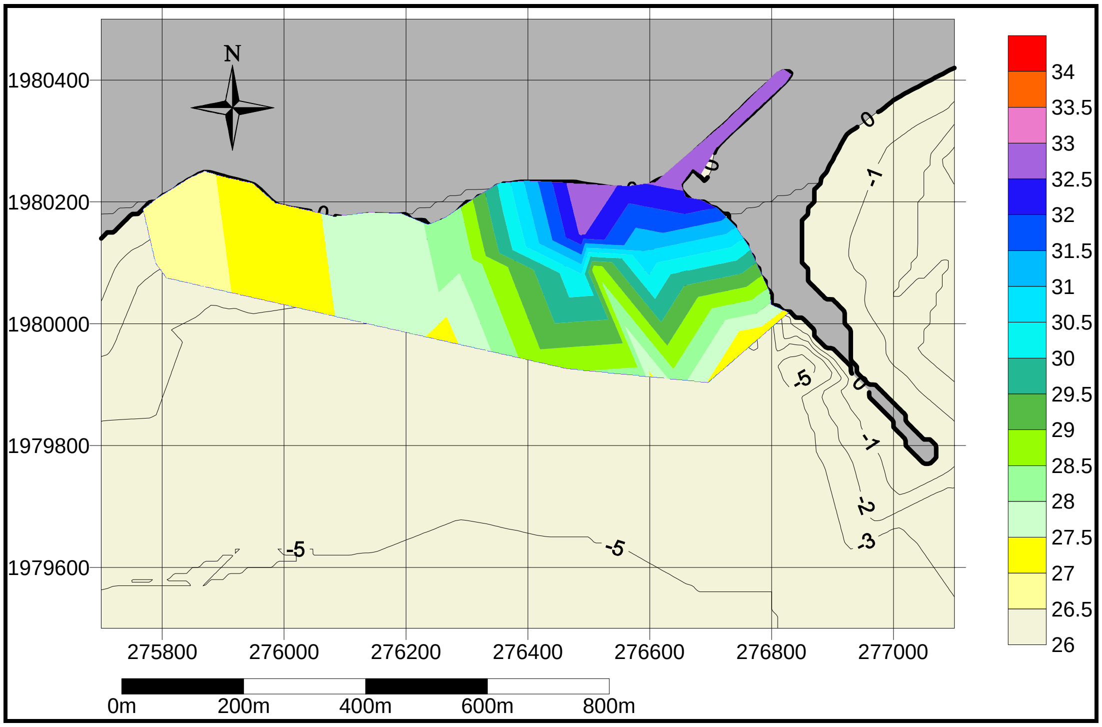


Figure 24 **Surface water temperatures of falling tide, at JEP on the 3rd of January, 2005 (2nd session in night)**

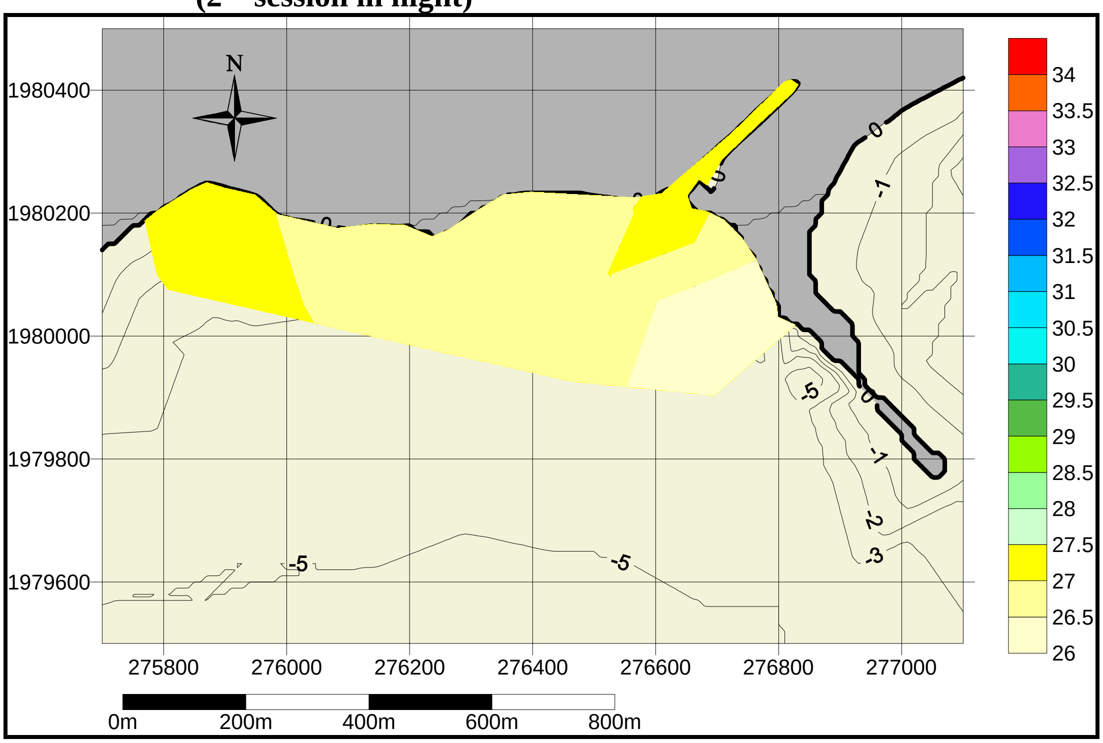


Figure 25 **Water temperature at 1m depth falling tide, at JEP on the 3rd of January, 2005 (2nd session in night)**

4.4.2 *Sediment quality*

The proposed site for the location of the barge is 0.5 to 1.5 m deep. The existing sediment type is predominantly mud but without a large organic component. The fine particle size which dominates the benthos results in sediment resuspension, low visibility and poor water quality. Particle size analysis revealed a dominance (greater than 50%) of fine particles dark grey but not anoxic mud. These muds, while soft, were sufficiently consolidated to support human weight and contained few living organisms. Biochemical Oxygen Demand (BOD) of sediment samples indicated moderate values with no signatures of sewage or high organic loading. This finding was naturally influenced by the high dissolved oxygen in the water column above the sediment associated with high wave action and the absence of large quantities of oxygen depleting organisms. Heavy metal analysis also yielded results with no significant elevated values. In fact all metals analysed (Cadmium, Mercury, Lead, Arsenic and Copper) returned trace values or values below the detection limit. Risks from metal contamination are therefore minimal.

4.5 BIOLOGICAL RESOURCES

TERRESTRIAL

4.5.1 *Flora*

Introduction

Jamaica Energy Partners proposes to construct another power barge in close proximity to the existing barge. In order to gain a ‘holistic’ view of the impact of the project, vegetation in the immediate vicinity of the proposed site and neighbouring ecosystems was assessed. Five areas were identified for assessment, namely the Thorn thicket immediately beside the discharge outlet; the fringe of mangroves in front of the salina; the salina itself, a stand of mangroves to the west of the salina and the coastal/grassland community in the vicinity of the proposed area for construction of the barge (Figure 26). The area to the south east of the proposed project consists of the existing barge and other industrialized areas of JPS.

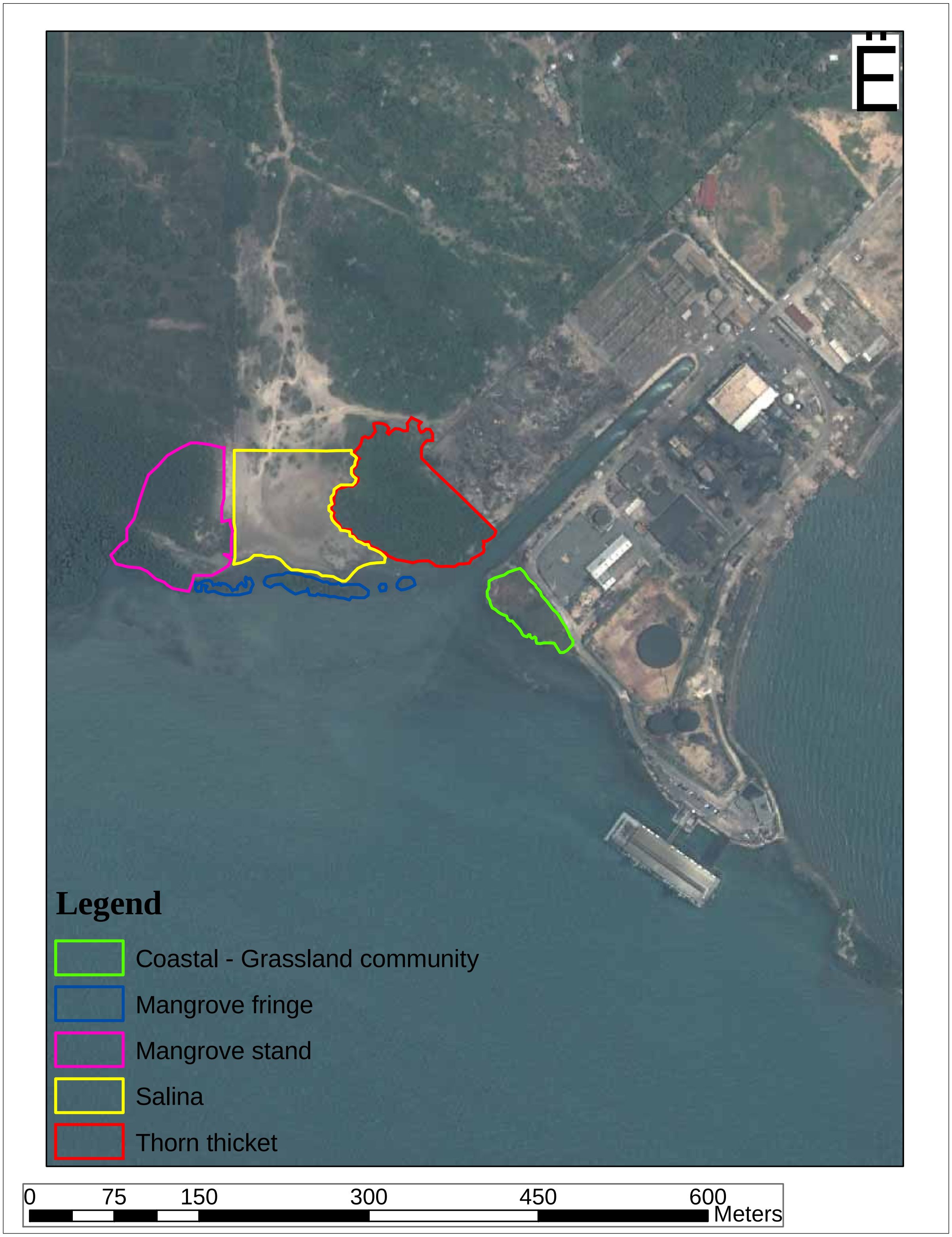


Figure 26 Map showing areas of flora assessment

Observations

Site 1 – Thorn thicket

This area covered approximately 1.08 hectares (2.67 acres) and was dominated by *Acacia tortuosa* (Wild Poponax), 2-3 m in height (Plate 2). The area was relatively homogenous and disturbed as evidenced by discrete solid waste disposal piles. The understorey consisted mainly of herbs, namely, *Ruellia tuberosa*, *Sida acuta*, *Capraria biflora* (Goatweed) and *Abutilon umbellatum* (Plate 3). The Wild Poponax trees were draped with two twiners, either *Antigonon leptopus* (Coralita) or *Momordica balsamina* (Cerasee) or both (Plate 4). Two representatives of the Cactaceae family were also observed in the thicket in discrete stands. The majority of the cacti were dead and where death was not evident, new growth were seen.

Plate 2 A section of the thorn thicket

Plate 3 Under-storey of the thorn thicket

Plate 4 Coralita (left) and Cerasee (right) draped over Wild Poponax trees (indicated by arrows)

The understorey of the Thorn thicket changed closer to the salina. Here, the understorey changed from terrestrial to coastal species, that is, *Sesuvium portulacastrum* (Seaside Purslane) and *Batis maritima* (Jamaican Samphire) (Plate 5).

Plate 5 Coastal species under the canopy of Wild Poponax trees (indicated by arrow)

In general, a total of 17 species were observed, which were not significantly important, ecologically or commercially (Table 6).

Table 6 Species observed in the Thorn Thicket

Scientific Name	Common Name
Acacia tortuosa	Wild Poponax
Abutilon umbellatum	
Antigonon leptopus	Coralita
Batis maritima	Jamaican Samphire
Capraria biflora	Goatweed
Gomphrena decumbens	
Heliotropium indicum	Scorpion Weed
Momordica balsamina	Cerasee
Ricinus communis	Oil Nut
Ruellia tuberosa	Duppy Gun
Salicornia perennis	Glasswort
Sesuvium portulacastrum	Seaside Purslane
Sida acuta	Broomweed
Sida glutinosa	
Triumfeta lappula	

Scientific Name	Common Name
Unknown Species 1 and 2 – Family Cactaceae	

Site 2 – Mangrove fringe

The mangrove fringe directly in front of the salina was dominated by *Rhizophora mangle* (Red Mangrove) (Plate 6). This fringe formed an arc which merged into the mangrove stand to the west of the salina. The Red Mangrove trees were relatively healthy and served as perch for birds observed in the area.

Plate 6 One section of the Red Mangrove fringe in front of the salina

Site 3 - Salina

The salina was dominantly (90%) open space with an abundance of Jamaican Samphire. Seaside Purslane, *Avicennia germinans* (Black Mangrove) and *Heliotropium curassavicum* were occasionally seen. Wild Poponax was observed furthest from the coast. In general, a total of four species were observed (Table 7). The species were not significantly important, ecologically or commercially.

Table 7 Species observed in the salina

Scientific Name	Common Name
Acacia tortuosa	Wild Poponax
Avicennia germinans	Black Mangrove
Heliotropium curassavicum	
Sesuvium portulacastrum	Seaside Purslane

<u>Site 4 – Stand of mangroves</u>

The stand of mangroves bordering the salina was dominantly Black Mangrove, ranging in height from 0.5 – 3m. The stand was relatively healthy, evident by the abundance of young trees at varying stages of development (Plate 7). Black pneumatophores were the only dominant floor species. Closer to the shore, there was an evident zonation in the stand as Black Mangroves were replaced by Red Mangroves (Table 8).

Plate 7 Section of the mangrove stand showing various stages of growth in Black Mangrove

Table 8 Species observed in the mangrove stand

Scientific Name	Common Name
Avicennia germinans	Black Mangrove Black Mangrove pneumatophores
Rhizophora mangle	Red Mangrove

<u>Site 5 – Coastal/Grassland community</u>

This community, located in the immediate vicinity of the proposed site, exhibited both coastal vegetation and grass (Plate 8). Grass was the dominant feature of this community with representatives of coastal vegetation, namely Red Mangrove, *Thespesia populnea* (Seaside Mahoe), Jamaican Samphire occasionally observed. Wild Poponax was rarely observed in the community (Table 9).

Plate 8 Section of the coastal/grassland community

Table 9 Species observed in the coastal/grassland community

Scientific Name	Common Name
Acacia tortuosa	Wild Poponax
Batis maritima	Jamaica Samphire
Rhizophora mangle	Red Mangrove
Thespesia populnea	Seaside Mahoe

4.5.2 Fauna

Introduction

An assessment of the avifauna of the proposed construction site was conducted in the five sites used in the flora assessment. Due to the relatively small area of land being assessed, a point count sampling method could not be employed; instead, a thorough observation was done by walking throughout the property for approximately one hour. Particular care was taken to minimise the possibility of recounting the same birds. The birds were identified based on visual cues, with the assistance of a field guide (Raffaele *et. al.*, 2003) and based on their calls. Birds that were utilizing the habitat were differentiated from the birds that simply flew by.

Observations

Fourteen (14) species of birds representing ten (10) families and totalling thirty-six (36) individuals were observed over the one hour period. These figures decreased to twenty-three (23) birds from twelve (12) species when the Great Egrets and Brown Pelicans were not considered as they were not utilizing the habitat, but simply flew by.

The species list consisted of two (2) endemic birds; the Jamaican Mango and the Jamaican Euphonia (Table 10). The low species diversity and numbers of birds seen are testament of the disturbed nature of the area and its small importance as a habitat for birds.

Other fauna observed included *Anolis lineatopus*, dragonflies and four species of butterflies of which two were unidentifiable and the others, *Anartia jatrophe jamaicensis* (Jamaican White

Peacock) and *Junonia evarete* (*Precis evarete zonalis*) (West Indian Buckeye) (Plate 9). A crocodile was sighted during the marine assessment. In general, the Old Harbour area is known for crocodile incidences and sightings (Figure27).

Plate 9 Left, Jamaican White Peacock and right, West Indian Buckeye

Table 10 Species list and numbers of birds encountered at the proposed site in Old Harbour, St. Catherine

FAMILY	SCIENTIFIC NAME	COMMON NAME	Amount	STATUS
Pelecanidae	*Peilcanus occidentalis**	Brown Pelican*	3	CYR
Ardeidae	*Egretta caerulea* *Ardea alba**	Little Blue Heron Great Egret*	1 10	CYR CYR
Charadiidae	Charadrius wilsonia	Wilson's Plover	1	CYR
Scolopacidae	*Catoptrophorus semipalmatus*	Willet	3	CYR
Columbidae	*Columba leucocephala* *Zenaida asiatica*	White-crowned Pigeon White-winged Dove	1 2	CYR CYR
Trochilidae	**Anthracothorax mango**	Jamaican Mango	1	CE
Alcedinidae	**Ceryle aclyon**	Belted Kingfisher	1	CNBR
Tyrannidae	*Tyrannus caudifasciatus*	Loggerhead Kingbird	2	CYR
Mimidae	*Mimus polyglottos*	Northern Mockingbird	3	CYR
Emberizidae	*Dendroica petechia* *Euphonia jamaica* *Coereba flaveola*	Yellow Warbler Jamaican Euphonia Bananaquit	5 1 2	CYR CE CYR
TOTAL			**36**	

Key

*	- Birds observed but not utilizing the habitat
CYR	- Common Year-round Resident
CE	- Common Endemic
CNBR	- Common Non-breeding Resident (Winter Migrant)

Definition of terms used to represent the overall status and chances of observing each species:

Endemic	A species which is confined to a specific island or small group of islands and is found nowhere else in the world.
Common	5 or more individuals likely to be seen daily within its habitat
Year-round Resident	A species which spends its entire life-cycle on a particular island or group of islands
Non-breeding Resident	A species which breeds elsewhere, but occurs on a particular island or group of islands during the non-breeding season; sometimes referred to as a 'visitor' or 'winter migrant'.

4.5.3 Marine Community

Site visits and grab sampling across the bay revealed few animals and variable benthic plant communities influenced by temperature, light and wave action. Observations on site included a crocodile (*Crocodilius acutus*), a spotted eagle ray (*Aetobatus narinari*), juvenile fish (bream (*Haemulon plumieri*), doctor (*Acanthurus sp.*), snapper (*Lutjanus sp*.) and parrot (*Sparisoma viride*) and a few jellyfish. The area is clearly used by a number of animal species for feeding and as nursery grounds for juvenile development. The warm, shallow waters with low light penetration and patchy seagrass coverage provide ideal conditions for both activities. Quantification under these conditions is difficult but it is sufficient to note the presence of the resource and note the activities.

Seagrass presence and proliferation in patches confirm the site is moderately stressed in specific areas. Absence of benthic floral communities at sites appears to be driven by a combination of effects. For most deep areas, reduced or absent seagrasses and algae was the result of poor light penetration while in shallow areas increased temperature may have been responsible since these two observations were correlated. Where light penetration was sufficient, seagrasses were further impacted by epiphytic growth of algae and hydroids (sometimes 100% epiphytic cover) usually associated with some degree of nutrient input. Seagrass blade length was short (<14 cm, not luxuriant growth) and rhizome distribution was surface dominated, indicating more consolidated or more anoxic substrate below.

Not surprisingly there were no coral reef communities within the bay although fringing reef systems were observed some distance offshore (≈ 1km). Prevailing current direction takes the thermal plume along the coast away from these offshore reef systems. Furthermore, resuspended fine sediments are also kept away from the fringing reefs reducing the impact of smothering.

There have been sightings of the green, hawksbill and loggerhead turtles, manatees, and the Jamaican iguana within the study area recorded by NEPA (Figure 27). All of these species are protected under the Wildlife Protection Act.

Figure 27 Incidents or sightings of species of importance

4.6 HYDROLOGY

4.6.1 Ground Water

There are two principal aquifers, the White Limestone Group and the overlying alluvial deposits. In the Clarendon Plains, just west of the project site, the alluvium is less important as an aquifer than the limestone aquifer in both extent and quality (FAO 1974). Harris and Williams (1999) stated that in their study area, a 20-kilometre radius around Old Harbour Power Station, that water is obtained largely from alluvial deposits and to a lesser extent the underlying upper white limestone. The alluvium deposits function primarily as clayey aquicludes. However, the upper 20 to 30 meters of coastal alluviums often have sufficiently thick layers of sand and gravel to function as aquifers (Underground Water Authority, 1990). Test pit and shallow borehole data in the Old Harbour area show a perched water table in the clay and gravel in the upper 3 meter layer of soils (Harris and Williams, 1999). Over most of the plains limestone is covered by alluvium and marine sediments that have a high clay content that restricts flow into the limestone (FAO 1974).

Direction of groundwater flow at the proposed project location is believed in general to be from the north to the south following the slope of the coastal plains (FAO, 1974). Groundwater recharged to the limestone aquifer flows southward to discharge points such as springs and wells, and possibly to the sea. A major discharge point in the south St. Catherine sub-basin is around the Whim, immediately south of the town of Old Harbour, which is an area of a high yield zone (Harris and Williams, 1999). Pumping tests carried out by Water Resources Authority indicate that transmissivity of alluvial wells varies from 230 to 15,649 meters squared per day (Harris and Williams, 1999).

There are a total of 45 wells withdrawing water in the 345 square kilometres Harris and Williams (1999) study area around the Old Harbour Station. Of this total, 35 are in limestone and 10 are alluvium wells. It was estimated that the limestone wells produced 116,285 cubic meters per day and the alluvium wells produced 12,379 cubic meters per day (Silha-Kahgbo, 1993; cited in Harris and Williams, 1999). Based on the figure presented by Harris and Williams (1999) the nearest pumping wells occur at Brampton Farm approximately 2.5 kilometres northeast of the site, and at Dorothy Lodge approximately 2.5 kilometres to the northwest of the site. Both wells are hydraulically upgradient of the site.

Variations in outflow directions of alluvium aquifers are caused by local abstraction centres. Seasonal fluctuations in groundwater levels also occur based on variations in recharge and discharge during rainy season and dry periods (Harris and Williams, 1999). Depth to water in monitoring wells installed at the project site and measured on February 1, 2002 ranged from 11.9 to 12.9 feet below ground surface (bgs) in wells MW-1 and MW-2 respectively. Well MW-3, to a depth of 16.5 ft-bgs was dry (Dave Lovejoy, pers. comm).

4.6.1.1 Ground Water Quality

Results of field and laboratory analyses for ground water samples are presented in Table 11. The data indicate pH was in the range 7.6 – 8.6 for all wells. The highest value was determined for well No. 1. Wells 2, and 3 had uniform pH of 7.6. The duplicate sample at well 3, identified as 3a had a pH of 8.1. Dissolved oxygen levels were low 0.2 mg/l – 1.1 mg/l.

Table 11 Ground water quality of Wells 1-3

PARAMETER	Well 1	Well 2	Well 3	Well 3a
Total Dissolved Solids (TDS mg/l)	N/A	4,034	806	849
Conductivity (UMHOS/cm)	N/A	4,317	1,073	
Salinity (ppt)	N/A	2.25	0.5	
Dissolved Oxygen (D.O. mg/l)	N/A	0.8	0.2	
pH	N/A	7.6	7.6	8.1
Chemical Oxygen Demand (COD mg/l)	0	0	0	0
Biological Oxygen Demand-5 day (BOD5 mg/l)	<2	<2	<2	<2

N/A – Not applicable

TDS was relatively high compared to surface water being in the range 806 – 4,034 mg/l. The highest value was determined for Well No. 2, while the lowest value was determined for Well No. 3. At well No. 1, TDS was 2136mg/l. Conductivity measurements support the TDS values.

Like TDS, conductivity is lowest at well No. 3 (1073 µs), and highest at Well No. 2 (4317 µs). At Well no. 1 conductivity was 2916.

4.6.2 Surface Water

NEPA Watershed Policy (www.nepa.gov.jm) states, "Landslides and slope failures are very common in the non-limestone watersheds due to the presence of steep slopes, thin or erosive soils. Heavy and high intensity rains in the upper watershed areas, soil erosion, and susceptibility to earthquakes further compound this situation. These natural conditions of instability are aggravated by the inappropriate use of slopes. Farming activities on the slopes have long been recognized as the single most important cause of the degradation of watersheds in Jamaica. Upwards of 170,000 farmers cultivating just under 245,000 hectares, and using unsuitable agricultural practices have contributed to massive soil loss through soil erosion, siltation of drains and rivers and destructive flooding downstream. Depending on crops and practices, the average soil loss reaches approximately 30 tons per hectare per year according to some statistics. Due to a lack of intensive agricultural extension, incentives and the insecurity of land tenure, most small farmers and other land users do not consider protection and conservation of natural resources in a watershed to be a priority.

With the growth in industrial and agricultural activity over the years and the corresponding increases in population and urbanization, the demand for and pressures on land and water resources have become greater. Because of crop expansion and the increased use of industrial and agricultural chemicals and the improper disposal of sewage effluents, surface water pollution has drastically increased. Rivers, beaches and harbours have become polluted and coral reefs degraded.

The large-scale removals of trees for resettlement programmes and for squatter settlements and the illegal removal of forest cover for lumber, charcoal production and yam sticks have greatly contributed to the relatively high rate of deforestation. Although the actual rate has not yet been determined, it could be 2 % or more, having increased significantly in the last two decades.

Forest fires have been contributing more and more to deforestation due to the extended periods of drought.

All of the above-mentioned factors have resulted in heavy siltation of rivers, reservoirs, irrigation canals and water intakes, as well as harbours. Surface runoff is greatly increased due to excavation of slopes, diminished vegetation cover, compacted soils, and many other activities that reduce water intake to the soils. During heavy rains and hurricane seasons, floods become more frequent and severe, whereas in dry seasons, water shortages become a serious problem. Over the last two decades, the incidence of serious floods has increased significantly resulting in considerable losses in life and property."

Bower's Gully occurs approximately 0.2 kilometres west of the project site boundaries, and the site is located in the 40.8 square kilometres Plantain River/Bowers Gully catchment. The Plantain River-Bower's Gully rises from the impermeable Createaceous Volcanics in the north and flows southwards to Old Harbour. During a February 5, 2002 site reconnaissance, the gully contained flowing water. Surface water flows are characterized by a marked seasonality associated with the annual rainfall cycle (Underground Water Authority, 1990).

The project site is located in Old Harbour Bay, within the Portland Bight Protection Area. Portland Bight has the largest remaining mangrove system in Jamaica (The Great Salt Pond, Galleon Harbour, West Harbour, the Goat Islands and almost all areas between), which, together with extensive sea-grass beds and coral reefs, provide probably the largest nursery area for fish, crustaceans and molluscs on the island.

4.6.2.1 Surface Water Quality

In 2002, JPS commissioned the sampling and analysis of surface water adjacent to its Old Harbour facility. The staff of Mactec Corporation collected a total of eight samples. Six of these samples were collected directly adjacent to the JPS plant, including the approximate location of the proposed project. The remaining two samples were collected at a distance from the JPS facility to represent background conditions.

The samples were analyzed for pH, salinity, and conductivity. The results of the analyses are provided in Table 12 below. The pH results ranged from 8.1-8.3. Salinity ranged from 3.1-3.2 percent. Conductivity ranged from 48,000-49,000 micromhos per cubic meter.

Table 12 Results of surface water sampling at eight locations adjacent to the JPS Old Harbour facility

Constituent	Method Unit	1	2	3	4	5	6	7	8
PH	150.1 S.U	8.2	8.1	8.1	8.3	8.2	8.2	8.2	8.2
Salinity	SB40C %	3.2	3.1	3.1	3.2	3.1	3.1	3.2	3.1
Conductivity	120.1 UMHOS/cm	49000	48000	48000	49000	48000	48000	49000	48000

4.7 LAND USE

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.

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.

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 and Windalco's Port Esquivel Alumina Storage and Port.

There are five (5) major residential areas within the (Social Impact Area (SIA)). These are sections of Old Harbour, Free Town and Longville Park Estates and Belmont Park Community and Old Harbour Bay. Other areas include Kellys Pen and an informal community of "squatters" adjunct to the JPS 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.

The proposed development occurs within an industrial area and therefore will fit into the existing land usage of the area.

4.7.1 Portland Bight Protected Area

The proposed project falls within the Portland Bight Protected area. The area covers approximately 1,876km2 of terrestrial and marine environment (Figure28) and is co managed by the Caribbean Coastal Area Management Foundation (CCAM) and the National Environment and Planning Agency (NEPA). CCAM is a registered non governmental organization (NGO) in Jamaica which is very active within the area.

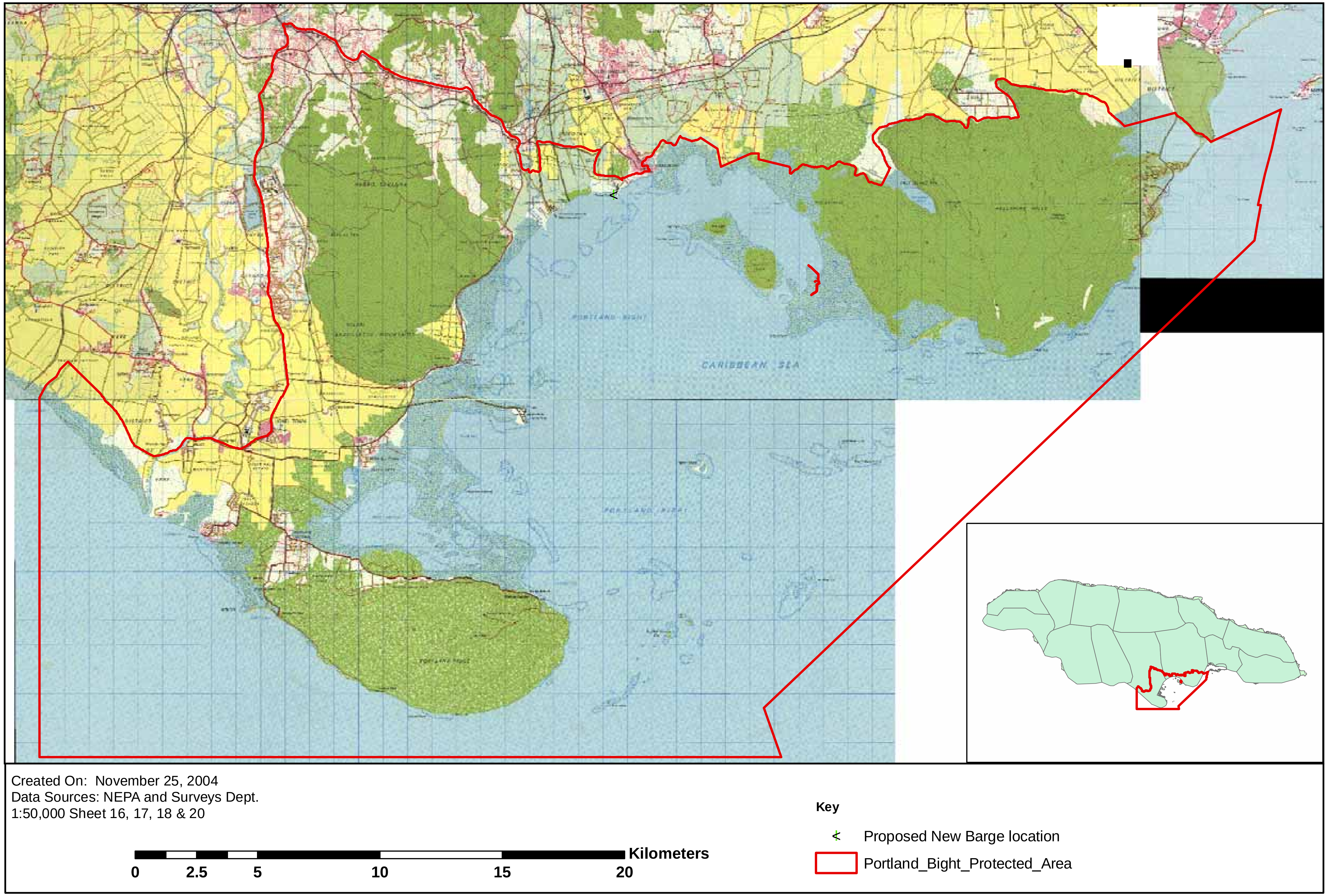


Figure 28 Portland Bight Protected Area

4.8 NOISE

4.8.1 Methodology

A 24-hour noise survey exercise was conducted to establish baseline conditions at the Jamaica Energy Partners (JEP) "Doctor Bird" facility located at Old Harbour Bay and its environs between 0:00 hrs Friday 26th, to 0:00 hrs Saturday 27th, November 2004. The readings were taken at seven (7) locations depicted in Figure 29.

Noise level readings were taken by using a Quest 2700 Sound Level Meter. The meter was turned on and the response was set to slow, the weighting to A and the mode to SPL and calibrated using a Quest QC - 10 sound calibrator (Appendix 5). A windscreen (sponge) was placed over the microphone to prevent measurement errors due to noise caused by wind blowing across the microphone.

4.8.2 Results

The results for the assessment are presented in Table 13.

Table 13 Results of noise measurements during the 24 hrs of measurements

STATION #	DISTANCE FROM BARGE (m)	AVERAGE (dBA)	7 am. - 10 pm. (dBA)	10 pm. - 7 am. (dBA)
N1	0	85.6	86.6	83.5
N2	99	70.1	70.3	69.9
N3	500	64.9	66.6	59.4
N4	1,585	53.3	54.5	50.0
N5	784	58.7	59.4	57.1
N6	1,928	51.3	53.4	44.8
N7	500	53	45.6	56.6

Stations N1, N2 and N3 are considered industrial locations. Stations N4-N7 are considered residential locations, with N7 being the nearest residential (informal settlement) location to the proposed power plant.

Figure 29 Locations of noise survey stations

4.9 HISTORICAL AND CULTURAL RESOURCES

There are three known historic sites within 5km of the proposed site (Halcrow 1991). This radius for this study is considered the Social Impact Area (SIA). The sites are the 19th century St. Phillip's Anglican Church with a clock tower at Old Harbour Bay, (Plate 10) a house of the 16th century US Naval Base which is found on the Little Goat Island and a 20th century monument in recognition of Indians coming to Jamaica (Figure 30).

Approximately eighty six percent (86%) of those interviewed were not aware of any historic or cultural resources in their area. Fourteen percent (14%) knew of such sites.

Plate 10 St. Phillips Anglican Church

There are other sites in proximity to the 5km radius and these are depicted on (Figure 30).

Figure 30 Historical/cultural sites in proximity to the proposed development area

4.10 SOCIO ECONOMICS

The Social Impact Area (SIA) for this study was demarcated as five (5) kilometres from the proposed barge location. This is outlined in the map below (Figure 31).

4.10.1 Introduction

<u>4.10.1.1 Methodology</u>

Interviews were conducted with residents within the communities in the study area. Questionnaires were administered in a stratified and random manner to persons throughout the SIA. A total of 160 community questionnaires were administered with the bulk being done within a 2.5 km radius of the location of the proposed barge, since those persons would be more likely impacted by the development (Appendix 6) In addition, windscreen surveys were conducted in the communities to verify and update the information on the maps. Historical socioeconomic data were obtained from the 2001 population census.

Population 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. 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 31 Map showing the Social Impact Area (SIA)

4.10.2 Demography

The total population within the SIA in 2001 was approximately 15,200 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, comparison of the 1991 population data showed that there were approximately 12,800 persons within the 5km radius of the proposed barge. From this population it was estimated that the actual growth within the SIA was approximately 1.72% per annum, which is less than that of the parish.

Based on the growth rate of 1.72%, at the time of this study the population was approximately 16,273 persons and is expected to reach 24,924 persons over the next twenty five years, if the current population growth rate remains the same.

The 15-64 years age category accounted for 61% of this population, with the age 0-14 years (33%) 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 (Table 14). The median age falls within the 20-24 year category, which is a relatively young age.

Table 14 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 was generally similar except for the 15-64 and 65 & over years categories in the national context. Nationally the working population (15-64 years) was lower while the elderly category (65 & over) was slightly higher than the regional and local figures.

Table 14 Age categories as a percentage of the population

AGE CATEGORIES	JAMAICA (%)	ST. CATHERINE (%)	SIA (%)
0-14	32	32	33
15 - 64	60	62	61
65 & Over	8	6	6

(Source: STATIN Population Census 2001)

The sex ratio (males per one hundred females) in the SIA in 2001 was 101.67, which indicates that a higher percentage of the population in the SIA were males. Only the 0-14 years category had more males than females. This sex ratio was greater than both the national (Jamaica) (96.9) and regional (St. Catherine) (94.4) ratios indicating that both populations had a higher level of females.

The child dependency ratio for the SIA in 2001 was 551.3 per 1000 persons of labour force age; old age dependency ratio stood at 95.8 per 1000 persons of labour force age; and societal dependency ratio of 647.1 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 indicate that the child dependency ratio for the study area (SIA) was higher than the regional and national figures (Figure 32). Both the old age and societal dependency ratios for the study area were higher than the regional, but lower than the national figures.

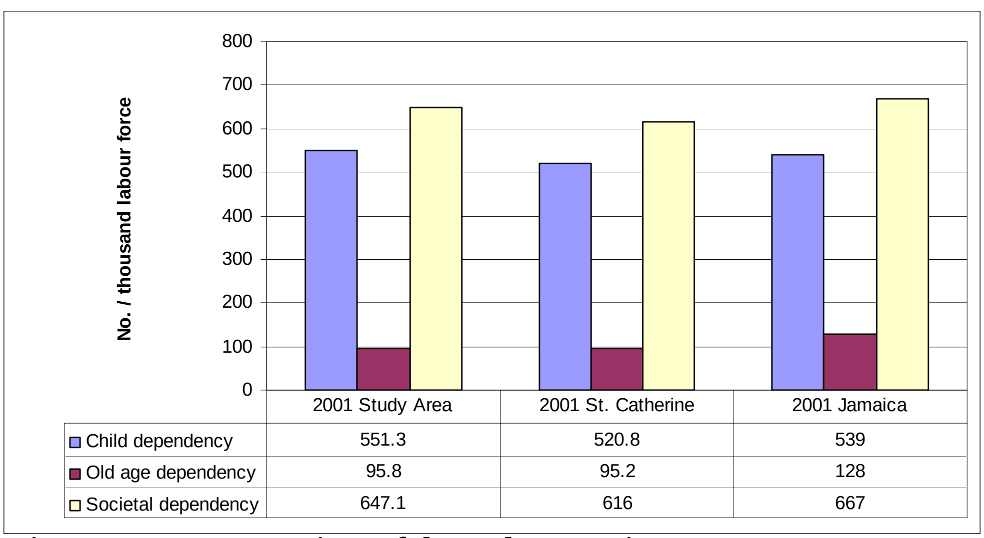


Figure 32 Comparison of dependency ratios

4.10.2.1 Population Density

The land area within the SIA was calculated to be approximately 36,685,512.56 m^2 (36.7 km^2). With a population of approximately 15,200 persons the overall population density was calculated to be ≈ 414.2 person / km^2. This population density is higher than the regional (Parish) level, which is at approximately 391.2 persons/km^2. When compared to the National figure (237.7 persons/ km^2), this density is still higher by nearly twofold.

4.10.2.1 Population Growth Areas

Figure 33 depicts the population within each enumeration district (ED) for the years 1991 and 2001. From the figure it is clearly seen that there were population increases between those two years, mainly north and northeast of the proposed barge. This is especially true immediately north of the proposed barge location, where there are more informal settlers ("squatters").

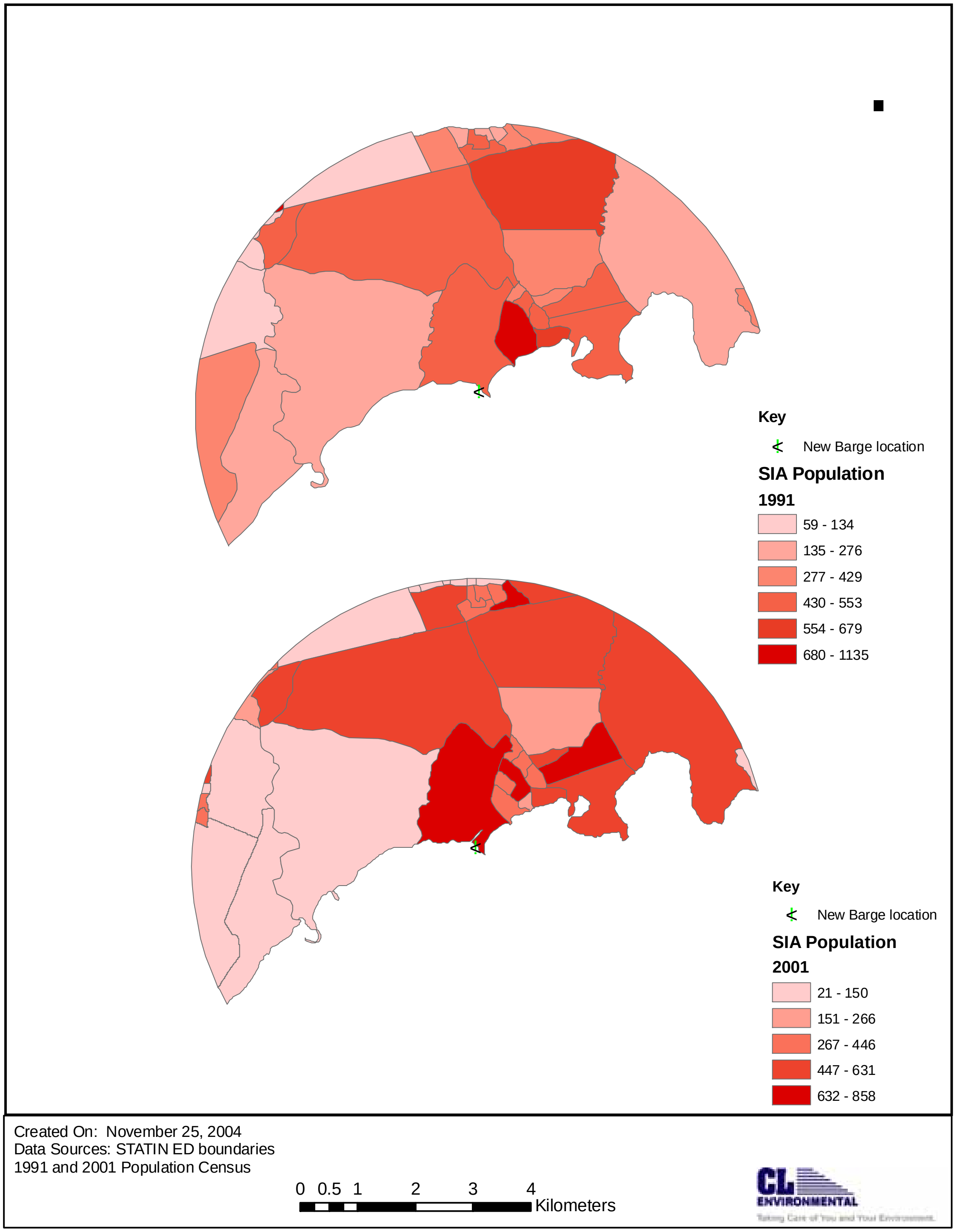


Figure 33 SIA 1991 and 2001 population data represented in enumeration districts

4.10.3 Employment and Income

The categories of the workforce within the SIA ranged from professional, skilled and semi-skilled.

The types were Business Persons, Accountants, Secretaries, Laboratory Technicians, Computer Technicians, Fishers, Mechanics, Masons, Electricians, Taxi Drivers Carpenters, Domestic Helpers and Watchmen to name a few.

The stated incomes were as varied as the status of employment. Approximately twenty four percent (23.9%) of the persons interviewed were unemployed. Within the ranks of the employed, 31.3% were full time employees, 28.3% were self employed, 10.4% part time workers and 6% were employed seasonally.

The stated incomes of those interviewed ranged from approximately J$501.00- over J$7,000.00 per week (US$8.15-113.82/week @ US$1.00 to J$61.50).

The majority (34.8%) of the respondents stated that they earned over J$7,000.00 (US$113.82) per week. Approximately seventeen percent (16.7%) stated earnings were in the J$3,001.00 - 4,000.00 category, 12.1% in the J$4,001.00-5,000.00 category, 9.1% each for the J$1,501.00-2,000.00 and J$2,001.00-3,000.00 categories, 6.1% in the J$6,001-7,000.00 category, 4.5% each for the 5 J$501.00-1,000.000 and J$5,001-6,000.00 categories and 3.0% in the J$1,001.00-1,500.00 category.

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.

There are approximately 1,400 fishing boats operating in the Old Harbour Bay region. Approximately 30% of the fishers own their boats. Fishing is done mainly five days per week, except for Sundays and Mondays. The number of crew per boat is dependent on the method of fishing. If pots are used then approximately three crew members are used, for nets two (2) are used. For line fishing the crew is at the captains' discretion, and for spear fishing, the boat is normally filled to its established capacity.

The average cost for a (8.5m) 28ft fibreglass fishing boat is approximately J$250,000 (US$4,052@ J$61.7 to US$1). It costs approximately J$265,000 (US$4,295) for a 40-75hp engine and approximately J$280,000 for a net.

On average a boat earns between J$15-20,000 per week. Of this, approximately J$7,500 per week is spent on gas, J$750 per week for ice and the net requires mending every two weeks which costs approximately J$15,000.

Within Old Harbour Bay, approximately 50.2% of fishers use nets, 34.3% used pots, 22.6% used lines, 13.2% spear guns and 0.5% dynamites (Espuet, pers. comm).

4.10.4 Education

The educational attainment of persons four years and older are represented in Table 15. Most persons within the SIA attained a secondary school education followed by those attaining a primary education. 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 maybe due to the fact that the area is mainly an agricultural one with sugar cane, aquaculture and fisheries being the main ones, which in Jamaica tends not to attract persons with tertiary education.

Table 15 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	5.4
Primary	31.2	28.5	29.9
Secondary	49.7	49.3	51.0
University	3.1	3.7	1.4

CATEGORY	JAMAICA	ST. CATHERINE	SIA
Other Tertiary	5.9	7.7	5.0
Other	2.8	3.4	4.2
Not Stated	1.7	2.0	2.2
None	0.9	0.7	0.9

Persons within the SIA attend schools within and outside of the area, some travelling as far as Kingston the National Capital and Clarendon. Some of the schools that were listed during the community survey were;

Old Harbour Bay Primary, Old Harbour High, Old Harbour Basic, Blackwood Gardens Basic, Inswood High, Marley Mount Primary and Infant, Glenmuir, Jose Marti, Freetown Primary, May Pen Primary, Clarendon College High, Planters Hall All Age and Infant, University of Technology and Cosmetology school (Nails and Design) to name a few. These persons travel up to 25-30 km to reach school.

The high proportion of the population in proximity to the proposed Barge 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 (Figure 34).

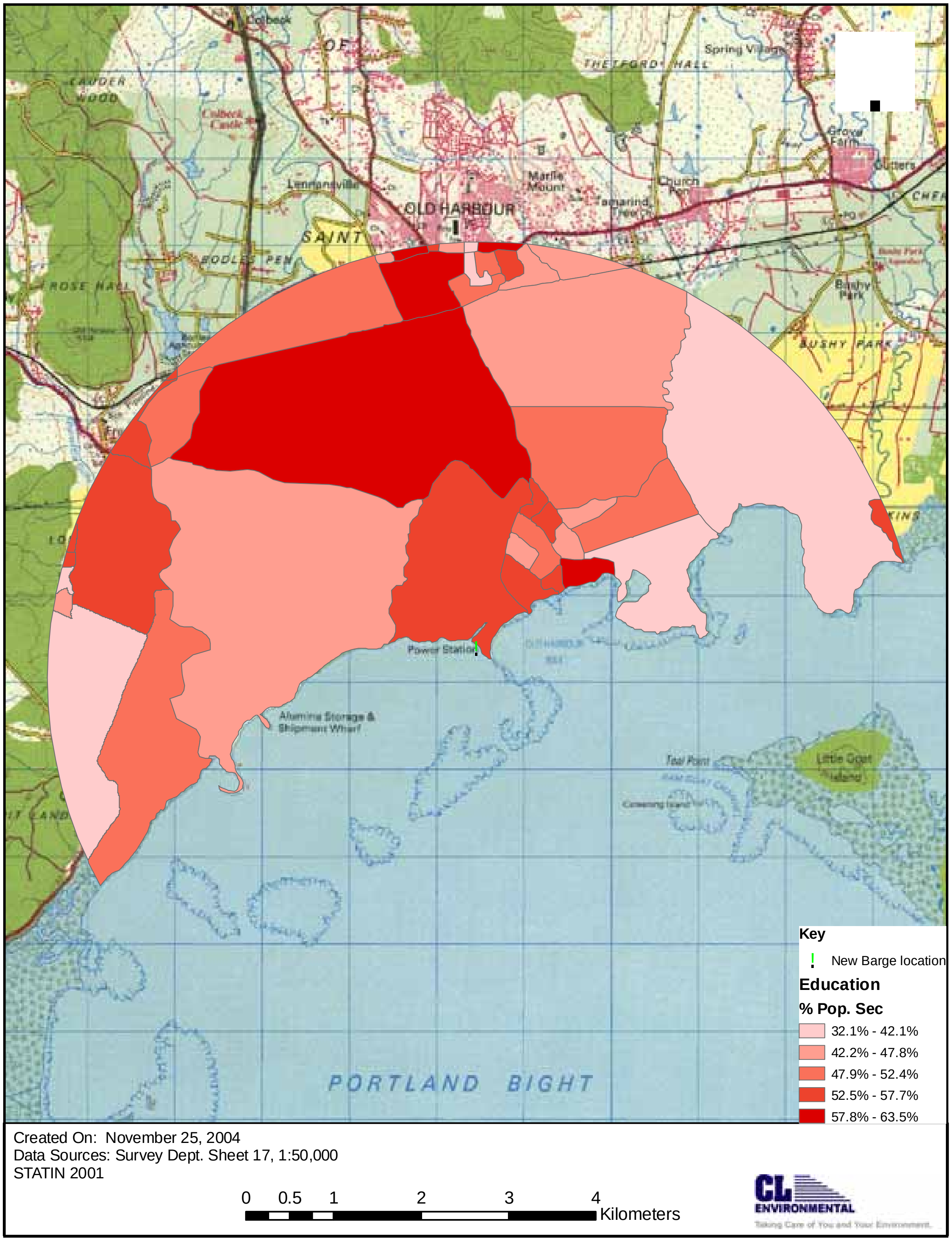


Figure 34 Percentage population attaining a secondary education

4.10.5 Housing

For the purposes of this study the definition of housing unit, dwelling and household are those used in the conduct of the population census conducted by the Statistical Institute of Jamaica. This 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 3,310 housing units, 4,304 dwellings and 4,412 households within the SIA in 2001. The average number of dwelling in each housing unit was 1.3 and the average household to each dwelling was 1.03. The average household size in the SIA was 3.45 persons/household (Table 16).

A comparison of the SIA and national and regional ratios indicate that they were generally similar except for the lower national dwelling/household ratio and the higher regional (parish) average household size.

Table 16 Comparison of national, regional and local housing ratios

	JAMAICA	ST. CATHERINE	SIA
Dwelling/Housing Unit	1.2	1.3	1.3
Households/Dwelling	1.03	1.03	1.03
Average Household Size	3.48	3.59	3.45

(Source: STATIN Population Census 2001)

Approximately 82% of the housing units in the SIA were of the separate detached type, 16% were attached, 0.5% part of a commercial building, 0.4% categorized as other, 0.3% improvised housing, and 0.8% did not state.

More than three quarters (79.1%) of the households in the SIA in 2001 used 1-2 rooms for sleeping. Approximately thirteen percent (≈13%) of the households occupied three rooms, 5%

used four rooms 2.5% used five rooms and 0.4% did not report the number of rooms used for sleeping. Most of the households (47.7%) used one room for sleeping.

The “squatter” community immediately adjacent to the JPS plant northern plant boundary wall has approximately thirty eight (38) houses, most of which are wooden with galvanised sheeting for roofs. They are mainly 1 and 2 bedrooms, examples of which are seen in Plate 11.

From the interviews conducted within the SIA, the majority of the housing units (24.2%) were in the 0-5 years category. Those older than thirty years (22.7%) accounted for the next group, the 25-30 years category was 19.7%, 12-17 years category (13.6%), 18-24 years category (12.1%) and the 6-11 years category 7.6%.

Most of those interviewed (52.8%), lived in the area for 0-11 years, 27.2% lived in the area for 12-24 years and 1.4% lived in the area for over 24 years.

Plate 11 **Picture depicting the typical housing units in the "squatter" community in proximity to the JPS boundary wall**

<u>4.10.5.1 Land Tenure</u>

In 2001, 30% of the households in the SIA owned the land on which they lived. Approximately 6.2% leased the land on which they were, 11.8% rented, 19.9% lived rent free, 8.1% "squatted" and 2% had other arrangements. A very high percentage (≈ 22%) 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 17).

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.

Table 17 Percentage household tenure nationally, parish and SIA

CATEGORY	JAMAICA (%)	ST. CATHERINE (%)	SIA (%)
Owned	37.5	29.6	30.0
Leased	5.0	7.3	6.2
Rented	14.8	9.6	11.8
Rent free	17.0	11.6	19.9
Squatted	2.9	2.5	8.1
Other	0.9	0.7	2.0
Not Reported	21.9	38.7	22.0

(Source: STATIN Population Census 2001)

4.10.6 Infrastructure

4.10.6. 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 18 details the percentage of households using a particular category of lighting.

Table 18 Percentage households by source of lighting

CATEGORIES	JAMAICA (%)	ST. CATHERINE (%)	SIA (%)
Electricity	87.0	89.3	77.5
Kerosene	10.6	8.1	19.9
Other	0.4	0.4	0.4
Not reported	2.0	2.2	2.2

(Source: STATIN Population Census 2001)

4.10.6.2 Telephone/Telecommunications

The parish of St. Catherine and the study area are served with landlines provided by Cable and Wireless Jamaica Limited. Wireless communication (cellular) is provided by Cable and Wireless, Digicel Jamaica Limited and Oceanic Digital Jamaica Limited.

Only 10% of those interviewed had no telephones. Cellular phones (70%) were the most common form of telephone, with 20% having land lines.

It is not anticipated that there will be any problems as it relates to the provision of telephone service to the proposed development.

4.10.6.3 Water Supply

4.10.6.3.1 Domestic

Eight seven percent (87%) of the households within the SIA received their domestic water supply from the National Water Commission (NWC) (Table 19). This public agency is responsible for providing Jamaica's domestic water supply. Water demand for the SIA is estimated to be 3,695,924 litres/day (≈976,360 gals/day) and is expected to increase to 5,660,739 litres/day (≈1,495,409 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 19 Percentage of households by water supply

	CATEGORY	JAMAICA (%)	ST. CATHERINE (%)	SIA (%)
Public Source	Piped in Dwelling	43.8	55.6	36.8
	Piped in Yard	16.3	18	39.8
	Stand Pipe	10.5	2.7	6.4
	Catchment	1.9	2.2	1.6
Private Source	Into Dwelling	6.3	4.1	1.5
	Catchment	9.9	5.2	4.0
	Spring/River	4.6	4.9	0.3
	Other	4.5	4.8	6.4
	Not Reported	2.2	2.5	3.2

(Source: STATIN Population Census 2001)

The proposed new barge will obtain its non potable water supply from the Jamaica Public Service Co. Ltd. (JPS) well and potable water will be obtained from the NWC and from private arrangements with bottled water suppliers.

It is estimated that an additional 475 litres/day (≈ 125 gals/day) (based on 25 employees) of water is needed for the operations of the new barge.

4.10.6.3.2 Cooling Water

Water for cooling the turbines within the proposed barge will be obtained from the waters of Portland Bight (Caribbean Sea) at a location to the aft of the barge. After the once through pass in the cooling system the water will be discharged at approximately 260m south west of the proposed barge. This water will be treated with United States Environmental Protection Agency (EPA) approved biocides.

4.10.6.4 Wastewater Generation and Disposal

It is estimated that approximately 2,956,739 litres/day (≈781,088gals/day) of wastewater is generated within the study area and is expected to increase to 4,528,591 litres/day (≈11,963,270 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 (Table 20). 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.

Table 20 Sewage disposal methods as a percentage of the households

METHOD OF DISPOSAL	LOCATION		
	JAMAICA (%)	**ST. CATHERINE (%)**	**SIA (%)**
Pit Latrine	37.9	33.3	52.7
Water Closet	58.2	63.5	41
Not Reported	1.4	1.4	1.4
No Facility	2.5	1.8	4.9

(Source: STATIN Population Census 2001)

The proposed barge will have a package (self contained) sewage treatment system which will meet the NEPA sewerage effluent standards.

Wastewater generation from the operation of the proposed barge is estimated to be 475 litres/day (≈ 125 gals/day). The sewage treatment system that is to be installed on the proposed barge has the capability of collecting and adequately treating the wastewater.

OILY WATER

The barge will be equipped with an oily water treatment system which has an oil skimmer and sludge separator. The separated sludge will be stored in drums and transported by private hired Contractors to the Petroleum Corporation of Jamaica (PETROJAM) which uses the recycled oil.

4.10.6.5 Solid Waste Generation and Disposal

The Metropolitan Parks and Markets Waste Management Limited is responsible for 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. Catherine, approximately 38 km (≈24 miles) east of the proposed barge.

It is estimated that households in the study area generated approximately 18,133kg (≈ 18 tonnes) of solid waste in 2001. Based on the population growth, it has been estimated that at the time of this study, approximately 19,528 kg (≈ 19.5 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 29,909 kg (≈ 30 tonnes).

The 2001 census data indicated that approximately 59% 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 lower percentage (54%) in the SIA. It also showed that the next preferred method of disposal in the SIA was by burning (Table 21). All the other categories of garbage disposal in the SIA were lower than the National and regional figures. The high percentage (43.5%) of households burning their garbage as a means of disposal (Plate 12 and Figure 35) is a cause for concern, as it has the potential to impact on ambient air quality by creating air pollution.

Plate 12 One of the improper and indiscriminate solid waste sites (depicting household waste) throughout the Social Impact Area (SIA)

Table 21 Percentage households by method of garbage disposal

DISPOSAL METHOD	JAMAICA (%)	ST. CATHERINE (%)	SIA (%)
Public Collection	47.7	58.6	53.8
Private Collection	0.5	0.3	0.1
Burn	43.0	33.7	43.5
Bury	1.2	0.8	0.4
Dump	6.0	5.1	0.8
Other Method	0.3	0.3	0.1
Not reported	1.3	1.2	1.3

(Source: STATIN Population Census 2001)

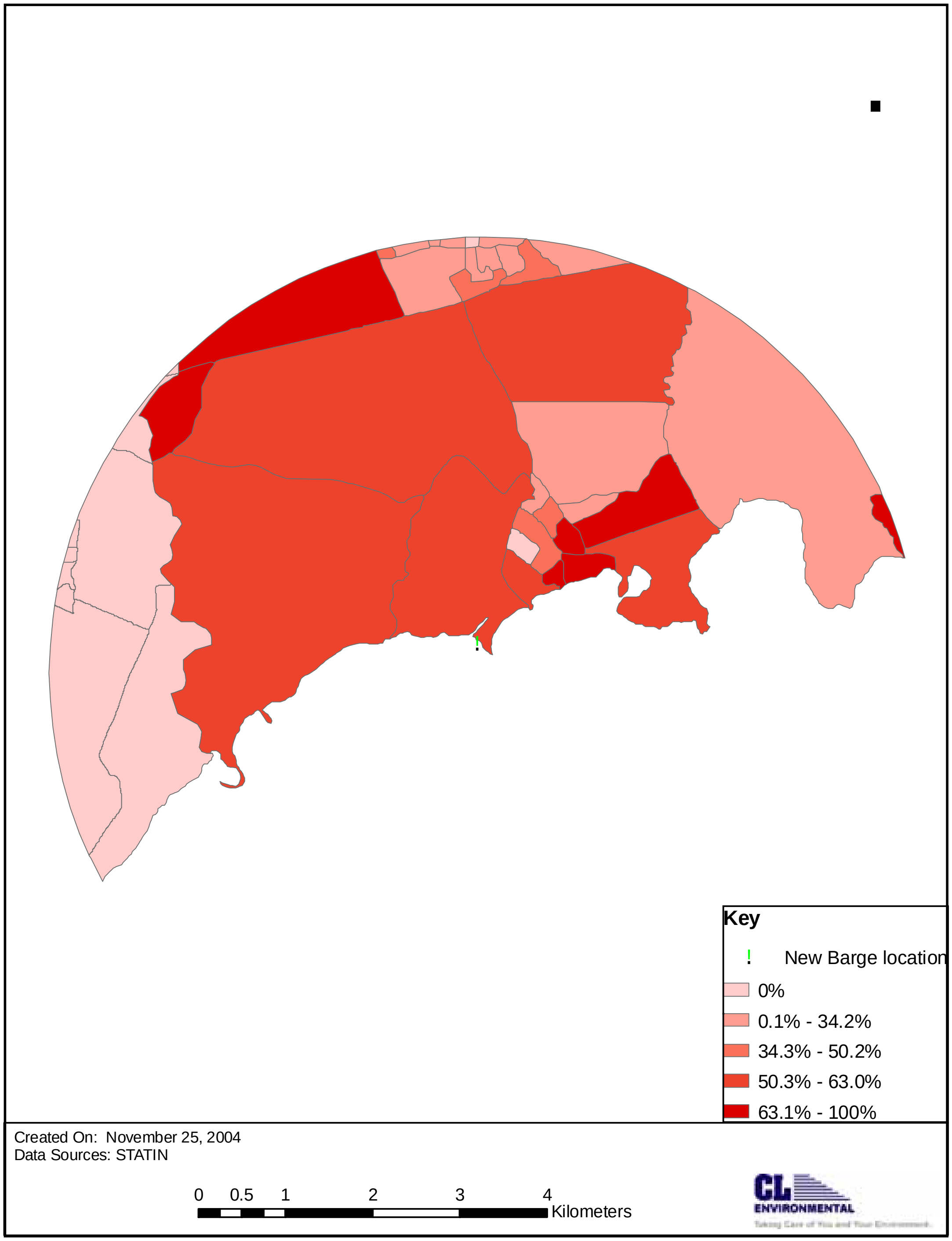


Figure 35 Percentage households in the SIA burning garbage

Solid waste generation at the new facility is expected to consist mainly of operational (oily rags, scrap metals etc.) and office waste. This will be collected by private Contractors and transported to the Riverton City landfill for disposal or properly recycled.

4.10.6.6 Health Services

There are no hospitals within the SIA. Most persons interviewed (≈ 74%) within the SIA obtained their health services in Old Harbour at either a private doctor or the health centre in Old Harbour. Fifteen percent (15%) went to Spanish Town hospital, 6% went to Kingston and 5% to May Pen.

The Old Harbour health clinic is a Type III. 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.

Old Harbour Bay has a satellite clinic which operates twice per month from the Baptist Church Hall. It offers family planning and child health. 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 (25 km away).

4.10.7 Other Services

4.10.7.1 Fire Station

The fire station that would respond to an emergency at the proposed site is located at Old Harbour approximately 5 km (≈ 3 miles) from the proposed development. 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 Port Esquivel (WINDALCO) some 13 km (≈ 8 miles) away or the Spanish Town some 25 km (≈16 miles) away or May Pen fire stations some 24 km (≈15 miles) away.

The proposed development will have its own designed fire control system, with a series of indoor hose rack stations, fire hydrants, portable fire extinguishers, foam units and a carbon dioxide system.

4.10.7.2 Police Station

The Old Harbour Bay police station is situated within the SIA. 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.

4.10.7.3 Post Office

The Old Harbour Bay and Old Harbour post offices serve the study area. The Old Harbour Bay post office would be responsible to serve the areas in proximity to the proposed barge location.

4.10.7.4 Market/Shopping

There are two markets within the SIA. These are the Old Harbour and the Old Harbour Bay markets. The market at Old Harbour Bay is in a dilapidated state. The households of most of the respondents (72.6%) used the Old Harbour Market, 13.7% used the May Pen Market, 6.8% used the Old Harbour Bay Market, 5.5% the Coronation Market in Kingston and 1.4% the Spanish Town Market.

Shopping for the household is also done mainly in Old Harbour (75%), 11.7% in May Pen, 6% in Kingston, 4.4% in Old Harbour Bay and 3% in Spanish Town.

4.10.8 Community Consultation and Perception

Most (61.4%) of those interviewed were not aware of the pending development. Of those who knew about it, 69.2% were informed by word of mouth, 26.8% by a town meeting and 4% by the media.

Approximately sixty five percent (65.7%) of the respondents said that the existing facility (JPS/JEP) did not impact on their lifestyle in anyway. Thirty one percent (31%) indicated that the present facility impacted on their lifestyle positively by providing employment and negatively at times generating noise, vibration and oil spills and twenty nine (29%) did not have an opinion.

Most persons interviewed (84%) were of the opinion that the proposed barge was suitable for the location, 10% did not agree and 6% had no opinion. When asked how the installation of another barge would affect their lifestyle, the majority (52.2%) of the interviewees said that it would have no effect; 15.9% said it would improve their lifestyle by providing employment and a more stable power supply; 15.9% had no opinion and 15.9% said it would impact negatively on their lifestyle as it would result in more noise.

Seventy five percent of the interviewees were aware of church groups within the SIA. Some of the church groups were;

i. Old Harbour Bay Baptist,
ii. Old Harbour Bay Seventh Day,
iii. Old Harbour Bay Church of God of Prophesy; and
iv. Old Harbour Bay Anglican

Most persons interviewed were not aware of any environmental groups within the area. Those who were aware listed the Caribbean Coastal Area Management Foundation and (CCAM) and the National Environment and Planning Agency (NEPA). When asked if they were aware of any nature reserves in their community or nearby, 79.6% said no, 18.5% said yes and 1.9% were not aware.

Approximately 23% of those interviewed indicated that they were actively involved in any community organization. That said, the community cohesiveness in Old Harbour Bay appeared to be good. They have listed the following as their greatest needs;

i. Unemployment
ii. The need for the area to be developed
iii. More street lights
iv. The need for better roads

4.10.8.1 Special Groups CCA, Fisherman Coop, NEPA

This section deals with consultations held with major interest groups. The method of engaging the discussions included a presentation outlining the proposed project and informal discussions and discussions. Feed back was sought and these are represented below.

Caribbean Coastal Area Management Foundation (CCAM)

Consultation with the Executive Director of CCAM, Mr. Peter Espuet and Brandon Hay (Scientific Officer), indicated that in principle there were no objections to the proposed project. However, they listed the increased potential for thermal water pollution, oil spills, especially at oil receival mooring facility, and noise as their major concerns. Additionally, the chemicals used for the treatment of the cooling water lines were also a concern.

Old Harbour Bay Fisherman's Co-op

Consultation with the Old Harbour Bay Fisherman's Co-op, Chairperson (Mr. Cameron), indicated that they would welcome the proposed Project especially if it created jobs for locals. Noise was initially a concern for the first Barge (Dr. Bird); however, that concern has become a non-issue. Another concern is oil spillage, especially at the oil receival mooring facility. He said that there were two such spills in 2003, which were dealt with by JEP. However, he thought that the oil spill contingency plan for that location could have been effected quicker.

The main breeding and fishing areas were ascertained based on discussions with Mr. Cameron. The main breeding grounds are West Harbour, Galleon Harbour, Coquar Bar and the Cays (e.g. Bare Bush, and Portland cays and Pigeon Island). Main breeding grounds can be found between Bowers River to Salt Island and Welcome Beach (between JAMALCO, Rocky Point and Port Esquivel). The best fishing time is in the months of April and November.

The locations of the main breeding and fishing grounds are outside of the impact area of the Proposed Project (Figure 36).

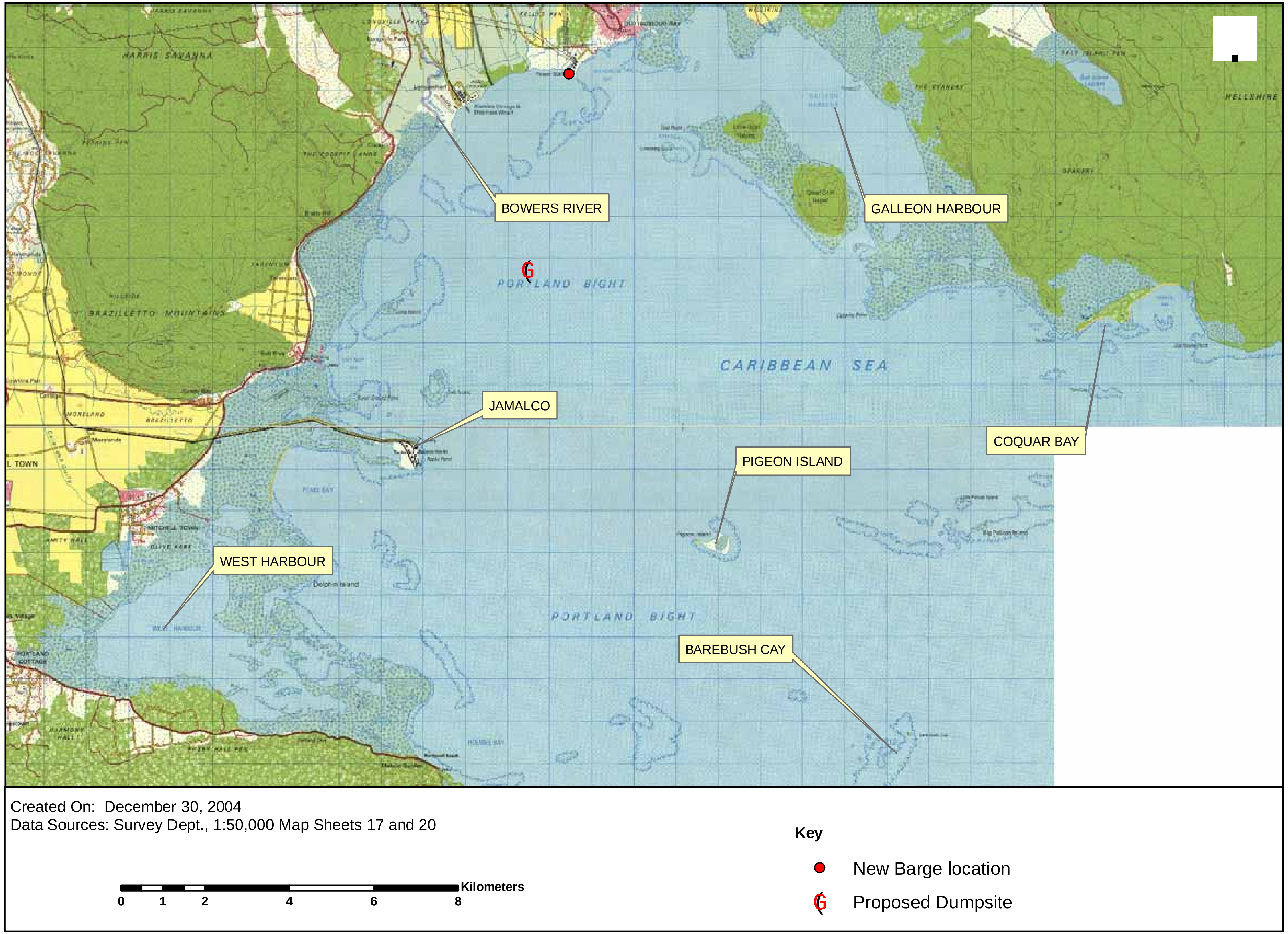


Figure 36 **Main breeding and fishing areas within proximity to the Proposed Project and the proposed dredge spoils dumpsite**

4.11 ROADS AND TRANSPORTATION

Roads within the SIA 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. From the turn off, the road is in a good state of repair as the surface was recently (last three months) repaved. The access roads on the site are also in a good state of repair.

Transportation within the SIA is achieved through minibuses, legal and illegal ("robot") taxis and private cars. Transportation to and from the site is adequate with workers having the option of taking a taxi or getting a ride through the two company buses, one of which travels from the Kingston area (east of the plant) to the plant and the other from the May Pen area (west of the plant) to the plant. Taxi fares from Old Harbour to Old Harbour Bay cost on average, forty Jamaican ($J40.00) one-way.

Of those interviewed, 49% used taxis as their main means of transportation. The use of the bus was the next major category with 32.3% of those interviewed using this mode of transport, personal vehicles accounted for 16.1% and those who used other means of transportation (e.g. bicycles) were 3%.

Air travel occurs within the SIA at the West Indies Alumina Company (WINDALCO) Port Esquivel plant which has a private airstrip. This is located approximately 12 km southwest of the proposed JEP barge.

4.12 AESTHETICS

The area of the proposed development is an industrialized area with the present “Dr Bird” barge and the JPS Old Harbour plant in proximity.

5.0 ENVIRONMENTAL IMPACTS

This Section will discuss the impacts associated with construction and operation of the proposed barge power plant project. Construction activities are mainly divided into site preparation (dredging activities) and construction of the docking facilities for the barge. Operation activities will consider the barge power plant by itself. Section 6.0 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 barge, an impact matrix was constructed which arrayed the main project activities against the relevant environmental factors. This matrix is shown in Tables 22 and 23.

Table 22 Significant Site Preparation and Construction Phase Impacts

ACTIVITY/IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE		EXTENT		SIGNIFICANCE	
	Pos	Neg	Long	Short	Direct	Indirect	Major	Minor	Wide	Local	Large	Small
1. Site Preparation												
Sea grass Removal		x	x		x			x		x		x
Habitat Removal		x	x		x			x		x	x	
Increased infiltration/runoff		x		x		x		x		x		x
Suspended solids		x		x	x		x			x		x
Noise		x		x	x			x		x		x
Air quality		x		x	x			x		x		x
Decreased water quality		x		x	x			x		x		x
Heavy metal re-suspension		x		x		x		x	x			x
2. Ballast Water Disposal												
Introduction of invasive species		x		x		x	x		x		x	
3. Material Transport												
Dusting & spillage		x		x	x			x		x		x
Traffic congestion, road wear		x		x	x			x		x		x
Routing through small towns		x		x	x			x		x		x
4. Improper Material Storage												
Dusting		x		x	x			x		x		x
Suspended solid runoff		x		x	x			x		x		x
5. Construction Works												
Noise		x		x	x			x		x		x
Refuelling of vehicles and fuel storage onsite		x		x	x			x		x		x
Repair of vehicles onsite		x		x	x			x		x		x
6. Construction Crew												
Sewage generation		x		x	x			x		x		x
Solid waste generation		x		x	x			x		x		x
Emergency response		x		x	x			x		x		x
7. Socioeconomics												
Job creation	x			x	x			x		x		x

Table 23 Significant Operation Phase Impacts

ACTIVITY/IMPACT	DIRECTION		DURATION		LOCATION		MAGNITUDE		EXTENT		SIGNIFICANCE	
	Pos	Neg	Long	Short	Direct	Indirect	Major	Minor	Wide	Local	Large	Small
1. **Barge Maintenance**												
Use of lead based paint		x	x			x		x		x		x
Sand blasting and scraping		x		x		x		x		x		
Polluted runoff off from asphaltic concrete		x		x	x			x		x		x
2.Storm Water/Drainage												
Increased flow & siltation		x	x			x		x		x		x
3. Air Quality												
Increased pollutants in air shed	x		x		x		x			x	x	
4. Noise Pollution												
Increased noise pollution		x	x			x		x		x		x
5. Occupational Health and Safety												
Increased air emissions exposure		x	x		x			x		x		x
Increased noise exposure		x	x		x			x		x		x
Increased potential for accidents		x	x			x		x		x		x
6. 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
7. 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
8. Socioeconomics												
Job creation	x		x			x	x			x	x	
Stable electricity supply	x		x			x	x			x	x	
Increased worker productivity	x		x		x		x			x	x	
Economic growth nationally	x		x		x			x	x		x	

5.1 POTENTIAL IMPACTS OF THE PROPOSED PROJECT DURING SITE PREPARATION

It will be necessary to dredge approximately 18,500 – 20,000 cubic metres of material from the sea-bed in order to provide a suitable basin close to shore and approximately 9,000 cubic metres will be filled to accommodate the power barge. The maximum cut is approximately 3.5m and the average cut will be of the order of 2.5m.

Two potential suitable techniques to conduct this dredging exercise are; (i) Floating grab crane, and (ii) A cutter suction dredge. Both would discharge into bottom-opening "split" barges which will be taken away to the dumpsite (Figure 36) offshore. The "split barges" will be transported to and from the dredge site by tugboat.

Impact: Loss of Bottom Habitat

Dredging will not be conducted in the area of coral reefs, but much of the area to be dredged is covered by seagrass in varying state of health and fishery resources. Inevitably, some existing seagrass and bottom biota will be destroyed by the dredging. Approximately 4,000 m^2 of seagrass in varying state of health will be removed during the dredging operation. This is an estimate as visibility in the water column was poor.

Impact: Suspension and Dispersal/ Resettlement of Sediments

The process of dredging and the disposal of dredge "spoils" will inevitably lead to soil particles being put into suspension in the water column. Depending on the direction and velocity of the prevailing sea-currents, the potential for aquatic resources down drift of the dredge and the dredge disposal site being adversely impacted by being smothered by sediments exists. The proposed disposal site is situated approximately 4.7 km south of the proposed facility (Figure 36). It has been previously used for this purpose with no significant environmental impact and the same is expected for this activity.

Impact: Heavy Metal Re-suspension

The dredging exercise has the potential to indirectly increase the heavy metal concentrations in the water column due to the bottom sediments that are re-suspended into the water column during construction and thereby releasing heavy metals sorbed unto their surface. Recent sampling does not indicate significant levels of trace metals.

Impact: Introduction of Invasive Species

The introduction of alien organisms to an environment has often been traced back to the translocation of ballast water and sediments. This process can have environmental, economic and health effects. There is the potential for the introduction of invasive species from ballast water and from those species that attach themselves to the hull of ocean vessels. These have the potential to out compete existing organisms. An example is *pernaviridis* (the green oyster).

5.2 POTENTIAL IMPACTS DURING CONSTRUCTION OF THE DOCKING FACILITIES FOR THE BARGE

The main elements of the docking facilities that will be constructed are:

1. Approximately 65m of shoreline protection (approx. 33m NW-SE and 32m NE-SW),
2. Three (3) free standing tubular steel piles to which vessels will be attached, and
3. Approximately 150m of sheet-piled seawall.

Approximately 4,390 m^2 of existing foreshore will be filled in to provide shore side operating space behind the barge.

Impact: Hydrology: Increase Particle suspension and Surface Runoff

The process of filling to create the docking facility has the potential for particles being put into suspension in the water column. Depending on the direction and velocity of the prevailing sea-currents, there is the potential for aquatic resources down drift to be adversely impacted by being smothered by sediments.

Surface runoff from the newly paved asphaltic concrete has the potential of introducing hydrocarbons to the marine environment.

Impact: Air quality (Fugitive Dust and Noise)

Site preparation and construction has the potential to have a two-folded direct negative impact on air quality. The first impact is air pollution generated from the exhaust emissions of construction equipment and vehicles. 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.

Impact: Noise

Site clearance and construction of the proposed development necessitates the use of heavy equipment to carry out the nature of the job. These equipment include bulldozers, backhoes, pile driving etc. They possess the potential to have a direct negative impact on the environment. Noise directly attributable to construction activities should not result in noise levels in the residential areas to exceed 55dBA during day time (7am – 10 pm) and 45dBA 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.

It is anticipated that persons closest to the proposed construction area will be most affected by the construction activities for example driving of the piles (impulse noise) for the bridge construction. For the purposes of this study an area of 700m was demarcated as the area which had the highest potential to be impacted. Within this area it is estimated that some 194 persons or approximately 56 households has the potential to be impacted.

The proposed project has the potential to be a noise nuisance during both the construction (driving of the dolphin piles) and the operation phases. However, with the proper mitigative steps the proposed project will have minimal if any impact on the surrounding community.

Impact: Biological: Vegetation Removal

The flora in proximity to proposed docking facility are not endemic, endangered or rare and are commonly found around the island.

Impact: Land Use

There are no impacts as it relates to land use as the proposed location is already an industrial area and the location will have little visual impacts.

Impact: Solid Waste Generation and disposal

During the construction phase of the proposed project, solid waste generation may occur mainly from two points:

i. From the construction campsite.
ii. From construction activities such as site clearance and excavation.

Impact: 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 groundwater. No significant environmental impacts were identified from this activity.

Impact: Storage of Raw Material and Equipment

Raw materials, for example sand, marl and asphaltic concrete used in the construction of the proposed development, will be stored onsite. There will be a potential for them to become air or waterborne. Stored fuels and the repair of construction equipment has the potential to leak hydraulic fuels, oils etc.

Impact: Transportation of Raw Material and Equipment

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.

Impact: Emergency Response

Construction of the proposed docking facility has the potential for accidental injury. Precautions will be taken to minimize the frequency and severity of construction accidents.

Impact: Employment

The major socio-economic impact during the construction is the potential direct positive benefit of employment opportunities. It is estimated that approximately 60 man months of professional/technical , 180 man months of skilled workers and 60 man months of unskilled/casual employment will be required for site and engineering works.

Impact: Historical and Cultural Resources

No significant impacts identified.

Impact: Aesthetics

No significant impacts identified.

5.3 OPERATION OF BARGE POWER PLANT

This section assesses the impacts of the proposed barge power plant by itself, while Section 6.0 will address the cumulative impacts in the project area.

5.3.1 Air Quality

This section addresses both the in-stack emission standards and guidelines for Jamaica and the World Bank as well as the ambient air quality guidelines and standards for Jamaica and the World Bank.

5.3.1.1 In-Stack Emission Standards and Guidelines

The Minister, in exercise of the powers conferred by Section 38 of the NRCA, promulgated draft Air Quality Regulations in 2002. These air quality regulations, among other things, contain in-stack air emission standards for new facilities (installed or commenced construction after September 1, 2001). Table 24 shows these in-stack air emission standards.

Table 24 Jamaican In-Stack Air Emission Standards

Pollutant	Standard
Sulphur Dioxide	A maximum of 2.2 percent sulphur in heavy fuel oil (No. 5 or 6 oil)
PM[(a)]	85 nanograms per Joule (ng/J) 100 milligrams (mg) per cubic meter at 15% oxygen[(b)]
NO_x[(a)]	2,981 ng/J 3,512 mg/normal cubic meter at 15% oxygen[(c)]

a) Liquid fuel fired internal combustion engines of 2-50 MW
b) It is not clear in the regulation whether this is normal cubic meters on a dry basis.
c) It is not clear in the regulation whether this is on a dry basis.

The following Table 25 provides the World Bank in-stack air quality guideline values for an internal combustion engine power plant of 49.6 megawatts capacity. The total SO_2 emission levels are not applicable for projects of less than 50 MW, and the allowable in-stack PM level is 100 mg/Nm^3 (as provided in Annex A of the World Bank guidelines).

Table 25 World Bank In-Stack Air Quality Guidelines

POLLUTANT	INTERNAL COMBUSTION ENGINES [a]
Nitrogen Oxides	2,000 milligrams/Nm^3
Sulphur Dioxide	2,000 milligrams/Nm^3
Particulate Matter	100 milligrams/Nm^3

[a] These NO_x , PM, and SO_2 values are expressed on a dry basis at 15 percent oxygen.

Wärtsilä, the IC engine manufacturer, has supplied exhaust air emissions data for the equipment, assuming the utilization of a 2.2%, (by weight) maximum sulphur content in the fuel oil. Table 3 provides a comparison of the manufacturer's data with the Jamaican in-stack air emission standards.

Table 26 Comparison of in-stack air emissions to Jamaican Standards

POLLUTANT	ENGINE SPECIFICATION	JAMAICAN STANDARD
SO_2	Maximum of 2.2% sulphur, by weight in fuel oil	Maximum of 2.2% sulphur by weight in No. 5 or 6 oil
PM	75.2 mg/Nm^3 (a)	100 mg/m^3 (b)
NO_2	1,990 mg/Nm^3 (a)	3,512 mg/Nm^3 (c)

a) This is a dry basis at 15% oxygen
b) This is specified at 15% oxygen, but not whether it is a dry basis, normal cubic meters;
c) This is not specified whether it is a dry basis, but it is at 15% oxygen.

As shown in Table 26, the engines will comply with the Jamaican in-stack standards for SO_2, PM, and NO_2 (assuming the Jamaican standards were corrected to dry basis and normal cubic meters).

Table 27 compares the proposed project in-stack emission rates, as provided by Wärtsilä, to the World Bank in-stack air quality guideline values for SO_2, PM, and NO_2.

Table 27 Comparison of in-stack emission levels to World Bank Guideline values

POLLUTANT	ENGINE SPECIFICATION[(a)]	WORLD BANK GUIDELINE VALUE[(a)]
SO_2	1,320 mg/Nm^3	2,000 mg/Nm^3
NO_2	1,990 mg/Nm^3	2,000 mg/Nm^3
PM	75.2 mg/Nm^3	100 mg/Nm^3

a) All values are dry basis, 15% oxygen

Thus, Table 27 shows compliance by the project for all applicable in-stack World Bank guideline values for SO_2, NO_2, and PM.

5.3.1.2 Air Dispersion Modelling Analysis

General Description

Jamaica Energy Partners (JEP) is planning to install and operate additional electric power generating capacity (nominally 49.5 MW) at the existing Old Harbour, Jamaica site. The JEP addition includes three internal combustion engine/diesel generators, using a maximum of 2.2% Sulphur in oil, which will exhaust to the atmosphere. JEP has an existing barge that contains eight engines, using a maximum 2.2% Sulphur in oil and generating 75 MW of electricity. Jamaica Public Service Company (JPS), located immediately adjacent to JEP, has four existing conventional steam boilers using a maximum of 3.0% Sulphur in oil to generate approximately 200MW.

Dispersion modelling for the JEP Old Harbour proposed electrical generating facility involved three US EPA supported dispersion models; CALPUFF, AERMOD and ISC. CALPUFF is typically used for longer range (e.g., 50 km and beyond) modelling analyses, though it can calculate concentrations very near the source. Because of the desire to assess impacts to the Old Harbour airshed, the CALPUFF model was initially used believing that its capacity to spatially represent meteorological components of dispersion and to include the potential effects of shoreline boundary layer influences would provide a truer indication of airshed impacts. Due to the gridded nature of CALPUFF and the location of the impacts (new-source terrain just north of

Old Harbour and also near the facility), it was decided that AERMOD may provide a more accurate prediction of impacts than CALPUFF.

There were considerable differences in predicted concentrations of pollutants between the two models used – ISCST3 and AERMOD. The differences are primarily due to the differences in how each model simulated dispersion through characterization of the planetary boundary layer (PBL).

The modelling results for SO_2 suggested that AERMOD predicted impacts 3-4 times greater than ISCST3 for 1-hour concentrations, twice as large as ISCST3 for 24-hour concentrations, and AERMOD annual concentrations were about 1.5 times greater than annual ISCST3 predicted SO_2 concentrations.

Primarily the differences are in how the two models actually predicted concentrations through simulation of PBL features based on the meteorological data.

The same meteorological data (Old Harbour/Kingston) was input to the meteorological processors of both models (AERMET for AERMOD and PCRAMMET for ISCST3). But these processors returned different parameterizations of boundary layer phenomena as used in each model.

For instance, PCRAMMET, for ISCST3, used hourly surface data (wind speed, direction, temperature, cloud cover) along with twice daily calculated mixing heights to return hourly wind direction (blowing toward), wind speed, temperature, stability, and urban/rural mixing heights. The mixing heights were calculated using the MIXHTS program which combined surface data with twice daily radiosonde measurements to determine the height of the mixing layer or PBL.

AERMET, on the other hand, used the same surface data and the morning radiosonde measurement to calculate a number of parameters used in the AERMOD simulation of dispersion in the PBL. AERMET calculated surface parameters such as friction velocity and Monin-

Obukhov lengths based on surface roughness, Bowen ratio, and albedo values specific to certain wind directions around the observing site. AERMET calculated mixing heights for both mechanical and convective schemes and included a smoothing iteration to avoid the hourly jumps in mixing heights often seen using the MIXHTS and PCRAMMET programs.

The hourly parameters calculated in AERMET include the sensible heat flux, surface friction velocity, convective velocity scale, vertical potential temperature gradient above the PBL, convective mixing height, mechanical mixing height, Monin-Obukhov length, wind speed, wind direction (blowing from), and temperature. Reported in the hourly file are the direction specific values of surface roughness length, Bowen ratio, and albedo. These AERMET hourly parameters are used in AERMOD to simulate dispersion in the PBL and calculate hourly concentrations at each receptor in the grid.

While AERMOD has yet to be an approved model, it has been proposed for acceptance by the EPA pending implementation of various components sought by the public commenters on prior draft versions.

Before it could be proposed for acceptance, AERMET/AERMOD and its terrain/grid processor AERMAP were all evaluated against the accepted models, especially ISCST3. The evaluation pitted AERMOD against ISCST3 along with short and long-term monitor results. The results of the evaluation were reported in Paine, et al., 2003, AERMOD: Latest Features and Evaluation Results, AWMA Paper #69878, and demonstrated that with considerable variability, AERMOD predicted values nearer those monitored than did ISCST3.

In reporting the results of the evaluation, the authors also tabulated comparison of model features between AERMOD and ISCST3 showing the many more “realistic” characterizations of AERMOD versus the simpler approaches used in ISCST3. The more robust handling of PBL dispersion and tracking of dispersion parameters in AERMOD also accounts for the considerably increased run-times in AERMOD over ISCST3.

Notwithstanding the favourable review and evaluation of AERMOD versus ISCST3, the differences reported in the modelled SO_2 concentrations seem to suggest considerable differences between the two models. To examine these differences a single 24-hour period was used – a period in which AERMOD predicted the greatest daily (and some large hourly) concentration of SO_2.

The maximum modelled daily concentration reported for SO_2 for the JEP/JPS sources occurred on October 31. Because of some missing hourly data, the AERMET file for that period showed missing values for the sensible heat flux, surface friction velocity, convective velocity scale, vertical potential temperature gradient above the PBL, convective mixing height, mechanical mixing height, and Monin-Obukhov lengths for hours 1, 3-7, 20, and 23, and therefore no dispersion or concentration calculations were made. Data for the other periods showed low wind speeds at hour 2, 19, and 24 (0.5 m/s) and low mechanical mixing heights based on those wind speeds (3 m msl).

The mechanical mixing height is calculated using a simple approximation of:

zim = 2300 u*3/2

where u* = surface friction velocity or approximately:

u* = CD * u/2

where u = wind speed and CD = k/ln(zref/z0)

and zref is the reference height and z0 is the surface roughness length.

The surface roughness length for winds arriving from over water (i.e., with southerly flow at Old Harbour) is suggested (see for instance Table 4-3 of the AERMET User's Guide) to be 0.001m, or very smooth. With an anemometer height of 10 m msl, and k (von Karman constant) of 0.4, CD becomes 0.043. With a low wind speed of 0.5 m/s then the surface friction velocity is 0.01 m/s and the mechanical mixing height is 2.6 m msl. This very low mechanical mixing height is unrealistic.

This does affect how AERMOD determined hourly dispersion coefficients though as unlike ISCST3, AERMOD calculated dispersion through and above mixing heights. A low mixing height as plumes approach terrain can lead to little dispersion and higher concentrations. The coincident hour mixing height in ISCST3's PCRAMMET program was shown to be 1,542 m msl – a considerable difference. The MIXHGTS program predicted a mixing height of 1,689 m msl the afternoon of October 30 and a mixing height of 1,247 m msl for the morning of October 31.

The actual sounding data for that morning (12Z sounding) showed three above surface levels less than or equal to 850 mb. Two of these levels were mandatory reporting levels (1000 mb and 850 mb) located at 142 m msl and 1526 m msl respectively. The third level was a significant level corresponding with 925 mb at a height of 826 m msl. Based on temperature and dewpoint values for the lower levels (surface at 1016 mb and 1000 mb) a lifting condensation level (LCL), the level typically associated with the cloud base and the height of the mixed layer, was calculated to be about the 950 mb level. This corresponds with a height of about 800 m msl, further suggesting that the AERMET mixing height levels were unrealistic.

These low mixing heights in AERMET have a considerable effect on calculated concentrations. Continuing to examine the October 31 averages, modelling of the single meteorological hour of 02 with the low mixing height described above, light wind speed and direction favouring transport of emitted plumes toward the north and elevated terrain, returned a maximum hourly concentration of 14,511 $\mu g/m^3$ for the ALL8 source group. Modelling the single hour of 19 for the same day, again with a low mixing height, light wind speed and direction favouring transport of emitted plumes toward the north and elevated terrain returned a maximum hourly concentration of 14,400 $\mu g/m^3$ for the ALL8 source group. When combined, these two hours alone suggest a daily concentration of over 1,200 $\mu g/m^3$. The maximum daily concentration for all hours of that day was 1,639 $\mu g/m^3$ with the remaining impacts in the northerly elevated terrain occurring during the hours of 10-16 for that day. Therefore, the 2 hours with unrealistically low mixing heights and low wind speeds account for most of the maximum 24-hour concentration reported in AERMOD.

For that same single hour of 02 on 31 October, ISCST3 predicted a maximum impact of 3,765 $\mu g/m^3$ in the same elevated terrain area. Again, this if for the ALL8 source and is 3.85 times less than the AERMOD result at the same receptor location. So both ISCST3 and AERMOD pick the same receptor location (i.e., wind direction/speed are the same) yet ISCST3 disperses the plume through a PBL with a height of 1,500 m and AERMOD through a much narrower layer.

Running the entire day in ISCST3 returns a maximum concentration of 258 $\mu g/m^3$, versus the 1,639 $\mu g/m^3$ reported for AERMOD at the same receptor location.

To see what concentrations would be predicted if AERMOD and ISCST3 used more similar input data for that same time period, the mixing height was raised slightly to 36 m msl and AERMOD rerun for hour 02, returning a maximum hourly SO_2 concentration of 7,302 $\mu g/m^3$ or nearly half of the prior hourly maximum impact using a 3 m msl mixing height. A further run was done with all mechanical mixing heights in AERMET changed to match those of the rural mixing heights used in ISCST3 for that 24-hour period (October 31). A daily re-run in AERMOD using the modified mixing heights returned a maximum 24-hour SO_2 concentration of 463 $\mu g/m^3$ and a maximum hourly value of 3,943 $\mu g/m^3$ occurring during hour 19. This maximum hourly value compares favourably with the maximum ISCST3 hourly value shown above.

A final AERMOD run for that day was done using modified AERMET data so that AERMET included use of the same mixing height for both mechanical and convective periods as well as the same wind speed and direction parameters as those used in ISCST3. Changing only these variables returned a maximum daily ALL8 SO_2 concentration of 464 $\mu g/m^3$ and a maximum hourly ALL8 SO_2 concentration of 2,217 $\mu g/m^3$. Changing these meteorological parameters now changed the locations of the maximum daily and hourly modelled concentrations. The daily maximum concentration moved from complex to simple terrain (elevation of 7 m msl) and the maximum hourly concentration, while still in complex terrain was at a lower elevation (115 m msl) and now occurred on hour 24.

It is obvious from the results discussed above that the two models use similar meteorological inputs in very different manners and as a result predict very different concentrations.

The ISCST3 model is an accepted model and has been used to support countless regulatory permit decisions, where compliance with ambient air quality standards is required. AERMOD is proposed as the replacement to ISC and is heralded as a more robust and better model. Comparative studies between the two models using monitored data in various scenarios suggest that AERMOD better predicts concentrations than ISC.

It has been shown above that unrealistically low mixing heights calculated by AERMET, based on model guidance, can return unrealistically large short-term modelled concentrations. Modifying these parameters returns more reasonable concentrations. Matching the parameters suggests better agreement between AERMOD and ISC.

Because changes are required to AERMET to remove these unrealistically low heights, changes that would need to be negotiated in any regulatory phase, the use of a credible and defensible, approved model (ISCST3) is preferred over AERMOD to assess the impact of emissions near Old Harbour Jamaica.

Air Contaminants Evaluated

This modelling analysis assessed the impacts associated with the JEP proposed barge source by itself. Section 6.1 will address cumulative air quality impacts associated with the proposed JEP barge plant, the existing JEP barge plant, and the existing JPS facility.

The air contaminants evaluated in this air dispersion modelling analysis and the applicable standards are summarized in Table 28.

Table 28 Air contaminants reviewed

Air Pollutant	Averaging Time	JAAQS ($\mu g/m^3$)	World Bank ($\mu g/m^3$)
Carbon Monoxide (CO)	1-hr 8-hr	40,000 10,000	-- --
Nitrogen Oxides (NO_x)	1-hr 24-hr Annual	400 -- 100	-- 150 100
Inhalable Particulate (PM_{10})	24-hr Annual	150 50	150 50
Total Suspended Particulate Matter (TSP)	24-hr Annual	150 60	230 80
Sulphur Dioxide (SO_2)	1-hr 24-hr Annual	700 365/280[1] 80/60[1]	-- 150 80

[1] Primary/Secondary Jamaica Ambient Air Quality Standards.

Plot Plan

This section presents the required site diagram. Figure 37 shows the locations of all proposed and existing JEP as well as all existing JPS sources. This figure also shows the property boundaries and the locations of all buildings and structures that could cause plume downwash.

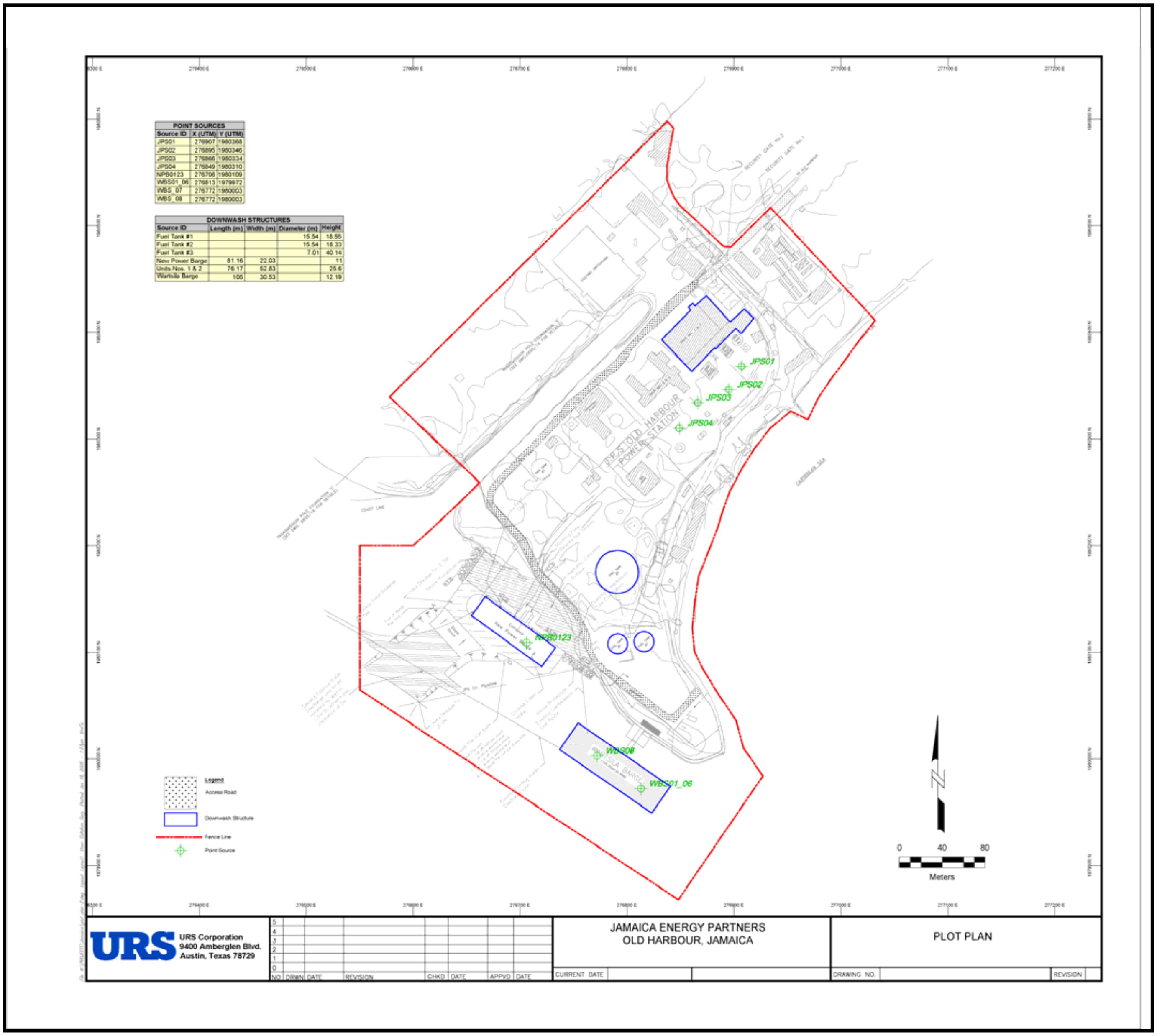


Figure 37 Plot Plan

Receptor Map

This section presents the required receptor map. Figure 38 shows the location of the Old Harbour Power Station and the region within 6 kilometres of the facility. Also shown is the AERMOD receptor grid, i.e., 100-meter spacing receptor grid from property line to 5-kilometres, and the 250-meter receptor grid starting at 5-kilometers and extending to 20-kilometres.

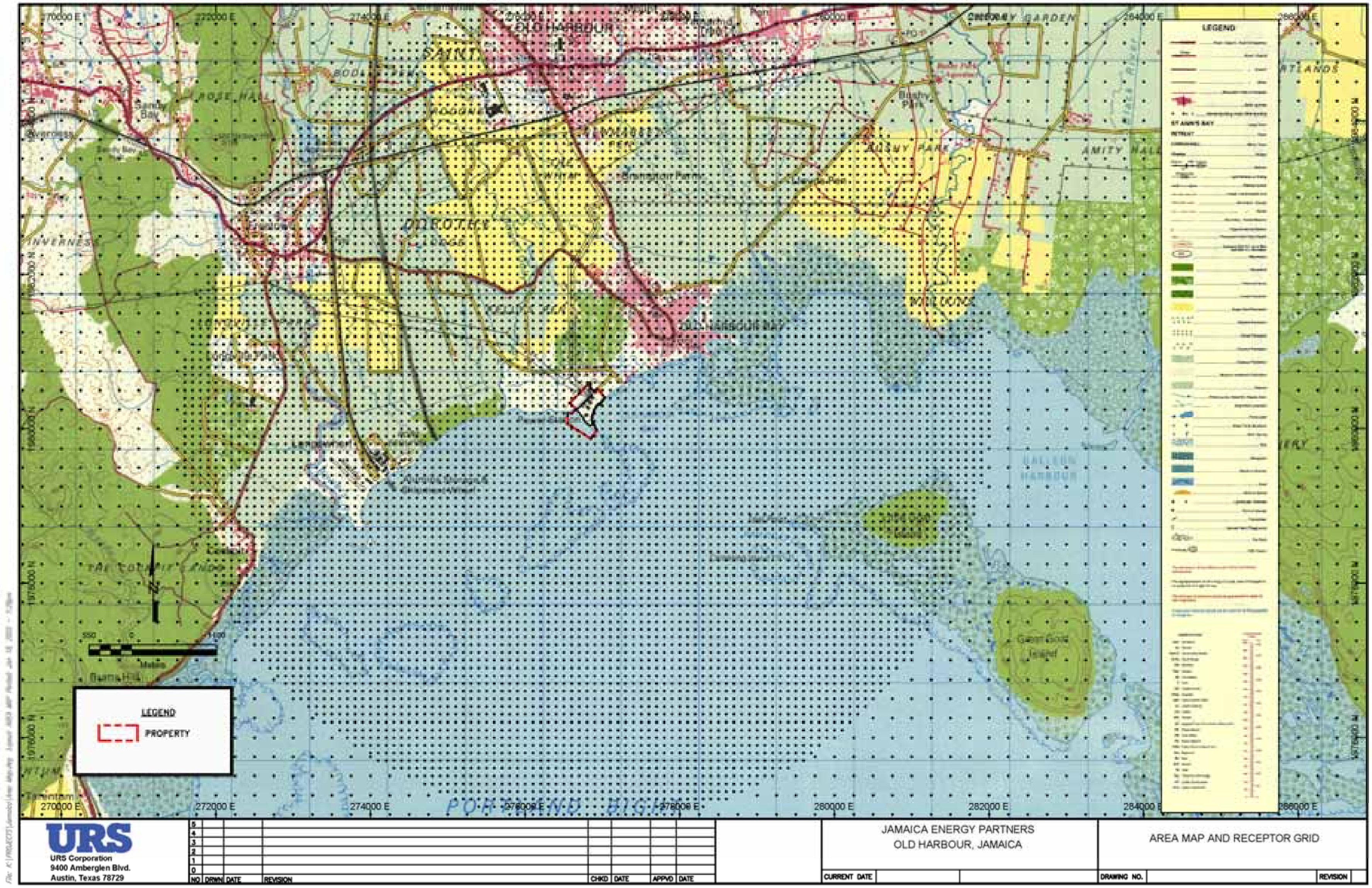


Figure 38 Location of the Old Harbour Power Station and the region within 6 kilometres of the facility

Topographic Map

This section presents the required topographic map. Figure 39 shows the Old Harbour Power Station and the elevation increasing inland with highest peaks located more than 15-kilometres north of the facility. This map also shows the locations of the two closet major facilities, Bauxite Works and a Sugar Factory in Monymusk. These two facilities are discussed further in this section.

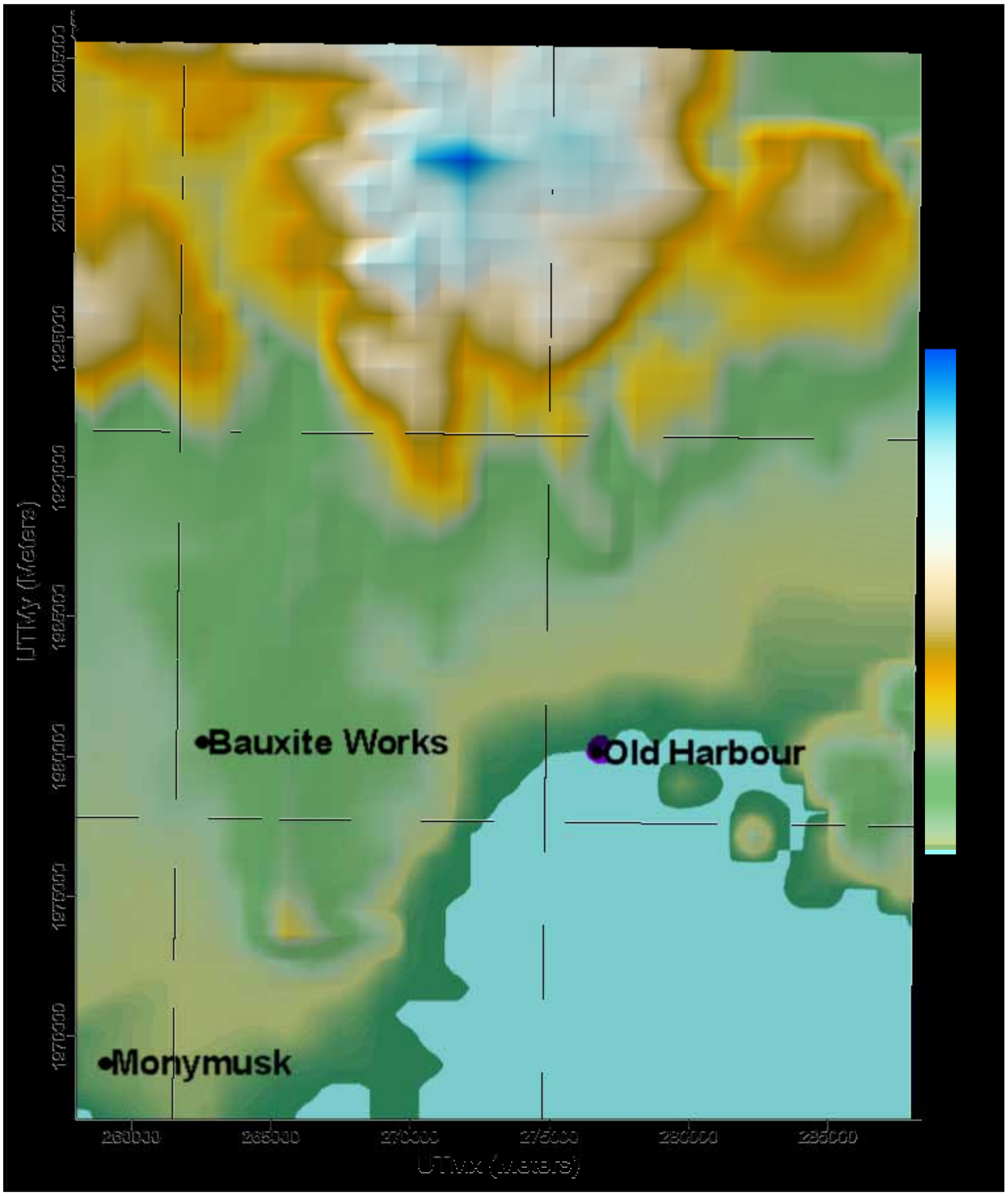


Figure 39 Topographic Map (Elevation in Meters)

Modelling Emissions Inventory

Project Sources

The project consists of three new diesel-powered generators on to a new barge. Proposed allowable emission rates were used for the new sources for this modelling analysis. The three stacks, having identical stack parameters and within close proximity, were combined into one stack to obtain an equivalent stack diameter to account for added buoyancy effects. After considering the combined flow rates and exit velocity, the equivalent stack diameter (for JEP 2) is equal to 2.42 meters. See Appendix 7 for detailed equivalent stack diameter calculations.

Table 29 summarizes emission rates modelled for all sources. Table 30 presents the modelled release parameters for all point sources.

Stack Parameter Justification

During normal operation, the units associated with this Project will operate at full load; therefore, maximum emission rates and corresponding release parameters will result in worst-case ground-level concentrations. As such, a load analysis was not performed for this air dispersion modelling analysis and only full load operation was modelled.

Table 29 Modelled Emission Rates

Pollutant	Analysis	Model ID	Emission Rate (g/s)
CO	AQA	JEP 2	10.2
NO_X	AQA	JEP 2	210
PM_{10}	AQA	JEP 2	7.8
SO_2	AQA	JEP 2	135

Table 30 Modelled Release Parameters for Point Sources

Model ID	Description	UTMX (m)	UTMY (m)	Height		Temperature		Velocity		Diameter		Flow	
				(ft)	(m)	(F)	(K)	(fps)	(mps)	(ft)	(m)	(ft3/s)	(m3/s)
NPB0123	JEP New Generators (Combined Stack)	276706	1980109	114.83	35.00	708.80	649.15	119.35	36.38	7.94	2.42	1808	168

Model Selection and Modelling Techniques

This section outlines the dispersion models and modelling techniques that were utilized in performing the air dispersion modelling analysis. As described earlier in this section, the ISCST3 air dispersion model was utilized for this modelling effort.

Dispersion Model Selection

The Industrial Source Complex 3rd version – short-term (ISCST3) (EPA Version 02035) model was used for refined analysis of the impacts from the proposed project. The ISCST3 model is a steady-state Gaussian plume model that can be used to assess pollutant concentrations from a variety of sources in short-term and annual (period) modes. The ISCST3 model was designed to specifically support the USEPA regulatory modelling programs. The model includes regulatory options such as final plume rise, stack-tip downwash, buoyancy-induced dispersion, a routine for processing averages when calm winds occur, and default values for wind profile exponents and for vertical potential temperature gradients. This model is acceptable for use by Jamaica and the World Bank.

Modelling Analyses

The modelling for the license application began with modelling the emissions for the proposed barge power plant by itself. Ground level concentrations were compared to the Jamaican Ambient Air Quality Standards and the World Bank Guidelines. The maximum modelled concentrations for all pollutants and their respective averaging periods were compared to the standards. Modelling for all pollutants was conducted with one-year of on-site meteorological data from July 1999 – July 2000.

Ratio Techniques

The Ambient Ratio Method as outlined in Section 5.2.1.3 of the NRCA's *Ambient Air Quality Guideline Document* was used to determine annual NO_2 concentrations. The value of 0.75 was used in determining modelled annual NO_2 concentrations.

To determine 24-hour NO_2 concentrations, the ambient ratio method as outlined in New Mexico's Air Quality Bureau's Dispersion Modelling Guidelines was used. The value of 0.40 was used in determining modelled 24-hour NO_2 concentrations.

Building Wake Effects

The effects of building cavities and wakes (i.e., downwash) upon the stack plumes were evaluated in accordance with EPA's *Guideline for Determination of Good Engineering Practice (GEP) Stack Height* (EPA, 1985). Direction-specific building data were generated for stacks below GEP stack height using the EPA's Building Parameter Input Program for Prime (BPIPPRM Version 04274). Figure 37 provides a plot plan illustrating facility-wide emission points and building structures. Structure dimension and height tables are provided on this figure and in Table31. Each building corner was digitized to obtain UTM coordinates. This information, along with emission point coordinates and heights, was input to the BPIPPRM model to obtain downwash inputs to the ISCST3 models.

The ISCST3 model considers direction-specific downwash using the Huber Snyder, Schulman-Scire, and PRIME algorithms as evaluated in the BPIPPRM program. Electronic BPIPPRM input and output files or a hardcopy of this analysis will be provided to NEPA on request.

Table 31 Building Dimensions

Name	Height (m)	Length (m)	Width (m)	Elevation (m)	Diameter (m)
Wärtsilä Barge	12.19	105.0	30.5	3.0	na
New Power Barge	11.00	81.2	22.0	3.0	na
Units Nos. 1 & 2	25.60	76.2	52.8	1.0	na
Fuel Tank #1	15.54	na	na	1.0	18.6
Fuel Tank #2	15.54	na	na	1.0	18.3

Name	Height (m)	Length (m)	Width (m)	Elevation (m)	Diameter (m)
Fuel Tank #3	7.01	na	na	1.0	40.1

Terrain

The facility is located along the southern shoreline of Jamaica in Old Harbour. The Shuttle Radar Topography Mission (SRTM) 3 Arc Second (~90-meter resolution) International Elevation Dataset based on the UTM Zone 18, NAD83 datum was obtained from the USGS Seamless Data Distribution System (http://seamless.usgs.gov/). This data set along with AERMAP – the AERMOD Terrain Preprocessor (AERMAP Version 03107) was used to determine terrain elevations for each receptor, source, and downwash structures, as well as receptor hill height values for use with complex terrain.

Meteorological Data

Surface Stations

Surface meteorological data are available from two sites in the JEP project vicinity; Old Harbour and Kingston. The Old Harbour data are available from July 1999 – July 2000. The surface data at Old Harbour include 10-minute averages of wind speed, direction, temperature and relative humidity, as well as other monitored parameters. These 10-minute averages were averaged to form the hourly values required for PCRAMMET. Hourly surface data are also available from Kingston. The Kingston surface data were acquired in CD144 format for the 1999-2000 period.

The hourly averaged Old Harbour surface data was also put into CD144 format. While the Old Harbour data was nearly complete, a few missing periods of one or another monitored value were found and missing parameters were filled with data from the complete Kingston surface data set. The Kingston CD144 data were also used to complete the CD144 formatted Old Harbour data for parameters not measured at Old Harbour, but needed for PCRAMMET processing (i.e., values expected to be found in a complete CD144 formatted file). Therefore the complete CD144 data used for Old Harbour was based primarily on wind, temperature, and relative humidity measurements at Old Harbour, but with all other variables measured at Kingston.

Upper Air Station

Upper air sounding data are available from Kingston and was obtained from the NOAA/FSL archives for the same time period, i.e., July 1999 through July 2000. The ISCST3 model requires 2 daily upper air soundings. Any missing upper air data from Kingston, therefore, had to be filled before running ISCST3.

The fill procedure was based primarily on persistence. That is given the location of Jamaica and the tropic coastal environment the atmosphere is more likely to persist in a certain pattern than a larger land area which can be subject to greater temperature fluctuations. For those days with a single missing sounding, the previous sounding was used to fill. For those periods with multiple missing soundings, the prior and following periods were used to fill. For example, if a period of 7 soundings were missing, then the prior sounding would be used to fill the first 4 and the following valid sounding would be used to fill the next 3. This would tend to "smooth" the transition between valid soundings. Similarly, missing sounding-specific data (e.g., top of the sounding data) were filled from the valid prior sounding or interpolated from valid levels immediately below the missing level parameter.

Land Use

Figure 40 shows the land use within 3-km of the power plant. The ISCST3 program was run in the "rural" mode.

Anemometer Height

An anemometer height of 10.0 meters was modelled since wind observations at the on-site monitor and at Kingston were taken at this height.

Figure 40 Land Use

Receptor Grid

This section presents the receptor grids used for air dispersion modelling analysis. Receptor spacing followed the guidance in NRCA's *Ambient Air Quality Guideline Document* (NRCA, 1999). The receptor grid used for the modelling analyses was as follows:

- 100-meter spacing extending from the property line out to 5 kilometres;
- 250-meter spacing within 5 to 20 kilometres of Project sources;
- 100-meter spacing was placed around maximum impacts within the 250-meter grid .

Figure 38 illustrates the 100-meter receptor grid and part of the 250-meter receptor grid used for the ISCST3 analyses.

Modelling Results

This section presents modelling results for all applicable guidelines and standards (Table 32).

For this analysis, the maximum measured background concentrations (from the baseline air quality section) for TSP, PM10, CO, SO_2, and NOx were taken for the 1-hour, 8-hour, 24-hour, and annual averaging periods. For the monitoring station, there are no concurrent PM10 and TSP values, so these data are somewhat staggered. Also, there is not a full year of monitored data, so the annual averages represent only the totals for the six or seven months of actual data. These background concentrations come from a monitoring station located very close to the JPS facility (within about 1 kilometre north), and these are the only background data available in the general area.

These background concentrations were added to the maximum modelled concentrations and the totals were compared to the World Bank guidelines and Jamaican ambient air quality standards.

For TSP, it is shown that the total (background plus JEP 2) 24 hour concentration is 89.6 $\mu g/m^3$, which is well below both the JAAQS of 150 $\mu g/m^3$ and the WB guideline value of

230 μg/m^3. The total annual concentration is 37.8 μg/m^3, which is well below the JAAQS of 60 μg/m^3 and the WB guideline value of 80 μg/m^3.

For PM10, the total 24-hour concentration is 117.8 μg/m^3, which is well below the JAAQS and WB standard and guideline value of 150 μg/m^3. The total annual concentration of 38.5 μg/m^3 is well below the JAAQS and WB standard and guideline value of 50 μg/m^3.

For CO, the total 1-hour concentration is 2,952 ug/m^3, which is well below the JAAQS of 40,000 ug/m^3. There is no World Bank guideline value for CO. For CO, the total 8-hour concentration is 1,761 ug/m^3, which is well below the JAAQS of 10,000 ug/m^3.

For SO_2, the total 1-hour concentration is 632 μg/m3, which is below the JAAQS of 700 μg/m^3. The second highest measured SO_2 background concentration of 280 ug/m^3 for the various months was used for this value. There is no WB 1-hour SO_2 guideline value. The total 24-hour concentration of 143 μg/m^3 is just below the WB guideline value of 150 μg/m^3 and well below the JAAQS primary standard of 365 μg/m^3. The total annual concentration of 22 μg/m^3 is well below the primary JAAQS and WB value of 80 μg/m^3 and the JAAQS secondary standard of 60 μg/m^3.

For NOx, the total 1-hour concentration (background plus JEP 2) is 271 μg/m^3. This value comes from using the Ozone Limiting Method (OLM). Maximum 1-hour NO2 concentrations in the vicinity of power plant site are assessed using the Ozone Limiting Method (OLM). The OLM is an approach, which is approved by the USEPA. For the OLM the following general equation was applied:

[NO2]1-hour = (0.1) x [NOx]pred + [O3]1-hour max
where
[NO2]1-hour is the predicted 1-hour NO2 concentration
[NOx]pred is the model-predicted 1-hour NOx concentration
[O3]1-hour max is the maximum 1-hour ambient ozone concentration

The maximum measured 1-hour ozone concentration was 101 μg/m^3, and this was measured at Ewarton in 2004. This location is 32 km (20 miles) north northeast of the proposed project site. This ozone concentration was considered representative of the project area, since ozone is a regional pollutant. The total 24-hour NOx concentration is 47 μg/m^3, and this is well below the WB guideline value of 150 μg/m^3, and there is no

JAAQS. The total annual NOx concentration is 15.7 μg/m^3, which is well below the JAAQS and the WB guideline value of 100 μg/m^3.

Figures 41, 42, and 43 show the 1-hour, 24-hour, and annual NOx isopleths, respectively, for the JEP 2 proposed project. Figure 41 shows the isopleths without any ozone limiting method correction applied. The Figures for 24-hour and annual NOx have applied the conversion factors. Figures 44, 45, and 46 show the 1-hour, 24-hour, and annual SO_2 isopleths, respectively for the JEP 2 proposed project by itself.

In summary, the JEP 2 project, by itself, meets all in-stack Jamaican standards and World Bank guideline values for SO_2, NOx, and PM. As for ambient impacts, the JEP 2 project, by itself, meets all Jamaican standards and World Bank guideline values for TSP, PM_{10}, CO, NO_x, and SO_2. When the monitored background concentrations are added to the JEP 2 project impacts all standards and guideline values are met. However, the ambient monitoring station may not be recording the highest ambient impacts associated with the combined operation of the JEP 1 and JPS operations. This issue will be further addressed in Section 6.1 for cumulative impacts.

Table 32 ISCST3 Modelled Concentrations

Pollutant	Ave. Period	Background, ug/m3	JEP2, ug/m3	Total Concentration, ug/m3	JAAQS, ug/m3	World Bank, ug/m3
TSP	24-hour	86.6	3	89.6	150	230
	Annual	37.4	0.4	37.8	60	80
PM_{10}	24-hour	114.8	3	117.8	150	150
	Annual	38.1	0.4	38.5	50	50
SO_2	1-hour	392	352	750	700	--
	24-hour	91	52	143	365/80	150
	Annual	16	6	22	80/60	80
CO	1-hour	13,500	27	13,527	40,000	--
	8-hour	1,800	11	1,811	10,000	--
NO_X	1-hour	NA	NA	271 [a]	400	--
	24-hour	15	32	47	--	150
	Annual	7.7	8	15.7	100	100

Source Group Descriptions
JEP2 is the proposed barge plant; three 35-meter stacks combined using 2.2%S in oil.
Nox concentrations have been adjusted for conversion percentages.

[a] This concentration comes from using the Ozone Limiting Method (OLM), which is described in the text.

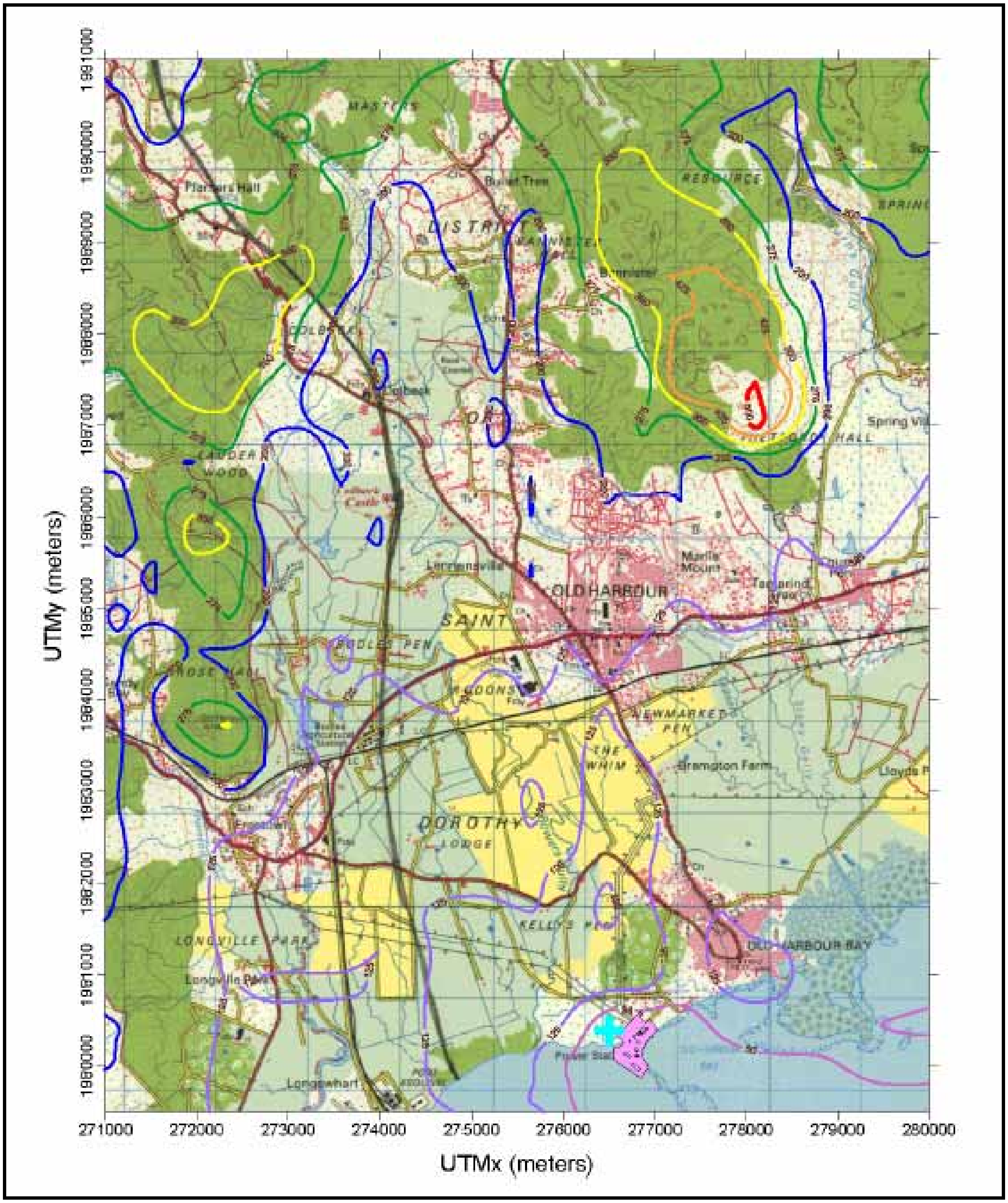


Figure 41 1-hour ISCST3 NOx Concentrations from JEP2 (2.2%S)

Note: Contours are 75 µg/m^3 intervals
Light Blue Cross = existing monitor

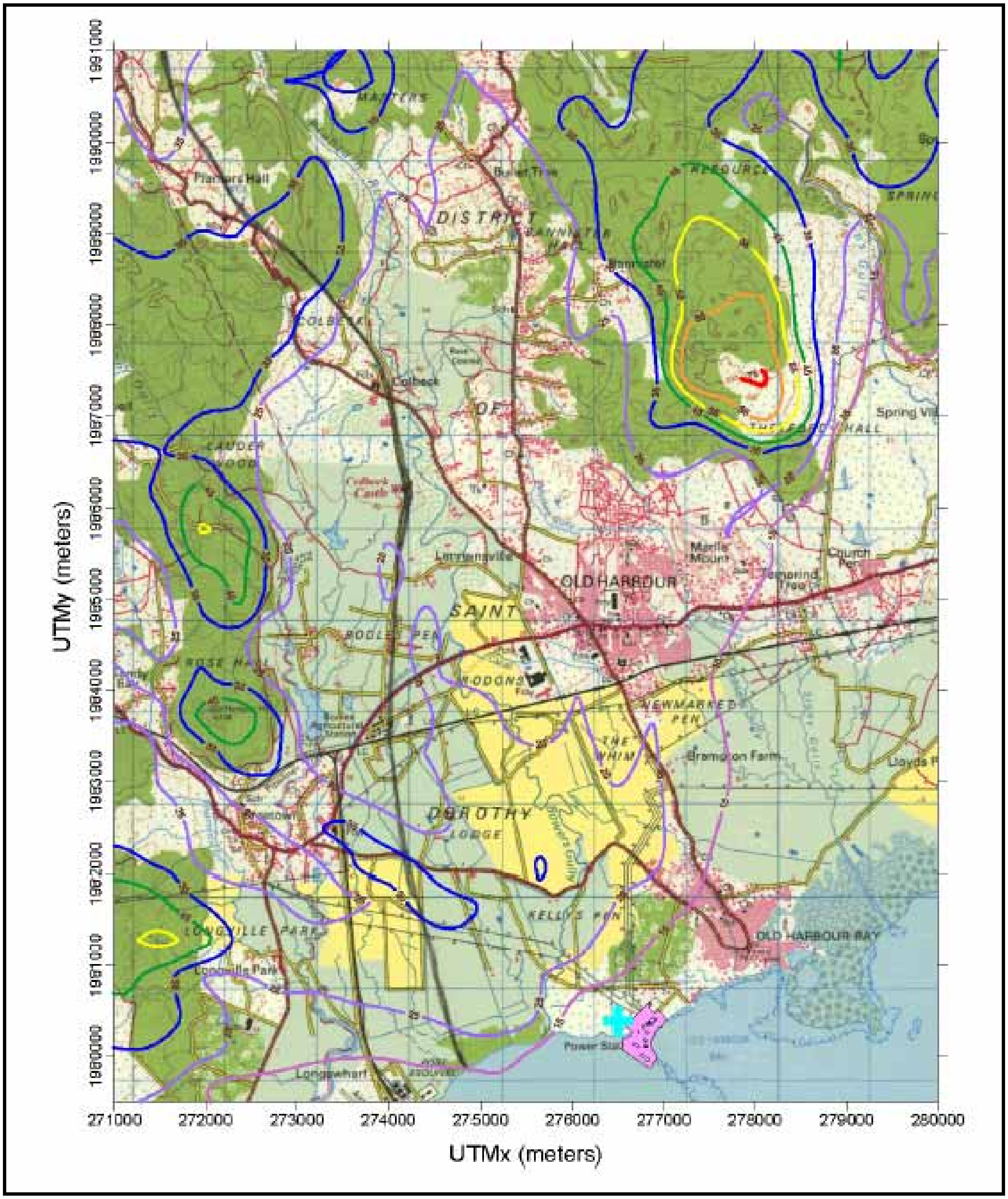


Figure 42 24-hour ISCST3 NOx Concentrations from JEP2 (2.2%S)

Note: Contours are 10 μg/m³ intervals
Light Blue Cross = existing monitor

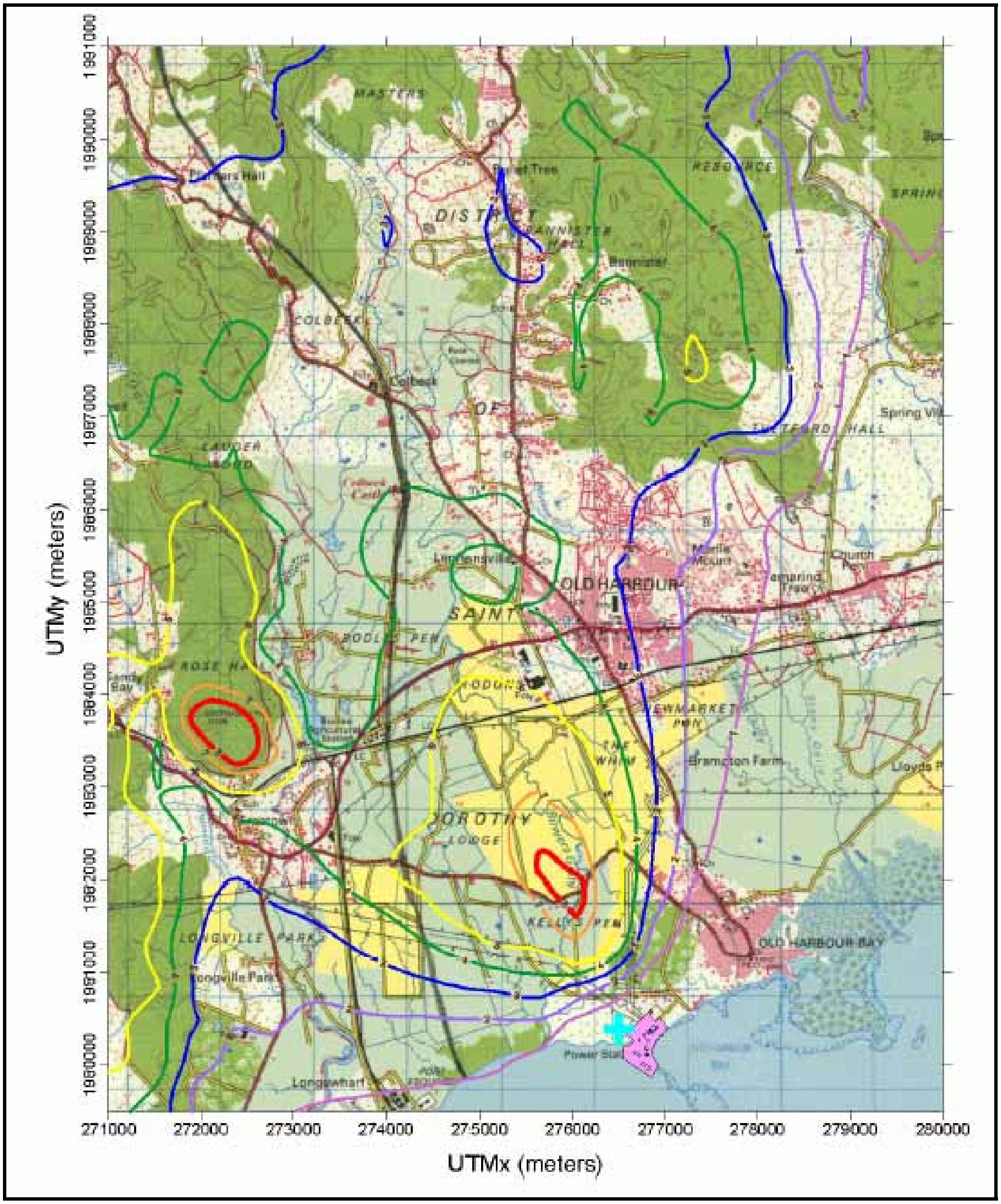


Figure 43 Annual ISCST3 NOx Concentrations from JEP2 (2.0%S)

Note: Contours are 1 µg/m^3 intervals
Light Blue Cross = existing monitor

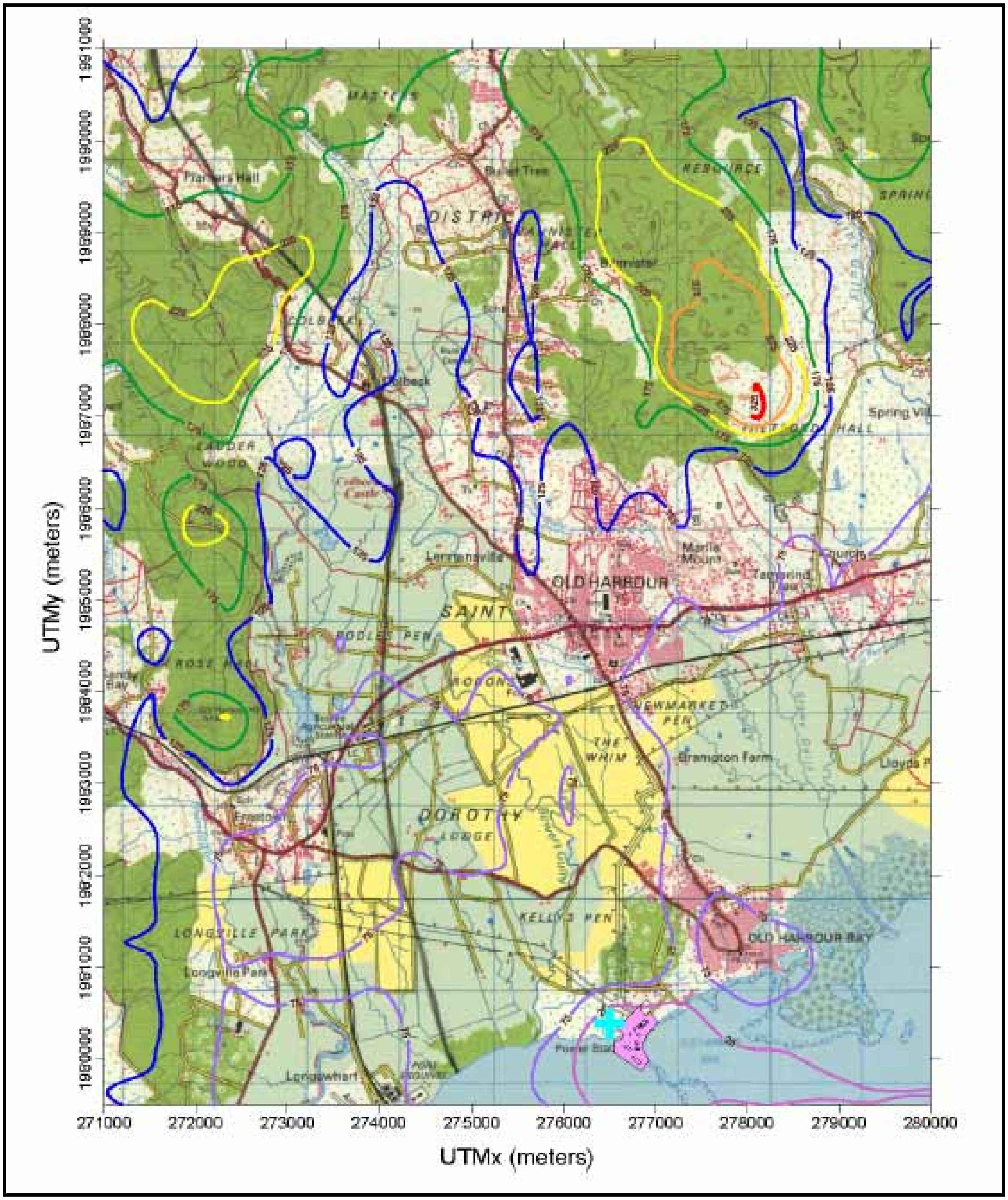


Figure 44 1-hour SO_2 Concentrations from JEP2 (2.2%S)

Note: Contours are 50 µg/m^3 intervals
Light Blue Cross = existing monitor

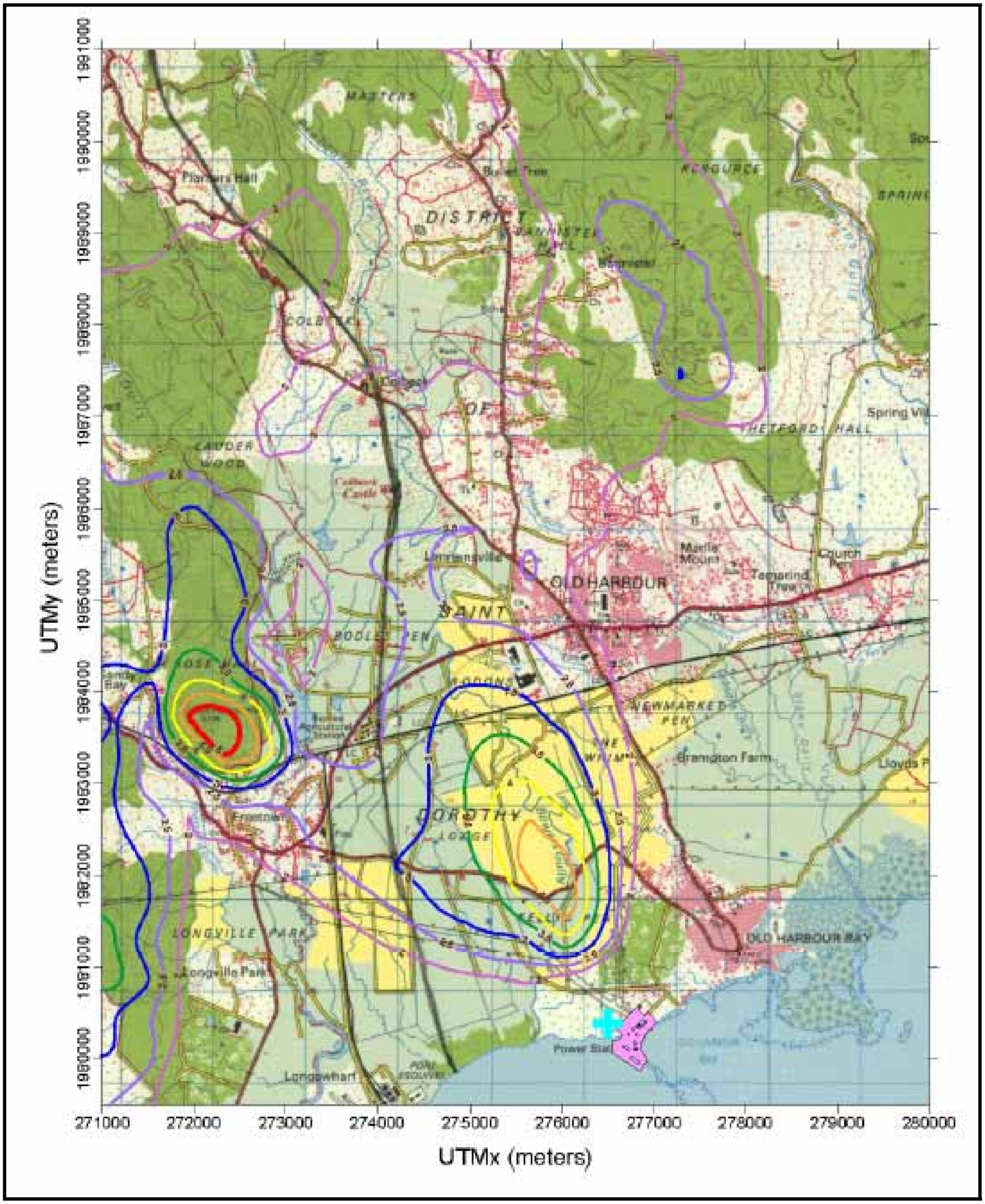


Figure 45 24-hour ISCST3 SO_2 Concentrations from JEP2 (2.2%S)

Note: Contours are 6 µg/m^3 intervals
Light Blue Cross = existing monitor

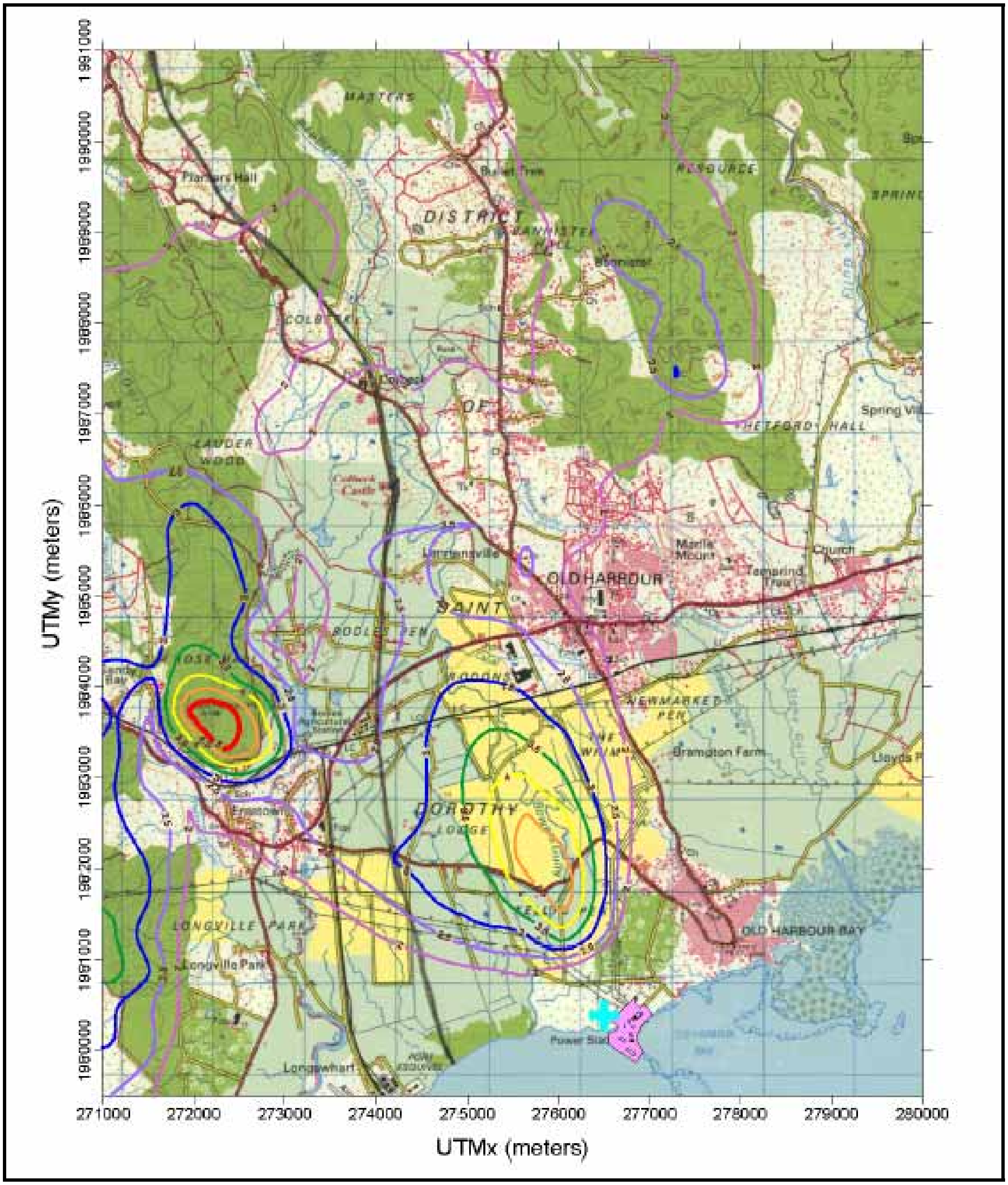


Figure 46 Annual ISCST3 SO_2 Concentrations from JEP2 (2.0%S)

Note: Contours are 0.5 µg/m^3 intervals
Light Blue Cross = existing monitor

5.3.2 Physiography, Geology, and Natural Hazards

Hurricane Ivan storm surge at the site was estimated by C.L. Environmental (2004) to be 1 to 1.5 m, based on conversations with observers at the plant. Hurricanes and tropical storms are frequently accompanied by heavy rainfall. It has also been widely suggested that the Atlantic-Caribbean region is moving, even has already moved, into a cycle of more frequent and more severe tropical disturbances. Storm surge modelling for the site was carried out and the results outlined below.

Additionally near shore hurricane wave climate modeling was conducted (Figures 47-50).

Extreme Wave Climate

Procedure

It was necessary to define the deepwater Extremal wave climate at the site as a part of defining the environment in which the project will exist. Hurricane data in the Caribbean Sea was available and a thorough statistical analysis was performed to determine the hurricane wind and wave conditions at a deep-water location offshore of the site.

The following procedure was implemented to assess wave height:

1. Extraction of Storms and Storm Parameters from the historical database. A historical database of storms was searched for all storms passing within a 500km 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 near shore end of the profile was then extracted from the model, stored in a database and all the returned near shore values were then subjected to an Extremal Statistical analysis and assigned exceedance probabilities with a Weibull distribution.

Extremal analysis results are summarized in the bi-variant Tables 33 and 34.
The results of the search clearly indicate that approximately 112 hurricane systems came within 500 kilometres of the site. This analysis shows the site overall vulnerability to such systems.

The bi-variant table analysis indicates that the waves generated offshore of Portland Bight propagate most frequently from a SE to W direction. However, the most intense hurricane waves have been noted to come from an Easterly direction. The Extremal analysis results indicate that the 100-year return period event has a deepwater wave height of 8.7 m for E waves and 8.3 m for SE waves.

Overall, these are relatively large waves and their potential resulting near shore climates were investigated.

Table 33 Bivariant table for Portland Bight Extremal analysis

Wind direction- NW

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

Wind direction- N

Tp(s) <value	2	4	6	8	10	12	14	16	18	20	Total
2											
4											
6											
8		2									2
10		5									5
12		3	2								5
14											
16											
18											
20											
Total		10	2								12

Wind direction- NE

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

Wind direction- W

Tp(s) <value	2	4	6	8	10	12	14	16	18	20	Total
2											
4											
6											
8		25	1								26
10		84	5								89
12		15	32	6							53
14			10	3							13
16											
18											
20											
Total		124	48	9							181

All directions

Tp(s) <value	2	4	6	8	10	12	14	16	18	20	Total
2											
4											
6											
8		94	1								95
10		264	38	1							303
12		33	168	18							219
14			23	32	4						59
16					1						1
18											
20											
Total		391	230	51	5						677

Wind direction- E

Tp(s) <value	2	4	6	8	10	12	14	16	18	20	Total
2											
4											
6											
8		7									7
10		27	9								36
12		3	31	4							38
14			7	18	2						27
16											
18											
20											
Total		37	47	22	2						108

Wind direction- SW

Tp(s) <value	2	4	6	8	10	12	14	16	18	20	Total
2											
4											
6											
8		26									26
10		60	6								66
12		2	28								30
14											
16											
18											
20											
Total		88	34								122

Wind direction- S

Tp(s) <value	2	4	6	8	10	12	14	16	18	20	Total
2											
4											
6											
8		22									22
10		49	8								57
12		6	26	1							33
14			1	1							2
16											
18											
20											
Total		77	35	2							114

Wind direction- SE

Tp(s) <value	2	4	6	8	10	12	14	16	18	20	Total
2											
4											
6											
8		11									11
10		39	10	1							50
12		4	49	7							60
14			5	10	2						17
16					1						1
18											
20											
Total		54	64	18	3						139

Table 34 Results of Extremal analysis for hurricanes that came within 500km of Portland Bight, Jamaica

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	2.0	7.2	1.0	5.1	1.0	5.1	1.0	5.1			1.0	5.1	1.0	5.1	1.0	5.1	1.0	5.1
2	3.7	9.6	3.3	9.2	3.5	9.4	3.8	9.8			4.0	10.1	4.7	10.8	4.5	10.6	3.5	9.3
5	5.1	11.3	4.2	10.2	4.5	10.6	5.0	11.2			5.4	11.5	6.1	12.3	5.8	12.0	4.5	10.6
10	6.0	12.2	4.6	10.7	5.0	11.2	5.7	11.9			6.1	12.3	6.9	13.0	6.6	12.7	5.1	11.2
20	6.9	13.0	5.0	11.1	5.5	11.7	6.2	12.4			6.7	12.8	7.5	13.6	7.2	13.3	5.5	11.7
25	7.1	13.3	5.1	11.2	5.6	11.8	6.4	12.5			6.9	13.0	7.7	13.7	7.4	13.5	5.7	11.9
50	7.9	13.9	5.3	11.5	6.0	12.2	6.8	13.0			7.4	13.5	8.2	14.2	7.9	13.9	6.1	12.3
75	8.4	14.3	5.5	11.7	6.2	12.4	7.1	13.2			7.6	13.7	8.5	14.4	8.1	14.1	6.3	12.5
100	8.7	14.5	5.6	11.8	6.3	12.5	7.2	13.4			7.8	13.9	8.7	14.6	8.3	14.3	6.4	12.6
150	9.1	14.9	5.7	11.9	6.5	12.7	7.5	13.6			8.1	14.1	8.9	14.8	8.6	14.5	6.6	12.8
200	9.4	15.1	5.8	12.0	6.6	12.8	7.6	13.7			8.2	14.2	9.1	14.9	8.8	14.6	6.8	12.9

Near shore Hurricane Wave Climate

Spatial wave transformation from deepwater to near shore was undertaken in order to determine the susceptibility of the site to direct wave attack from the deepwater waves previously described. See Figures 47, 48, 49 and 50 for the overviews and near shore wave transformation plots for SE and S 100-Year Return Period waves respectively.

The analysis indicates that the site for the new barge is, in general, reasonably well-sheltered by both wave directions. The protection from such deepwater wave waves comes predominantly from the existence of offshore sea grass beds and reef structure. The resulting waves at the barge are predicted to be 1 to 1.5 for the SE wave direction and 1 metre for the S direction. In summary, the barge project will be designed to accommodate those 1-1.5 m conditions without being adversely affected.

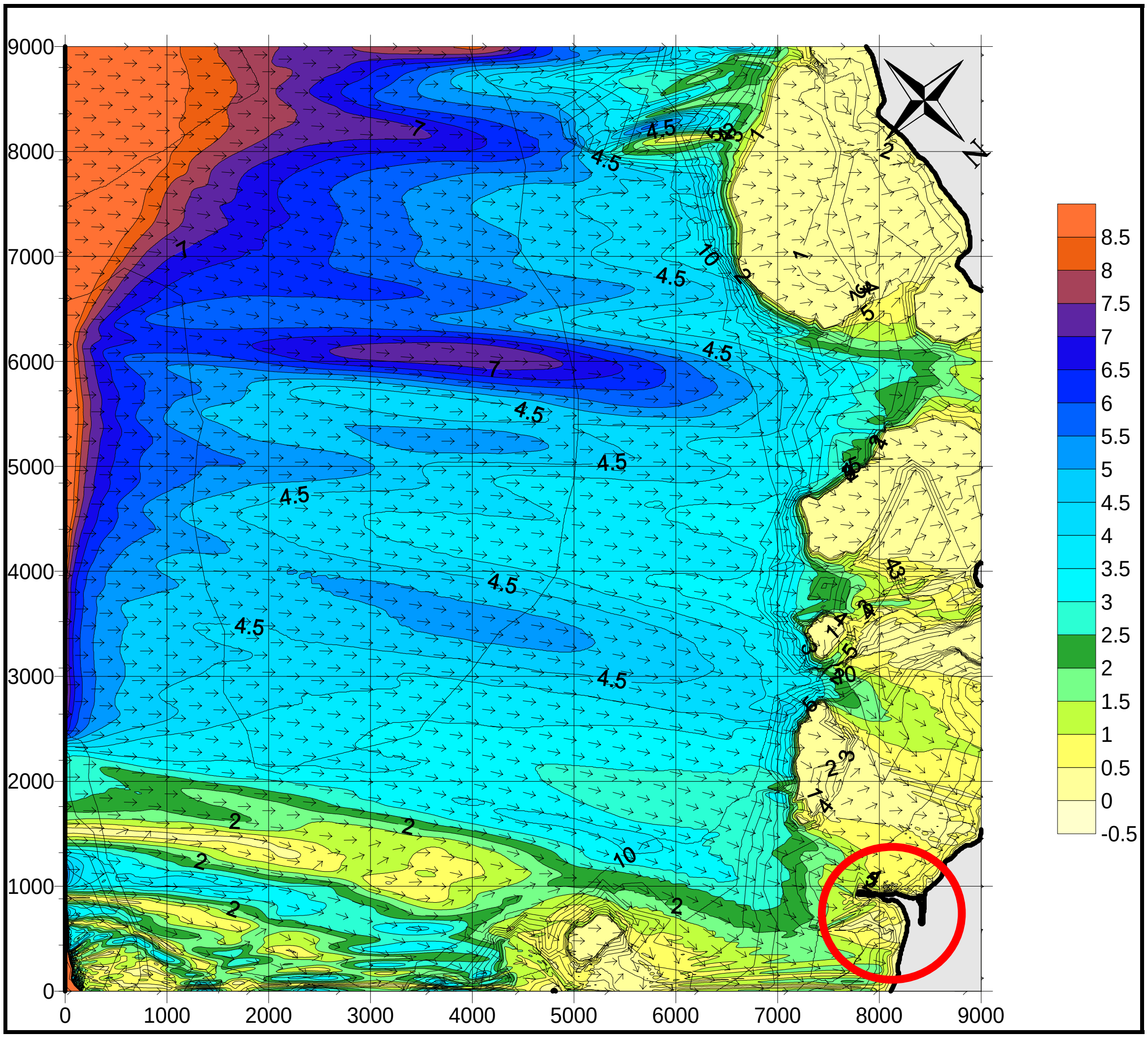


Figure 47 Wave height for SE hurricane Extremal (100 year) event (Hs =8.83, Tp=14.7) at JEP (in red circle)

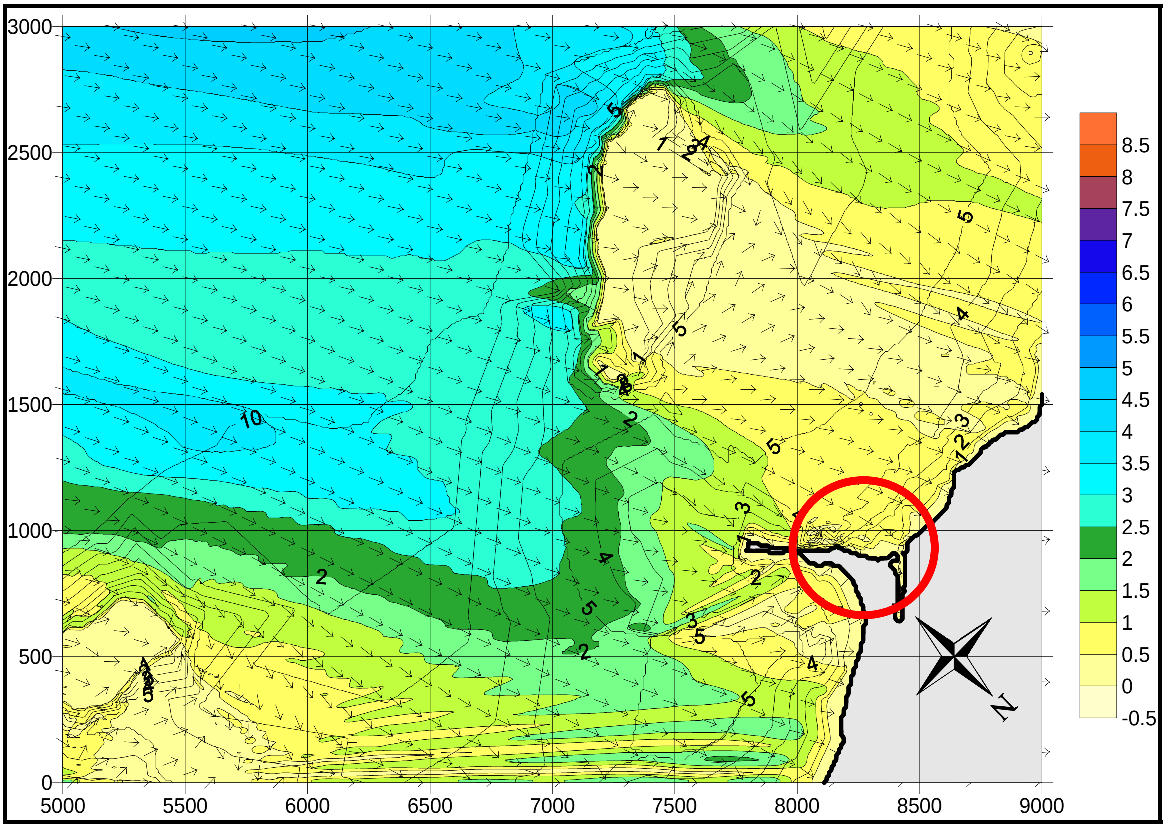


Figure 48 **Wave height for Near shore view of SE hurricane Extremal (100 year) event (Hs =8.83, Tp=14.7) at JEP (in red circle)**

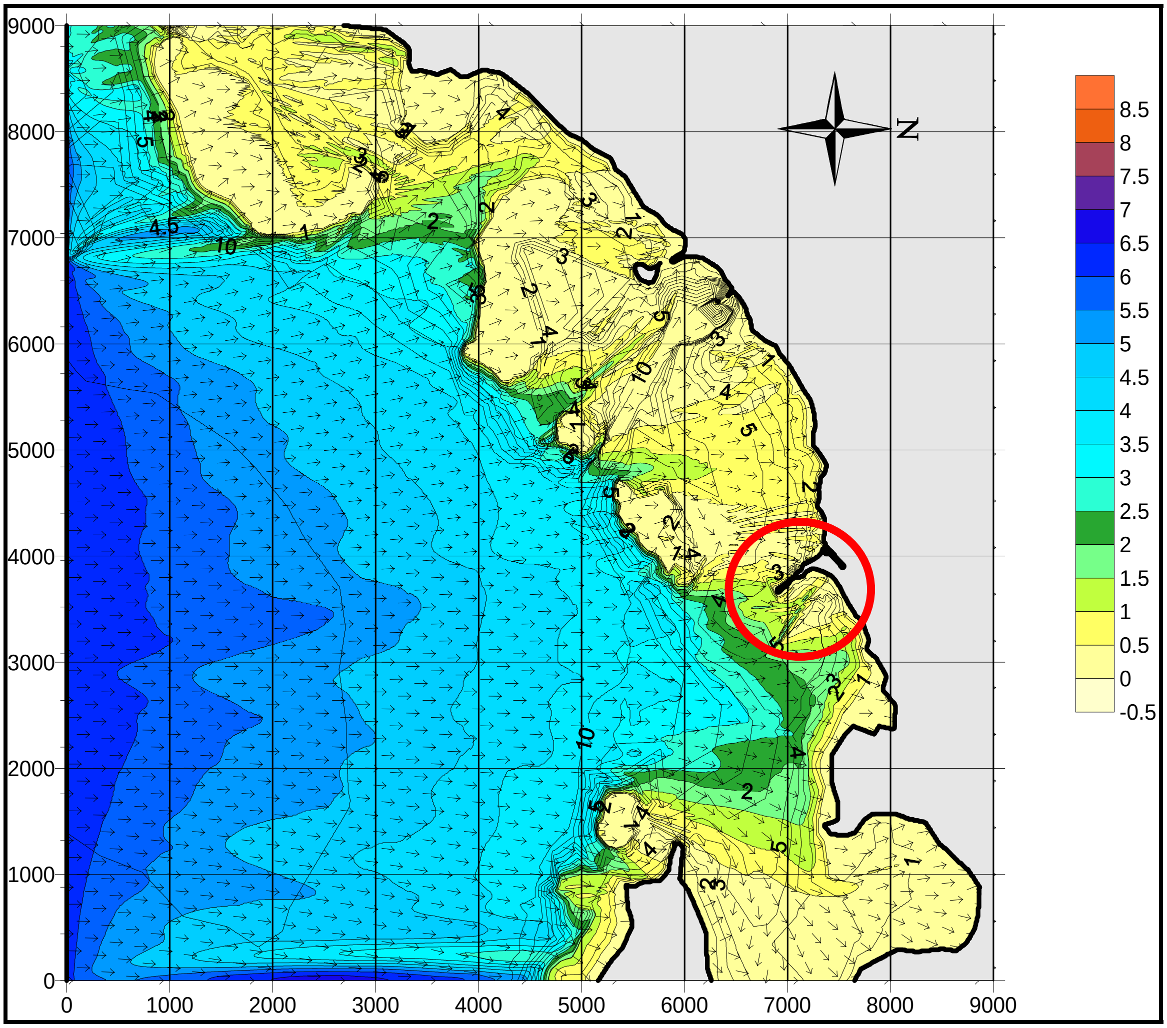


Figure 49 **Wave height for S hurricane Extremal (100 year) event (Hs = 6.4, Tp=12.5) at JEP (in red circle)**

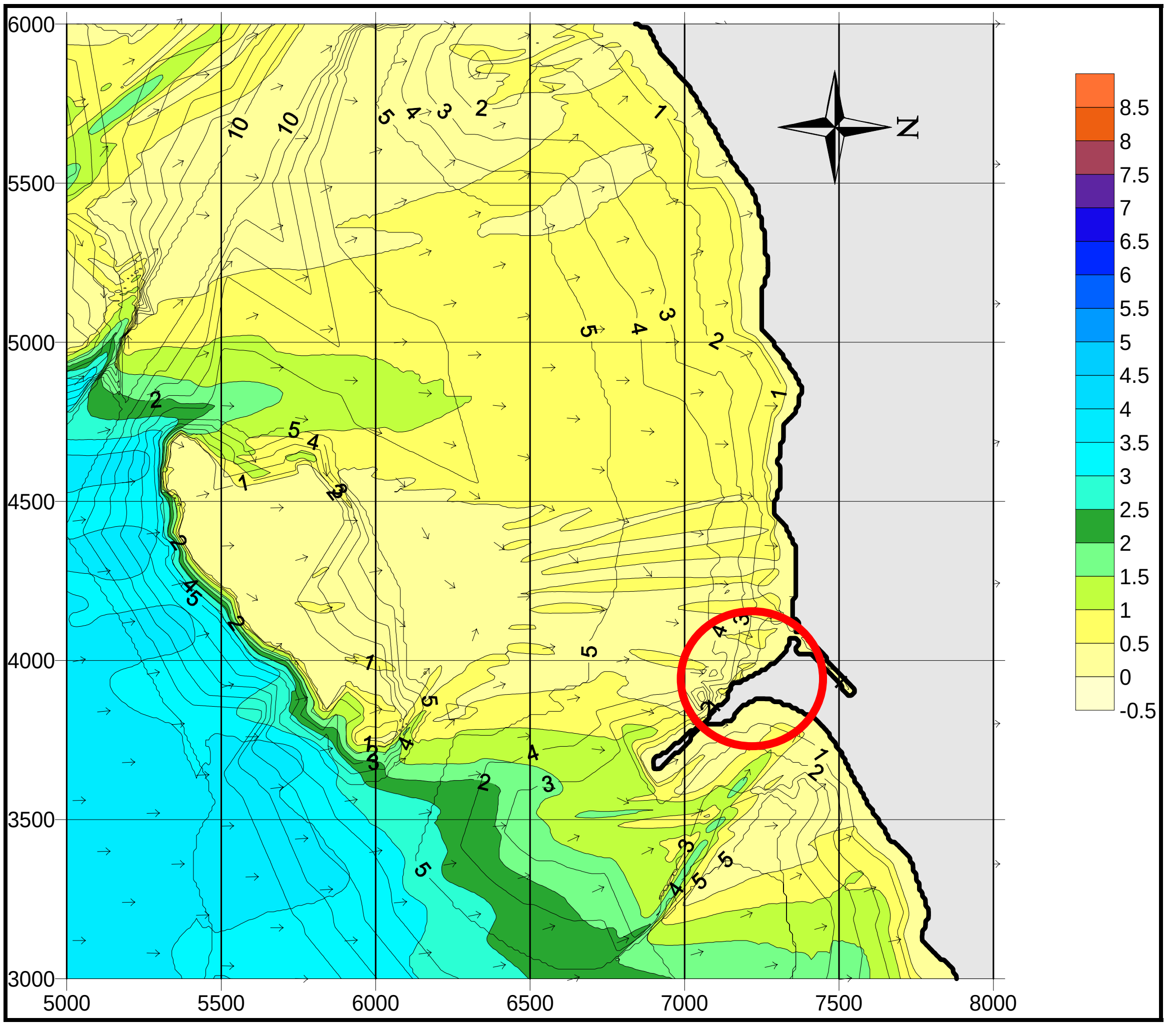


Figure 50 **Wave height for Near shore view of S hurricane Extremal (100 year) event (Hs = 6.4, Tp=12.5) at JEP (in red circle)**

Hurricane Set-up: Wave, Wind and IBR

An analysis of the set-up at the site from the simultaneous actions of waves, wind set-up and Inverse Barometric Rise (IBR) was undertaken on the same database of hurricanes and the waves and wind generated in these storms. The results are summarized in Table 35.

The results indicate that the 100-Year storm is expected to generate a set-up of 1.13 metres at the site. This is relatively close to the apparent ground elevations across the site and should be checked by the engineers to ensure reasonable access to important sections of the facility and securing of areas that could be flooded. The spuds on the barge should also be designed for this possible variation in water levels.

Table 35 Extremal analysis for wave, wind and Inverse Barometric pressure set-up at JEP site, Portland Bight

Return Period	Total setup (m) All	SW	W	NW	N	NE	E	SE	S
1									
2									
5	0.47	0.49	0.25	0.13		0.15	0.33	0.65	0.70
10	0.62	0.56	0.35	0.19		0.21	0.46	0.75	0.82
20	0.76	0.62	0.46	0.25		0.29	0.60	0.84	0.92
25	0.80	0.64	0.49	0.28		0.32	0.64	0.87	0.96
50	0.93	0.69	0.59	0.36		0.42	0.78	0.95	1.05
75	1.00	0.72	0.65	0.41		0.48	0.86	0.99	1.10
100	1.05	0.74	0.69	0.45		0.52	0.91	1.02	1.13
150	1.12	0.76	0.75	0.51		0.59	0.99	1.05	1.18
200	1.17	0.78	0.79	0.55		0.64	1.05	1.08	1.21

Wind Speeds

An Extremal analysis of the estimated winds at JEP was also conducted. The results indicate that the 100-Year wind speed at JEP is 73 m/sec or 163 miles per hour (Table 36).

Table 36 Extremal analysis for wind speeds at JEP, Portland Bight, Jamaica

Return Period	All
1	
2	35.0
5	47.7
10	54.9
20	61.1
25	62.9
50	68.2
75	71.1
100	73.0
150	75.7
200	77.5

5.3.3 Physical and Chemical Oceanography

Impact: Thermal Plume

The modelling of the thermal plume from the proposed barge plant (created from once through cooling water) involves using a three dimensional hydrodynamic and water quality model. It is very important to define the surface currents accurately because of the buoyancy of the thermal effluents. Such effluents quickly rise to the surface and spread in a surface layer. The modelling of the thermal plume therefore involved calibrating such a hydrodynamic model and then exploring the likely scenarios with a new outfall.

Hydrodynamic Model Description and Development

Description of RMA-10 and Development Process

RMA-10 is a three-dimensional finite element model for stratified flow by King (1993). The development exercise involves the following steps:

1. Conversion of the electronic bathymetric information into RMA-10 format;
2. Construction of a 2-dimensional mesh;
3. Reduction and application of currents, tide, wind and hydrographic information to the model;
4. Preliminary calibration for the 2-D model; and
5. Conversion to a 3-D model, via the application of more detailed information on the number of vertical layers and currents

3-D Finite Element Model Construction

A mesh was constructed of the entire Portland Bight area and part of the south coast. The mesh was constructed out to 2000 metres of water. The reason for such a large hydrodynamic model was to allow for the proportion of the tidal flows into and out of the project area.

3-D Finite Element Model Calibration

Two oceanographic scenarios were simulated. These were fast and slow wind speed conditions from an easterly direction (Figures 51 to 56). Fast conditions (15 to 20 knots) are typical of late morning and early afternoon conditions when the wind velocity increases. The slow wind conditions (<10 knots) are more typical of night time and early morning conditions.

Fast Current Speed Conditions

The fast current speed conditions for rising and falling tide conditions are shown in Figures 52 and 53. A driving wind speed of 20 knots was used for this model run. This simulation is comparable to the conditions that existed on the afternoon session of the 30th of October, 2004. Ocean current speeds of 8 to 10 cm/sec were predicted over the project area. This is relatively close to the measured current values of 8 to 11 cm/sec.

The thermal plume in this scenario was predicted to be approximately 1000 metres long. Again this corresponds reasonably well with the observations (Figure 55).

Slow Current Speed Conditions

The slow current speed conditions for the entire Portland Bight and the project area are shown in Figures 53 and 54. A driving wind speed of approximately 10 knots was used for this model run. Surface current speeds of 3 to 5 cm/sec in the vicinity of the entrance to Port Esquivel were predicted by this model. This was the measured range by the drogue survey as well. Currents in the vicinity of the JEP were predicted to be 5 to 6 cm/sec. These correspond to the measured values as well.

The thermal plume in this scenario was predicted to be approximately 800 metres long. Again this corresponds reasonably well with the observations (Figure 52).

The calibration of the hydrodynamic model was undertaken using relatively good but short term data. No detailed information on the seasonal variation of the surface currents or influence due to wind was available for the calibration exercise.

The detailed observation of the spatial and temporal distribution of the surface currents is important for the eventual modelling of thermal plumes. The results of the model should therefore be qualified by the limitations imposed by the data.

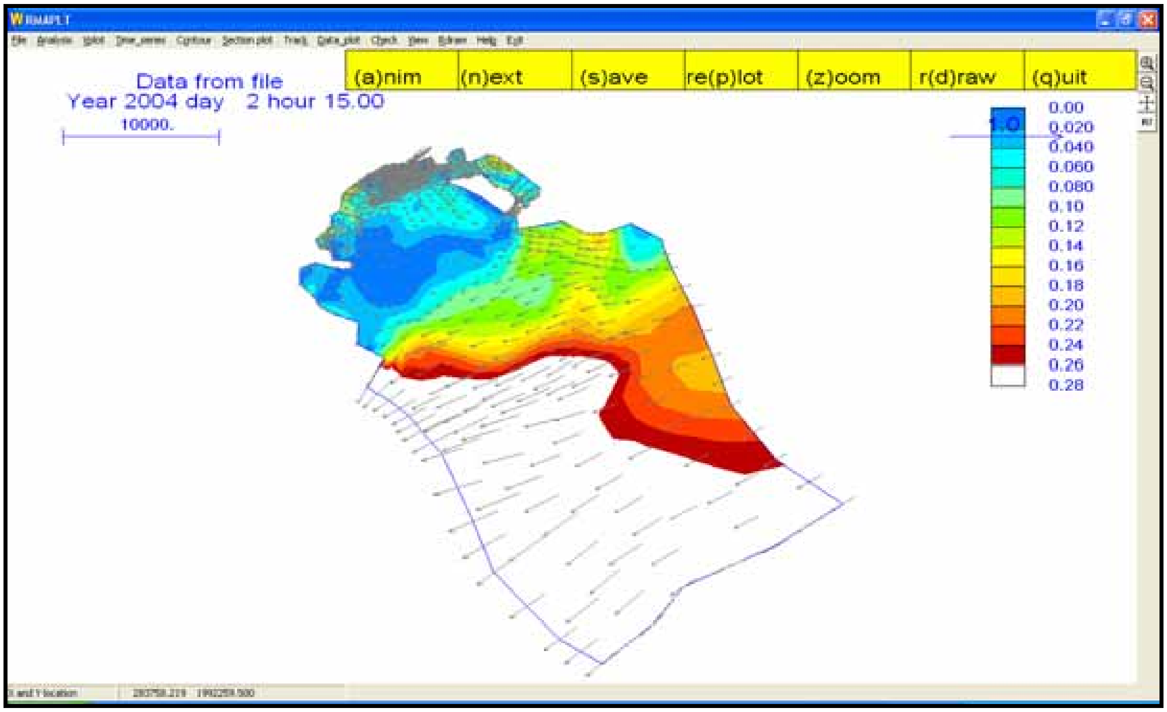


Figure 51 **Predicted surface current speeds and direction, under high operational (15 to 20 knots) East-south easterly wind conditions**

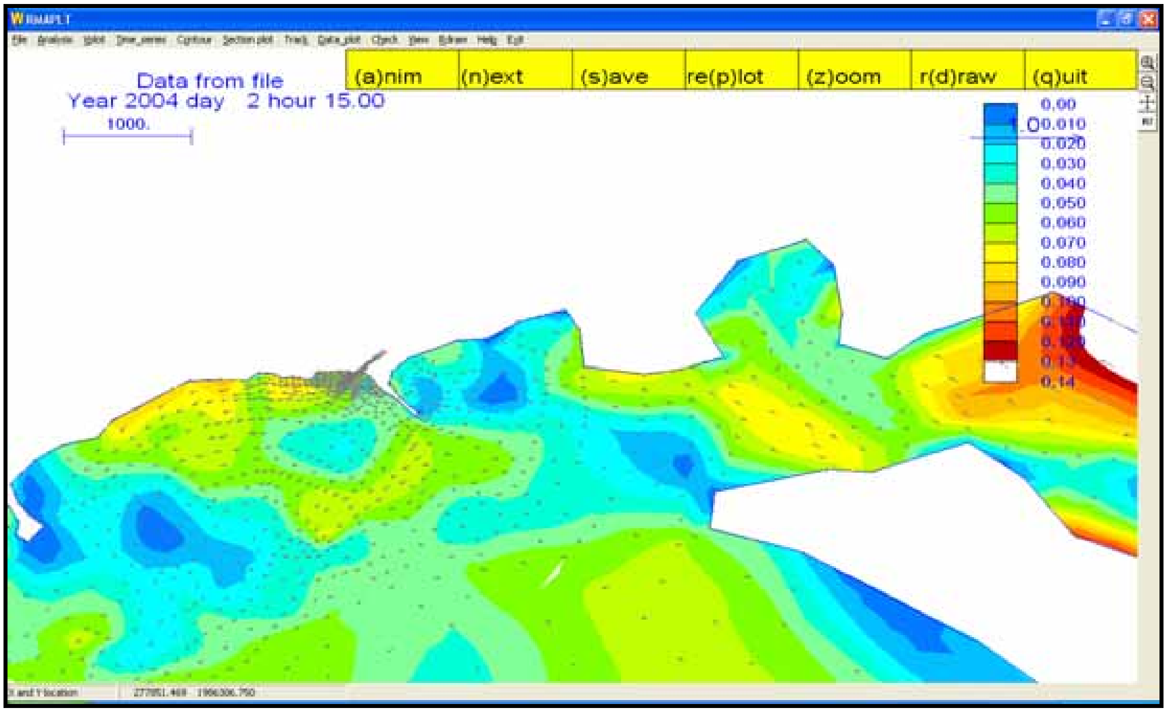


Figure 52 **Predicted surface current speeds and direction, under high operational (15 to 20 knots) East-south easterly wind conditions, near JEP complex**

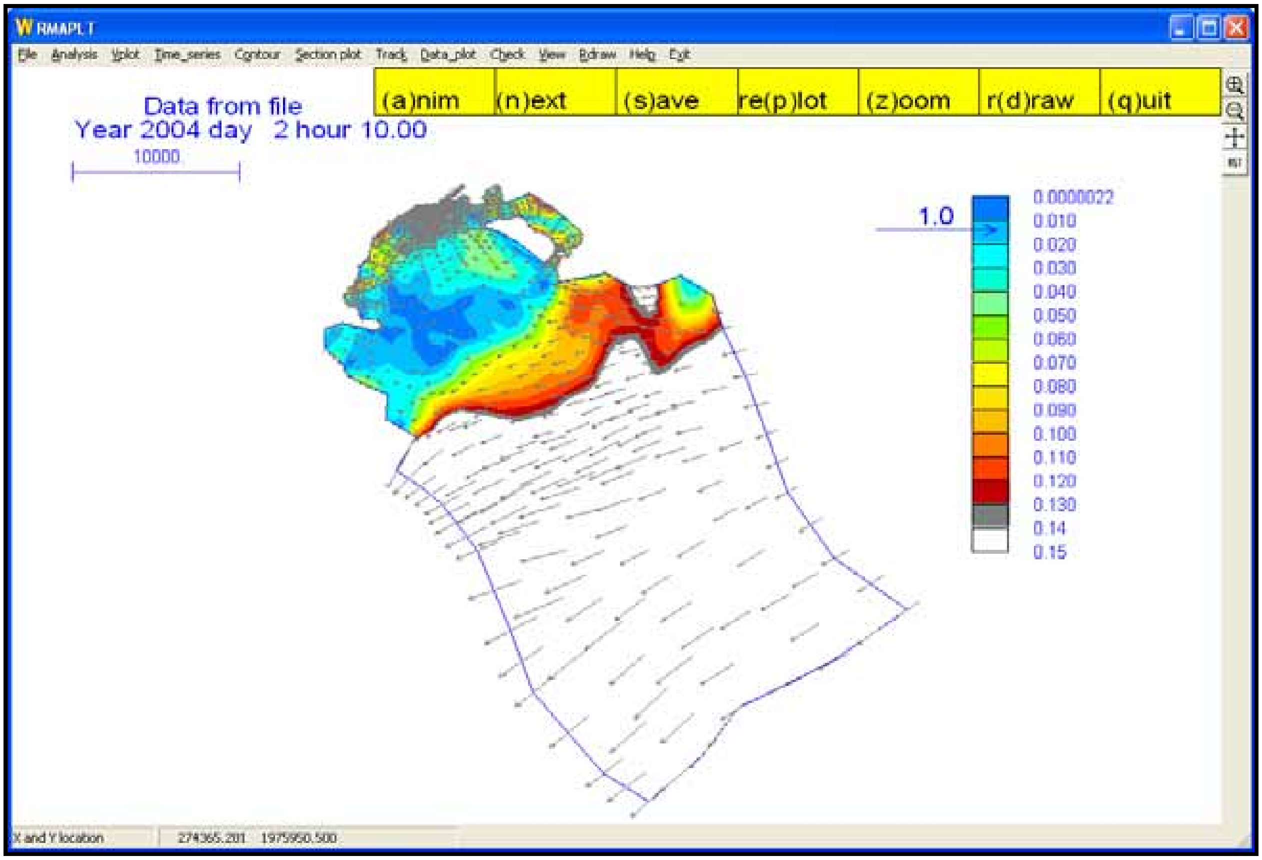


Figure 53 **Predicted surface current speeds and direction, under slow operational (<10 knots) East-south easterly wind conditions**

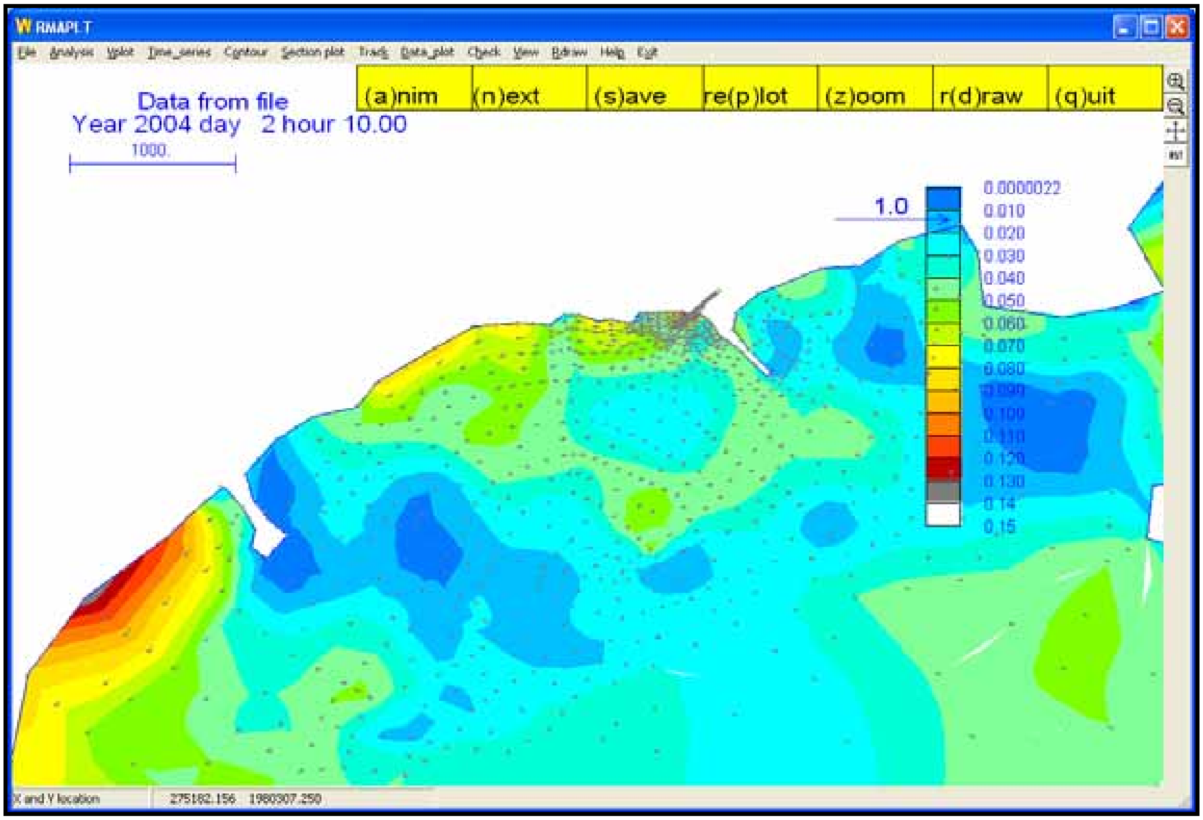


Figure 54 **Predicted surface current speeds and direction, under slow operational (<10 knot) East-south easterly wind conditions, near JEP complex**

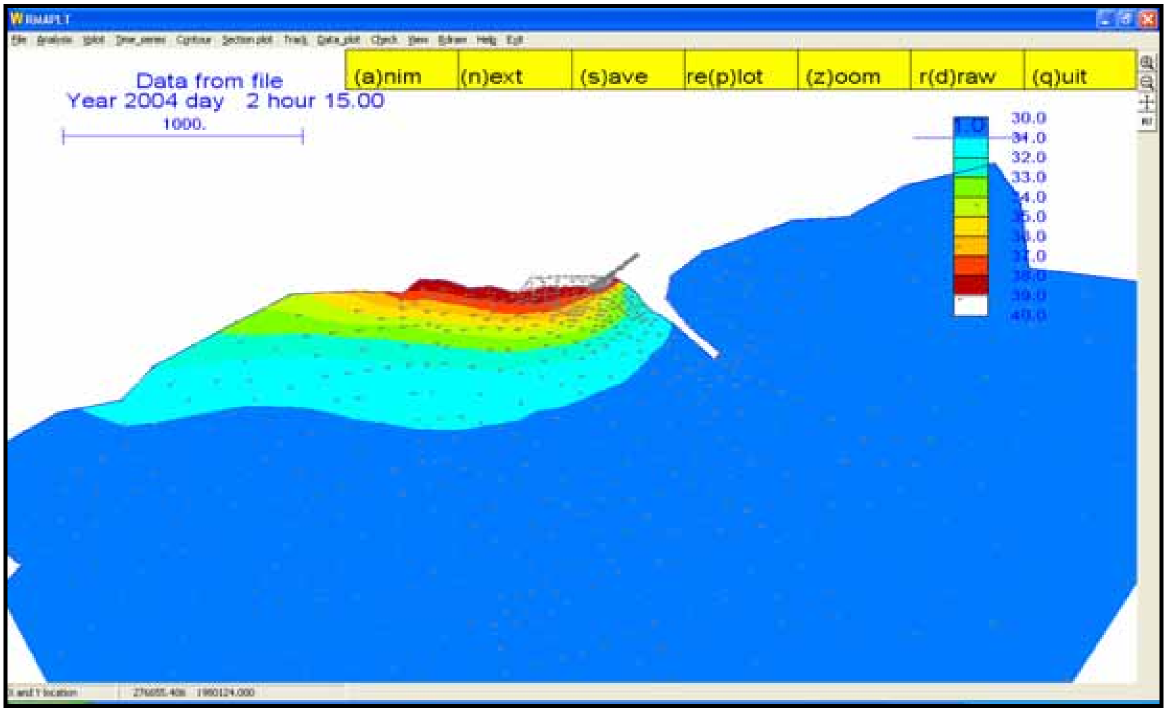


Figure 55 Predicted surface thermal plume for JEP existing and JPS existing outfalls, under high East-south easterly wind conditions

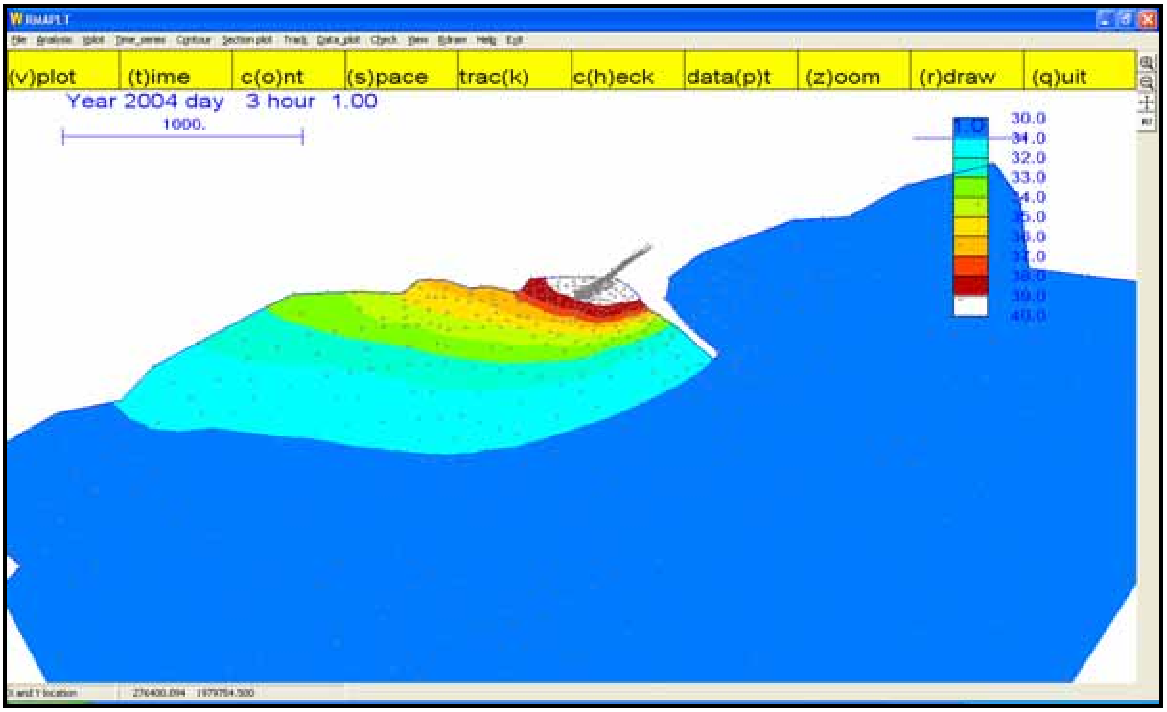


Figure 56 Predicted surface thermal plume for JEP existing and JPS existing outfalls, under slow East-south easterly wind conditions

Proposed Thermal Outfall

An outfall with a discharge of 0.8 cubic metres per second and surface temperature of 35.8 degrees Celsius was considered. A location in approximately 3.0 metres water depth and some 100 metres away from the existing JEP outfall in a SW direction was considered so as to limit the interaction with the other outfalls (existing JEP and JPS) and to prevent the plume from touching the shoreline. This position is at 738330.22 E and 638527.90 N in the JAD 2001 Jamaica Grid (Figure 57).

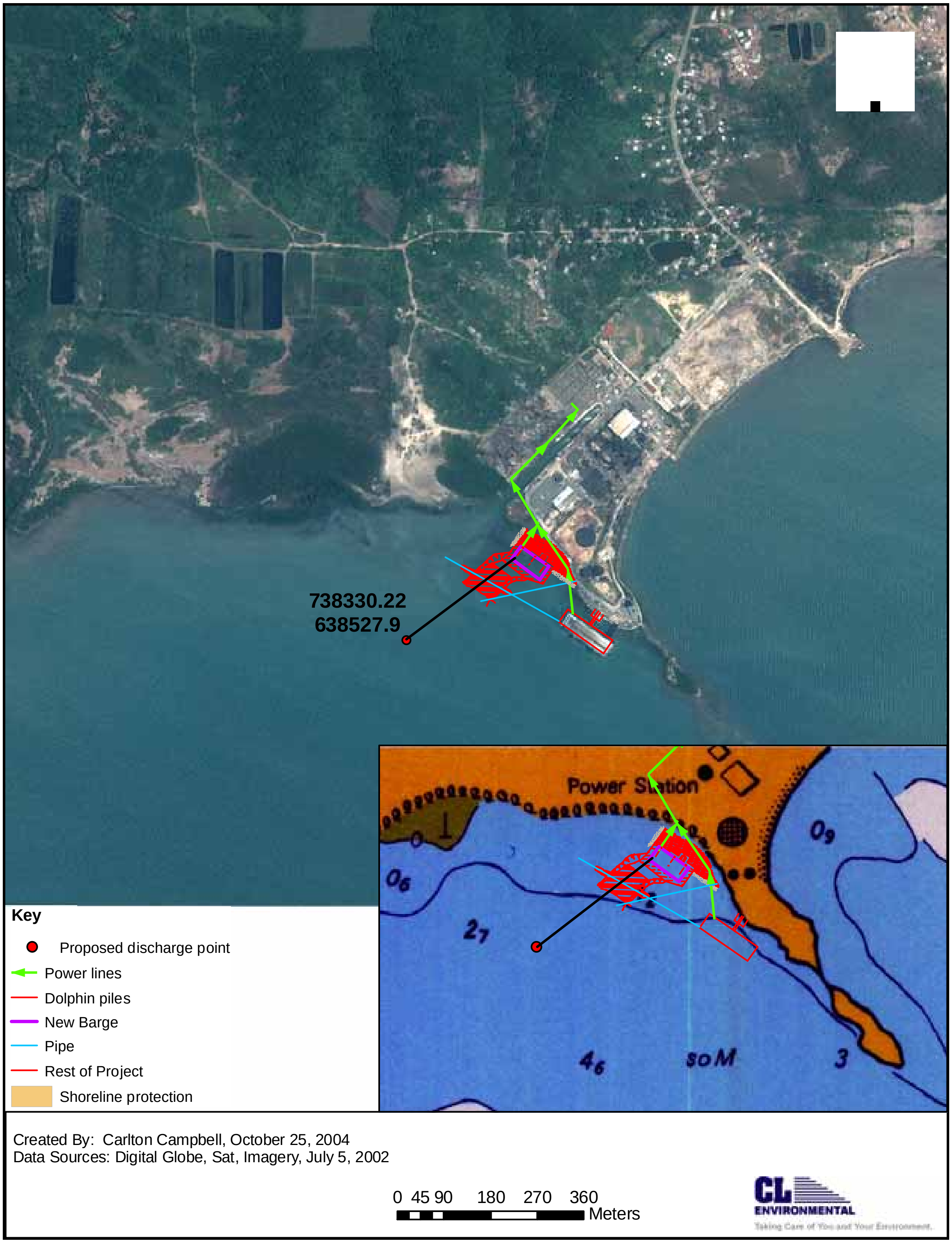


Figure 57 Location of proposed outfall

Thermal modelling results indicate that the outfall will produce a a surfaced thermal plume temperature of 35.8°C, which will quickly falls off to 33.5 °C some 30 metres from the outfall. This is less than 3 °C above ambient temperatures of 30.7 °C, in less than 100 metres (Figures 58 and 59).

The plume is therefore expected to meet the NEPA and World Bank guidelines of 3 °C within 100 metres

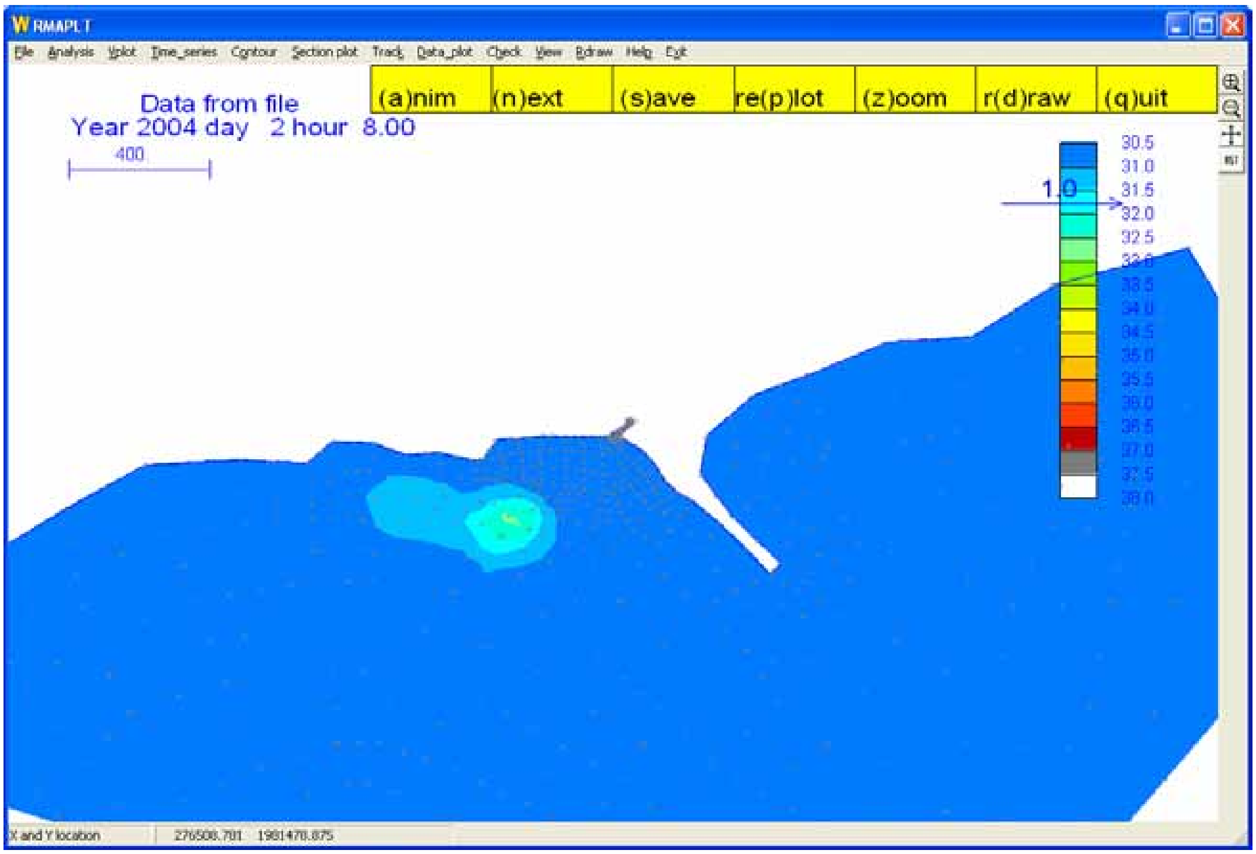


Figure 58 **Predicted surface thermal plume for proposed JEP outfall, under slow East-south easterly wind conditions**

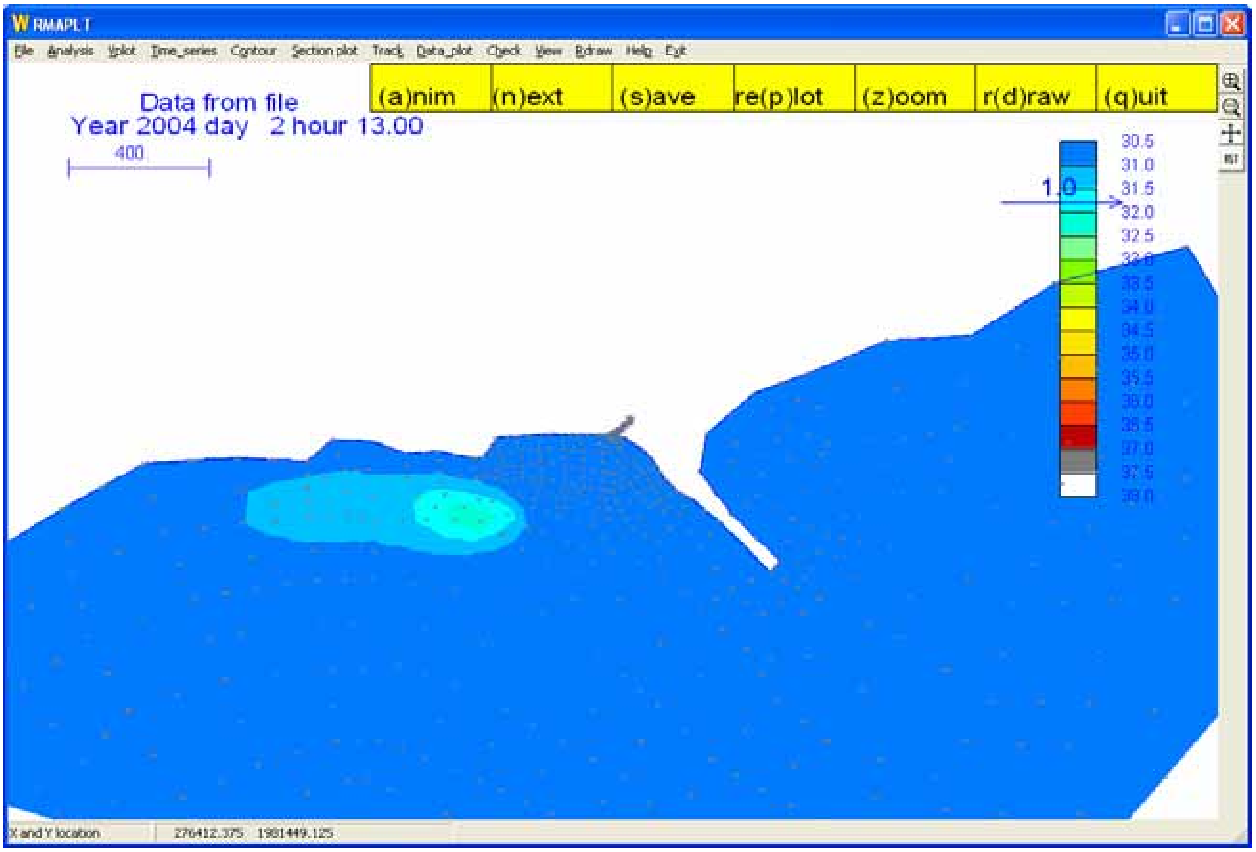


Figure 59 Predicted surface thermal plume for proposed JEP outfall, under fast East-south easterly wind conditions

5.3.4 Biological Resources

The proposed project will not have significant impact on the terrestrial flora. The species identified were not significantly important, ecologically or commercially. The low species diversity and numbers of birds seen are testament of the disturbed nature of the area and its small importance as a habitat for birds.

The proposed location is outside of the major fish nurseries and fishing grounds in the area and as such will have no or very little impact on fisheries in the area. The sightings of protected species (Figure 27) are in locations that are away (except for a crocodile) from the proposed project site and are not expected to be impacted by the proposed development. This crocodile was seen just southwest of the JPS cooling canal outlet, and it is reasoned that the species is attracted to the warm water which it uses to regulate its body temperature.

5.3.5 Hydrology

The operation of the barge is not expected to have significant impact on the surface and ground water in the Project Area. The barge will receive its drinking water from the National Water Commission's domestic supply and private bottled water suppliers. The project will have a curbed and diked area to minimize surface water runoff to the surrounding area.

5.3.6 Land Use

The proposed project will not have significant impact on the existing land use as the project location is already an industrialized area.

5.3.7 Noise Impacts

The noise impact at the closest fence line (industrial) and residential locations were assessed below. These two locations are located at Station N3 and N7 (Figure 29).

COMPARISON WITH NEPA GUIDELINES

Both stations (N3 & N7) will be compliant with the NEPA day time guidelines. However, at station N7, existing noise levels were already above the NEPA night time guidelines. It is expected that noise level at this station will increase by 1 dBA resulting in exceeding the guideline by 2.2 dBA (Table 37).

COMPARISON WITH WORLD BANK GUIDELINES

Similarly, stations N3 and N7 will be compliant with the World Bank day time guidelines. The night time noise level at station N7 although above the 45 dBA World Bank guideline (Table 37), is considered compliant as the 3 dBA rule is applied. This rule states that the existing noise level should not be increased by more than 3 dBA. In this case the increase will be 1 dBA (Table 37).

Table 37 Comparison of anticipated noise readings with NEPA and World Bank guidelines

STATION		DAYTIME (dBA)				NIGHT TIME (dBA)			
STN #	TYPE	EXISTING	EXPECTED	NEPA STD	WB STD	EXISTING	EXPECTED	NEPA STD	WB STD
N3	Industrial	66.6	67.1	75	70	59.4	61.3	70	70
N7	Residential	54.5	55	55	55	51.2	52.2	50	45

WB STD. = World Bank Guidelines

OCCUPATIONAL NOISE

Individual worker noise exposure on the existing barge ('Dr. Bird") was measured by using a Quest Technologies Q-300 noise dosimeter in the data logging mode. The exposure (dose) was calculated by the Q-300 internally using a complex formula. A technician on the barge was the subject, and the dosimeter was worn throughout the twelve (12) hour shift.

The results from the dosimeter were compared with OSHA standards for hearing conservation and permissible level (PEL) for engineering controls.

The results from the exercise indicated that the technician was exposed to minimum noise level of 69.9 dB, and a maximum level of 129.5 dB. In terms of the OSHA hearing conservation threshold, the noise exposure for the employee was 303.2 % and a Time Weighted Average (TWA) of 98 dB. At this dose, the Hearing Conservation Amendment (1983) calls for a hearing conservation program to be put in place as the 8-hour TWA exceeds 85dB (50% dose). Jamaica Energy Partners have such a programme in place and the workers are outfitted with personal protective equipment (ear muffs and plugs).

In terms of the need for engineering controls, the OSHA threshold is 90 dBA and the reading obtained was 292.1% of the maximum daily allowable noise exposure recommended.

The results indicated that the areas assessed were not compliant to both the OSHA hearing conservation and OSHA PEL standards and hearing conservation and engineering controls which are in place are necessary to protect the workers.

5.3.8 Historical and Cultural Resources

The three known historic sites within the SIA (19^{th} century St. Phillip's Anglican Church (1.6 km), the house of the 16^{th} century US Naval Base (4.5 km) and 20^{th} century monument in recognition of Indians coming to Jamaica (4.6 km)) are sufficiently far from the proposed project that they will not be impacted by the operation of this project.

5.3.9 Socioeconomic Impacts

The proposed project will employ twenty five (25) persons on a permanent basis during its operation. Casual workers are employed on a rotational basis so as to enable a wider cross section of the community to benefit.

The project will result in a more reliable and constant supply of electricity to the national power grid, which, will increase worker productivity and economic growth for the island of Jamaica.

5.3.10 Aesthetics

The proposed development will have little, if any; visual impact on the aesthetics of the location due to the fact that the plant (barge) is as such that it will blend into the surroundings. There will however, be the potential impact of blocking the vista to the (bay) sea but this will be mitigated by the fact that there will be a space of approximately 90m between the present and future barge. Although the bay is not a traditional sightseeing area, there will be a window left to view the bay.

6.0 CUMULATIVE IMPACTS

The three areas of primary concern for cumulative impacts are air quality, thermal plume discharge and noise. Each of these areas will be described below.

6.1 AIR QUALITY

The cumulative impacts analysis for air quality in the Old Harbour area involves the operation of the existing JPS facility, the JEP 1 barge plant, and the proposed JEP 2 barge power plant. Two additional facilities were considered for this analysis, the Bauxite Works facility located 14-kilometers west of Old Harbour and a Sugar Factory in Monymusk, located 20-kilometers to the southwest. These two major facilities are located a significant distance from Old Harbour and the plumes of these facilities would not overlap significantly with the JEP and JPS sources due to the prevailing southerly and southeasterly wind directions. Thus, these two sources were not considered in the cumulative impacts analysis.

6.1.1 Air Emission Rate

Table 38 shows the air emissions rates for JEP 1, JEP 2, and the JPS facilities for the pollutants of CO, SO_2, NO_x and PM_{10} (assumed to be the same as PM). The JEP 2 emission rates for all four pollutants were taken from Wärtsilä engineering data sheets, except that SO_2 emissions were pro-rated. The JEP 2 SO_2 emission rates represent 1.8% sulfur (annual basis) and 2.0 (short term, 1-hour and 24-hour basis), which are closer to the historical averages for the last 2-3 years (for JEP 1 operations). The JEP 1 emission rates represent vendor data for CO, the same pro-rated approach described above for SO_2, and the average of actual source tests for PM_{10} and NO_x for the last five years. The JPS boiler emission rates for SO_2 are mass balance values based upon 2.2% sulphur (annual basis) and 2.4% sulfur for short term basis (1-hour and 24-hour basis). The JPS emission rates for the other three pollutants are based upon actual source test data over the last several years. Boiler #4 has low-NO_x burners, and this emission rate is reflected in the Table 38.

Table 38 Modelled Emission Rates

Pollutant	Model ID	Emission Rate (g/s)
CO	JEP 2	10.2
	JEP 1(1-6)	10.8
	JEP 1(7)	1.8
	JEP 1(8)	1.8
	JPS01	83
	JPS02	16.9
	JPS03	103.6
	JPS04	103.6
NO_X	JEP 2	210
	JEP 1(1-6)	226.8
	JEP 1(7)	37.8
	JEP1 (8)	37.8
	JPS01	22.05
	JPS02	37.5
	JPS03	49.3
	JPS04	21.1
PM_{10}	JEP 2	7.8
	JEP 1(1-6)	7.44
	JEP 1(7)	1.24
	JEP 1(8)	1.24
	JPS01	9.25
	JPS02	11.8
	JPS03	27
	JPS04	27
SO_2	JEP 2	122.7(110.5)[a]
	JEP 1(1-6)	118.4(106.5)[a]
	JEP 1(7)	19.7(17.8)[a]
	JEP 1(8)	19.7(17.8)[a]
	JPS01	170.7
	JPS02	299.6
	JPS03	339.2
	JPS04	339.2

a-Values represent short term and annual (in parenthesis)

6.1.2 Stack Parameters

JEP 1 has one existing barge that contains eight generators. The eight combustion sources have vertical stacks and were modeled as point sources using physical release parameters. Six of the eight stacks, which have identical stack parameters and within close proximity, were combined to obtain an equivalent stack diameter to account for added buoyancy effects. After considering the combined flow rates and exit velocity, the equivalent stack diameter is equal to 2.66 meters. See Appendix 7 for detailed equivalent stack diameter calculations.

The three JEP 2 stacks, which will be vertical, having identical stack parameters and within close proximity, were combined into one stack to obtain an equivalent stack diameter to account for added buoyancy effects. After considering the combined flow rates and exit velocity, the equivalent stack diameter is equal to 2.42 meters. See Appendix 7 for detailed equivalent stack diameter calculations.

The JPS sources are four individual boiler stacks. Table 39 provides the stack parameters for the three sets of point sources.

Table 39 Modelled Release Parameters for Point Sources

Model ID	**Description**	**UTMX (m)**	**UTMY (m)**	**Height**		**Temperature**		**Velocity**		**Diameter**		**Flow**	
				(ft)	**(m)**	**(F)**	**(K)**	**(fps)**	**(mps)**	**(ft)**	**(m)**	**(ft3/s)**	**(m3/s)**
JEP 2	JEP 3 New Generators (Combined Stack)	276706	1980109	114.83	35.00	708.80	649.15	119.35	36.38	7.94	2.42	1808	168
JEP 1	JEP Existing Barge Plant 6 Generators (Combined Stack)	276813	1979972	98.42	30.00	624.20	602.15	141.11	43.01	8.73	2.66	2557	237.6
JEP 1	JEP Existing Barge Plant	276772	1980003	98.42	30.00	624.20	602.15	141.11	43.01	3.55	1.08	426	39.6

Model ID	Description	UTMX (m)	UTMY (m)	Height		Temperature		Velocity		Diameter		Flow	
				(ft)	(m)	(F)	(K)	(fps)	(mps)	(ft)	(m)	(ft3/s)	(m3/s)
	Generator #7												
JEP 1	JEP Existing Barge Plant Generator #8	276772	1980003	98.42	30.00	624.20	602.15	141.11	43.01	3.55	1.08	426	39.6
JPS01	JPS Power Plant Stack No. 1	276907	1980368	150.00	45.72	329.00	438.15	41.36	12.61	8.14	2.48	656	60.9
JPS02	JPS Power Plant Stack No. 2	276895	1980346	150.00	45.72	329.00	438.15	49.36	15.04	9.32	2.84	1026	95.3
JPS03	JPS Power Plant Stack No. 3	276866	1980334	150.00	45.72	316.40	431.15	70.90	21.61	9.61	2.93	1568	145.7
JPS04	JPS Power Plant Stack No. 4	276849	1980310	150.00	45.72	316.40	431.15	70.90	21.61	9.61	2.93	1568	145.7

6.1.3 Air Dispersion Modelling Approach

The air dispersion modeling approach utilized the ISC3ST air dispersion model. All of the terrain (topography), receptor grid, building wake effects, land use, ratio techniques (for NO_x annual and 24-hour conversion), and meteorological data (surface and upper air) are the same as those described in Section 5.3.1 of this report. The two cases modelled include the existing scenario, which has JEP 1 and the JPS facilities, and the future scenario, which includes JEP 1, JEP 2, and the JPS facilities all operating together.

For both scenarios, the JEP 1 and JEP 2 sources will be operating from 10 AM to 8 PM when the JPS facility is operating all four boilers. This is the typical scenario for JEP when all four JPS boilers are running.

6.1.4 Air Dispersion Modelling Results

Table 40 provides a summary of the air dispersion modeling results for the two scenarios described in Section 6.1.3.

Table 40 Jamaican Energy Partners Air Dispersion Modelling Impacts Analysis (μg/m^3)

		Scenario 1 JEP1 & JPS	Scenario 2 JEP1, JEP2, & JPS	JAAQS	World Bank
TSP	24-hour	38	38	150	230
	Annual	7	8	60	80
PM10	24-hour	38	38	150	150
	Annual	7	8	50	50
SO2	1-hour	2,963	2,963	700	--
	24-hour	692	692	365/280	150
	Annual	90	94	80/60	80
CO	1-hour	1,013	1,013	40,000	--
	8-hour	378	378	10,000	--
NOX	1-hour	192	238	400	--
	24-hour	44	59	--	150
	Annual	22	28	100	100
Source Group Descriptions					
Scenario 1					
JEP1 & JPS is the existing JEP barge plant (6 stacks combined) at (1.8%S Annual and 2.0%S Short-term) and the four existing JPS stacks at (2.2%S Annual and 2.4%S Short-term).					
(JEP1 operating only from 10:00 AM until 8:00 PM, JPSCo operating 24 hrs/day) **Scenario 2** JEP1, JEP2, & JPS is the 2 barge plants (using 1.8%S Annual and 2.0%S Short-term) and the 4 JPS stacks using 2.2%S Annual and 2.4%S Short-term. (JEP1+2 operating only from 10:00 AM until 8:00 PM, JPS operating 24 hrs/day)					
The 24-hour Nox impacts have been multiplied by 0.4 to account for Nox conversion to NO2 The annual Nox impacts have been multiplied by 0.75 to account for Nox conversion to NO2.					
The 400 μg/m3 Nox 1-hour number is a priority pollutant value in the draft Jamaican air quality regs of 2002.					

From Table 40 it can be seen that for PM_{10}, TSP, and CO, that there is overall compliance with both the JAAQS and the World Bank guideline values for all averaging periods. Thus, from a cumulative impacts perspective, there is compliance with the appropriate standards and guidelines for these three pollutants. The values in Table 40 also show that contributions from other background sources, such as traffic and area sources (charcoal burning), can be accommodated.

For NO_x, the results in Table 40 show that there is compliance with the 24-hour World Bank guideline value of 150 $\mu g/m^3$ and with the JAAQS and World Bank guideline value of 100 $\mu g/m^3$ for the annual averaging period, thus, cumulative impacts are in compliance with applicable standards and guidelines. Also, a certain amount of other background source (traffic, charcoal burning) contribution can be accommodated and still show compliance with standards and guideline values.

For the 1-hour NO_x standard of 400 $\mu g/m^3$ for Jamaica, the ozone limiting method can be applied. For NO_x, the total 1-hour concentration is 238 $\mu g/m^3$. This value comes from using the Ozone Limiting Method (OLM). Maximum 1-hour NO_2 concentrations in the vicinity of power plant site are assessed using the Ozone Limiting Method (OLM). The OLM is an approach, which is approved by the USEPA. For the OLM the following general equation was applied:

$$[NO_2]_{1\text{-hour}} = (0.1) \times [NOx]_{pred} + [O_3]_{1\text{-hour max}}$$

Where

$[NO_2]_{1\text{-hour}}$ is the predicted 1-hour NO_2 concentration
$[NOx]_{pred}$ is the model-predicted 1-hour NOx concentration
$[O_3]_{1\text{-hour max}}$ is the maximum 1-hour ambient ozone concentration

The maximum measured 1-hour ozone concentration was 101 $\mu g/m^3$, and this was measured at Ewarton, Jamaica, which is just 32 kilometers (20 miles) from the JEP plant in 2004. This ozone value was the maximum 1-hour concentration measured within the last three years. This ozone concentration was considered representative of the project area, since ozone is a regional pollutant. The total NO_2 concentration is 137 $\mu g/m^3$ (10% of the maximum modelled concentration) plus the maximum 1-hour ozone concentration of 101 $\mu g/m^3$ to give a total of 238 $\mu g/m^3$. Thus, when taking OLM into account, the cumulative impacts are in compliance with the 1-hour JAAQS for NO_x.

For SO_2, the 1-hour JAAQS of 700 μg/m^3, the 24-hour JAAQS of 365 ug/m^3 and the World Bank guideline value of 150 μg/m^3, and the annual JAAQS and World Bank guideline value of 80 μg/m^3 are being exceeded by JEP 1 and JPS together. And also when JEP 2 is added, there is non-compliance with all standards and guideline values as well. The most significant influence in these exceedances is the contribution from the JPS boilers. In fact, it is shown in Table 6-3 that when JEP 2 is added there is no change in maximum SO_2 concentrations except for the annual averaging period.

It is acknowledged that the existing ambient air quality monitoring station is not located in a position to detect the maximum actual concentrations from the combined activities of JEP 1 and JPS, so there is no valid measurement of actual ambient concentrations of SO_2 in the airshed in the Old Harbour area at this time. Section 8.1.3 discusses mitigation for SO_2 impacts.

6.2 THERMAL PLUME

The cumulative impact of the proposed outfall for the new generating plant and the two existing outfalls was considered. The hydrodynamic model was executed with the three outfalls all operating at the same time. The result is shown in Figures 61 and 62.

There is very little noticeable difference between the predicted resultant thermal plumes for the scenario when all three outfalls are operation versus the existing situation. This is primarily so because the JPS outfall is the dominant outfall in terms of flow and temperature and thus the resulting thermal energy input the environment. This outfall having not changed in output characteristics will result in the overall plume remaining the same.

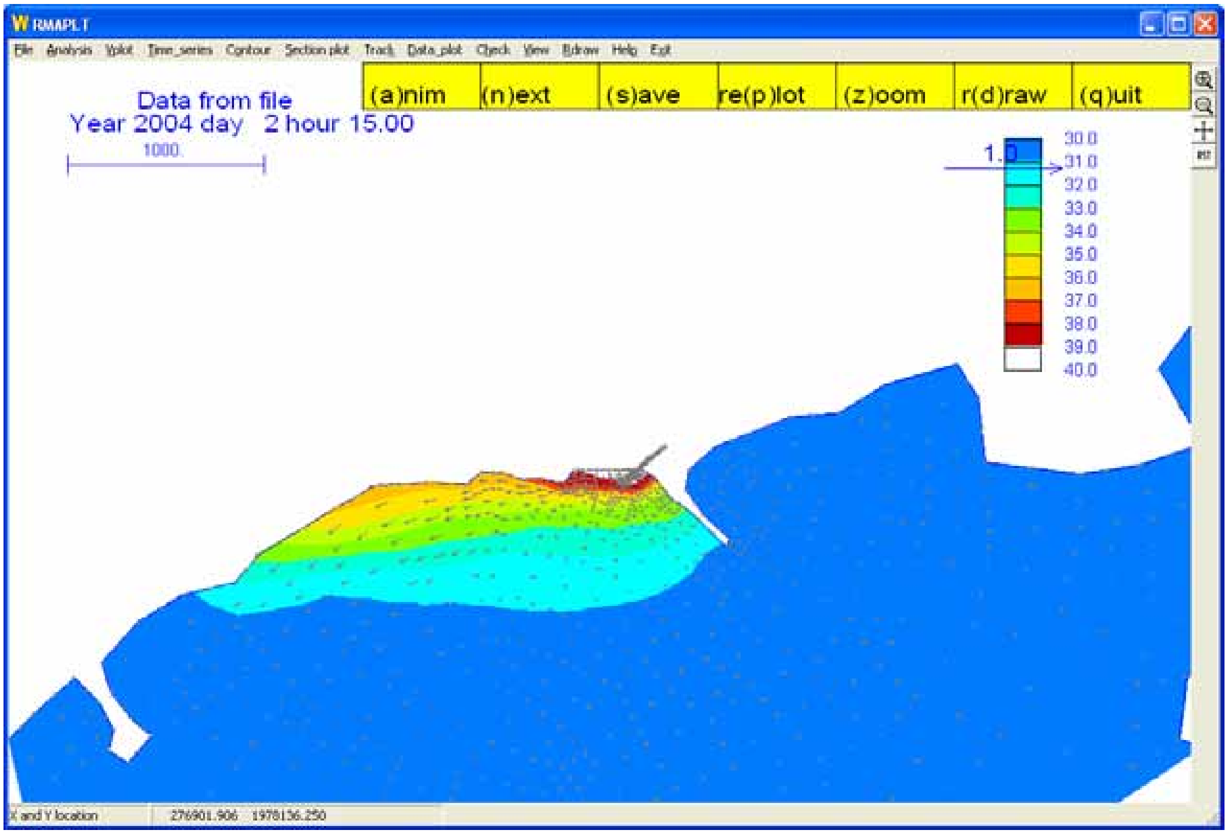


Figure 60 Predicted surface thermal plume for JEP proposed outfall, JEP existing and JPS existing outfalls, under high East-south easterly wind conditions

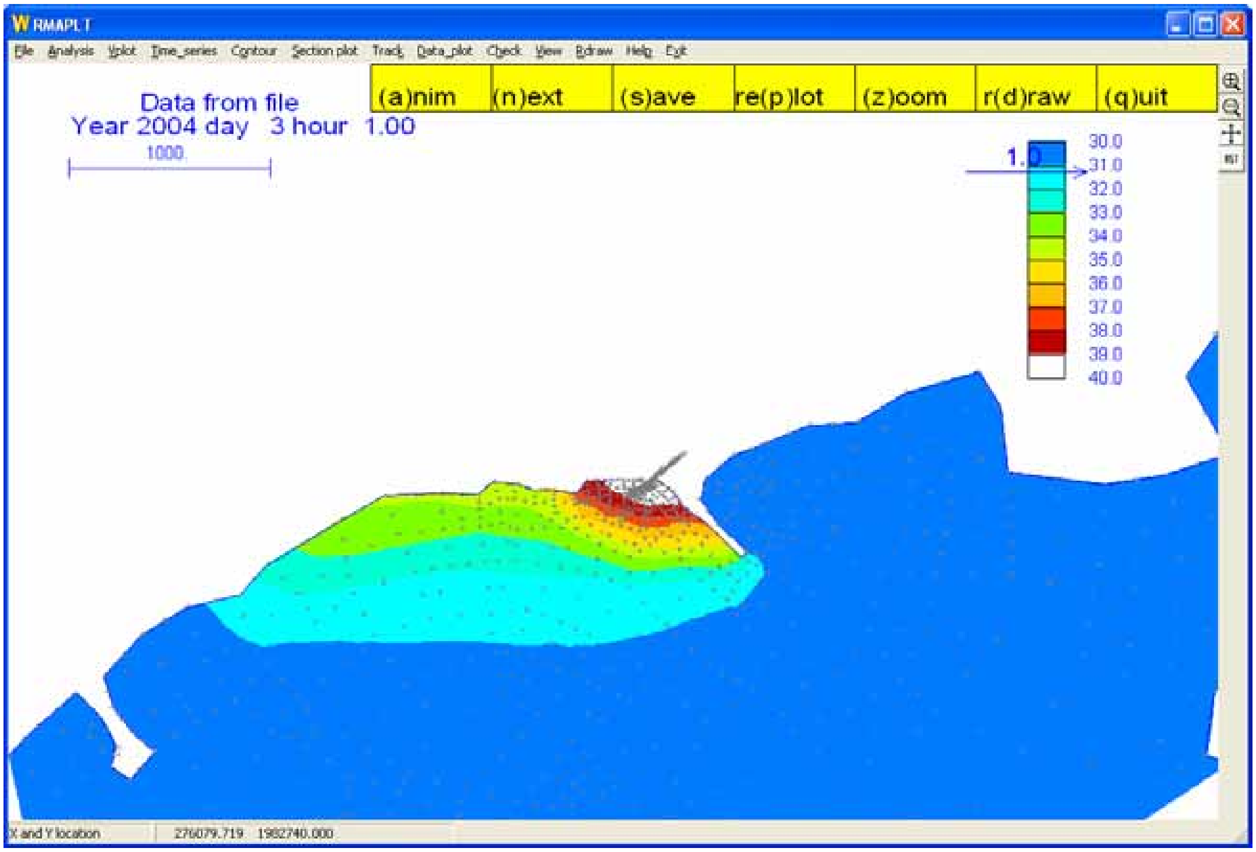


Figure 61 **Predicted surface thermal plume for JEP proposed outfall, JEP existing and JPS existing outfalls, under slow East-south easterly wind conditions**

6.3 NOISE

The installation of the proposed barge will result in an increase in the existing noise level (cumulative).

The cumulative noise impact takes into account all the existing background noise sources which include the Jamaica Public Service power plant and the existing Jamaica Energy Partners barge ("Dr. Bird"). Noise from the new noise source (the proposed barge) is then added to the existing noise levels to determine what if any impact this new development would have on the surrounding community.

Assuming that the barge was placed at each noise measurement station (worst case scenario) then the resultant cumulative noise levels that would be arrived at is listed in Table 41. This is based on a 59 dBA at 500 feet (≈152m) as indicated by the Wärtsilä data. This assumption is overly conservative as the noise source (proposed barge) will be at varying distances to these stations which would result in the attenuation of the noise.

Table 41 Comparison of cumulative noise (if the barge was located at the individual stations) and the NEPA and World Bank guidelines

STATION		DAYTIME				NIGHT TIME			
No.	TYPE	ACTUAL	CUMM	NEPA STD	WB STD	ACTUAL	CUMM	NEPA STD	WB STD
N1	Occupational	86.6	86.6	95	N/A	83.5	83.5	95	N/A
N2	Industrial	70.3	70.7	75	N/A	69.9	70.2	70	N/A
N3	Industrial	66.6	67.2	75	70	59.4	62.3	70	70
N4	Residential	54.5	54.6	55	55	49.9	50.3	50	45
N5	Residential	59.4	62.3	55	55	57.1	59.4	50	45
N6	Residential	45.6	45.9	55	55	56.6	58.6	50	45
N7	Residential	54.5	54.6	55	55	51.2	51.9	50	45

WB – World Bank guidelines, N/A Not applicable

NEPA GUIDELINES

Only station N5 would exceed the NEPA day time standard when the cumulative noise levels are calculated but the NEPA Guidelines was being exceeded prior to the addition of the proposed project. During the night, stations N2 and N4 to N7 (residential) would not be compliant with the standard; however, stations N5-N7 were exceeding the NEPA guidelines prior to the addition of the proposed project. In the case of station N2 and N4, the addition of the proposed project caused an increase above existing levels of less than 0.5 dBA.

WORLD BANK GUIDELINES

For station N5, the resultant increase due to the proposed project in the background levels would be less than a 3dBA increase for both daytime and nigh time periods, thus there is compliance with World Bank guidelines.

7.0 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 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 JEP project team and the consulting scientists worked together, utilising 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 east of the existing Dr. Bird Barge.
- The proposed Development as described in the EIA but immediately south of the existing Dr. Bird Barge.
- The proposed Development as described in the EIA, but along the southern coast of Jamaica either east or west of the current location ("Dr. Bird" barge).
- The proposed Development as described in the EIA but using liquid natural gas or coal as fuel.

7.1 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 JEP facility already in the vicinity, 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.

7.2 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 thermal pollution of the surrounding water body. These impacts will be properly mitigated.

7.3 THE PROPOSED DEVELOPMENT AS DESCRIBED IN THE EIA BUT EAST OF THE EXISTING DR. BIRD BARGE

An alternate location east of the existing Dr. Bird barge was investigated for siting the proposed Barge. This site proved unacceptable as it would infringe on the existing system and obstruct the existing cooling water uptake point for the existing barge (Figure 1). In addition, the EIA team could not identify any significant positive environmental impact of this alternative.

7.4 THE PROPOSED DEVELOPMENT AS DESCRIBED IN THE EIA BUT IMMEDIATELY SOUTH OF THE EXISTING DR. BIRD BARGE

Locating the proposed Barge immediately south of the existing Barge is also not any more environmentally sound, but it would create daily logistical challenges for JEP as it relates to access for servicing, etc (Figure 63).

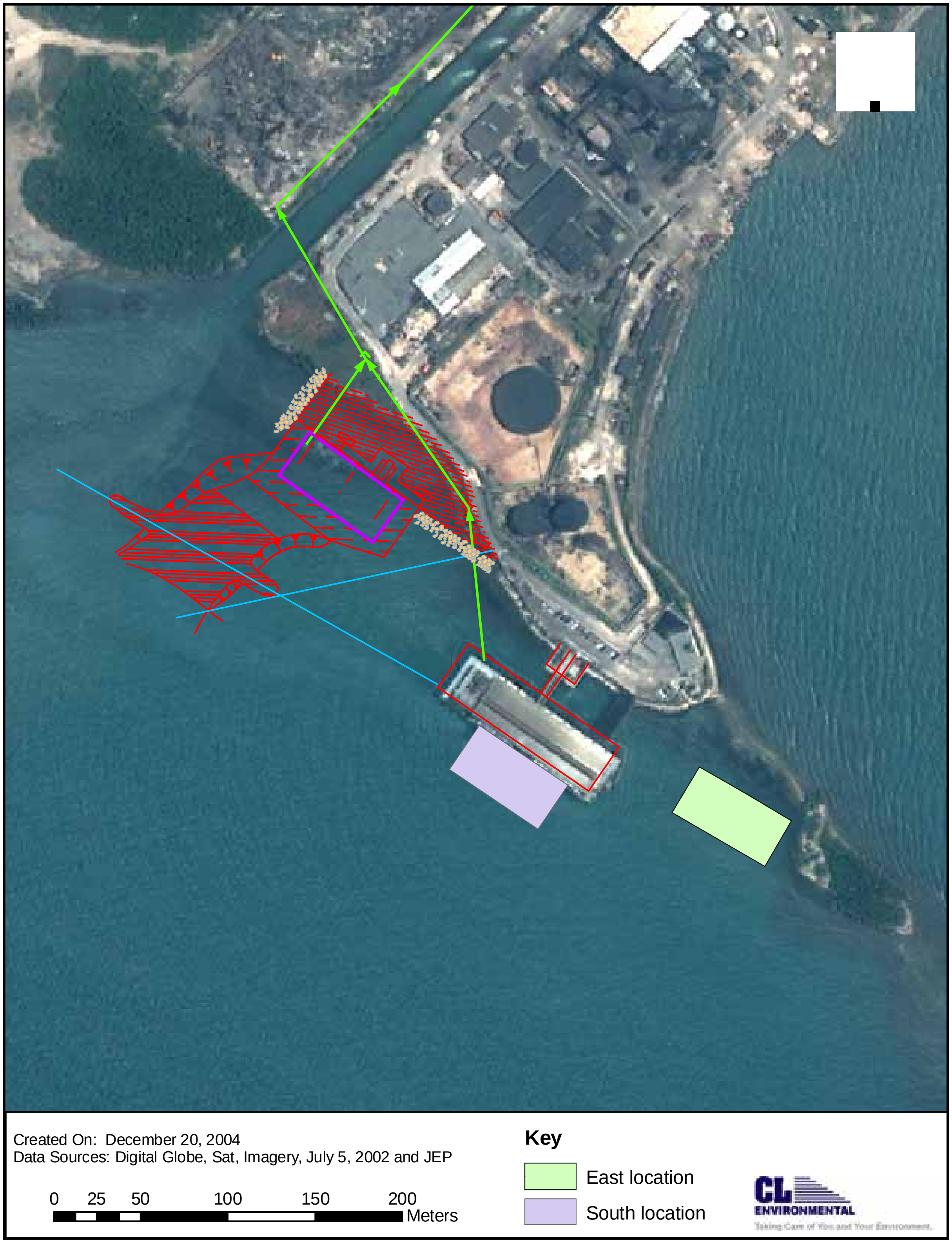


Figure 62 Proposed and alternate locations of the new Barge

7.5 THE PROPOSED DEVELOPMENT AS DESCRIBED IN THE EIA, BUT ALONG THE SOUTHERN COAST OF JAMAICA EAST OR WEST OF THE CURRENT LOCATION ("DR. BIRD" Barge)

Other locations along the coast were investigated as far as Portland Ridge (≈ 22 km SW in a straight line from the existing barge) and as far southeast as Manatee Bay (≈ 15 km) (Figure 64).

These potential sites do not have the existing infrastructure, for example, port facilities, electrical transmission lines, ease of access to handle this project in a timely manner. Additionally, some of these areas would infringe on the existing fishing grounds and fish nurseries area. Also the majority of the area is covered with healthy mangrove stands, which would necessitate clearing during construction.

The factors listed above and the fact that the proposed area is already in an established industrial zone and the sheltering nature of the proposed location from storms makes it the most suitable.

7.6 THE PROPOSED DEVELOPMENT AS DESCRIBED IN THE EIA BUT USING LIQUID NATURAL GAS (LNG) OR COAL AS FUEL

Alternate types of fuel types to diesel (oil) were investigated. These were LNG and coal. LNG is increasingly becoming a popular alternative source of fuel. It produces less air emissions and pollutants than either coal or oil.

Although LNG would have been an excellent alternative, the short timeframe for this project (urgent need for power generation), the preparation (construction of specialized storage and infrastructure) and negotiations for supply would result in approximately a three (3) year delay. This would result in not meeting the timeframe for provision of additional power generation.

Using coal as the fuel would also result in a delay in installation of power generating capacity. In addition, the environmental impact of using coal is potentially more significant and would require certain mitigation.

7.7 OVERVIEW OF ALTERNATIVE ANALYSIS

Based on the above, the most environmentally sound and most economical alternative is the development as proposed in the EIA (Section 7.2). This option will result in the shortest possible time for the provision of the needed additional power generating capacity with impacts which can be mitigated.

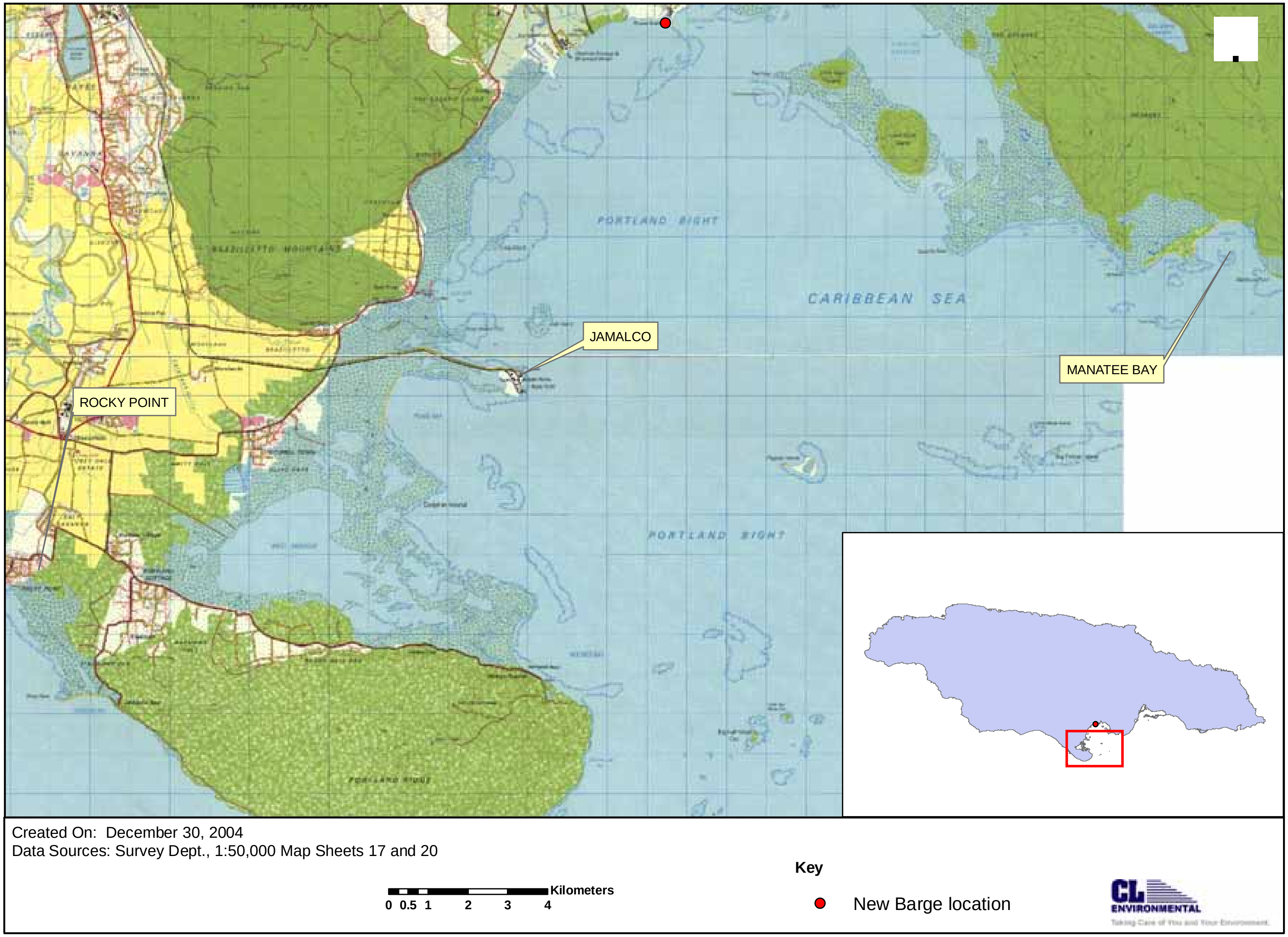


Figure 63 **Map depicting the coastline where possible alternative sites were investigated**

8.0 ENVIRONMENTAL ACTION PLAN

This section discusses appropriate mitigation measures for the proposed project during construction and operation. Also, ambient monitoring measures are described in Section 8.2 and Reporting requirements are discussed in Section 8.3.

8.1 MITIGATION

8.1.1 Site Preparation Phase

Loss of Bottom Habitat

1. Dredge in designated area
2. Dispose of dredge spoils at the designated point offshore
3. Conduct the dredging exercise during favourable sea conditions
4. An area for resuscitation (e.g. the mangroves north west of the proposed barge) or an environmental project or group should be identified and to substitute for the replanting of removed seagrass.

Suspension and Dispersal/ Resettlement of Sediments

1. Enclose the area being actively dredged by silt screens

Heavy Metal Re-suspension

1. No mitigation required. Sediments were already tested and trace amounts of certain metals were found.

Introduction of Invasive Species

1. A hull inspection should be conducted on the vessels entering the proposed area.

8.1.2 Construction Phase

Increase Particle suspension and Surface Runoff

1. Use silt curtains and ponding areas to reduce the impact of run off to the marine environment.

Noise Pollution

1. Use equipment that has low noise emissions as stated by the manufacturers.
2. Use equipment that is properly fitted with noise reduction devices such as mufflers.
3. 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.

Vegetation Removal

1. No mitigation required as the vegetation that will be removed is neither endemic, rare or of commercial value.

Air Quality

1. 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.
2. Minimize cleared areas to those that are needed to be used.
3. Cover or wet construction materials such as marl to prevent a dust nuisance.
4. Where unavoidable, construction workers working in dusty areas should be provided and fitted with N95 respirators.

Solid Waste Generation

1. Skips and bins should be strategically placed within the campsite and construction site.
2. The skips and bins at the construction campsite should be adequately designed and covered to prevent access by vermin and minimise odour.
3. The skips and bins at the construction site should be adequately covered to prevent a dust nuisance.
4. The skips and bins at both the construction campsite and construction site should be emptied regularly to prevent overfilling.
5. Disposal of the contents of the skips and bins should be done at an approved disposal site. The Riverton dump in Kingston is recommended. Appropriate permission should be sought.

Wastewater Generation and Disposal

1. 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 and Equipment

1. Raw materials that generate dust should be covered or wetted frequently to prevent them from becoming air or waterborne.
2. Raw material should be placed on hardstands surrounded by berms.
3. Equipment should be stored on impermeable hard stands surrounded by berms to contain any accidental surface runoff.
4. 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.

Transportation of Raw Material and Equipment

1. 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.
2. Heavy equipment should be transported early morning (12 am – 5 am) with proper pilotage.

Emergency Response

1. 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.
2. The JEP construction management team should have onsite first aid kits and make arrangements for the nurse and doctor on call for the construction site.
3. Make prior arrangements with health care facilities such as the Old Harbour Health Centre or the Spanish Town hospital to accommodate any eventualities.
4. Arrange with health practitioners to be on call during the construction period.
5. Material Safety Data Sheets (MSDS) should be stored onsite.

Employment

During this phase, an average of 50 professionals, trades men and labourers will be utilized. This represents a significant level of employment within the study area. This has the potential to be a significant positive impact.

Mitigation

1. Not required

8.1.3 Operation

Air Emissions

Prior to operation of the proposed JEP 2 plant, three ambient air quality monitoring stations will be located in the project area to provide representative data for existing operations of JEP 1 and JPS. These stations would collect 6 months of SO_2 and NO_x data. An air dispersion modelling study will be conducted during this 6 month period. The objective of this study will be to assess the impact of adding the JEP 2 facility to the existing operations and find what the resulting SO_2 impacts would be.

If the monitoring data and modelling study find that the addition of JEP 2 would not violate any SO_2 JAAQS or World Bank guideline values, then the project would proceed with construction as planned.

If the study finds that there could be exceedances of any JAAQS or World Bank ambient air quality guideline values for SO_2, then JEP 1 would provide SO_2 emission offsets by lowering its sulphur content in the fuel oil burned to 1%. In addition, JEP 2 would also burn fuel oil with a maximum sulphur content of 1%. The Table 42 shows the offsets that would be provided for this effort.

Table 42 JEP sulphur dioxide emission offsets

YEAR	FUEL USE, BARRELS PER YEAR	AVERAGE SULPHUR CONTENT, BY WEIGHT	SO_2 EMISSIONS, TONS PER YEAR	EMISSION OFFSETS, TONS PER YEAR[a]
2000	563,750	1.97	3,732	1,837
2001	631,289	1.89	4,009	1,889
2002	660,506	1.71	3,795	1,576
2003	598,828	1.82	3,662	1,650
2004	594,114	1.81	3,613	1,617

a These are offsets assuming 1% sulphur in oil burned by JEP 1

For JEP 2, the annual SO_2 air emissions, assuming 1% sulphur in oil at an 80% operating factor (annual basis) would be 1,714 tons per year. The average of the five years of data in Table 8-1 is

1,714 tons per year (assuming JEP 1 used 1% sulphur in oil). Thus, the JEP 2 SO_2 air emissions could be offset, if necessary, to accommodate its added impacts to the environment.

Table 43 also shows the air dispersion modelling impacts associated with JEP 1(at its existing operations) compared to JEP 1 and 2 at the lower (1%) sulphur operations.

Table 43 Air dispersion modelling Comparison

SULPHUR DIOXIDE	JEP 1 IMPACTS[a], ($\mu g/m^3$)	JEP 1 AND 2[b], ($\mu g/m^3$)
1-HOUR	407	436
24-HOUR	64	61
ANNUAL	8	7

a 1.8% sulphur annual basis, and 2.0% sulphur for 24-hour and 1-hour basis.
b 1.0% sulphur annual basis, and 1.2 % sulphur for 24-hour and 1-hour basis.

This table shows that on a 24-hour and an annual basis, there would be a reduction in SO_2 impacts associated with a switch to the lower sulphur fuel oil for JEP 1 and 2 as compared to JEP 1 at the higher sulphur fuel oil. Thus, there would be a net benefit to longer term air quality impacts with this change in fuels. There would be a slight increase in impacts for the 1-hour averaging period, but these impacts (by themselves) are well below the JAAQS of 700 $\mu g/m^3$.

Thermal Plume

1. Ensure that the cooling water discharge pipe is maintained in the designated location.
2. A preventative maintenance program will be implemented to detect and control any mechanical malfunctions that could result in the cooling water designed discharge temperature being exceeded.
3. The use of environmentally safe treatment systems will be used to maintain the cooling water piping system.

Natural Hazards

1. Ensure that the new structures can withstand hurricane and earthquake impacts.
2. Ensure that the new structures are designed to withstand a 50 –100 year flood event.
3. Barge integrity inspections should be conducted every two (2) years by qualified personnel.
4. Develop an emergency response plan and/or update the existing emergency response plan of the existing Dr Bird barge to reflect the addition of the proposed new barge.

Barge Maintenance

1. The use of lead based paints should be prohibited. If this is unavoidable care should be taken to prevent inhalation by the persons applying the paint and to minimize the potential for the paint to enter the ecosystem.
2. When sand blasting and scraping, collection mechanisms should be placed strategically to prevent the particulates from entering the marine environment below.

Overland Drainage

1. Drainage from the paved surface should not directly discharge to the marine environment. Instead drains should be designed so as to provide some treatment before disposal (e.g. silt trap and or oil/water separators)

Occupational Health and Safety

1. Provision of Personal Protective Equipment (PPE) e.g. noise muffs, plugs, helmets and Personal fall arrest systems (PFAS).
2. Establish a hearing conservation programme.
3. Ensure adequate ventilation within the work area.
4. A programme to monitor the thermal comfort of workers will be implemented.
5. 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.

6. A confined space policy will be developed and implemented.
7. Use the Occupational Safety and Health Administration (OSHA) standard 1910 as a guide to Occupational Health and Safety maters.

Solid Waste Generation and Disposal

1. Provision of solid waste storage bins and skips.
2. Contracting a private contractor to collect solid waste in a timely fashion to prevent a build up.
3. Ensure that the solid waste collected is disposed in an approved dumpsite such as the Riverton dump in Kingston.

Wastewater Generation and Disposal

1. All run-offs from potential contamination sources on the Barge (power house floor drains, workshops etc.) will be pumped to a contaminated water tank. This will be collected by a private contractor to be disposed in an environmentally friendly fashion.
2. Ensure that the package sewage system is operating at its optimum by practising preventative maintenance.

Emergency Response

1. Have first aid kits located in various sections of the barge.
2. Make prior arrangements with health care facilities such as the Old Harbour Health Centre or the Spanish Town hospital to accommodate any eventualities.
3. Arrange with health practitioners to be on call.
4. Design and implement an emergency response plan or update the existing plan to reflect the addition of the proposed new barge.
5. Staff should be trained in Cardio Pulmonary Resuscitation (CPR).

6. Coordinate with mutual aid organisations/agencies such as with the local fire brigade.

8.2 MONITORING

8.2.1 Monitoring During Site Preparation for the Proposed Barge

- A noise survey should be undertaken to determine workers exposure and construction equipment noise emission.

- 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 JEP 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 JEP may perform this exercise.

  No additional cost is anticipated for this exercise.

8.2.2 Monitoring During the Construction Phase of the Proposed Barge

- Daily inspection of the jetty 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 JEP 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$ 20,000** per monitoring exercise.
- Undertake daily water quality monitoring in the first week to two weeks and weekly thereafter to ensure that the dredging works are not negatively impacting on the marine environment quality. The parameters that should be monitored are **salinity**, **dissolved oxygen**, **nitrates**, **phosphates**, **turbidity and total suspended solids**.

  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 month.

  This is estimated to cost approximately **J$ 20,000** per monitoring exercise.

- A noise survey should be undertaken to determine workers exposure and construction equipment noise emission.

  The noise survey is estimated to cost approximately **J$15,000**.

- 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.

- 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 JEP 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 JEP may perform this exercise.
  No additional cost is anticipated for this exercise.

- Undertake daily assessment of the quantity of dredge spoils generated and keep records of its ultimate disposal. Additionally, solid waste generation and disposal of the construction site should also be monitored.

  Person(s) appointed by JEP 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 JEP 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 JEP 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 JEP 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 JEP may perform this exercise.

  No additional cost is anticipated for this exercise.

8.2.3 Monitoring During the Operational Phase of the Proposed Barge

- Every two years noise assessments should be conducted starting with the initial commissioning of the power barge. This should be contracted out by JEP 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$200,000** per assessment.

- Bi-monthly sewage effluent discharge monitoring should be conducted. Parameters that should be collected are BOD_5, TSS, Total Nitrogen, Phosphates, COD, pH, Faecal Coliform and Residual Chlorine. Additionally, the flow rate of the influent and effluent should be collected. All monitoring should be conducted according to generally accepted industry standards and the plant shall conform to the World Bank and the National Environment and Planning Agency Standards.

  Person(s) appointed by JEP may perform this exercise.

  It is anticipated that it will cost approximately **$20,000** per sampling exercise.

- Quarterly monitoring of the cooling water discharge from the barge (including a location 100m from the point of discharge). Parameters that should be monitored include Temperature, pH, TSS, Oil and Grease, Total Residual Chlorine, Ammonia, Iron, Copper, Zinc and Total Heavy Metals.

  This should be contracted out by JEP to a third party company or individual that specializes in performing such tests. The contracted party shall have a proven experience in water quality monitoring. All monitoring should be conducted according to generally accepted industry standards and shall conform to the World Bank Guidelines and the National Environment and Planning Agency Standards.

  It is anticipated that it will cost approximately **$40,000** per sampling exercise.

- 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 JEP may perform this exercise.
  No additional cost is anticipated for this exercise.
- During the operation of the proposed barge power plant project, there will be three ambient air quality monitoring stations which will monitor sulphur dioxides and nitrogen oxides on a continuous basis. These monitors will be located to provide a representative picture of the proposed operations at the power barge.

  Person(s) appointed by JEP may perform this exercise.

8.3 REPORTING REQUIREMENTS

8.3.1 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, JPS loading, JEP loading).
ix. Evaluation of data, discussions and statement giving a professional opinion of the noise impact of the facility.

A. The report shall be submitted to Plant Manager or his designate within two weeks after completion of testing.

B. The Plant Management shall distribute the report within forty five (45) days of testing being completed.

C. 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.

D. Reports will be maintained on file at the plant for a minimum of three years.

8.3.2 Cooling Water Quality

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

A. The report will be submitted to the Plant Manager or his designate within fifteen two weeks of the monitoring being completed.

B. Plant management shall distribute the report within forty five (45) days of testing being completed.

C. 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.

D. Reports will be maintained on file at the plant for a minimum of three years.

8.3.3 Air Emissions

A quarterly report will summarize the results of the three (3) 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.

APPENDICES

Appendix 1 Approved Terms of Reference

PROPOSED TERMS OF REFERENCE

Environmental Impact Assessment
49.47 MW Generation Expansion
Old Harbour, St. Catherine

1.0 BACKGROUND

The Jamaica Energy Partners (JEP) owns a 74.16 MW (net) electricity-generating facility (Doctor Bird Power Barge) located adjacent to the Jamaica Public Service Company (JPS) Power plant in Old Harbour Bay, St. Catherine. The Doctor Bird Power Barge has been in operation since 1995.

JEP has proposed to increase its capacity by 49.47 MW, which would result in the company having a total net installed capacity of 123.63 MW.

The proposed new floating electricity generating facility (proposed plant) will be similar to the existing Doctor Bird Power Barge and will include mooring it in proximity to the Doctor Bird Power Barge. The Proposed Plant will supply power from three or four Wärtsilä Medium Speed Diesel generating sets.

It will be transported to its location by tugboats and the route taken to access the Bay will be that used to transport the Doctor Bird Power Barge. The Proposed Plant will be docked near the shore (See preliminary sketch of the proposed layout included with the Project application forms).

Although an Environmental Impact assessment was prepared for the Doctor Bird Power Barge, it is anticipated that another EIA will be required for the Proposed Plant. The Terms of reference included in this document were prepared in order to guide the EIA preparation process for this project. The Proposed Plant would be located adjacent to the JPS Old Harbour Substation (200-300 meters) and the right-of-way for the existing electrical transmission lines will be used for the electrical transmission lines leaving the new facility. Consequently there will be no new disturbed path for these lines.

Based on the site profile it is anticipated that the Proposed Plant will present few environmental issues. The proposed TORs for the EIA to be conducted are outlined in section 3.0 (pages 3 to 5) of this document.

2.0 DEFINITIONS:

The following definitions will apply for the purposes of this document:

1. **Terms of Reference (TOR)**: The terms that will be used to guide the preparation of the Environmental Impact assessment.

2. **JEP**: “Jamaica Energy Partners” which is the company responsible for the project. i.e. the developer.

3. **The Consultant**: The company that will be hired by JEP to conduct the EIA.

4. **Doctor Bird Power Barge**: The existing 74.16 MW (net) electricity generating facility in Old Harbour Bay, St. Catherine that is owned by JEP.

5. **Proposed Plant or "the project"**: The 49.47 MW Floating Power Generation Facility being proposed by JEP.

6. **NEPA**: Refers to the National Environmental and Planning Agency.

7. **JPS**: Refers to the Jamaica Public Service Company Limited.

3.0 TERMS OF REFERENCE

The proposed Terms of Reference for conducting the Environmental Impact Assessment for the construction and operation of the 49.47 MW Diesel Plant (proposed plant) described in the background to this document are outlined below:

(i) **<u>Project Description</u>:**

A detailed description of all elements of the project during the pre-construction, construction and operational phases will be prepared. The elements analyzed will include the infrastructures of the project including: drainage features; roads; waste collection, storage, disposal, and management; and utility requirements.

With regards to waste management and disposal, special emphasis will be placed on:

- Civil works (e.g. dredging)
- Stack Emissions.
- Noise Pollution
- Cooling Water (Sea Water) Discharge
- Wastewater management (e.g. sewage and oily water).

Deliverable: Analysis and assessment of designs to ensure environmental soundness, sustainability and regulatory compliance in the Draft and Final Report.

<u>(ii)</u> ***<u>Field Assessments and Identification of the major Environmental issues</u>:***

Field assessments of the physical, ecological, and socioeconomic aspects of the site and associated environs will be conducted. These assessments will be used to determine the potential impacts, if any, of the project. The assessment will include a photo-inventory of the physical and biological features of the site and environs, and the areas will be viewed with respect to the suitability of the Proposed Plant . It will also include compilation (s) of relevant baseline data. The assessments will include:

Physical: Climate, air quality, geology, topography, groundwater/surface water hydrology and quality, Coastline stability and hazard vulnerability.

Ecological: Terrestrial and aquatic communities; presence of rare, threatened, and endangered species. (Special attention will be given to coral reefs, mangroves and wetlands, sea grass and all marine life).

Socioeconomic: Demography, regional setting, location assessment, and land uses.

Deliverable: Detailed qualitative assessments of the physical, ecological, and socioeconomic conditions associated with the site in the Draft and Final Report.

(iii) ***Analysis of Alternatives:***

This will include the no action alternative, the proposed action, and a possible alternative action.

These alternatives will be discussed and assessed relative to the physical, ecological, and socioeconomic parameters of the site. The rationale for the identified alternatives will be examined and the preferred alternative substantiated. Where necessary, appropriate recommendations will be developed for design features of the project.

Deliverable: All alternatives of the project will be evaluated and the best possible design option presented as the preferred alternative in the Draft and Final Reports.

(iv) ***Legislation and Regulatory Considerations:***

Government policies, legislation and regulations relevant to the project will be identified. Local plans and policies will also be evaluated. Project characteristics will be analyzed to ensure compliance with these policies, legislation and regulations. Appropriate recommendations will be provided to ensure regulatory compliance.

Deliverable: The legislation relevant to the project will be summarized and presented in the Draft and Final Reports.

(v) ***Identification of Significant Environmental Impacts:***

An analysis of the elements of the project and their interaction with the environment will be conducted to identify the potential impacts. This information for all elements and phases of the project will be presented in an impact matrix.

The impacts to be included in the matrix are:

- i. Change in drainage pattern
- ii. Flooding potential
- iii. Landscape impacts of excavation and construction
- iv. Loss of natural features, habitats and species by construction and building
- v. Pollution of surface and ground water
- vi. Air pollution
- vii. Thermal pollution
- viii. Socio-economic and cultural impacts
- ix. Risk assessment
- x. Noise
- xi. Risk of spontaneous combustion
- xii. Disposal of hazardous waste
- xiii. Fluid and/or chemical spills

Deliverable: The potential impacts (direct, indirect and cumulative) of this project on the environment and their relevant importance to the design of the facilities will be presented in the Draft and final reports.

(vi) Mitigation of Environmental Impacts:

For each potential negative impact identified, recommendations will be presented for avoidance, minimization or mitigation of impacts. This will include the costs associated with the proposed mitigation measures.

Deliverable: Identification and avoidance, minimization or mitigation of potential negative impacts presented in the Draft and Final Report.

(vii) Environmental Monitoring

An environmental monitoring and management plan will be developed for the sensitive elements of the environment that may require monitoring. Monitoring will be done during the construction, start up and operational phases of the project. Some of the key environmental issues that will be considered are identified under "Project Description" (page 3). The findings from the "Identification of Significant Environmental Impacts" (page 4) will be used to help to guide the development of the Environmental Monitoring Plan. Recommendations will be made concerning the institutional arrangements that will be necessary to ensure effective monitoring and management.

Deliverable: A detailed management and monitoring program will be developed to reduce the effects of potential negative environmental impacts.

(viii) JEP Representation:

The Consultant (and it's employees), as directed by JEP, will maintain contact (where necessary) with the National Environment & Planning Agency (NEPA) to ensure that potential problems are efficiently and expeditiously rectified.

Deliverable: The Consultant and/or designated employee will represent the client, as required, at the NEPA and relevant government bodies to help ensure that regulatory compliance is maintained.

(ix) Public Participation:

While conducting the EIA, the Consultant will provide the local community and relevant stake-holders (as directed) with the opportunity to review and comment on the construction and operation of the Proposed Plant. On completion of the EIA, NEPA may require public meeting(s) to present the findings of the EIA for public review and comment.

Deliverable: The Consultant and/or designated employees will represent JEP (as directed by JEP) at Stakeholder meetings (e.g. Public meetings, meetings with NEPA etc.).

Appendix 2 List of Environmental Impact Assessment Team

Dale Webber, PhD.	Water Quality and Vegetation
Carlton Campbell, M. Phil., CIE	Noise and Socio-economics
Professor Edward Robinson	Geology
Deborah-Ann C. Rowe	Geology
Christopher Burgess M.Sc. Eng., PE	Thermal modelling and Oceanography
Johan Rampair, B.Sc. Eng.	Thermal modelling and Oceanography
Mark Irwin, B.Sc. Eng.	Thermal modelling and Oceanography

<u>URS Corp</u>

Joe David Kuebler, P.E.	Air Quality Modelling
Tom Petroski	Air Quality Modelling

Appendix 3 Guidelines for Public Presentation - EIA

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 1] 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. A typical notice is in Appendix 2.

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 advice 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 role and responsibilities of the chairmen are in Appendix 4.

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.

A typical agenda for a meeting is given in Appendix 3

APPENDIX 1

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 2

NOTIFICATION OF

P U B L I C   M E E T I N G

THERE WILL BE A PUBLIC PRESENTATION ON THE ENVIRONMENT IMPACT ASSESSMENT REPORT

OF:

VENUE:

DATE:

TIME:

THE PUBLIC IS INVITED TO PARTICIPATE IN THE PRESENTATION BY WAY OF ASKING QUESTIONS RELATING TO THE PROPOSED PROJECT.

A COPY OF THE ENVIRONMENTAL IMPACT ASSESSMENT REORT MAY BE CONSULTED AT THE

______________________ PARISH LIBRARY

______________________ PRAISH COUNCIL OFFICE

____

For further information contact:

APPENDIX 3

A G E N D A

1. WELCOME AND INTRODUCTION

2. PRESENTATION OF EIA FINDINGS AND MEASURES TO MINIMIZE IMPACTS

3. QUESTION AND ANSWER SESSION

4. CLOSING REMARKS

APPENDIX 4

ROLE AND RESPONSIBLITIES OF THE CHAIRMAN

The Chairman has the main role of guiding the conduct of the meeting and seeing to it that the concerns of the public are adequately aired and addressed by the consultants/ proponent.

The responsibilities of the Chairman include explaining the NRCA approval process, that is, the steps involved and the role of the NRCA at these public presentations. In other words, the Chairman should explain the context within which the meeting is taking place.

The Chairman should ensure that adequate time is allowed for questions and answers, and must understand clearly and communicate the purpose of the meeting to the audience. The Chairman is responsible for introducing the presenters.

The Chairman should contribute but not monopolize the meeting.

Appendix 4 Relevant Sections of the Pollution Abatement Handbook

Thermal Power: Guidelines for New Plants

Industry Description and Practices

This document sets forth procedures for establishing maximum emissions levels for all fossil-fuel-based thermal power plants with a capacity of 50 or more megawatts of electricity (MWe) that use coal, fuel oil, or natural gas.[1]

Conventional steam-producing thermal power plants generate electricity through a series of energy conversion stages: fuel is burned in boilers to convert water to high-pressure steam, which is then used to drive a turbine to generate electricity.

Combined-cycle units burn fuel in a combustion chamber, and the exhaust gases are used to drive a turbine. Waste heat boilers recover energy from the turbine exhaust gases for the production of steam, which is then used to drive another turbine. Generally, the total efficiency of a combined-cycle system in terms of the amount of electricity generated per unit of fuel is greater than for conventional thermal power systems, but the com-bined-cycle system may require fuels such as natural gas.

Advanced coal utilization technologies (e.g., fluidized-bed combustion and integrated gasification combined cycle) are becoming available, and other systems such as cogeneration offer improvements in thermal efficiency, environmental performance, or both, relative to conventional power plants. The economic and environmental costs and benefits of such advanced technologies need to be examined case by case, taking into account alternative fuel choices, demonstrated commercial viability, and plant location. The criteria spelled out in this document apply regardless of the particular technology chosen.

Engine-driven power plants are usually considered for power generation capacities of up to 150 MWe. They have the added advantages of shorter building period, higher overall efficiency (low fuel consumption per unit of output), optimal matching of different load demands, and moderate investment costs, compared with conventional thermal power plants. Further information on en-gine-driven plants is given in Annex A.

Waste Characteristics

The wastes generated by thermal power plants are typical of those from combustion processes. The exhaust gases from burning coal and oil contain primarily particulates (including heavy metals, if they are present in significant concentrations in the fuel), sulfur and nitrogen oxides (SO_x and NO_x), and volatile organic compounds (VOCs). For example, a

500 MWe plant using coal with 2.5% sulfur (S), 16% ash, and 30,000 kilojoules per kilogram (kJ/kg) heat content will emit each day 200 metric tons of sulfur dioxide (SO_2), 70 tons of nitrogen dioxide (NO_2), and 500 tons of fly ash if no controls are present. In addition, the plant will generate about 500 tons of solid waste and about 17 giga-watt-hours (GWh) of thermal discharge.

This document focuses primarily on emissions of particulates less than 10 microns (µm) in size (PM_{10}, including sulfates), of sulfur dioxide, and of nitrogen oxides. Nitrogen oxides are of concern because of their direct effects and because they are precursors for the formation of ground-level ozone. Information concerning the health and other damage caused by these and other pollutants, as well as on alternative methods of emissions control, is provided in the relevant pollutant and pollutant control documents.

The concentrations of these pollutants in the exhaust gases are a function of firing configuration, operating practices, and fuel composition. Gas-fired plants generally produce negligible

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quantities of particulates and sulfur oxides, and levels of nitrogen oxides are about 60% of those from plants using coal. Gas-fired plants also release lower quantities of carbon dioxide, a greenhouse gas.

Ash residues and the dust removed from exhaust gases may contain significant levels of heavy metals and some organic compounds, in addition to inert materials. Fly ash removed from exhaust gases makes up 60–85% of the coal ash residue in pulverized-coal boilers. Bottom ash includes slag and particles that are coarser and heavier than fly ash. The volume of solid wastes may be substantially higher if environmental measures such as flue gas desulfurization (FGD) are adopted and the residues are not reused in other industries.

Steam turbines and other equipment may require large quantities of water for cooling, including steam condensation. Water is also required for auxiliary station equipment, ash handling, and FGD systems. The characteristics of the wastewaters generated depend on the ways in which the water has been used. Contamination arises from demineralizers, lubricating and auxiliary fuel oils, and chlorine, biocides, and other chemicals used to manage the quality of water in cooling systems. Once-through cooling systems increase the temperature of the receiving water.

Policy Framework

The development of a set of environmental requirements for a new thermal power plant involves decisions of two distinct kinds. First, there are the specific requirements of the power plant itself. These are the responsibility of the project developer in collaboration with relevant local or other environmental authorities. This document focuses on the issues that should be addressed in arriving at project-specific emissions standards and other requirements.

Second, there are requirements that relate to the operation of the power system as a whole. These strategic issues must be the concern of national or regional authorities with the responsibility for setting the overall policy framework for the development of the power sector. Examples of such requirements include measures to promote energy conservation via better demand-side management, to encourage the use of renewable sources of energy rather than fossil fuels, and to meet overall targets for the reduction of emissions of sulfur dioxide, nitrogen oxides, or greenhouse gases.

In the context of its regular country dialogue on energy and environmental issues, the World Bank is willing to assist its clients to develop the policy framework for implementing such environmental requirements for the power sector as a whole. One step in this process might be the preparation of a sectoral environmental assessment. This document assumes that the project is consistent with broad sectoral policies and requirements that have been promulgated by the relevant authorities in order to meet international obligations and other environmental goals affecting the power sector.

In some cases, strategies for meeting system-wide goals may be developed through a power-sector planning exercise that takes account of environmental and social factors. This would, for instance, be appropriate for a small country with a single integrated utility. In other cases, governments may decide to rely on a set of incentives and environmental standards designed to influence the decisions made by many independent operators.

Determining Site-Specific Requirements

This document spells out the process—starting from a set of maximum emissions levels acceptable to the World Bank Group—that should be followed in determining the site-specific emissions guidelines. The guidelines could encompass both controls on the plant and other measures, perhaps outside the plant, that may be necessary to mitigate the impact of the plant on the airshed or watershed in which it is located. The process outlines how the World Bank Group's policy on Environmental Assessment (OP 4.01) for thermal power plants can be implemented. The guidelines are designed to protect human health; reduce mass loading to the environment to acceptable levels; achieve emissions levels based on commercially proven and widely used technologies; follow current regulatory and technology trends; be cost-effective; and promote the use of cleaner fuels and good-management practices that increase energy efficiency and productivity.

It is important to stress that the results of the environmental assessment (EA) are critical to defining many of the design parameters and other assumptions, such as location, fuel choice, and the like, required to develop the detailed specification of a project. The assessment results must be integrated with economic analyses of the key design options. Thus, it is essential that the work of preparing an environmental assessment be initiated during the early stages of project conception and design so that the initial results of the study can be used in subsequent stages of project development. It is not acceptable to prepare an environmental assessment that considers a small number of options in order to justify a predetermined set of design choices.

Evaluation of Project Alternatives

The EA should include an analysis of reasonable alternatives that meet the ultimate objective of the project. The assessment may lead to alternatives that are sounder, from an environmental, sociocultural, and economic point of view, than the originally proposed project. Alternatives need to be considered for various aspects of the system, including:

- .Fuels used
- .Power generation technologies
- .Heat rejection systems
- .Water supply or intakes

- .Solid waste disposal systems
- .Plant and sanitary waste discharge
- .Engineering and pollution control equipment (see Annex B for some examples)
- .Management systems.

The alternatives should be evaluated as a part of the conceptual design process. Those alternatives that provide cost-effective environmental management are preferred.

Clean Development Mechanism (CDM)

The Kyoto Protocol provisions allow for the use of the clean development mechanism (CDM), under which, beginning in 2000, greenhouse gas emissions from projects in non–Annex I countries that are certified by designated operating entities can be acquired by Annex I countries and credited against their emissions binding commitments. The

availability of CDM financing may alter, in some cases, the choice of the least-cost project alternative. Once the CDM is enacted, it will be advisable to incorporate the following steps into the process of evaluating project alternatives:

- .Identification and assessment of alternatives that are eligible for CDM-type financing (e.g., alternatives that are not economical without carbon offsets and whose incremental costs above the least-cost baseline alternative, taking account of local environmental externalities, are smaller than the costs of resulting carbon off-sets).
- .Negotiation with Annex I parties of possible offset arrangements, if CDM-eligible alternatives exist. The World Bank Group will be prepared to assist in the process of identifying the CDM-eli-gible alternatives and negotiating offset arrangements for projects that are partly financed or guaranteed by the World Bank Group.

Environmental Assessment

An EA should be carried out early in the project cycle in order to establish emissions requirements and other measures on a site-specific basis for a new thermal power plant or unit of 50 MWe or larger. The initial tasks in carrying out the EA should include:

- .Collection of baseline data on ambient concentrations of PM_{10} and sulfur oxides (for oil and coal-fired plants), nitrogen oxides, (and ground-level ozone, if levels of ambient exposure to ozone are thought to be a problem) within a defined airshed encompassing the proposed project.[2]
- .Collection of similar baseline data for critical water quality indicators that might be affected by the plant.
- .Use of appropriate air quality and dispersion models to estimate the impact of the project on the ambient concentrations of these pollutants, on the assumption that the maximum emissions levels described below apply. (See the chapters on airshed models in Part II of this *Handbook*.)

When there is a reasonable likelihood that in the medium or long term the power plant will be expanded or other pollution sources will increase significantly, the analysis should take account of the impact of the proposed plant design both immediately and after any probable expansion in capacity or in other sources of pollution. The EA should also include impacts from construction work and other activities that normally occur, such as migration of workers when large facilities are built. Plant design should allow for future installation of additional pollution control equipment, should this prove desirable or necessary.

The EA should also address other project-spe-cific environmental concerns, such as emissions of cadmium, mercury, and other heavy metals resulting from burning certain types of coal or heavy fuel oil. If emissions of this kind are a concern, the government (or the project sponsor) and the World Bank Group will agree on specific measures for mitigating the impact of such emissions and on the associated emissions guidelines.

The quality of the EA (including systematic cost estimates) is likely to have a major influence on the ease and speed of project preparation. A good EA prepared early in the project cycle should make a significant contribution to keeping the overall costs of the project down.

Emissions Guidelines

Emissions levels for the design and operation of each project must be established through the EA process on the basis of country legislation and the *Pollution Prevention and Abatement Handbook*, as applied to local conditions. The emissions levels selected must be justified in the EA and acceptable to the World Bank Group.

The following maximum emissions levels are normally acceptable to the World Bank Group in making decisions regarding the provision of World Bank Group assistance for new fossil-fuel-fired thermal power plants or units of 50 MWe or larger (using conventional fuels). The emissions levels have been set so they can be achieved by adopting a variety of cost-effective options or technologies, including the use of clean fuels or washed coal. For example, dust controls capable of over 99% removal efficiency, such as electrostatic precipitators (ESPs) or baghouses, should always be installed for coal-fired power plants. Similarly, the use of low-NO_x burners with other combustion modifications such as low excess air (LEA) firing should be standard practice. The range of options for the control of sulfur oxides is greater because of large differences in the sulfur content of different fuels and in control costs. In general, for low-sulfur (less than 1% S), high-calorific-value fuels, specific controls may not be required, while coal cleaning, when feasible, or sorbent injection (in that order) may be adequate for medium-sulfur fuels (1–3% S). FGD may be considered for high-sulfur fuels (more than 3% S). Fluidized-bed combustion, when technically and economically feasible, has relatively low SO_x emissions. The choice of technology depends on a benefit-cost analysis of the environmental performance of different fuels and the cost of controls.

Any deviations from the following emissions levels must be described in the World Bank Group project documentation.

Air Emissions

The maximum emissions levels given here can be consistently achieved by well-designed, well-op-erated, and well-maintained pollution control systems. In contrast, poor operating or maintenance procedures affect actual pollutant removal efficiency and may reduce it to well below the design specification. The maximum emissions levels are expressed as concentrations to facilitate monitoring. Dilution of air emissions to achieve these guidelines is unacceptable. Compliance with ambient air quality guidelines should be assessed on the basis of good engineering practice (GEP) recommendations. See Annex C for ambient air quality guidelines to be applied if local standards have not been set.[3] Plants should not use stack heights less than the GEP recommended values unless the air quality impact analysis has taken into account building downwash effects. All of the maximum emissions levels should be achieved for at least 95% of the time that the plant or unit is operating, to be calculated as a proportion of annual operating hours.[4] The remaining 5% of annual operating hours is assumed to be for start-up, shutdown, emergency fuel use, and unexpected incidents. For peaking units where the start-up mode is expected to be longer than 5% of the annual operating hours, exceedance should be justified by the EA with regard to air quality impacts.

Power plants in degraded airsheds. The following definitions apply in airsheds where there already exists a significant level of pollution.

An airshed will be classified as having *moderate air quality* with respect to particulates, sulfur dioxide, or nitrogen dioxide if either 1 or 2 applies:

1. 1. (a) The annual mean value of PM_{10} exceeds 50 micrograms per cubic meter (µg/m^3) for the airshed (80 µg/m^3 for total suspended particulates, TSP); (b) the annual mean value of sulfur dioxide exceeds 50 µg/m^3; or (c) the annual mean value of nitrogen dioxide exceeds 100 µg/m^3 for the airshed.
2. 2. The 98th percentile of 24-hour mean valuesof PM_{10}, sulfur dioxide, or nitrogen dioxide for the airshed over a period of a year exceeds 150 µg/m^3 (230 µg/m^3 for TSP).

An airshed will be classified as having *poor air quality* with respect to particulates, sulfur dioxide, or nitrogen dioxide if either 1 or 2 applies:

1. 1. (a) The annual mean of PM_{10} exceeds 100 µg/ m^3 for the airshed (160 µg/m^3 for TSP); (b) the annual mean of sulfur dioxide exceeds 100 µg/m^{3}for the airshed; or (c) the annual mean of nitrogen dioxide exceeds 200 µg/m^3 for the airshed.
2. 2. The 95th percentile of 24-hour mean valuesof PM_{10}, sulfur dioxide, or nitrogen dioxide for the airshed over a period of a year exceeds 150 µg/m^3 (230 µg/m^3 for TSP).

Plants smaller than 500 MWe in airsheds with moderate air quality are subject to the maximum emissions levels indicated below, provided that the EA shows that the plan will not lead *either* to the airshed dropping into the “poor air quality” category *or* to an increase of more than 5 µg/m^3 in the annual mean level of particulates (PM_{10} or TSP), sulfur dioxide, or nitrogen dioxide for the entire airshed. If either of these conditions is not satisfied, lower site-specific emissions levels should be established that would ensure that the conditions can be satisfied. The limit of a 5 µg/m^3 increase in the annual mean will apply to the cumulative total impact of all power plants built in the airshed within any 10-year period beginning on or after the date at which the guidelines come into effect.

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Plants larger than or equal to 500 MWe in airsheds with moderate air quality and all plants in airsheds with poor air quality are subject to site-specific requirements that include offset provisions to ensure that (a) there is no net increase in the total emissions of particulates or sulfur dioxide within the airshed and (b) the resultant ambient levels of nitrogen dioxide do not exceed the levels specified for moderately degraded airsheds.[5] The measures agreed under the offset provisions must be implemented before the power plant comes fully on stream. Suitable offset measures could include reductions in emissions of particulates, sulfur dioxide, or nitrogen dioxide as a result of (a) the installation of new or more effective controls at other units within the same power plant or at other power plants in the same airshed, (b) the installation of new or more effective controls at other large sources, such as district heating plants or industrial plants, in the same airshed, or (c) investments in gas distribution or district heating systems designed to substitute for the use of coal for residential heating and other small boil-ers.[6] The monitoring and enforcement of the offset provisions would be the responsibility of the local or national agency responsible for granting and supervising environmental permits. Such offset provisions would normally be described in detail in a specific covenant in the project loan agreement.

Project sponsors who do not wish to engage in the negotiations necessary to put together an offset agreement would have the option of relying on an appropriate combination of clean fuels, controls, or both.

Particulate matter. For all plants or units, PM emissions (all sizes) should not exceed 50 mg/ Nm^3.[7] The EA should pay specific attention to particulates smaller than 10 µm in aerodynamic diameter (PM_{10}) in the airshed, since these are inhaled into the lungs and are associated with the most serious effects on human health. Where possible, ambient levels of fine particulates (less than 2.5 mm in diameter) should be measured. Recent epidemiologic evidence suggests that much of the health damage caused by exposure to particulates is associated with these fine particles, which penetrate most deeply into the lungs. Emissions of PM_{10} and fine particulates include ash, soot, and carbon compounds (often the results of incomplete combustion), acid condensates, sulfates, and nitrates, as well as lead, cadmium, and other metals. Fine particulates, including sulfates, nitrates, and carbon compounds, are also formed by chemical processes in the atmosphere, but they tend to disperse over the whole airshed.

Sulfur dioxide. Total sulfur dioxide emissions from the power plant or unit should be less than

0.20 metric tons per day (tpd) per MWe of capacity for the first 500 MWe, plus 0.10 tpd for each additional MWe of capacity over 500 MWe.[8] In addition, the concentration of sulfur dioxide in flue gases should not exceed 2,000 mg/Nm^3 (see note 4 for assumptions), with a maximum emissions level of 500 tpd. Construction of two or more separate plants in the same airshed to circumvent this cap is not acceptable.

Nitrogen oxides. The specific emissions limits for nitrogen oxides are 750 mg/Nm^3, or 260 nanograms per joule (ng/J), or 365 parts per million parts (ppm) for a coal-fired power plant, and up to 1,500 mg/Nm^3 for plants using coal with volatile matter less than 10%; 460 mg/Nm^3 (or 130 ng/J, or 225 ppm) for an oil-fired power plant; and 320 mg/ Nm^3 (or 86 ng/J, or 155 ppm) for a gas-fired power plant.

For combustion turbine units, the maximum NO_x emissions levels are 125 mg/Nm^3 (dry at 15% oxygen) for gas; 165 mg/Nm^3 (dry at 15% oxygen) for diesel (No. 2 oil); and 300 mg/Nm^3 (dry at 15% oxygen) for fuel oil (No. 6 and others).[9] Where there are technical difficulties, such as scarcity of water available for water injection, an emissions variance allowing a maximum emissions level of up to 400 mg/Nm^3 dry (at 15% oxygen) is considered acceptable, provided there are no significant environmental concerns associated with ambient levels of ozone or nitrogen dioxide.

For engine-driven power plants, the EA should pay particular attention to levels of nitrogen oxides before and after the completion of the project. Provided that the resultant maximum ambient levels of nitrogen dioxide are less than 150 $\mu g/m^3$ (24hour average), the specific emissions guidelines are as follows: (a) for funding applications received after July 1, 2000, the NO_x emissions levels should be less than 2,000 mg/Nm^3 (or 13 grams per kilo-watt-hour, g/kWh dry at 15% oxygen); and (b) for funding applications received before July 1, 2000, the NO_x emissions levels should be less than 2,300 mg/Nm^3 (or 17 g/kWh dry at 15% oxygen). In all other cases, the maximum emissions level of nitrogen oxides is 400 mg/Nm^3 (dry at 15% oxygen).

Offsets and the role of the World Bank Group. Large power complexes should normally not be developed in airsheds with moderate or poor air quality, or, if they must be developed, then only with appropriate offset measures. The costs of identifying and negotiating offsets for large power complexes are not large in relation to the total cost of preparing such projects. In the context of its regular country dialogue on energy and environmental issues, the World Bank is prepared to assist the process of formulating and implementing offset agreements for projects that are partly financed or guaranteed by the World Bank Group. If the offsets for a particular power project that will be financed by a World Bank Group loan involve specific investments to reduce emissions of particulates, sulfur oxides, or nitrogen oxides, these may be included within the scope of the project and may thus be eligible for financing under the loan.[10]

Long-range transport of acid pollutants. Where ground-level ozone or acidification is or may in future be a significant problem, governments are encouraged to undertake regional or national studies of the impact of sulfur dioxide, nitrogen oxides, and other pollutants that damage sensitive ecosystems, with, in appropriate cases, support from the World Bank (see Policy Framework, above). The aim of such studies is to identify least-cost options for reducing total emissions of these pollutants from a region or a country so as to achieve load targets, as appropriate.[11]

A possible (but not the only) approach to identifying sensitive ecosystems is to estimate critical loads for acid depositions and critical levels for ozone in different geographic areas. The analysis must, however, take into account the large degree of uncertainty involved in making such estimates.

In appropriate cases, governments should develop cost-effective strategies, as well as legal instruments, to protect sensitive ecosystems or to reduce transboundary flows of pollutants.

Where such regional studies have been carried out, the environmental assessment should take account of their results in assessing the overall impact of a proposed power plant.

The site-specific emissions requirements should be consistent with any strategy and applicable legal framework that have been adopted by the host country government to protect sensitive ecosystems or to reduce transboundary flows of pollutants.

Liquid Effluents

The effluent levels presented in Table 1 (for the applicable parameters) should be achieved daily without dilution.

Coal pile runoff and leachate may contain significant concentrations of toxics such as heavy metals. Where leaching of toxics to groundwater or their transport in surface runoff is a concern, suitable preventive and control measures such as protective liners and collection and treatment of runoff should be put in place.

Solid Wastes

Solid wastes, including ash and FGD sludges, that do not leach toxic substances or other con-

Table 1. Effluents from Thermal Power Plants
(milligrams per liter, except for pH and temperature)

Parameter	Maximum value
pH	6–9
TSS	50
Oil and grease	10
Total residual chlorine[a]	0.2
Chromium (total)	0.5
Copper	0.5
Iron	1.0
Zinc	1.0
Temperature increase	≤ 3°C[b]

.a. "Chlorine shocking" may be preferable in certain circum-stances. This involves using high chlorine levels for a few seconds rather than a continuous low-level release. The maximum value is 2 mg/l for up to 2 hours, not to be repeated more frequently than once in 24 hours, with a 24-hour average of 0.2 mg/l. (The same limits would apply to bromine and fluorine.)
.b. The effluent should result in a temperature increase of no more than 3° C at the edge of the zone where initial mixing and dilution take place. Where the zone is not defined, use 100 meters from the point of discharge when there are no sensitive aquatic ecosystems within this distance.

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taminants of concern to the environment may be disposed in landfills or other disposal sites provided that they do not impact nearby water bodies. Where toxics or other contaminants are expected to leach out, they should be treated by, for example, stabilization before disposal.

Ambient Noise

Noise abatement measures should achieve either the levels given below or a maximum increase in background levels of 3 decibels (measured on the A scale) [dB(A)]. Measurements are to be taken at noise receptors located outside the project property boundary.

	Maximum allowable log equivalent (hourly measurements), in dB(A)	
Receptor	Day (07:00–22:00)	Night (22:00–07:00)
Residential, institutional,	55	45

educational		
Industrial, commercial	70	70

Monitoring and Reporting

For measurement methods, see the chapter on Monitoring in this *Handbook*.

Maintaining the combustion temperature and the excess oxygen level within the optimal band in which particulate matter and NO_x emissions are minimized simultaneously ensures the greatest energy efficiency and the most economic plant operation. Monitoring should therefore aim at achieving this optimal performance as consistently as possible. Systems for continuous monitoring of particulate matter, sulfur oxides, and nitrogen oxides in the stack exhaust can be installed and are desirable whenever their maintenance and calibration can be ensured. Alternatively, surrogate performance monitoring should be performed on the basis of initial calibration. The following surrogate parameters are relevant for assessing environmental performance. (They require no changes in plant design but do call for appropriate training of operating personnel.)

- .*Particulate matter*. Ash and heavy metal content of fuel; maximum flue gas flow rate; minimum power supply to the ESP or minimum pressure drop across the baghouse; minimum combustion temperature; and minimum excess oxygen level.
- .*Sulfur dioxide*. Sulfur content of fuel.
- .*Nitrogen oxides*. Maximum combustion temperature and maximum excess oxygen level.

Direct measurement of the concentrations of emissions in samples of flue gases should be performed regularly (for example, on an annual basis) to validate surrogate monitoring results or for the calibration of the continuous monitor (if used). The samples should be monitored for PM and nitrogen oxides and may be monitored for sulfur oxides and heavy metals, although monitoring the sulfur and heavy metal content of fuel is considered adequate. At least three data sets for direct emissions measurements should be used, based on an hourly rolling average.

Automatic air quality monitoring systems measuring ambient levels of PM_{10}, sulfur oxides, and nitrogen oxides outside the plant boundary should be installed where maximum ambient concentration is expected or where there are sensitive receptors such as protected areas and population centers. (PM_{10} and SO_x measurements are, however, not required for gas-fired plants.) The number of air quality monitors should be greater if the area in which the power plant is located is prone to temperature inversions or other meteorological conditions that lead to high levels of air pollutants affecting nearby populations or sensitive ecosystems. The purpose of such ambient air quality monitoring is to help assess the possible need for changes in operating practices (including burning cleaner fuels to avoid high short-term exposures), especially during periods of adverse meteorological conditions. The pollutant guidelines specify short-term ambient air quality guideline values which, if exceeded, call for emergency measures such as burning cleaner fuels.

Any measures should be taken in close collaboration with local authorities. The specific design of the ambient monitoring system should be based on the findings of the EA. The frequency of ambient measurements depends on prevailing conditions; ambient measurements, when taken, should normally be averaged daily.

The pH and temperature of the wastewater discharges should be monitored continuously. Levels of suspended solids, oil and grease, and residual chlorine should be measured daily, and heavy metals and other pollutants in wastewater discharges should be measured monthly if treatment is provided.

Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. Records of monitoring results should be kept in an acceptable format. The results should be reported in summary form, with notification of exceptions, if any, to the responsible government authorities and relevant parties, as required. In the absence of specific national or local government guidelines, actual monitoring or surrogate performance data should be reported at least annually. The government may require additional explanation and may take corrective action if plants are found to exceed maximum emissions levels for more than 5% of the operating time, or on the occasion of a plant audit. The objective is to ensure continuing compliance with the emissions limits agreed at the outset, based on sound operation and maintenance. Exceedances of the maximum emissions levels would normally be reviewed in light of the enterprise's good-faith efforts in this regard.

As part of the Framework Convention on Climate Change, countries will be asked to record their emissions of greenhouse gases (GHG). As an input to this, and to facilitate possible future activities implemented jointly with Annex I countries, the emissions of individual projects should be estimated on the basis of the chemical composition of the fuel or measured directly. Table 2 in the chapter on Greenhouse Gas Abatement and Climate Change in Part II of this *Handbook* provides relevant emissions factors.

In order to develop institutional capacity, training should be provided with adequate budgets to ensure satisfactory environmental performance. The training may include education on environmental assessment, environmental mitigation plans, and environmental monitoring. In some cases, it may be appropriate to include the staff from the environmental implementation agencies, such as the state pollution control board, in the training program

Key Issues

The key production and emissions control practices that will lead to compliance with the above guidelines are summarized below. It is assumed that the proposed project represents a least-cost solution, taking into account environmental and social factors.

- .Choose the cleanest fuel economically available (natural gas is preferable to oil, which is preferable to coal).
- .Give preference to high-heat-content, low-ash, low-sulfur coal (or high-heat-content, high-sulfur coal, in that order) and consider beneficiation for high-ash, high-sulfur coal.
- .Select the best power generation technology for the fuel chosen to balance the environmental and economic benefits. The choice of technology and pollution control systems will be based on the site-specific environmental assessment. Keep in mind that particulates smaller than 10 microns in size are most important from a health perspective. Acceptable levels of particulate matter removal are achievable at relatively low cost. Consider cost-effective technologies such as pre-ESP sorbent injection, along with coal washing, before in-stack removal of sulfur dioxide. Use low-NO_x burners and other combustion modifications to reduce emissions of nitrogen oxides.
- .Before adopting expensive control technologies, consider using offsetting reductions

in emissions of critical pollutants at other sources within the airshed to achieve acceptable ambient levels.

- .Use SO_x removal systems that generate less wastewater, if feasible; however, the environmental and cost characteristics of both inputs and wastes should be assessed case by case.
- .Manage ash disposal and reclamation so as to minimize environmental impacts—especially the migration of toxic metals, if present, to nearby surface and groundwater bodies, in ad-

dition to the transport of suspended solids in surface runoff. Consider reusing ash for building materials.

- .Consider recirculating cooling systems where thermal discharge to water bodies may be of concern.
- .Note that a comprehensive monitoring and reporting system is required.

Annex A. Engine-Driven Power Plants

Engine-driven power plants use fuels such as diesel oil, fuel oil, gas, orimulsion, and crude oil. The two types of engines normally used are the me-dium-speed four-stroke trunk piston engine and the low-speed two-stroke crosshead engine. Both types of engine operate on the air-standard diesel thermodynamic cycle. Air is drawn or forced into a cylinder and is compressed by a piston. Fuel is injected into the cylinder and is ignited by the heat of the compression of the air. The burning mixture of fuel and air expands, pushing the piston. Finally the products of combustion are removed from the cylinder, completing the cycle. The energy released from the combustion of fuel is used to drive an engine, which rotates the shaft of an alternator to generate electricity. The combustion process typically includes preheating the fuel to the required viscosity, typically 16–20 centiStokes (cSt), for good fuel atomization at the nozzle. The fuel pressure is boosted to about 1,300 bar to achieve a droplet distribution small enough for fast combustion and low smoke values. The nozzle design is critical to the ignition and combustion process. Fuel spray penetrating to the liner can damage the liner and cause smoke formation. Spray in the vicinity of the valves may increase the valve temperature and contribute to hot corrosion and burned valves. If the fuel timing is too early, the cylinder pressure will increase, resulting in higher nitrogen oxide formation. If injection is timed too late, fuel consumption and turbocharger speed will increase. NO_x emissions can be reduced by later injection timing, but then particulate matter and the amount of unburned species will increase.

Ignition quality. For distillate fuels, methods for establishing ignition quality include cetane number and cetane index for diesel. The CCAI number, based on fuel density and viscosity, gives a rough indication of the ignition behavior of heavy fuel oil.

Fuel quality. Fuel ash constituents may lead to abrasive wear, deposit formation, and high-tem-perature corrosion, in addition to emissions of particulate matter. The properties of fuel that may affect engine operation include viscosity, specific gravity, stability (poor stability results in the precipitation of sludge, which may block the filters), cetane number, asphaltene content, carbon residue, sulfur content, vanadium and sodium content (an indicator of corrosion, especially on exhaust valves), presence of solids such as rust, sand, and aluminum silicate, which may result in blockage of fuel pumps and liner wear, and water content.

Waste characteristics. The wastes generated are typical of those from combustion processes. The exhaust gases contain particulates (including heavy metals if present in the fuel), sulfur and nitrogen oxides, and, in some cases, VOCs. Nitrogen oxides are the main concern after particulate matter in the air emissions. NO_x emissions levels are (almost exponentially) dependent on the temperature of combustion, in addition to other factors. Most of the NO_x emissions are formed from the air used for combustion and typically range from 1,100 to 2,000 ppm at 15% oxygen. Carbon dioxide emissions are approximately 600 g/kWh of electricity, and total hydrocarbons (calculated as methane equivalent) are 0.5 g/kWh of electricity.

The exhaust gases from an engine are affected by (a) the load profile of the prime mover; (b) ambient conditions such as air humidity and temperature; (c) fuel oil quality, such as sulfur content, nitrogen content, viscosity, ignition ability, density, and ash content; and (d) site conditions and the auxiliary equipment associated with the prime mover, such as cooling properties and exhaust gas back pressure. The engine parameters that affect nitrogen oxide emissions are (a) fuel injection in terms of timing, duration, and atomization; (b) combustion air conditions, which are affected by valve timing, the charge air system, and charge air cooling before cylinders; and (c) the combustion process, which is affected by air and fuel mixing, combustion chamber design, and the compression ratio. The particulate matter emissions are dependent on the general conditions of the engine, especially the fuel injection system and its maintenance, in addition to the ash content of the fuel, which is in the range 0.05–0.2%. SO_x emissions are directly dependent on the sulfur content of the fuel. Fuel oil may contain around 0.3% sulfur and, in some cases, up to 5%.

Annex B. Illustrative Pollution Prevention and Control Technologies

A wide variety of control technology options is available. As usual, these options should be considered after an adequate assessment of broader policy options, including pricing and institutional measures. Additional information is provided in the relevant documents on pollution control technologies.

Cleaner Fuels

The simplest and, in many circumstances, most cost-effective form of pollution prevention is to use cleaner fuels. For new power plants, combined-cycle plants burning natural gas currently have a decisive advantage in terms of their capital costs, thermal efficiency, and environmental performance. Natural gas is also the preferred fuel for minimizing GHG emissions because it produces lower carbon dioxide emissions per unit of energy and enhances energy efficiency.

If availability or price rule out natural gas as an option, the use of low-sulfur fuel oil or high-heat-content, low-sulfur, low-ash coal should be considered. Typically, such fuels command a premium price over their dirtier equivalents, but the reductions in operating or environmental costs that they permit are likely to outweigh this premium. In preparing projects, an evaluation of alternative fuel options should be conducted at the outset to establish the most cost-effective combination of fuel, technology, and environmental controls for meeting performance and environmental objectives.

If coal is used, optimal environmental performance and economic efficiency will be achieved through an integrated approach across the whole coal-energy chain, including the policy and investment aspects of mining, preparation, transport, power generation and heat

conversion, and clean coal technologies. Coal washing, in particular, has
a beneficial impact in terms of reducing the ash content and ash variability of coal used in thermal power plants, which leads to consistent boiler performance, reduced emissions, and less maintenance.

Abatement of Particulate Matter

The options for removing particulates from exhaust gases are cyclones, baghouses (fabric filters), and ESPs. Cyclones may be adequate as precleaning devices; they have an overall removal efficiency of less than 90% for all particulate matter and considerably lower for PM_{10}. Baghouses can achieve removal efficiencies of 99.9% or better for particulate matter of all sizes, and they have the potential to enhance the removal of sulfur oxides when sorbent injection, dry-scrubbing, or spray dryer absorption systems are used. ESPs are available in a broad range of sizes for power plants and can achieve removal efficiencies of 99.9% or better for particulate matter of all sizes.

The choice between a baghouse and an ESP will depend on fuel and ash characteristics, as well as on operating and environmental factors. ESPs can be less sensitive to plant upsets than fabric filters because their operating effectiveness is not as sensitive to maximum temperatures and they have a low pressure drop. However, ESP performance can be affected by fuel characteristics. Modern baghouses can be designed to achieve very high removal efficiencies for PM_{10} at a capital cost that is comparable to that for ESPs, but it is necessary to ensure appropriate training of operating and maintenance staff.

Abatement of Sulfur Oxides

The range of options and removal efficiencies for SO_x controls is wide. Pre-ESP sorbent injection can remove 30–70% of sulfur oxides, at a cost of US$50–$100 per kW. Post-ESP sorbent injection can achieve 70–90% SO_x removal, at a cost of US$80–$170 per kW. Wet and semidry FGD units consisting of dedicated SO_x absorbers can remove 70–95%, at a cost of US$80–$170 per kW (1997 prices). The operating costs of most FGDs are substantial because of the power consumed (of the order of 1–2% of the electricity generated), the chemicals used, and disposal of residues. Esti-

mates by the International Energy Agency (IEA) suggest that the extra levelized annual cost for adding to a coal-fired power plant an FGD designed to remove 90% of sulfur oxides amounts to 10–14% depending on capacity utilization.

An integrated pollution management approach should be adopted that does not involve switching from one form of pollution to another. For example, FGD scrubber wastes, when improperly managed, can lead to contamination of the water supply, and such SO_x removal systems could result in greater emissions of particulate matter from materials handling and windblown dust. This suggests the need for careful benefit-cost analysis of the types and extent of SO_x abatement.

Abatement of Nitrogen Oxides

The main options for controlling NO_x emissions are combustion modifications: low-NO_x burners with or without overfire air or reburning, water/steam injection, and selective catalytic or noncatalytic reduction (SCR/SNCR). Combustion modifications can remove 30–70% of nitrogen oxides, at a capital cost of less than US$20 per kW and a small increase in operating costs. SNCR systems can remove 30–70% of nitrogen oxides, at a capital cost of US$20–$40 per kW and a moderate increase in operating cost. However, plugging of the preheater because of the formation of ammonium bisulfate may pose some problems. SCR units can remove 70–90% of nitrogen oxides but involve a much larger capital cost of US$40–$80 per kW and a significant increase in operating costs, especially for coal-fired plants. Moreover, SCR may require low-sulfur fuels (less than 1.5% sulfur content) because the catalyst elements are sensitive to the sulfur dioxide content in the flue gas.

Fly Ash Handling

Fly ash handling systems may be generally categorized as dry or wet, even though the dry handling system involves wetting the ash to 10–20% moisture to improve handling characteristics and to mitigate the dust generated during disposal. In wet systems, the ash is mixed with water to produce a liquid slurry containing 5–10% solids by weight. This is discharged to settling ponds, often with bottom ash and FGD sludges, as well. The ponds may be used as the final disposal site, or the settled solids may be dredged and removed for final disposal in a landfill. Wherever feasible, decanted water from ash disposal ponds should be recycled to formulate ash slurry. Where heavy metals are pre-sent in ash residues or FGD sludges, care must be taken to monitor and treat leachates and overflows from settling ponds, in addition to disposing of them in lined places to avoid contamination of water bodies. In some cases, ash residues are being used for building materials and in road construction. Gradual reclamation of ash ponds should be practiced.

Water Use

It is possible to reduce the fresh water intake for cooling systems by installing evaporative recirculating cooling systems. Such systems require a greater capital investment, but they may use only 5% of the water volume required for once-through cooling systems. Where once-through cooling systems are used, the volume of water required and the impact of its discharge can be reduced by careful siting of intakes and outfalls, by minimizing the use of biocides and anticorrosion chemicals (effective nonchromium-based alternatives are available to inhibit scale and products of corrosion in cooling water systems), and by controlling discharge temperatures and thermal plumes. Wastewaters from other processes, including boiler blowdown, demineralizer backwash, and resin regenerator wastewater, can also be recycled, but again, this requires careful management and treatment for reuse. Water use can also be reduced in certain circumstances through the use of air-cooled condensers.

Annex C. Ambient Air Quality

The guidelines presented in Table C.1 are to be used only for carrying out an environment assessment in the absence of local ambient standards. They were constructed as consensus values taking particular account of WHO, USEPA, and EU standards and guidelines. *They do not in any way substitute for a country's own ambient air quality standards.*

Table C.1. Ambient Air Quality in Thermal Power Plants
(micrograms per cubic meter)

Pollutant	24-hour average	Annual average
PM_{10}	150	50
TSP[a]	230	80
Nitrogen dioxide	150	100
Sulfur dioxide	150	80

a. Measurement of PM_{10} is preferable to measurement of TSP.

Notes

1. 1. For plants smaller than 50 MWe, including those burning nonfossil fuels, PM emissions levels may be as much as 100 mg/Nm³. If justified by the EA, PM emissions levels up to 150 mg/Nm³ may be acceptable in special circumstances. The maximum emissions levels for nitrogen oxides remain the same, while for sulfur dioxide, the maximum emissions level is 2,000 mg/Nm³.

   2. *Airshed* refers to the local area around the plant whose ambient air quality is directly affected by emissions from the plant. The size of the relevant local airshed will depend on plant characteristics, such as stack height, as well as on local meteorological conditions and topography. In some cases, airsheds are defined in legislation or by the relevant environmental authorities. If not, the EA should clearly define the airshed on the basis of consultations with those responsible for local environmental management.

   In collecting baseline data, qualitative assessments may suffice for plants proposed in greenfield sites. For nondegraded airsheds, quantitative assessment using models and representative monitoring data may suffice.
2. 3. See, e.g., United States, 40 CFR, Part 51, 100 (ii). Normally, GEP stack height = $H + 1.5L$, where H is the height of nearby structures and L is the lesser dimension of either height or projected width of nearby structures.
3. 4. The assumptions are as follows: for coal, flue gas dry 6% excess oxygen—assumes 350 Nm^3/GJ. For oil, flue gas dry 3% excess oxygen—assumes 280 Nm^3/ GJ. For gas, flue gas dry 3% excess oxygen—assumes 270 Nm^3/GJ (see annex D). The oxygen level in engine exhausts and combustion turbines is assumed to be 15%, dry. See the document on Monitoring for measurement methods.
4. 5. Gas-fired plants (in which the backup fuel contains less than 0.3% sulfur) and other plants that achieve emissions levels of less than 400 mg/Nm^3 for sulfur oxides and nitrogen oxides are exempt from the offset requirements, since their emissions are relatively lower.

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Annex D. Conversion Chart

To convert To (multiply by):

Table D.1. SO_2 and NO_x Emissions Conversion Chart for Steam-Based Thermal Power Plants From	Mg/Nm^3	ppm NO_x	ppm SO_2	g/GJ Coal[a]	g/GJ Oil[b]	g/GJ Gas[c]	$lb/10^6$ Btu Coal[a]	$lb/10^6$ Btu Oil[b]	$lb/10^6$ Btu Gas[c]
Mg/Nm^3	1	0.487	0.350	0.350	0.280	0.270	8.14 x 10-4	6.51 x 10-4	6.28 x 10-4
ppm NO_x	2.05	1		0.718	0.575	0.554	1.67 x 10-3	1.34 x 10-3	1.29 x 10-3
ppm SO_2	2.86		1	1.00	0.801	0.771	2.33 x 10-3	1.86 x 10-3	1.79 x 10-3
G/GJ									
Coal[a]	2.86	1.39	1.00	1			2.33 x 10-3		
Oil[b]	3.57	1.74	1.25		1			2.33 x 10-3	
Gas[c]	3.70	1.80	1.30			1			2.33 x 10-3
$lb/10^6$ Btu									
Coal[a]	1,230	598	430	430			1		
Oil[b]	1,540	748	538		430			1	
Gas[c]	1,590	775	557			430			1

Note:g/GJ, grams per gigajoule; $lb/10^6$ Btu, pounds per 100,000 British thermal units; Mg/Nm^3, megagrams per normal cubic meter; ppm, parts per million.

.a. Flue gas dry 6% excess O_2; assumes 350 Nm^3/GJ.
.b. Flue gas dry 3% excess O_2; assumes 280 Nm^3/GJ.
.c. Flue gas dry 3% excess O_2; assumes 270 Nm^3/GJ.
Source: International Combustion Ltd.; data for coal, oil, and gas based on IEA 1986.

1. 6. Wherever possible, the offset provisions shouldbe implemented within the framework of an overall air quality management strategy designed to ensure that air quality in the airshed is brought into compliance with ambient standards.
2. 7. A normal cubic meter (Nm^3) is measured at 1 atmosphere and 0° C. The additional cost of controls designed to meet the 50 mg/Nm^3 requirement, rather than one of 150 mg/Nm^3 (e.g., less than 0.5% of total investment costs for a 600 MW plant) is expected to be less than the benefits of reducing ambient exposure to particulates. The high overall removal rate is necessary to capture PM_{10} and fine particulates that seriously affect human health. Typically about 40% of PM by mass is smaller than 10 µm, but the collection efficiency of ESPs drops considerably for smaller particles. A properly designed and well-operated plant can normally achieve the lower emissions levels as easily as it can achieve higher emissions levels.

An exception to the maximum PM emissions level may be granted to engine-driven power plants for which funding applications are received before January 1, 2001. PM emissions levels of up to 75 mg/Nm^3 would be allowed, provided that the EA presents documentation to show that (a) lower-ash grades of fuel oil are not commercially available; (b) emissions control technologies are not commercially available; and (c) the resultant ambient levels for PM_{10} (annual average of less than 50 $\mu g/m^3$ and 24-hour mean of less than 150 $\mu g/m^3$) will be maintained for the entire duration of the project.

1. 8. The maximum SO_x emissions levels were back-calculated using the U.S. Environmental Protection Agency Industrial Source Complex (ISC) Model, with the objective of complying with the 1987 WHO Air Quality Guidelines for acceptable one-hour (peak) ambient concentration levels (350 $\mu g/m^3$). The modeling results show that, in general, an emissions level of 2,000 mg/m^3 (equivalent to 0.2 tpd per MWe) results in a one-hour level of 300 $\mu g/m^3$, which, when added to a typical existing background level of 50 $\mu g/m^3$ for greenfield sites, produces a one-hour level of 350 $\mu g/m^3$ (see the discussion of degraded airsheds in the text). Compliance with the WHO one-hour level is normally the most significant, as short-term health impacts are considered to be the most important; compliance with this level also, in general, implies compliance with the WHO 24-hour and annual average guidelines. For large plants, the emissions guidelines for sulfur dioxide were further reduced to 0.1 tpd per MWe for capacities above 500 MWe to maintain acceptable mass loadings to the environment and thus address ecological concerns (acid rain). This results in a sulfur dioxide emissions level of 0.15 tpd/MWe (or 1.275 lb/mm Btu) for a 1,000 MWe plant.
2. 9. Where the nitrogen content of the liquid fuel isgreater than 0.015% and the selected equipment manufacturer cannot guarantee the emissions levels pro

vided in the text, an NO_x emissions allowance (i.e., added to the maximum emissions level) can be computed based on the following data as exceptions:

Nitrogen content (percentage by weight)	*Correction factor (NO_x percentage by volume)*
0.015–0.1	0.04 N
0.1–0.25	0.004 + 0.0067 (N – 0.1)
> 0.25	0.005

*Note: C*orrection factor, 0.004% = 40 ppm = 80 mg/Nm^3.

There may be cases in which cost-effective NO_x controls may not be technically feasible. Exceptions to the NO_x emissions requirements (including those given in this note) are acceptable provided it can be shown that (a) for the entire duration of the project, the alternative emissions level will not result in ambient conditions that have a significant impact on human health and the environment, and (b) cost-ef-fective techniques such as low-NO_x burners, LEA, water or steam injection, and reburning are not feasible.

1. 10. It should be noted that the offset requirement, which focuses on the level of total emissions, should result in an improvement in ambient air quality within the airshed, compared with the baseline scenario (as documented with ambient air monitoring data), if the offset measures are implemented for non-power-plant sources. Such sources typically emit from stacks of a lower average height than those for the new power plant.
2. 11. Part II of this *Handbook* provides guidance on possible approaches for dealing with acid emissions. There is substantial scope for exploiting the synergies between the local and long-range benefits of emissions reductions.

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Appendix 5 Noise Calibrator Certificate

Certificate of Calibration

Certificate No: 1028544-0QI0110126

Submitted By: CL ENVIRONMENTAL CO LTD
APT #7 117 CONSTANT SPRING ROAD
KINGSTON, 10
JM

Serial No:	0QI0110126	**Date Received:**	3-Nov-2004
Customer ID:	N/A	**Date Issued:**	8-Nov-2004
Model:	QC-10	**Valid Until**	8-Nov-2005

SubAssemblies:

Description	**Serial Number**

Test Conditions:

		Model Conditions:	
Temperature:	18°C to 29°C	As Received:	Fully Functional and In Tolerance
Humidity:	20% to 80%	Final Condition:	Fully Functional and In Tolerance
Barometric Pressure:	890 mbar to 1050 mbar		

Calibrated per Procedure: 56V981

Reference Standard

Device	**Serial Number**	**Last Calibration**	**Date Calibration Due**
B&K Ensemble	ET0000366	3-Aug-2004	3-Aug-2005
Fluke 45	ET0000389	27-Mar-2003	27-Mar-2005
Fluke PM6666	ET0000416	27-Mar-2003	27-Mar-2005

Measurement Uncertainty:
+/- 2.4% Acoustic (0.2dB) +/- 1.4% AC Voltage +/- 0.001% Frequency
Estimated at 95% Confidence Level (k=2)

Calibrated By: Brian Bayer 8-Nov-2004
Brian Bayer **Service Technician**

This report certifies that all calibration equipment used in the test is traceable to the 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.

In order to ensure best instrument performance over time and in the event of inspection, audit or litigation, we recommend the instrument be recalibrated annually. Any number of factors may cause the calibration item to drift out of calibration before the recommended interval has expired.

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098-393 Rev. A

Appendix 6   A Copy of the Community Survey Questionnaire

JEP NEW POWER BARGE EIA

COMMUNITY QUESTIONNAIRE

DATE:___________________ **INTERVIEWER:_______________**

LOCATION:___________________

EMPLOYMENT & INCOME

1 Who is the head of the household? (i) father (ii) mother (iii) grandparents
(iv) uncle (v) aunt (vi) other_______________

2 What is the age of the household head? (i) 18- 25 yrs (ii) 26-33 yrs
(iii) 34-41 yrs (iv) 42 – 50 yrs (v) 51 – 60 yrs (vi) older than 60 yrs

3 What is the main employment status of the household head? (If the interviewee is not the head of the household).
(i) part time, (ii) seasonal, (iii) full time, (iv) unemployed (v) retired
(vi) self employed (v)other ____________

4 What is the trade of the household head? ______________________________________

5 What is the trade of the partner? ____

6 How many persons in the household are presently employed? _____________________

7 Are you currently (i) employed (ii) unemployed (iii) retired

8 If employed do you work (i) part time, (ii) seasonally, (iii) full time (vi) self employed
(v) other ____________

9 If employed, what do you do? ____
(i) casual labour (ii) semi - skilled (iii) skilled (iv) artisan (v) professional

10 Where do you work? ___________________________

11 How far is your work from home? (i) less than a km, (ii) 1- 5km, (iii) 6- 15km (iv) >15km.

**** Use Table 1 to answer questions 9 - 11.**

1. Below $500	6. $3001 - $4000
2. $ 501 - $1000	7. $4001 - $5000
3. $1001 - $1500	8. $5001 - $6000
4. $1501 - $2000	9. $6001 - $7000
5. $2001 - $3000	10.Over $7000

9 What is the average weekly income of the household head? ______________________

10 What is the average weekly income of the partner?
____

11 What is the average weekly income of the household? (All sources)
____

12 Do you depend on the proposed barge location and adjoining land area for business?

____

EDUCATION

1 Which school do members of your household attend?
Basic [ ] Primary [ ] All Age [ ] Junior High [ ] New Secondary [ ] Secondary High [ ] Comprehensive High [ ] Technical High [ ] Vocational Agricultural [ ] Community College [ ] Teachers College [ ] University [ ] HEART [ ] Other [ ] ____

NAME / TYPE OF SCHOOL	DISTANCE FROM HOME (Km)	# OF PERSONS

HOUSING & SOCIAL AMENITIES

1 Approximately how old is the house you are living in?

0 - 5 yrs. [ ] 6 - 11 yrs. [ ] 12 - 17 yrs. [ ] 18 - 24 yrs. [ ] 25 - 30yrs. [ ] Over 30 yrs. [ ]

2 How long have you (household) been living here?

0 - 5 yrs. [ ] 6 - 11 yrs. [ ] 12 - 17 yrs. [ ] 18 - 24 yrs. [ ] Over 24 yrs. [ ]

3 Number of bedrooms? __________

4 Do you have telephone? (i) Yes (ii) No (iii) Cellular phone (iv) Cables are being laid

NATURAL HAZARDS

1 Are there problems with frequent flooding? (i) Yes (ii) No

2 How frequently does flooding occur?

3 Where are the affected areas?

4 How high does the water level rise?

5 Are there problems with frequent earthquakes? (i) Yes (ii) No

6 Are there problems with frequent fires?

7 During Hurricane Ivan were you affected by storm surge or sea level rise? (i) Yes (ii) No

SERVICES, COMMUNITY COHESIVENESS & DEVELOPMENT

1 How do you travel? (i) Bus (ii) Personal vehicle (iii) Taxi (iv) Other ___________________

2 How much do you pay to travel? ____

3 Where do you normally shop for the household? ___________________________

4 Where do you go to market? ____

5 Where do you go for health care when you are sick? ________________________

6 Over the past twelve months did you or any member of your household have frequent: (i) bouts of diarrhoea (ii) coughing (iii) suffocating feelings (iv) congestion (v) chest pains?

7 If yes how often? ______________________________

8 Are there any church groups in your area? (i) Yes _____________________(ii) No

9 Are there any environmental groups in your area? (i) Yes ____________ (ii) No

10 Are there any other organizations in your area? (i) Yes _____________________ (ii) No

11 How active are these organizations? ______________________________________

12 Are you actively involved in any of these groups? (i) Yes (ii) No (iii) Used to be

____

RECREATION & CONSERVATION

1 Are there any recreational facilities nearby? (i) Yes (ii) No

2 If yes, name and location of facility ____________________________________

3 Are you aware of any historic or cultural areas / sites in your community or nearby?

(i) Yes ____ (ii) No

4 If yes, what do you know about the site? _______________________________________

5 Are you aware of any nature reserves in your community or nearby? (i) Yes (ii) No

If yes, where is the site? ____

PERCEPTION

1 Are you aware that the Jamaica Energy Partners (JEP) intends to install a second power barge in your area? (i) Yes (ii) No

2 If yes, how were you informed?

____

3 Do you think this type of facility is suitable for this location?

____

4 If not, which location would you suggest?

____

5 Does the presence of the existing facility (JPS/JEP) impact on your lifestyle in any way? (i) Yes (ii) No
If yes how? ____

6 How would the installation of another barge affect your lifestyle?

____

____

7 Is there anything in particular about your area that you would like to tell us?

____

____

8 Any other comments:

Signature: ....
Interviewer

Appendix 7 Background Information Air Quality

Equivalent Stack Diameter Calculation(for 6 JEP 1 stacks)

Given:
Stack velocity (from source test data): 43.01 meters/second
Stack Flow rate (from 1 stack): 2,373 actual cubic meters per minute

Calculations:
2,373 acm/m x 1 min/60 sec = 39.6 acm/sec

6 stacks x 39.6 acm/sec = 237.6 m3/sec

$Q = 3.1417 \times r^2 \times V$
$237.6 = 3.1417 \times r^2 \times 43.01$
$r = 237.6/3.1417 \times 43.01$
$r = 1.33$ m
diameter = 2.66 m

Equivalent Stack Diameter Calculation(for 3 JEP 2 stacks)

Given:
Stack Velocity (from vendor data): 36.38 m/sec
Stack Flow Rate from one stack): 56 m^3/sec

Calculations:
3 stacks x 56m^3/sec = 168m^3/sec

$Q = 3.1417 \times r^2 \times V$
$168 = 3.1417 \times r^2 \times 36.38$
$r = 168/3.1417 \times 36.38$
$r = 1.21$ m
Diameter = 2.42 meters

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