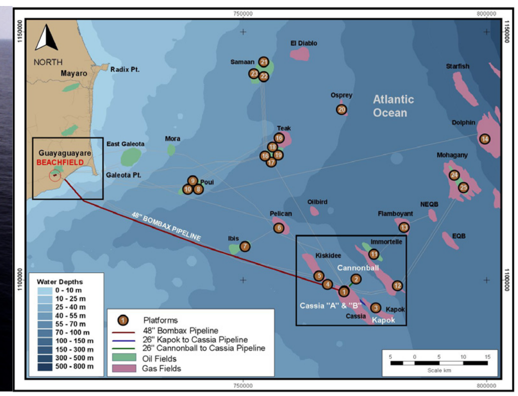
ENVIRONMENTAL IMPACT ASSESSMENT

CANNONBALL FIELD DEVELOPMENT PROJECT
EAST COAST, TRINIDAD





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Prepared by
Coastal Dynamics
#3 Second Avenue
Cascade
Port of Spain
Republic of Trinidad and Tobago
+868 627 4336 voice
+868 627 1183 fax
www.coastaldynamics.com

CoastalDynamics
Marine environmental solutions

Standard Information Sheet

Project name	The Cannonball Field Development Project
Development location	South East Galeota Block (SEG)
CEC Reference Number	CEC0564/2003
Type of project	Design, fabrication, installation and operation of a Wellhead Protector Platform with an associated 5 km long, 26” pipeline offshore on the east coast of Trinidad. Onshore modifications to the existing Beachfield Gas Receiving facility, which include construction, installation and operation of an associated 48” pipeline.
Undertaker	bpTT LLC of Trinidad and Tobago Queen’s Park Plaza Queen’s Park Savannah Port-of-Spain
Licensee/owner	bpTT LLC Company of Trinidad and Tobago. The construction and installation of the associated pipeline (575 m, 48” pipeline between Beachfield Gas Receiving Facility and NGC’s 56” Cross Island Pipeline is being done on behalf of NGC.
Short description	bpTT intends to develop the Cannonball west gas field which is located in the South East Galeota Block approximately 60km offshore the East Coast of Trinidad. The Cannonball Field Development comprises a wellhead protector platform (WPP) with the capacity to produce 1 billion standard cubic feet of gas per day from 2 to 3 wells. The WPP is designed as a 9 well slot platform to accommodate future developments. The Cannonball WPP will be connected to the existing Cassia B hub via a 5 km long 26’ pipeline. The onshore portion of the project occurs at the existing Beachfield Gas Receiving facility. The objective of the modifications is to upgrade the capacity of Beachfield from 1.8 bcfd to 2.9 bcfd. The scope includes the installation of additional pieces of equipment and the construction and installation of an associated 575m 48” pipeline which will tie into NGC’s 56” Cross Island Pipeline (CIP).

Dates	Installation and commissioning of the WPP:	April 2005
	Installation of 26'offshore pipeline	April 2005
	Commissioning of 26'offshore pipeline	May 2005
	Completion of the WPP	March 2005
	Construction at Beachfield Gas Receiving Facility	May 2004
	Installation and Commissioning of the 48" pipeline	May 2005
	Drilling	May 2005
	First gas	3rd Quarter 2005
Significant environmental aspects identified	Yes	
Statement prepared by	bpTT LLC Company of Trinidad and Tobago	

ACRONYMS	
Acronyms	**Meaning**
Atlantic LNG	Atlantic Liquefied Natural Gas Company of Trinidad and Tobago
ASCO	Aberdeen Service Company
BOP	Blowout Preventer
CEC	Certificate of Environmental Clearance
CIP	Cross Island Pipeline
CCTV	Command and Control Training Vehicle
CBO	Community Based Organisation
CID	Criminal Investigative Department
CO_2	Carbon Dioxide
COPE	Council of Presidents for the Environment
CO	Carbon Monoxide
CFR	Code of Federal Regulations
CPH	Central Processing Hub
CSO	Central Statistical Office
CIF	Cassia, Immortelle and Flamboyant
CIP	Cross Island Pipeline
DVC	Diver Support System
DSV	Diver Support Vessel
DHI	Danish Hydraulic Institute
DHSV	Down Hole Safety Valve
EIA	Environmental Impact Assessment
ERP	Emergency Response Plan
EEZ	Exclusive Economic Zone
EIT	Electrical, Instrumentation and Telecommunications
EMA	Environmental Management Agency
EMP	Environmental Management Plan
EMS	Environmental Management Plan
FAO	Fisheries and Agricultural Organisation (United Nations)
FAD	Fish Attracting Devices
FBE	Fusion-bonded Epoxy
GOM	Gulf of Mexico
GDP	Gross Domestic Product
GPS	Global Positional System
GIS	Geographic Information System
HVAC	Heating Ventilation and Air Conditioning
HSE	Health, Safety and Environment
HC	Hydrocarbon
HIPPS	High Integrity Pressure Protection System
IMA	Institute of Marine Affairs
ISO	International Standards Organization
LAO	Linear Alpha Olefins

ACRONYMS	
Acronyms	**Meaning**
LAN	Local Area Network
LABIDCO	La Brea Industrial Company
MIC	Metals Industries Company
MEEI	Ministry of Energy and Energy Industries
MARPOL	Marine Pollution convention
MEL	Micro Enterprises Loan Facility
MGOUCC	Mayaro/Guayaguayare Unemployment Organization for Concerned Citizens
MCC	Motor Control Centre
MMSCFD	Million Standard Cubic Feet per Day
NGC	National Gas Company
NDT	Non Destructive Testing
NGC	National Gas Company
NESC	National Energy and Skills Center
NEMA	National Emergency Management Authority
NO_x	Nitrous Oxides
NGOs	Non-Governmental Organizations
OAS	Organisation of American States
O_2	Oxygen
QRA	Quantitative Risk Assessment
ROC	Retention of oil on cuttings
ROW	Right of Way
RAM	Reliability, Availability and Maintenance Study
RMZ	Regulatory Mixing Zone
SCF	Standard Cubic Feet
SOBM	Synthetic Oil Based Mud
SO_2	Sulphur Dioxide
SBDC	Small Business Development Company
SWMCOL	Solid Waste Management Company Limited
SPCC	Spill Prevention, Control and Countermeasure
SCSSSV	Surface Controlled Subsea Safety Valve
SOLAS	Safety Of Life At Sea
TOR	Terms of Reference
TCPD	Town and Country Planning Division
TT	Trinidad and Tobago
TPSD	Total Platform Shutdown
TSS	Total Suspended Solids
TTHTI	Trinidad and Tobago Hospitality and Tourism Institute
TTBS	Trinidad and Tobago Bureau of Standards
UTM	Universal Transverse Mercator
U.S.	United States
USEPA	United States Environmental Protection Agency
UWI	University of the West Indies

ACRONYMS	
Acronyms	**Meaning**
UPS	Uninterruptible Power Supply
UNCLOS	United Nations Convention on the Law of the Sea
VOC	Volatile Organic Compounds
WPP	Wellhead Protector Platform
WGS	World Geodetic System
WBM	Water Based Muds
WASA	Water and Sewage Authority

GLOSSARY	
Term	**Meaning**
Bathymetry	The measurement of ocean depth and the study of sea floor topography.
Benthic	Relating to organisms that are attached to or resting on the sediment at the seabed.
Blowout	An uncontrolled flow of gas or oil from the reservoir into unprotected shallow formations or to the surface.
BOP	A hydraulically operated wellhead device designed to safely close in a well and ensure a release of fluids (a blowout) does not occur. A blowout occurs when gas, oil or saltwater escapes in an uncontrolled manner.
Commissioning	This activity demonstrates that the facility constructed performs to the design specification.
Cathodic Protection	The protection of a metal surface from corrosion using less reactive metal via an electrolysis method, where the protecting metal is made the anode and the surface to be protected is made the cathode.
Casing	Steel lining used to prevent caving of the sides of a well, to exclude unwanted fluids and to provide a means of the control of well pressures and oil and gas production.
Cuttings	The small chips and residue from the drilling of the rock formation at the well site.
Downhole Completion	The process by which a finished well is either sealed off or prepared for production by fitting a wellhead.
Drill String	The drill string is made up of the following: • Drill collar: heavy lengths of pipe • Stabilizers: are added to the drill string at intervals to hold, increase or decrease the hole angle • Drill pipe: consists of 30 foot long sections of steel pipe (joints) screwed together.
Exploration Well	A well drilled to determine the presence and extent of hydrocarbons present in the proposed reservoir.
Faults	Zones of inherent weakness in rock.
Fusion-Bonded Epoxy	A chemical coating used to protect pipelines.
Hydrotesting	Pipelines and/or production equipment are pressured and filled with water to determine its integrity.
Helideck	An area on the platform designed for the landing of a helicopter.
Hydrocyclones	The separation of light oil particles from the heavier water phase by centrifugation.

GLOSSARY	
Term	**Meaning**
Hydrate Formation	Under certain conditions of temperature and pressure, and in the presence of free water, hydrocarbon gases can form hydrates, which are a solid formed by the combination of water molecules and methane, ethane, propane or butane.
Impermeable Shales	Type of rock.
Jacket Piles	The structure which supports the decks of the production facility
Jack-up rig	A rig that is towed to the drilling location with extendable legs, which are lowered onto the sea bed to lift the rig to a determined operating height above sea level.
Lay Barge	This barge installs the jacket and the pipeline at its offshore location.
Manifolding	A piping arrangement which allows one stream of liquid or gas to be divided into two or more streams or which allows several streams to be collected into one.
Metering Skid	Meters which monitor production for fiscal, tariffing and re-allocation purposes.
Pig	Pigs are used to clean and inspect pipelines (they are usually made of a steel body fitted with rubber cups and brushes or scrapers).
Pig Launcher	A piece of equipment, which propels a pig into a pipeline. The launcher is pressured up to initiate movement of the pig.
Pressure Control System	An automated system used to control the pressure of the fluid.
Platform Blowdown	Release of the total inventory on the platform (inventory can refer to gas and/or crude oil).
Production Separators	Devices which separate water and solids from the production stream (oil, gas and/or condensate).
Pig Receiver	A chamber which receives the pig once it has been launched.
Pockmarks	Crater-like structures that are a result of gas escaping from the deeper strata to the surface and could indicate danger from shallow gas accumulations.
Potable Water	Water suitable for human consumption.
Recovery Factor	Percentage of hydrocarbon in the reservoir which can be extracted through the development.
Riser	A pipe which connects a drilling rig or platform to a subsea wellhead or pipeline during drilling or production operations

GLOSSARY	
Term	**Meaning**
Rotary Table	The Rotary table is a piece of equipment on the jack up drilling rig which is used to turn the drill bit several meters downhole.
Slug Catcher	A device that removes any slugs of liquid, which have condensed and accumulated in the pipeline during the journey.
Sessile organisms	Organisms which are not mobile.
Stakeholders	An individual or groups of people who are affected by, or have an interest in the activities and/or outcome of the project.
Shale Shakers	A device that separates drill fluids from cuttings.
Seismic Amplitudes	A measure of the strength of an earthquake, the magnitude is measured on the Richter scale.
Tuyere / Vane Separator	This piece of equipment is used to separate liquids from the gas stream.
Topside Piping	Piping above the water level.
Temporary Safe Refuge	An area on the platform designed for the temporary shelter of personnel.
Unmanned Facility	A facility that is fully automated and does not require continuous operation by personnel.
Wellhead	The control equipment fitted to the top of a well casing incorporating outlets, valves, blowout preventers etc.
Wireline Operations	A means of monitoring the operations at the facility during the production lifetime.
Workover	Done to increase production, reduce operating cost or reinstate the technical integrity of wells.

EXECUTIVE SUMMARY

The Cannonball Field Development is located in the South East Galeota Block 60km offshore the East Coast of Trinidad (Figure 0-1). The project comprises the design, construction, installation and operation of a wellhead proetctor platform and an associated 5 km long 26" pipeline connecting to the Cassia B hub. The gas and condensate will be transported via the existing 48" BOMBAX Line to the Beachfield Gas Receiving Facility. Two to three wells will be drilled, each with a production rate of up to 350mmscfd.

Modifications at the Beachfield Gas Receiving Facility will be carried out to upgrade its capacity from 1.8 bcfd to 2.9 bcfd and to install an associated 48" pipeline which will tie into NGC's 56" Cross Island pipeline (CIP). First gas is planned for the 3Q of 2005.

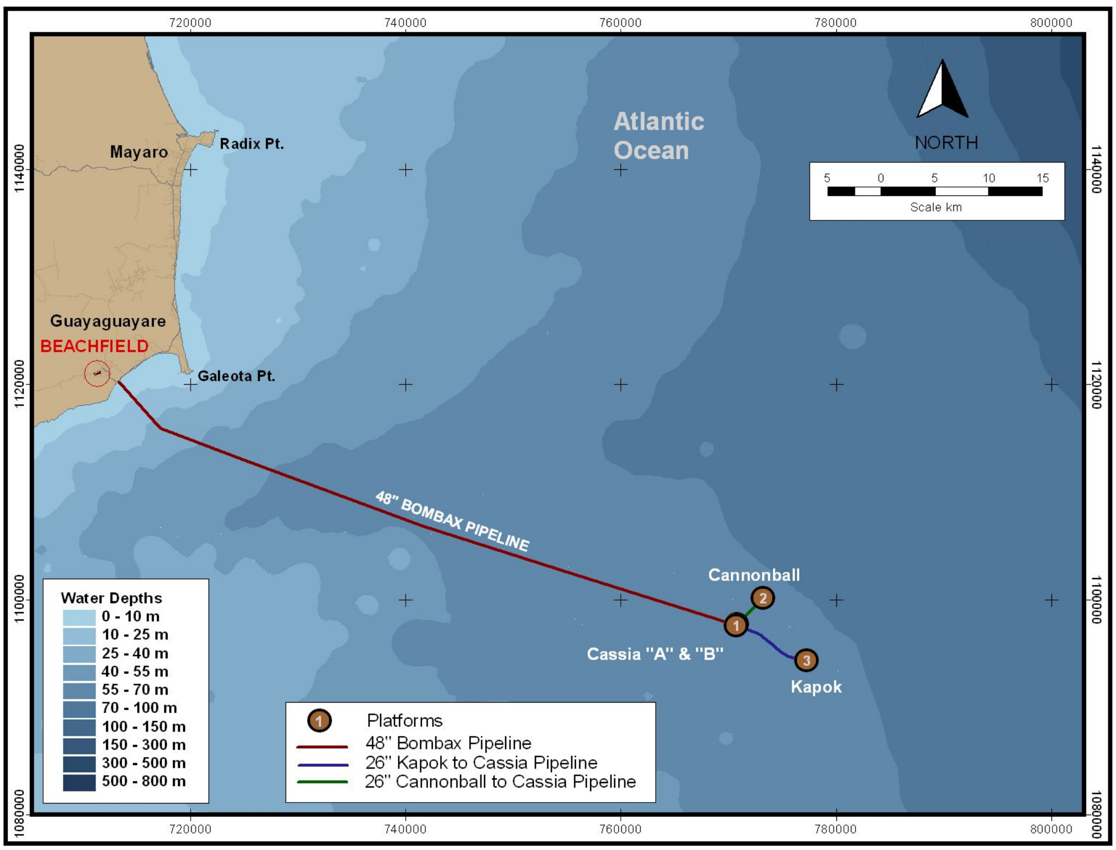

Figure 1. Location of the Cannonball Wellhead Protector Platform and the Beachfield Gas Receiving Facility

Scope

This Environmental Impact Assessment (EIA) investigates the environmental aspects associated with the Cannonball Field Development Project and identifies appropriate mitigation measures. The Terms of Reference (TOR) issued by the Environmental Management Authority (EMA) formed the basis for the EIA (refer to Appendix A). Additional items, outside of the initial TOR, have been assessed for this EIA such as the offhsore meiofaunal assessment, visual recording of the seabed and onshore avifaunal survey and lepidotptera survey.

Options Screening

Initially the options evaluated were based on the viable reservoir opportunities available within the bpTT portfolio. Concept selection was the next phase; this decision was based on several criteria such as Health, Safety and Environmental issues, operability, maintenance, capital and operating costs and alignment with strategic issues. As the project became more defined, many major decisions were made regarding key pieces of equipment on the facility. The final concept chosen is as outlined above.

Environmental Management

The bpTT Environmental Management System (EMS) is certified to ISO 14001 and has been established to manage the environmental aspects of bpTT operations including new projects/developments. As a minimum, the EMS requires a commitment to pollution prevention, compliance with environmental legislation and continual improvement in environmental performance. The EMS is well established and is very effective in delivering improved environmental performance. Cannonball specific objectives will be developed and incorporated into the bpTT EMS and an implementation programme developed to achieve them.

Project Description

The Cannonball Field Development involves the design, fabrication, installation, drilling and operation of an offshore Wellhead Protector Platform (WPP) with an associated 26" pipeline connecting to the existing Cassia B hub. This facility is designed to deliver a production of 1 billion standard cubic feet of gas per day (bcfd) to Cassia B through the existing 48" BOMBAX pipeline onwards to the Beachfield Gas Receiving Facility in Guayaguayare (Figure 0-1). This production will be delivered by 2 to 3 wells with a flow rate of up to 350 million standard cubic feet of gas per day (350mmscfd). Modifications will take place at the Beachfield Gas Receiving Facility to upgrade its capacity to accept these increased volumes. An associated 48" pipeline will also be installed and connected to NGC's 56" Cross Island Pipeline (CIP) (Figure 2).

A key aspect to note about the design of the Cannonball WPP is that it is an unmanned facility with a visitation frequency of once per quarter for maintenance activities. This is a step change for bpTT existing operating facilities.

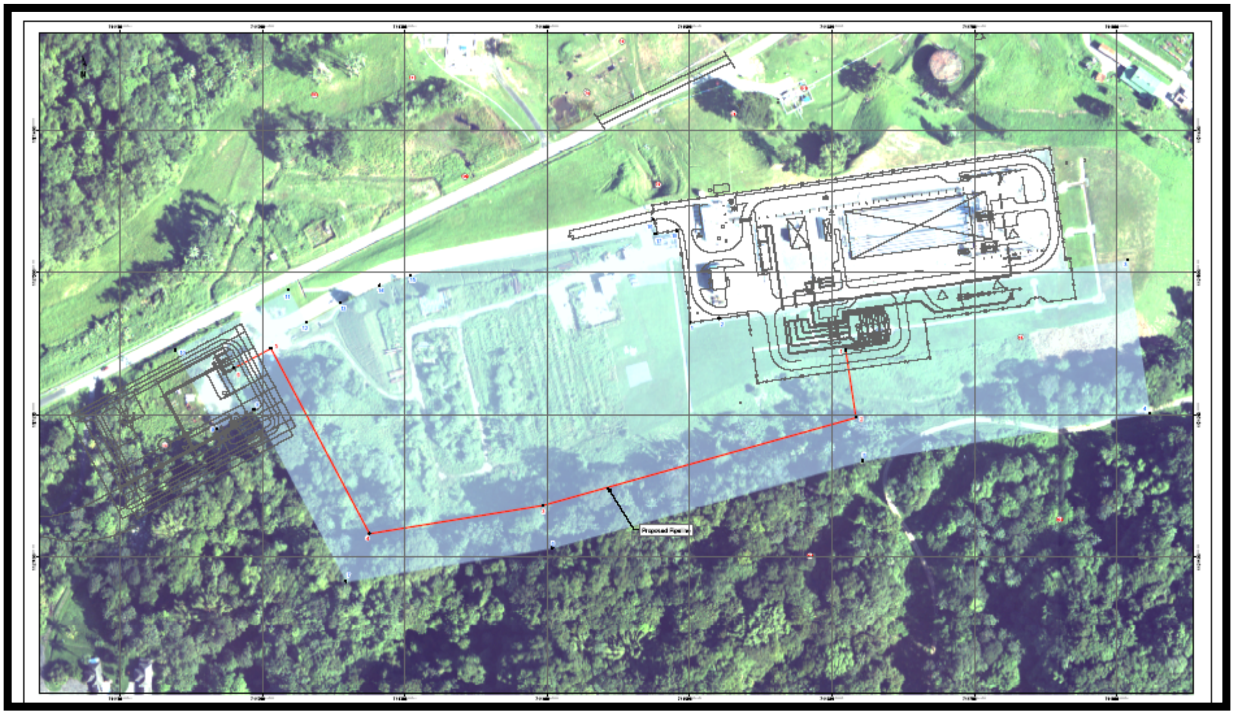

Figure 2 Modifications to the Beachfield Gas Receiving Facility

Environmental Description

bpTT has commissioned extensive studies of the offshore and onshore environment to establish the pre-development baseline conditions specifically for this Cannonball EIA. It is bpTT's intention to manage the environmental aspects of this project so that it is in keeping with bpTT's stated HSE goal of "no harm to the environment".

This project can be broken into two areas:

- Offshore environment
- Onshore environment

<u>Offshore Area</u>

1. Water Quality Survey – surface, middle and bottom depths offshore
2. Sediment Quality Survey – Surficial Sediments collected offshore
3. Current Speed and Direction data for the offshore area
4. Conductivity, Temperature and Density Data for the offshore area

5. Macrobenthic Survey of the offshore area
6. Meiobenthic Survey of the offshore area
7. Video Survey of the offshore seabed

Onshore Area

1. Fisheries Survey
2. Socio-Economic Survey
3. Vegetation and Forest Survey
4. Avifaunal Survey
5. Butterfly Survey
6. Wetland and Sensitive Habitat Survey

Offshore

The bathymetry for this portion of the East Trinidad Shelf slopes gently to the east. The water depth at the planned Cannonball WPP location is 71.5 meters. The seafloor is generally characterised by generally soft mud/clay sediment with no hard substrates are present. Currents in the area are usually of persistent northwesterly currents with speeds generally higher in the upper part of the water column with little tidal influence in the upper column current speeds and directions.

In general, the water and sediment quality of the east coast, as identified in the literature survey, is good as evident by the low reported levels and the quality criteria quoted by the USEPA for water (1986) and Kennicutt *et al.,* (1994) for sediments. For water and sediment quality the following conclusions can be made:

1. The environmental quality (chemical pollutant parameters) of the study area compares favourably with other areas of Trinidad's offshore east coast environment.

2. The levels of pollutants in the water column and surficial sediment (with the exception of copper in water) are below quality criteria USEPA quoted by the USEPA (1986) and Kennicutt *et al*., (1994).
3. The levels of copper are within the range reported for marine waters off Trinidad's coast (IMA archival data).

4. The environmental quality of the study area can be considered "non-impacted" in terms of chemical pollution parameters.

Analysis of the seabed sediment for macrobenthic organisms suggests that this offshore marine area is similar to earlier surveys (carried out in the general marine area), in terms of a relatively low benthic biological diversity. This may be attributed to natural environmental parameters such as the coarseness of sediment in which the fauna live.

The results from the Meiofaunal assessment (using the foraminifera as proxies for environmental conditions), implies that environmental conditions on the shelf around Trinidad have changed considerably over the past 50 years, perhaps due to the onset of environmental stress. Further sampling and analysis need to be carried out.

The study region serves as a habitat for marine mammal species. Historically the waters of Trinidad's & Tobago have been reported with concentrations of Cetaceans and Sirenia populations with depletions historically resulting from direct anthropologic impact of over harvesting especially for whales from shore and ship whaling. Dolphins are also reported to be harvested directly and incidentally in fish nets (Kenny & Bacon. 1981) Sea Turtles have been reported nesting beaches of the east coast of Trinidad; four species in particular have been identified.

Onshore

Southeast Trinidad has been established as the land-based focal point for the oil and gas exploration and production activities in the marine fields off Trinidad's east coast. The Beachfield Gas Receiving Facility is located approximately 1.5km northwest from the Guayaguayare Bay coastline. It lies at the northeastern foot of the Guayare Hill. 500m to the east is the Lawai River, which runs to the Rustville Wetlands along the Guayaguayare Coastline. The main pipeline running into the Beachfield Facility is the 48" BOMBAX Pipeline which lands in Rustville and runs along a Right of Way (ROW) leading to the Beachfield Facility.

A description of the terrestrial ecology of the general study area and the specific Beachfield site was carried out using a combination of literature review of previous studies and a field data collection exercise.

A survey of the forested area around the Beachfield Gas Receiving Facility shows the area is relatively impoverished with a notable absence of most of the common canopy dominants which appears to be a result of the forest being high-graded (i.e. the selective extraction of commercial timber species) in the past (over 50 yrs ago). Species richness is extremely low at all the sites.

The status of the Rustville wetland can be described as healthy but impacted by road construction.

Bird and butterfly surveys were conducted as these organisms can be used as indicators of environmental conditions and effects of development. The Point butterfly Counts within this area, not surprisingly, recorded a significant number of forest and forest edge species. The trends seen in the Lepidoptera fauna mirror the patterns observed in the avian fauna with high habitat specificity among community members. The patterns observed clearly shows that the past history of the Guayaguayare area has resulted in fragmentation of the landscape and the edge effects associated with habitat alteration.

Socio-Economic Results

An assessment of the socio-economic conditions in the study area is an integral part of the environmental impact assessment process. This assessment will determine the direct and indirect impacts or implications of project activity on the socio-cultural and economic activities in the study area. The study area for the Socio-Cultural Resources Section includes the immediate study area, of the five villages of Guayaguayare, La Savanne, Grand Lagoon, Radix and Mayaro. These villages were closest to the project site

Generally this area is under-populated, with a population density of 40 persons per square kilometer. This figure is significantly lower than the average population density of 237 per square kilometer for Trinidad and Tobago. This relatively depressed rural area has a lower than average national standard of living. Again it is noted that data on the economic welfare indicators were not available in a dis-aggregated form for the immediate study area. The county of Nariva/Mayaro was reported among the geographic areas in the country with the lowest average monthly household income.

- On a macro-economic level increase gas finds is expected to increase bpTT's revenue over the life of the project, which would impact positively on the contribution to Government's revenue and GDP.

- Temporary employment creation

Environmental Aspects/Impacts

bpTT EMS Aspect/Impact Evaluation Methodology was used to assess the significance of environmental aspects associated with the Cannonball Field Development Project. This methodology provides an efficient tool for determining the significance of emergency, normal and abnormal situations. The environmental assessment process began at project inception, was carried through the options selection process and will continue throughout the project lifecycle. The assessment identified a number of activities with the potential to affect the environment.

Transportation and Installation of the Cannonball Wellhead Protector Platform

There are many impacts identified during the transportation and installation of the WPP however they have all been identified as temporary and minimal in nature. There are permanent impacts to benthic communities from installing the platform:

Examples of various types of impacts include:

- Impact to water quality from discharges of sanitation and domestic wastes

- Disposal of solid wastes
- Increased marine traffic
- Increases interaction with the Fishermen.

Installation of the 26” Pipeline offshore

Several impacts have been identified from this activity and are similar to those mentioned above however there are two permanent impacts to benthic communities from laying the pipeline on the sea:

- Loss of benthic communities due to the physical presence of the pipeline
- Loss of benthic communities due to the scouring of the pipeline corridor.

Drilling

The most important discharge to sea from drilling are the drill cuttings and Water Based Mud. Based on the conditions at the well site and the modeled depth of drill cuttings of 0.5m there can be expected impacts to the benthic fauna within a 50m radius of the discharge point. At distances further than 50m from the discharge point the concentrations of drill cuttings will be diminished and the thin veneer (less than a few millimeters) will rapidly biodegrade. The impacts of the drill cuttings and mud discharge on the benthic community will be minimized as the communities can regenerate over time (up to a year) (Gobin, J., 2003).

Operation of the Cannonball WPP

The main areas of concern for normal operation of the Cannonball WPP are:

Produced water
The model run shows that the discharge of the produced water into the marine environment will meet local standards for Total Petroleum Hydrocarbons (TPH) even when the discharge is at a maximum rate of 0.0021 m^3/s. The value of the effluent concentration for the Cannonball Field Development Project at the edge of the 100m Regulatory Mixing Zone (RMZ) is lower than the known LC50 estimates for produced water from similar oil and gas facilities (5-6%).

Oil Spill Risk
The potential for an oil spill from the platform is very low because the platform is a natural gas producer and is unmanned however, there will be some movement of boats near the platform during the scheduled quarterly maintenance visits. There is the possibility that a collision could occur between the vessel and the platform resulting in a spill to sea. The results show that the spill moves rapidly to the northwest and after 43 hours is less than 1mm thick. The spill will rapidly disperse, as waves will lead to mixing

and the dispersion of the spill into the water column. The spill covers a small area (less than 10 km^2) during the movement from the spill site and does not impact land, but is dispersed to very low levels as it travels towards the northwest.

Modifications of the Beachfield Gas Receiving Facility

The significant environmental aspects identified during construction are associated with the following:

- Clearance of trees for the installation of the pipeline right of way
- Increased traffic from movement of equipment in and around the Mayaro/Guayaguayare area
- Sanitation wastes
- Noise from the equipment
- Local Air quality (combustion emissions from construction equipment)

Operation of Beachfield Gas Receiving Facility

Beachfield Gas Receiving Facility has an existing EMS, which is certified to ISO 14001, the aspects which will integrated into the existing register are:

- Disposal of Garbage and Debris
- Combustion Emissions from engine and generators
- Noise
- Pipeline Rupture
- Fire and Gas Explosion.

Cumulative Aspects

The cumulative aspects associated with this project are mainly around:

- ***Interaction with the fishermen***

  Activities such as increased marine traffic, presence of the Cannonball WPP and the establishment of a 500 m safety zone have a cumulative impact on the fishermen operating off the east coast

- ***Clearance of trees at Beachfield***

  The forest around the Beachfield Gas Receiving Facility has been impacted in the past by timbering activities hence the forest exhibits a low species density. The clearance of tree in this forest exacerbates this impact.

- ***Increased gas volumes throughout the system (offshore and onshore facilities)***

  The increased gas volumes from Cannonball will be entering existing facilities such as the 48" Bombax pipeline and the existing Beachfield Facility. However all facilities have been designed to appropriate capacities and maximum operating allowable pressures (MAOP). This impact is negligible.

Mitigation measures

All phases of the Cannonball Field Development Project will be carried out in accordance with bpTT Environmental Management System, which is externally certified to the International Standard, ISO 14001. Major contractors will also be required to manage their environmental risk to a level comparable to bpTT's EMS, these requirements make up part of the contractor HSE Bridging document. The EMS provides an overall framework of control to ensure compliance with legislation and other requirements and to ensure that all environmental aspects of the development have been considered. bpTT encourages contractors to use their objectives in parallel with their own, striving for continual improvement.

Although the proposed development is not expected to be environmentally significant, a number of control measures will be implemented to ensure that environmental impacts are kept to a minimum:

- All chemicals used will be approved by the Ministry of Energy and Energy Based Industries (MEEI)
- Cannonball Field Development will implement a rigorous Environmental Monitoring Plan, which will inform the proposed mitigation measures (as outlined in Section 8)
- No synthetic oil based muds will be discharged to sea only the associated cuttings
- Continue produced water reinjection.
- Cannonball operations will be incorporated into bpTT's existing EMS to ensure that significant environmental aspects are controlled.
- No clearance of trees for the installation of the pipeline Right of Way (ROW)

Main conclusions

Overall, it is concluded that the proposed Cannonball Field Development Project will not result in any significant long-term environmental impacts. In terms of cumulative impacts, the overall contribution of the Cannonball Field Development is not considered to be significant.

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1. INTRODUCTION

bpTT Company of Trinidad and Tobago (bpTT) plans to develop its Cannonball West Gas Field located offshore 60km southeast of Trinidad. The development plans include the installation and operation of a Wellhead Protector Platform (WPP) to extract natural gas, which will then be transported to shore via existing pipelines. bpTT has applied to the Environmental Management Authority (EMA) for a Certificate of Environmental Clearance (CEC) for this development. The EMA has requested that an Environmental Impact Assessment (EIA) be conducted to determine the scope of the project, the potential impacts and the measures that should be taken to mitigate these impacts. The EMA has also provided the Terms of Reference for the EIA contained in the ***"Draft Terms of Reference for the Environmental Impact Assessment- CEC0564/2003*"** shown in Appendix A.

This Environmental Impact Assessment has been prepared to support the CEC application by bpTT Company of Trinidad and Tobago (bpTT) to the Environmental Management Authority (EMA).

1.1. Background

The Cannonball Wellhead Protector Platform (WPP) is expected to produce up to 1 bcfd of Natural Gas, which will be sent through the existing 48" Bombax Line to bpTT's Beachfield Gas Receiving Facility located in Guayaguayare, southeast Trinidad. The gas will be then processed by the existing Beachfield Gas Facility and then transported to downstream users along the west coast of Trinidad via NGC's 56" Cross Island Pipeline (CIP). Figure 1.1 below shows the proposed location of the Cannonball WPP offshore and the location of the Beachfield Gas Receiving Facility onshore at Guayaguayare, Trinidad.

The project entails the following activities:

- Installation, drilling and operation of the Cannonball Platform 60km off the southeast coast of Trinidad.
- Installation of a 5.0km 26" pipeline between the Cannonball Platform and the offshore Cassia Central Processing Hub (CPH).
- Modifications to the Beachfield Gas Receiving Facility located inland of Guayaguayare Bay.

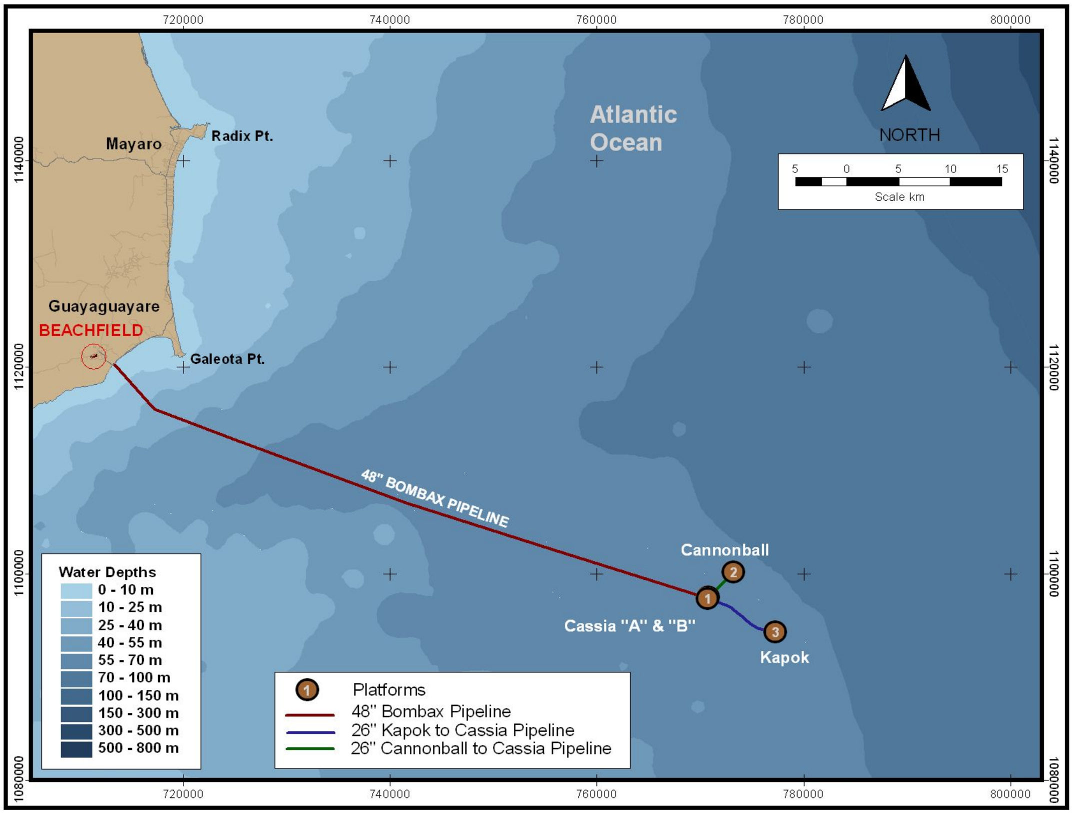


Figure 1.1: Location of the Cannonball WPP and the Beachfield Gas Receiving Facility

1.2. Scope of Environmental Impact Assessment

The scope of this EIA is governed by the Terms of References (TORs) provided by the Environmental Management Authority (EMA). The TORs are contained in the ***"Draft Terms of Reference for the Environmental Impact Assessment- CEC0564/2003"*** issued by the EMA in response to the application for CEC by bpTT for the Cannonball Development Field Project. This TOR can be found in Appendix A for reference. To address the Terms of Reference this EIA has the following sections:

Section 1: Introduction
Section 2: Legislative and Regulatory Framework
Section 3: Description of the Proposed Project
Section 4: Description of the Environment
Section 5: Socio, Cultural and Economic Impact Assessment
Section 6: Analysis of Alternatives
Section 7: Significant Environmental Impacts
Section 8: Mitigation Management Plan
Section 9: Monitoring Plan
Section 10: Inter Agency and Public/NGO Involvement
Section 11: Cannonball EIA: Geographic Information System (GIS)
Section 12: List of References

Appendices
- A: CEC Terms of Reference
- B: List of EIA Preparers
- C: Cannonball Construction HSE Plan
- D: Material Data Sheets
- E: Cannonball Environmental Impact Register
- F: Cannonball Concept Options Register
- G: Cannonball Electrical Power Study
- H: Cannonball Decision Record for Sewage Treatment Facility
- I: Modelling Report
- J: Fisheries Report
- K: Beachfield Vegetation Survey Results
- L: Beachfield Avifaunal Survey Results
- M: Beachfield Lepidoptera Survey Results
- N: Cannonball Offshore Meiofaunal Assessment

1.3. Approach

bpTT has conducted several Environmental Impact Assessments in the offshore area of the East Coast and the Beachfield Gas Receiving Facility area. Some of these are listed below:

- Offshore Environmental Impact Assessment, AMOCO Trinidad LNG Upstream Project, 1997
- Environmental Impact Assessment for Natural Gas Pipeline from Rustville to Point Fortin, prepared for BP AMOCO Energy Company of Trinidad and Tobago, 1995
- Marine Baseline Surveys for the EIA For AMOCO Trinidad Oil Company LNG Upstream Development Project (Wet and Dry Seasons Data), 1997.
- Supplemental Environmental Impact Assessment – Amoco Amherstia Project, 1998
- Environmental Impact Assessment for Red Mango 1 Exploratory Well, 2000

Therefore, there has been considerable baseline data collected for the both the East Coast and the Beachfield Area. While this data is available for use in this Cannonball EIA, bpTT has also commissioned an extensive baseline field survey to collect up-to-date data on the physical, chemical and biological conditions of the Cannonball WPP Site offshore as well the onshore Guayaguayare area. bpTT has also commissioned an extensive survey into the Socio, Economic and Cultural Baseline Conditions to inform this EIA. The collection of this Environmental Baseline data:

- To establish of the existing environmental conditions before the development takes place
- To assess the potential impacts that the Cannonball Project might have on the environment
- To allow a comparison of the environmental conditions pre-development and post-development

- To establish a specific monitoring plan that records the actual impacts of the Cannonball Field Development Project
- To provide input into the Cannonball Environmental Management Plan that will mitigate the potential environmental impact of the project.

This EIA also employs the use of visual records of the offshore seabed conditions using underwater video. This will allow a direct comparison to be made of the offshore physical conditions before and after the implementation of the Cannonball WPP offshore.

Furthermore, all the data collected for this EIA will be made available on a Geographic Information System (GIS) that will allow easy storage and access to the data. This GIS will be user friendly to allow anyone access to the data by simply pointing and clicking on a map of the offshore and onshore study areas.

2. LEGISLATIVE AND REGULATORY FRAMEWORK

bpTT is committed to undertaking the Cannonball Field Development Project under a strict Health, Safety and Environmental (HSE) framework. As such, the policy, legal and administrative framework for this project will be shaped by the following:

1. Relevant local regulations, standards and guidelines governing environmental quality, health and safety that apply to the proposed Cannonball Field Development Project based on the Laws of Trinidad and Tobago.

2. Regional and International Accords to which Trinidad and Tobago is party.

3. Policy and Practices of BP Trinidad and Tobago LLC as well as the company wide BP Group.

This section describes the relevant local regulations, standards and guidelines under the laws of Trinidad and Tobago governing environmental quality, health and safety that apply to the proposed Cannonball Field Development Project. International Accords and Treaties signed by Trinidad and Tobago that are applicable to this project are also examined. Finally, the HSE policies and practices governing this project are discussed. This section is mainly derived from previous EIAs submitted to the EMA in the past by bpTT particularly bpTT (2001).

2.1. National Laws and Regulations

There are environmental controls on the oil and gas industries that are set in the following Trinidad and Tobago laws:

- Petroleum Act
- Mines, Borings and Quarries Act.
- Oil Pollution of Territorial Waters Act
- Continental Shelf Act
- Environmental Management Act
- Certificate of Environmental Clearance Rules
- Environmental Sensitive Species and Areas Rules
- Noise Pollution Control Rules
- Trinidad and Tobago Standard: Specification for the Effluent from Industrial Processes Discharged into the Environment (TTS 547:1998).

There are also existing bills addressing occupational health, safety and environment that have been introduced before the Trinidad and Tobago Parliament but have yet to be made into law:

- Occupational Safety and Health Bill
- Shipping (Marine Pollution) Bill

- Air Pollution Rules
- Water Pollution Rules

Before 1995, the Government of Trinidad and Tobago used the above laws to govern the environmental practices of the oil and gas industries. However, in 1995 and 2000, Parliament passed legislation creating the EMA, an independent agency that assumed sole responsibility for environmental management and protection. The above laws and bills all may affect the Cannonball Field Development Project and are discussed in the following sections.

2.1.1. Petroleum Act

The petroleum industry is regulated by the Petroleum Act (Chap. 62:01) and its regulations, which give the Ministry of Energy and Energy Industries (MEEI) specific powers and define the legal basis whereby the MEEI is empowered to regulate the petroleum industry on all issues. This empowerment includes health, safety and environmental issues for both onshore and offshore.

Among the MEEI's specific powers under this act are the following:

- Monitoring of the effluent (whether gaseous or liquid) of petroleum companies, which are being emitted into the environment, including marine areas and inland waterways.

- Monitoring the petroleum companies both onshore and offshore to ensure safe operations especially in relation to operations: which may lead to oil spill risks.

- Monitoring and investigations of all complaints of any type of pollution emitted from petroleum operations (oil, gas, water, drilling mud, etc.).

- Setting of allowable standards for petroleum and petroleum products, and their emission levels into the environment.

- Co-ordination and supervision activities aimed at responding to emergencies in the Petroleum Industry including the cleaning up of oil spills.

- Supervision of activities at the Petroleum Testing Laboratory as they relate to the identification of pollutants and assisting in determining the parties or companies which are liable for pollution.

2.1.2. Mines, Boring and Quarries Act

The Minerals Act No. 61 of 2000 repeals the Mines, Borings and Quarries Act but the regulations made under the Mines, Borings and Quarries Act remain valid as if made under the Minerals Act.

The Mines, Borings and Quarries Act (Chap. 81:01) details drilling and other regulations for the petroleum industry. This act also empowers the MEEI as the regulatory agency for drilling of oil and gas wells both onshore and offshore.

2.1.3. Oil Pollution of Territorial Waters Act

The Oil Pollution of Territorial Waters Act (Chap. 37:03) of the laws of Trinidad and Tobago seeks to eliminate discharge of oil into the sea. This act outlines legal procedures and penalties in the event of such a discharge.

2.1.4. Continental Shelf Act

This Act makes provision for the exploration and exploitation of the Continental Shelf, and gives effect to certain provisions of the Convention of the High Seas. The ”Continental Shelf” includes all areas of the seabed outside from the limit of the territorial sea (that is, three miles from the coast), to a depth of 200 m and beyond that limit to the depth where exploitation of natural resources is possible. Thus, most elements of this project are situated within the Continental Shelf and thus are covered by this Act.

2.1.5. Environmental Management Act (2000) (EM Act)

The Environmental Management Authority (EMA) is a statutory body established by the Government of the Republic of Trinidad and Tobago to address the nation’s growing environmental concerns. It was established with the enactment of the Environmental Management Act of 1995. This Act was amended in 2000. The legislation is aimed at ensuring the protection, conservation and enhancement of the environment of Trinidad & Tobago.

In fulfilling its statutory mandate to coordinate and oversee environmental management functions performed by persons in Trinidad and Tobago, the EMA entered into Memoranda of Understanding (MOU’s) with 31 Participating Agencies which had traditionally dealt with one aspect or another of environmental management before 1995. These MOU’s are intended to facilitate a collaborative and coordinated approach to dealing with the country’s environmental problems. These agencies will also advise the EMA during the Certificate of Environmental Clearance (CEC) application procedure. The following is a list of the participating agencies:

- Airports Authority of Trinidad & Tobago
- Caribbean Industrial Research Institute
- Chaguaramas Development Authority
- Institute of Marine Affairs
- National Housing Authority
- National Institute of Higher Education (Research, Science & Technology)
- Port Authority of Trinidad & Tobago
- The Trinidad & Tobago Solid Waste Management Company Limited

- Trinidad and Tobago Bureau of Standards
- The University of the West Indies
- Water and Sewerage Authority
- Ministry of Agriculture, Land and Marine Resources
- Ministry of Community Development, Culture and Women's Affairs
- Ministry of Education
- Ministry of Energy and Energy Industries
- Ministry of Finance
- Ministry of Foreign Affairs
- Ministry of Health
- Ministry of Housing and Settlements
- Ministry of Labour and Cooperatives
- Ministry of Legal Affairs
- Ministry of Local Government
- Ministry of Planning & Development
- Ministry of Public Utilities
- Ministry of Social Development
- Ministry of Trade & Industry
- Ministry of Consumer Affairs
- Ministry of Works and Transport
- Ministry of the Attorney General
- Ministry of National Security
- Tobago House of Assembly

There are four (4) pieces of subsidiary legislation under the EM Act:

- Certificate of Environmental Clearance (CEC)
- Noise Pollution Control Rules
- Industrial Effluent Standards
- Environmental Sensitive species and Areas Rule

These are discussed below:

2.1.5.1. Certificate of Environmental Clearance (CEC)

In 2001, the rules pertaining to the granting of a Certificate of Environmental Clearance (CEC) by the EMA came into force. These Rules apply to new or significantly modified construction, process, works or other activity. These activities cannot proceed until this certificate is received from the EMA. Pursuant to section 26(h) of the EM Act, the Certificate of Environmental Clearance (Designated Activities) Order lists activities (including development activities) which require a CEC application. For the Cannonball Field Development Project the following activities have been identified as requiring a CEC:

The EMA, upon receiving an application for a CEC, may ask for further information including the preparation of an EIA. The EMA will then review the EIA and issue or refuse the granting of a CEC. If the EMA refuses the CEC it will provide in writing the reasons for the refusal. If the EMA grants the CEC then there usually will be conditions applied to the CEC including mandatory monitoring of the development activity.

Table 2.1: Cannonball Field Development activities requiring a CEC	
Activity 25	The establishment, modification, expansion, decommissioning or abandonment (inclusive of associated works) of a facility for the extraction on crude oil or production of associated gas or condensates.
Activity 26(a)	The establishment, modification, expansion, decommissioning or abandonment (inclusive of associated works) of a facility for natural gas or condensate production.
Activity 27	The establishment, modification, expansion, decommissioning or abandonment (inclusive of associated works) of a pipeline or pipeline systems for transmission of produced fluids, crude oil or natural gas.
Source: CEC Application by bpTT for Cannonball Field Development Project (#0564/2003)	

The EMA's refusal to grant a CEC can be appealed to the Environmental Commission. Section 81 of the Environmental Management Act makes provision for the establishment of a tribunal known as the Environmental Commission, which is a superior court of record. The Commission has jurisdiction to hear and determine:

- **Appeals against decisions or actions of the EMA, including**:
  - appeals against designations of environmentally sensitive areas or species);
  - appeals against a decision to refuse to issue a Certificate of Environmental Clearance, or a decision to issue such a Certificate with conditions; and
  - appeals against a decision to disclose information claimed to be confidential.

- **Applications for deferment of decisions or designations.**

- **Applications by the Authority for enforcement of consent agreements or final administrative orders.**

- **Administrative civil assessments.**

- **Complaints brought by persons (the direct private party action provision**

2.1.5.2. Noise Pollution Control Rules

The Noise Pollution Control Rules were issued in 2000 under the EM Act and it addresses the noise limits permitted within three designated zones:

- Zone I: Industrial Areas
- Zone II: Environmentally Sensitive Areas
- Zone III: The General Area (This is classified as all of Trinidad and Tobago not covered by the other two (2) zones)

The Cannonball Field Development Project will affect two (2) areas: The Cannonball Platform site 60km off the southeast coast of Trinidad and the Beachfield Gas Receiving Facility in Guayaguayare. These two sites fall under Zone III: The General Area.

The Noise Pollution Rules, 2000 that apply to the Cannonball Field Development Project are as follows for Zone III:

Daytime Limits - On Mondays to Sundays of every week from 8:00 am to 8:00 pm on each day:

> *(a) the sound pressure level when measured as equivalent continuous sound pressure level shall not be more than 5 dBA above the background sound pressure level," and*
>
> *(b) the sound pressure level when measures as instantaneous unweighted peak sound pressure level shall not exceed 120 dB (peak).*
>
> *Notwithstanding the above, no person shall emit or cause to be emitted any sound that causes the sound pressure level when measured* as *the equivalent continuous sound pressure level to exceed 80 dBA.*

Night-time Limits - On Mondays to Sundays of every week from 8:00 pm to 8:00 am on each day.

> *(a) the sound pressure level when measured as equivalent continuous sound pressure level shall not be more than 5 dBA above the background sound pressure level; and*
>
> *(b) the sound pressure level when measures as instantaneous unweighted peak sound pressure /eve/ shall not exceed 115 dB (peak).*
>
> *Notwithstanding the above, no person shall emit or cause to be emitted any sound that causes the sound pressure/eve/when measured* as *the equivalent continuous sound pressure level to exceed 65 dBA*

It should be noted that Section 7(k) of the Noise Pollution Control Rules states that construction activity when conducted on a construction site between the hours of 7:00 am and 7:00 pm on the same day is exempt from the prescribed standards.

Under the Rules, if a person or an operator of a facility to conduct and activity or an event that will cause sound in excess of the prescribed standards, an application has to be made for a variation to the EMA before the date of the event or the activity.

The granting of a variation is made by the EMA based on the advice of the Noise Advisory Council (appointed by the Board of the EMA) and the variation will be valid for a fixed period. The EMA may establish a maximum permissible sound pressure levels and conditions as required (which could include among other things measures to minimize environmental impact, a monitoring program).

2.1.5.3. Industrial Effluent Standards

The Trinidad and Tobago Bureau of Standards (TTBS) and the EMA have developed an industrial effluent standard designated TTS 547:1998 ***"The Trinidad and Tobago Standard Specification for the Effluent from Industrial Processes Discharged into the Environment"***. The Cannonball Field Development Project will be required to conform to this standard.

The standard specifies the limits of various discharge parameters permitted based on the receiving environment: Inland Surface Waters, Coastal Nearshore Waters, Marine Offshore Waters and Environmentally Sensitive Areas. Table 2.2 shows the applicable standards. It is expected that the Cannonball Field Development Project will fall under the Inland Surface Waters (for the Beachfield Gas Receiving Facility modifications) and the Marine Offshore Waters (for the installation and operation of the Cannonball Well Protector Platform).

Table 2.2: Industrial Waste Water Standards for Offshore Oil and Gas Exploitation

Parameter	Receiving Environment			
	Inland Surface Waters	Environmentally Sensitive Areas	Coastal Nearshore Waters	Marine Offshore Waters
Absolute Temperature (°C)	35	Same as receiving water	40	45
Temperature Increase	3	0	3	5
pH	6 to 9	6 to 9	6 to 9	6 to 9
COD (mg/l)	250	60	250	--
BOD_5 at 20°C (mg/l)	30	10	100	100
Total Suspended Solids (mg/l)	50	15	200	200
Total Petroleum Hydrocarbons (mg/l)	25	Discharge not permitted	40	80

In the event that the limits of this standard are exceeded (or expected to be exceeded), an application would have to be made for a water pollution permit.

2.1.5.4. Environmentally Sensitive Species and Areas

Under the Environmental Management Act, there are provisions for the designation of "environmentally sensitive areas" and "environmentally sensitive species" requiring special protection.

The designation of species or areas as "environmentally sensitive" is to meet one of more of the following categories of objectives:

- Conservation of biological diversity and protection of the environment
- Sustainable economic and human development
- Logistical support e.g. environmental education, information sharing, etc

The designation of an environmentally sensitive species may permit the wise use of such an area or species and provide for the undertaking or appropriate mitigation measures. At the time of writing the rules to establish the procedure for designating specific areas and species as environmentally sensitive were in force, but no such designation had yet been made.

2.1.6. Shipping (Marine Pollution) Bill

This Bill seeks to provide for powers and jurisdiction in relation to pollution of the seas from ships, intervention on the high seas in cases of oil pollution, dumping of wastes at sea, prevention of pollution from ships, preparedness and response for oil pollution emergencies, liability and compensation for pollution damage and matters incidental. At present, this bill has not yet been made into law.

2.1.7. Occupational Health and Safety Bill

This Bill seeks to govern all aspects of health and safety in the workplace and it will replace earlier laws such as the Factories Ordinance, Factories (Boilers) Regulation and the Employment of Women (Night Work) Act.

2.1.8. Air Pollution Rules

The EMA has circulated draft Air Pollution Rules for public comment in 2002; however, as of the time of writing such rules have not yet come into force in Trinidad and Tobago. The rules distinguish between Air Pollutants from a Chimney and Fugitive Releases. The following tables give selected pollution limits to be imposed by this Air Pollution Rules when in force:

Table 2.3: Selected Limits of Air Pollutants from a Chimney	
Substance	**Maximum Permissible Levels (mg/Nm^3)**
Particulate Matter	100mg of particulate in each normal cubic meter of residual gases, (adjusted to a basis of 12% CO_2 for air emissions from fuel-burning equipment, if required by the specified test method)
Sulphur Dioxide (SO_2)	1000 as (SO_2)
Oxides of Nitrogen	500 as (NO_2)
Carbon Monoxide	1000
Hydrogen Sulphide	15
Volatile Organic Compounds (VOC)	20 as (VOC)

Table 2.4: Selected Fugitive Release Limits				
Parameter	Short Term Limits		Long Term Limits	
	Maximum Permissible Level (ug/m^3)	Averaging Time	Maximum Permissible Level (ug/m^3)	Averaging Time
Total Suspended Particulate (TSP)	230	24 hrs		
PM_{10}	150	Max 24-hour conc.		
Carbon Monoxide	100,000	15 minutes		
	60,000	30 minutes		
	30,000	1 Hour		
	10,000	8 hours		
Nitrogen Dioxide (NO_2)	200	1 Hour	40	1 year
Sulphur Dioxide	500	10 minutes	50	1 year
	125	24 Hours		
Hydrogen Sulphide	30 ug of H_2S per cubic meter of air	30 Minutes		

2.2. Other Laws, Regulations, Codes of Practice and Policies

2.2.5. Ministry of Energy and Energy Industries (MEEI)

This Ministry has provided guidelines and codes of practice to oilfield companies, as follows:

- Code of Practice for Drilling and Production Rigs, and
- Guidelines for Handling and Storage of Petroleum Products and Combustible Liquids.

Code of Practice for Drilling and Production Rigs

The "Code of Practice for Drilling and Production Rigs Operating in Trinidad and Tobago" was published by the Ministry of Energy and Energy Industries (MOEEI) in July, 1990; and it gives some guidelines as to proper drilling practices, which should be followed. The following are the sections of this code relevant to the environment:

19 Pollution Prevention

19.1.1 No oil, oily products or harmful substances shaft be discharged from an offshore rig installation into the sea.

19.1.2 No oil, oily products, drilling fluids, or other harmful substances shall be allowed to escape from a land well location over adjacent /ands, to enter streams, or seep into shallow fresh water bearing sands.

19.1.3 Rig waste, such as engine oil, waste oil, grease, etc. shall be accumulated in suitable containers, drip trays, sump tanks or collected by some other suitable means.

19.1.4 Waste water used in cleaning the rig tools, and equipment shall be collected with the aid of an effective drainage system in a storage pit or sump

19.2 Drilling/Well Servicing Fluids and Cuttings

19.2.1 Drilling/well servicing fluids containing harmful substances in toxic concentrations shall be safely treated and/or disposed of on location or transported to an approved disposal site,

19.2.2 Where oil-based fluids are in use, the cuttings shall be effectively cleaned and washed prior to transfer to mud disposal pits or discharge into the sea.

19.3 Sanitation and General Housekeeping

19.3.1 Sanitation

All garbage shall be collected and temporarily retained in suitable containers for proper disposal by:

- *transporting to an approved garbage collection site*
- *burning or incinerating*
- *burial in the drilling site disposal pit if one is used and properly covered with dirt- (applicable to /and);*
- *any other means approved by the ministry*

19.3.2 Genera/Housekeeping

- *Rig main and auxiliary equipment shall be kept clean and painted as far as is reasonably and practically possible*
- *Following rig-up, all miscellaneous equipment such as boards, tools etc., which are not essential to ongoing rig operations on the well, shall be removed or neatly stored.*
- *All well fluid chemicals and materials shall be neatly stacked and as easily accessible to the mud hopper as is practical.*
- *The rig crew must ensure that proper housekeeping is maintained on the location at all times*

Guidelines for Handling and Storage of Petroleum Products and Combustible Liquids

"Guidelines for Handling and Storage of Petroleum Products and Combustible Liquids" have been published by the Ministry of Energy and Energy Industries. The following are the sections of this code relevant to the environment:

1.0 Tanks

1.1 All above ground petroleum spirit tanks should be completely surrounded by a fire wall unless the topography of the surrounding area is such that spillages due to overflow or major leak from any tank are directed quickly and safely to a depression located within the boundary. Fire walls are not required in the case of tanks, which are buried or mounded

Separate walls around each tank are unnecessary

Where a number of tanks are in a walled enclosure it is good practice to provide *intermediate walls up to half the height of the main walls to divide the tankage into groups.*

The net volume retained by the wafted enclosure or by the depression should generally be equivalent to the capacity of the largest tank. A reduction of this capacity will provide adequate protection in many instances and may be adopted where conditions are suitable.

1.3 Adequate means for the removal of water from the walled enclosure or from the depression should be provided. This water and water from other areas, which may be contaminated with hydrocarbons, should pass through a petroleum interceptor before connection to any public system or water course.

1.4 The tanks together with all pumps, pipes, and fittings should be designed, constructed and maintained as to prevent any leakage of petroleum spirit. The suction and delivery lines of each tank should be of steel and should be fitted with all-steel master-valves attached to the tank. Provision should be made in the design of the depot to allow for differential movement between tanks and pipelines due to settlement.

4.0 Containers

4.1 Every container in which dangerous petroleum is kept shall have the nature of the contents and the words "highly inflammable" distinctly marked thereon. Such container shall be painted, at both ends thereof, with red paint. Such containers shall be properly secured and stored and at all times kept in good order and repair so that no leakage of either spirit or vapour can take place there from.

6.0 Pollution

6.1 *No crude petroleum, petroleum, petroleum or dangerous petroleum shall be allowed to leak or escape into an inlet or drain communicating with a public drain or sewer*

6.2 *A sufficient quantity of clean sand shall always be kept at every warehouse for the purpose of absorbing any petroleum, which may leak from any receptacle.*

6.3 *All pipes or openings for draining out water from enclosures shall be constructed that they are capable of being closed, and that they shall only be kept open when actually necessary for drainage purposes.*

8.0 General Safety

8.3 Maintenance and operating practices shall be in accordance with established procedures, which will tend to control leakage and prevent the accidental escape of liquids. Spill s shall be cleaned up promptly.

8.4 Combustible waste material and residues in a building or operating area shall be kept to a minimum, stored in closed metal waste cans, and disposed of daily.

2.2.6. National Environmental Policy

The National Environmental Policy is intended to satisfy the requirements of the Environmental Management Act 2000, in which "environment" means all land area beneath the land surface, atmosphere, climate, surface water, groundwater, sea, marine and coastal areas, seabed, wetlands and natural resources within the jurisdiction of Trinidad and Tobago. The goal of this policy is the conservation and wise use of the environment of Trinidad and Tobago to provide adequately for meeting the needs of present and future generations and enhancing the quality of life.

2.2.7. Water Pollution Rules

The EMA plans to implement a waste water discharge permitting system to be run in parallel with the CEC requirements. The draft Water Pollution Rules were issued for public comment in 1999 and again in 2001. As with the Air Pollution Rules, the Water Pollution Rules have not yet come into force in Trinidad and Tobago.

2.2.8. Compliance to Permit Regulation

Besides the application to the EMA for a Certificate of Environmental Clearance (CEC), the Cannonball Field Development Project may require other permits for various activities including the following:

Table 2.5: Possible Permits required for Cannonball Activities

Authority	Permit/ License	Description
EMA	Certificate of Environmental Clearance	To carry out works related to oil and gas exploration
Ministry of Energy	Exploration and Production (Public Petroleum Rights) License	To conduct petroleum operations
Town and Country Planning Division (TCPD)	Final Planning Permission	To start field construction work
Landowners and Occupants	Permit	To conduct seismic operations in closed to occupied lands
Forestry Division	Permit	To cut timber on State and Private lands
Commissioner of State Lands	Permit	To enter State Lands and conduct the seismic and drilling exploration
Wild Life Division	Notification Approval	To enter prohibited areas
Mayaro Rio Claro Regional Corporation	Permit	To transport equipment along roads
Lands and Surveys Division	Water abstraction license	To enter and survey on State Lands
Water and Sewage Authority	Notification	To obtain water from streams and rivers
National Gas Company	Notification	To conduct seismic operations in the vicinity of buried natural gas lines
Petrotrin	Notification	To conduct seismic operations in the vicinity of buried natural oil pipelines and producing wells
Ministry of National Security	Permit	To store transport and use explosives
Factories Inspectorate	Permit	To conduct blasting operations

2.3. International Accords and Treaties

The Government of Trinidad and Tobago has recognized and ratifies with several international and regional treaties and accords, which formalize cooperation on regional and global environmental protection strategies. While these are not enacted as law in Trinidad and Tobago, bpTT is committed to the adherence to these accords and treaties.

Trinidad and Tobago are listed as being party to 63 International Treaties on the environment (Environment Treaties and Resource Indicators (ENTRI), 2003). Table 2.6 below outlines the most important International Treaties that are relevant to the Cannonball Field Development Project:

Table 2.6: Selected International Treaties to which Trinidad and Tobago is a Signatory

Treaty	Adoption Date	TT Adoption Date
Convention of Nature Protection and Wildlife Preservation in the Western Hemisphere	1940	1969
Convention of the Continental Shelf	1958	1968
Convention of Fishing and Conservation of the Living Resources of the High Seas	1958	1966
Convention of the High Seas	1958	1966
International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)	Not signed but legislation currently drafted to bring into compliance	Not signed but legislation currently drafted to bring into compliance
United Nations Convention on the Law of the Sea	1982	1994
UN Framework on Climate Change (Including the Kyoto Protocol)	1994	1997
Protocol Concerning Cooperation in Combating Oil Spills in the Wider Caribbean Region	1983	1986
Specially Protected Areas and Wildlife Protocol	1990	1990
RAMSAR Convention (April 21, 1993)	1993	1993
UN Convention of Biological Diversity	1996	1996

2.4. bpTT's Environmental Management Policy

2.4.5. Environmental Management

bpTT is committed to conducting its activities in compliance with all applicable legislative requirements, and in a manner, which contributes to the company's stated goals of 'no accidents, no harm to people, and no damage to the environment.' In order to achieve this, a hierarchy of common policies, commitments and expectations exists, which identify policy and regulatory requirements, and provide tools to assist in compliance and performance improvement throughout the business. Figure 2.1 and 2.2 and the following sections summarize bpTT's Health, Safety, & Environmental (HSE) policies and management processes.

bpTT's commitment to health, safety and environmental performance (HSE)

bp
Trinidad and Tobago

Our goals are simply stated
no accidents, no harm to people, and no damage to the environment

Everyone who works for bpTT anywhere is responsible for getting HSE right. Good HSE performance and the health, safety and security of everyone who works for us are critical to the success of our business.

Our goals are simply stated - no accidents, no harm to people, and no damage to the environment.

We continue to improve our HSE performance by systematically identifying risks, implementing mitigation plans and measuring and reviewing performance.

We:

- comply with all relevant HSE legislation and other requirements
- commit to improvement of the health and safety of our workforce and pollution prevention
- commit to continual improvement
- consult, listen and respond openly to our customers, employees, neighbors, public interest groups and those who work with us
- continue to drive down the environmental and health impact of our operations by reducing waste, emissions and discharges, and using energy efficiently
- work with others - our partners, suppliers, contractors, competitors and regulators - to build capability and raise the standards of our industry
- openly report our performance, good and bad
- recognize those who contribute to improved HSE performance

Our business plans include measurable HSE targets. We are committed to meeting them.

Robert Riley
Chairman and CEO
BP Trinidad and Tobago
September 2003

Figure 2.1: bpTT's Commitment to Health, Safety and Environmental Performance (HS&E).

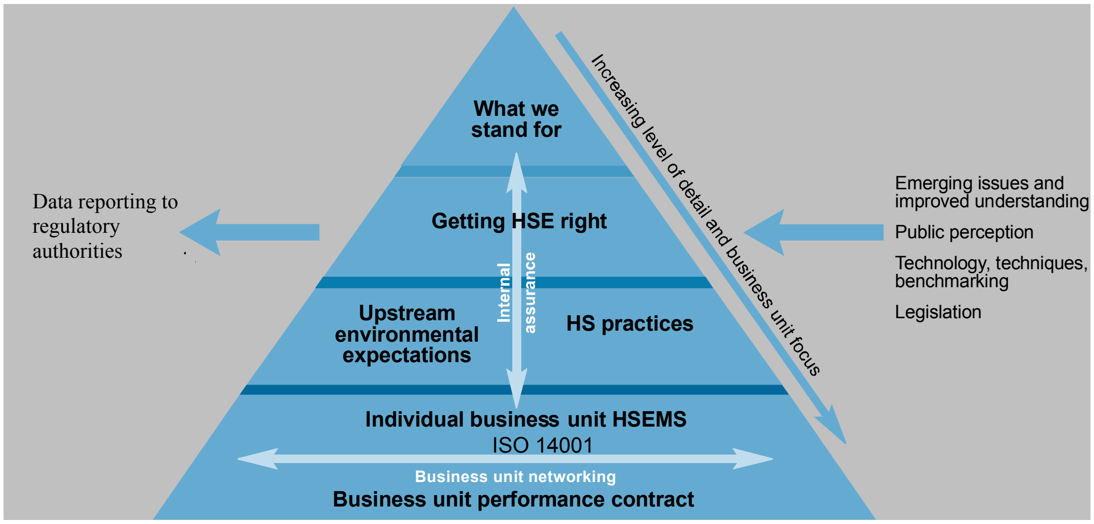


Figure 2.2: Summary of Environmental Management in BP

2.4.6. What we stand for

BP's business policies and commitments are clearly set out in 'What we stand for' and are summarized in Figure 2.3

What we stand for

Our business policies focus on five areas. They apply to all our activites world wide.

We are committed to:

Ethical conduct	*Employees*	*Relationships*	*Health, safety and environment*	*Control and finance*
Respect the rule of law, conduct our business with integrity, and show respect for human dignity and the rights of the individual wherever we do business	Develop employment practices which create a stimulating working environment in which diversity is valued and encouraged	Create mutual advantage in all our relationships so that people will trust us and want to do business with us	Demonstrate respect for the natural environment and work towards our goals of no accidents, no harm to people and no damage to the environment	Manage our financial performance to maximise long-term value for our shareholders

Figure 2.3: "What we stand for"

These policy commitments apply to all aspects and phases of business operations. Everyone within bpTT is responsible for implementing them and Operating Company and Business Unit leaders are accountable for ensuring the policies are put into practice within their sphere of influence. bpTT's commitment to Health, Safety and Environmental performance is endorsed by the Chairman and Chief Executive Officer and is stated in the policy (Figure 2.1). Overall BP's (includes bpTT) environmental performance is reported regularly in the annual report and is available 'live' on the company website (www.bp.com).

2.4.7. Getting HSE right

The HSE policy objectives within 'What we stand for' are translated into a series of expectations in the BP HSE Management System Framework, 'Getting HSE Right'. Individual Operating Companies and Business Units are responsible for implementing 'Getting HSE Right' through their own local management systems.

'Getting HSE Right' (GHSER) provides a broad-based set of expectations, which are collated into a series of thirteen elements of accountability. Individual Operating Companies and Business Units must address all thirteen elements locally, and if necessary provide a justification where an expectation is considered to be not applicable. Cross Business Unit networking, and central resource groups are used to ensure standard application of element requirements and to disseminate best practices across Business Units, providing for continuous improvement. Each Business Unit's compliance with GHSER is verified through the conducting of audits by parties outside the Business Unit once every 3 years.

The thirteen elements of the HSE expectations are arranged into a series that form the mandatory basis of Business Unit management systems. The elements are shown in Figure 2.4.

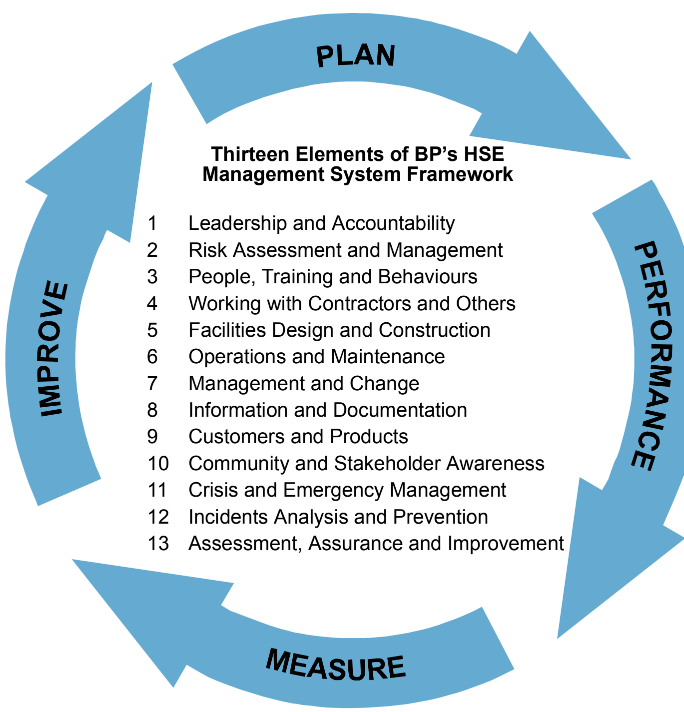


Figure 2.4: HSE Expectations

Emphasis on the involvement of all in getting HSE right is given in the introduction to Element 1: Leadership and Accountability:

"People at all levels in the BP organization are responsible for leading and engaging the workforce in meeting our health, safety, technical integrity and environmental goals and objectives. Leaders will be held accountable for accomplishing this by demonstrating correct HSE behaviours, by clearly defining HSE roles and responsibilities, by providing needed resources, and by measuring, reviewing and continuously improving our HSE performance."

2.4.8. Upstream Environmental Expectations

BP environmental expectations for exploration and production operations are documented in the 'Upstream Environmental Expectations'. These Expectations, are structured into two basic elements:

- General expectations which reiterate and reinforce commitments presented in 'getting HSE right'; and
- Specific areas of performance focus with specific target dates for implementation.

These expectations will contribute to BP's stated goal of achieving 'No damage to the environment' by driving continual or step changes in improvement in key areas of environmental performance (e.g. emissions to air, discharges to water, waste disposal and local environmental protection). The use of the expectations is mandatory for all BP upstream operations worldwide and the Cannonball Field Development will comply with all of the expectations. Within BP there are internal assurance processes in place to ensure that projects comply with the intent of the expectations (see below).

2.4.9. Upstream Environmental Performance Guidelines for New Projects and Developments

BP Upstream Environmental Performance Guidelines for New Projects and Developments provide a consistent process for complying with the environmental expectations. The purpose of these guidelines is to help new projects and developments strive to achieve the corporate goal of no damage to the environment in the most cost effective manner. They explain the key technical and operational elements that contribute towards the final performance level, and the process that should be followed to establish the best achievable environmental performance in any project. These guidelines outline the following six-step process:

1. Define the project environmental goals and stakeholder expectations.
2. Identify the no damage base case for the final development option(s).
3. Justify any proposed variation from the goal of No Damage; present the project environmental strategy.

4. Define the minimum damage level based on the chosen development concept and final technical solutions, including considerations for remediation.

5. Prepare for sanction approval including remediation recommendations.

6. Ensure that decisions made earlier in the process are implemented.

The Cannonball Field Development has used these guidelines for the project development and has attempted to implement the principles outlined. In some instances, we have deviated from the process however these have been clearly documented internally.

2.4.10. bpTT EMS

bpTT's Environmental Management System (EMS) is certified to ISO 14001 since the year 2000 and has been established to manage the environmental aspects of the operations and the new projects/developments.

It is vital that the way in which activities interact with the environment, eg. discharges to water are understood. To this end, a register of environmental aspects and impacts associated with these processes and activities has been developed. This involves the review of every process and activity within bpTT operations and new projects/developments and the identification of the associated potential environmental aspects.

Potentially significant aspects are assessed using a simple risk assessment technique. Significant aspects are then managed in two key ways:

- Environmental objectives and targets – by setting objectives for a number of our potentially significant aspects the Business Unit striving to improve.
- Operations procedures – environmental requirements have been integrated into bpTT operational processes and procedures to help ensure that environmental aspects are managed.

Contractors, e.g. construction, drilling, and installation vessels, undertake a number of activities and processes for bpTT. It is ensured that BP's key contractors have systems and controls in place to manage their environmental aspects.

The EMS has allowed Cannonball to identify key environmental aspects, rank aspects according to significance and develop programmes to continually improve and integrate environmental issues into the business. The EMS is well established and is very effective in delivering improved environmental performance.

Cannonball's potentially significant environmental aspects will be managed through the existing bpTT' s EMS; for example, potential significant environmental aspects have already been identified using the existing EMS procedure.

Cannonball EMS

As mentioned previously, Cannonball has developed an Environmental Aspect/Impact Register from which we have identified the significant aspects. In the first quarter 2004, Cannonball will be setting up Environmental Management Plans to ensure that these aspects are dealt with in a manner consistent with the bpTT internal standards and the local regulations. Details around these plans have been provided in this ESIA.

According to bpTT internal standards the Cannonball Field will be certified to ISO 14001, six to nine months following first gas (October 2005).

The Cannonball Field Development project aspirations are based on the BP Upstream Environmental Performance Guidelines for New Projects and Developments such as

- Zero Discharge to sea
- Zero emissions to atmosphere

Zero Discharge to sea

- Investigate the feasibility of re-injection of muds and cuttings
- Continue to comply, with Ministry of Energy Guidelines for muds and cuttings discharge, and improve muds and cuttings environmental performance from previous projects.

Zero Emissions to Atmosphere

- Minimize emissions from this facility
- Eliminate continuous venting from this facility.

3. DESCRIPTION OF PROPOSED PROJECT

This section provides a description of the proposed Cannonball Field Project being developed by bpTT off the East Coast of Trinidad and on land at the Beachfield Gas Receiving Facility in Guayaguayare in order to identify the associated environmental impacts. The impacting activities can be separated into three main areas:

- Installation, drilling and operation of the Cannonball Wellhead Protector Platform (WPP) 60km off the southeast coast of Trinidad.
- Installation of a 5.0km 26" pipeline between the Cannonball WPP and the offshore Cassia Central Processing Hub (CPU).
- Modifications to the Beachfield Gas Receiving Facility located inland of Guayaguayare Bay.

The following section is designed to describe the above activities such that all possible environmental impacts arising from the proposed activities can be identified and then discussed in Section 5. The areas covered by the project description are governed by the CEC TOR Section 3.2 presented in Appendix A. The CEC requirements for the project description are given in Table 3.1 below along with an indication of where the relevant information can be found.

Table 3.1: Project Description Requirements

Project Description	EIA Section
Location	Section 3.1
Design Basis	Section 3.4.3
Equipment and Machinery	Section 3.4, 3.4.4
Description of Proposed Cannonball Platform	Section 3.4
Description of subsidiary inputs (including chemicals)	Section 3.4.9.1
Description of Utilities – Requirements, availability and sources	Section 3.4.5.1
Description of activities during construction, operation and maintenance	Section 3.4.8
Scheduling of Project	Section 3.3
Identification staffing, support, facilities and services	Section 3.4.1.4, 3.4.5.2
An estimation of the quantity and concentration of expected emissions, effluents, hazardous and non-hazardous wastes and noise	Section 3.4.9.1

3.1. Project Location

Figure 3.1 below shows the general project location on the east coast of Trinidad. The Cannonball WPP will be located offshore 60km southeast of bpTT's Galeota Port Facility. Figure 3.2 below shows the proposed location of the Cannonball WPP. The platform will be installed approximately 3.7km northeast from the Cassia "A" and "B" facilities and approximately 7.2km north-northwest of the Kapok Facility. The proposed position of the

Cannonball WPP is 773073.7m E and 1100173.8m N (WGS84, UTM Zone 20). Figure 3.2 also shows the location of the 48" "BOMBAX" Gas Pipeline transporting natural gas and condensate from the Cassia Facility to the Beachfield Gas Receiving Facility. Gas and condensate from the Cannonball WPP will be transported to the Beachfield Gas Receiving Facility via this existing pipeline.

The Beachfield Gas Receiving Facility will also be modified for this project and its location is shown in Figure 3.1 below. It is approximately 1.5km inshore from Guayaguayare Bay.

3.2. Overview of Proposed Activities

bpTT currently operates an extensive network of gas producing facilities off the east coast of Trinidad. Figure 3.2 shows the locations of the bpTT gas platforms. The gas generated by these offshore facilities is fed into the Beachfield Gas Receiving Facility located in Guayaguayare along the southeast coast of Trinidad. From there the gas is fed into the existing 36" line and the proposed NGC 56" line traversing the southern portion of the island to industrial clients along the west coast of Trinidad.

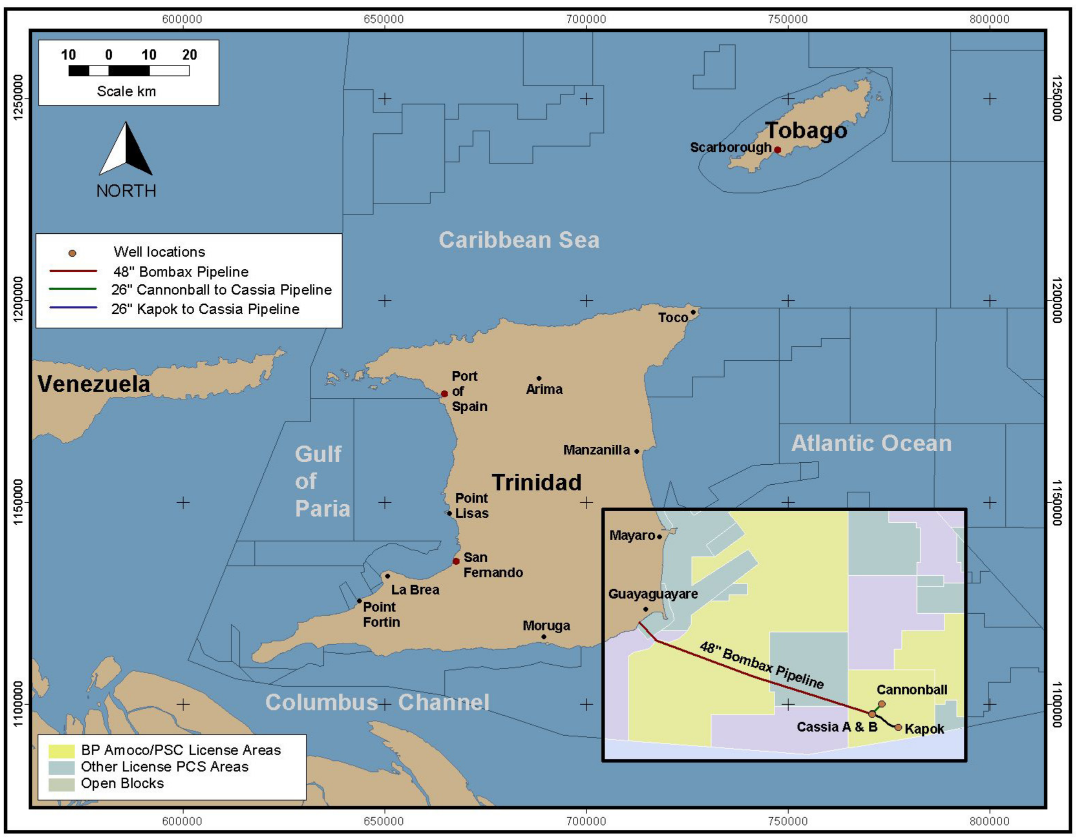


Figure 3.1: General Project Location

The Beachfield facility requires an ongoing supply of gas to satisfy the supply demand agreements that have been established with bpTT. As the reservoir life of the existing facilities are projected to begin diminishing in production then planned facilities will be developed and brought on line to replace the deficits and to sustain the supply needs.

The proposed Cannonball Field Development is one such planned project. This facility will consist of a four-leg wellhead protector platform that will be strategically installed between the Cannonball West and Cannonball East reservoirs located approximately 60km southeast of Trinidad (Figure 3.2). The gas produced from these fields will be transported to the present Cassia B central processing hub via a 5 km long 26" pipeline. A pipeline connection will be conveniently placed along the line to allow for possible tie-in of a future development.

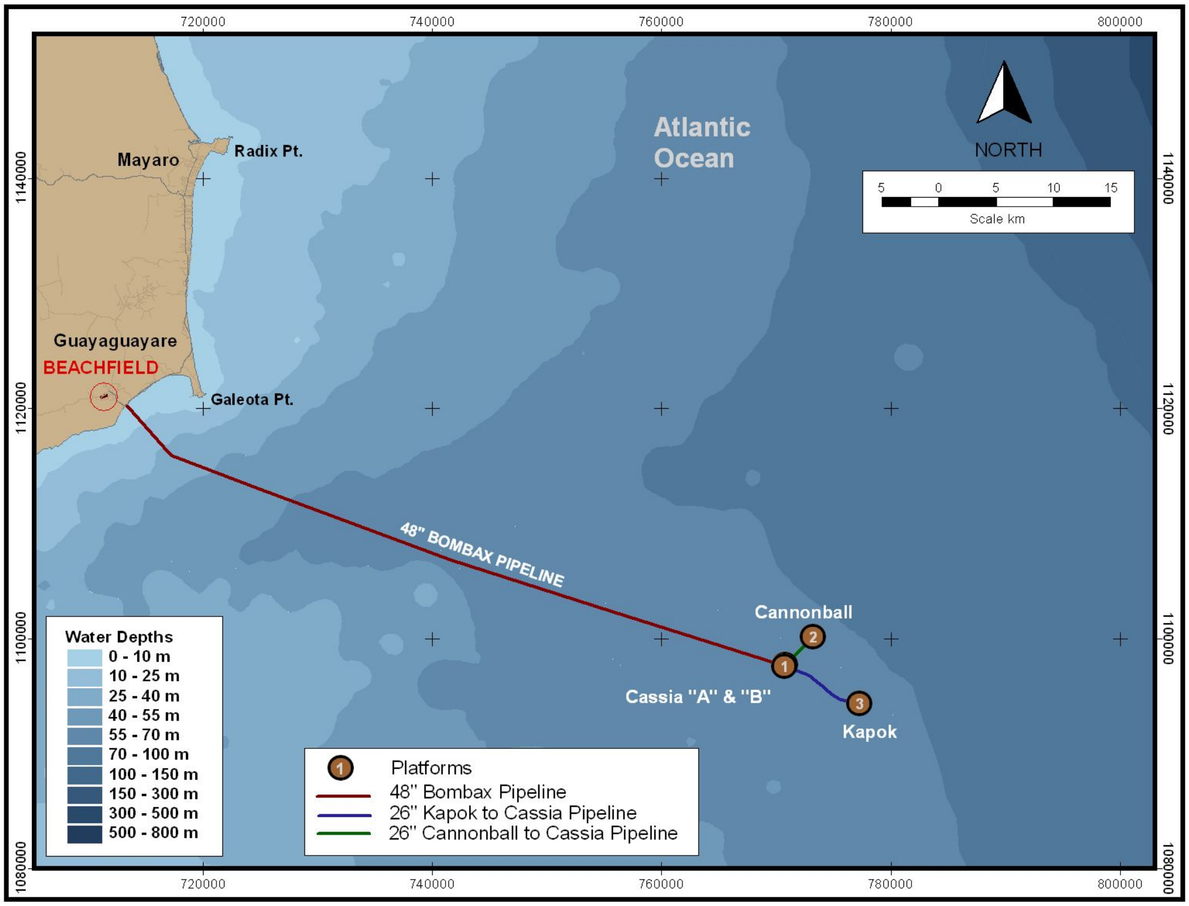


Figure 3.2: Location of the Cannonball Platform and Beachfield Receiving Facility

After processing at the Cassia B Hub, the gas and condensate will be sent to the Beachfield Gas Receiving facility in Guayaguayare along the 48" "BOMBAX" pipeline already installed. The Cannonball Field Development also includes modifications of the Beachfield Gas Receiving Facility to handle increased volumes of natural gas from this new field development.

3.2.1. Key Project Elements

The main elements of this project can be divided between the offshore and onshore aspects of the Cannonball Project.

The offshore facilities required for this project are:

1. Design, fabrication, assembly, installation and hook up of Cannonball Wellhead Protector Platform

2. The installation of a 26" diameter pipeline from Cannonball, approximately 5.0km, to the Cassia "B" hub.

3. Drilling of 2 to 3 wells from the Cannonball Wellhead Protector Platform using a Jack up drilling rig.

4. Operation of the Cannonball Field Development Wellhead Protector Platform: 9 well slots, development wells with a flow rate of up to 350 mmscfd per well (for short periods). Other major functions on the platform are as follows
   - Manifolding
   - Well Testing
   - Power generation
   - Control Room
   - Helideck
   - Crane operations

The onshore scope of this project includes:

5. Modifications to the Beachfield Gas Receiving Facility in Guayaguayare to handle the increased gas and condensate volumes which will be coming in from the development of Cannonball Field. This will include the following:

   - Addition of a new Tuyere Separator/piping in parallel with existing at the slug catcher
   - Installation of a new Metering Skid including two (2) new Tuyere Separators
   - 26" Temporary Bypass above ground from Pig Launcher to Pressure Control System
   - 36" Tie-ins to Pig Launcher and 36" Tie-in to the Pressure Control System

3.3. Schedule of Proposed Works

The proposed Cannonball Field Development is aiming for bpTT internal approval in January 2004. It is hoped that the project will obtain Environmental Management Authority (EMA) approval in May 2004. Fabrication and assembly in Trinidad, of the Cannonball WPP, is expected to start in June 2004 with its transportation and installation at the offshore site to begin in March 2005. Drilling of the two (2) initial wells at the Cannonball Platform is expected to be in May 2005 and would continue for approximately 184 days ending in October 2005. The necessary modifications to the Cassia "B" hub to receive the additional gas from Cannonball would occur between April 2004 and Feb 2005 with the installation of the 26" offshore pipeline-connecting Cannonball to Cassia "B" occurring in April 2005. The modifications to the Beachfield Gas Receiving Facility in Guayaguayare will begin in April 2004 and will continue for 15 months ending in April 2005.

It is expected that first gas will be delivered to the Beachfield Gas Receiving Facility from the Cannonball WPP in 3rd Quarter 2005. Figure 3.3 below shows a summary of the key project activities for the Cannonball Project and their proposed time frame.

Figure 3.3: Proposed Schedule for Cannonball Project

PROJECT ACTIVITY	2004												2005											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
CANNONBALL PLATFORM																								
Fabrication				■	■	■	■	■	■	■	■	■	■	■	■	■								
Transportation to offshore site																	■							
Installation Offshore																	■							
Drilling																	■	■	■	■	■	■	■	■
OFFSHORE 26" PIPELINE																								
Installation Offshore																	■							
Hydrotesting																		■						
Commissioning																		■						
BEACHFIELD MODIFICATIONS																								
48" Pipeline Tie-in				■	■	■	■	■	■	■	■	■	■	■	■	■	■							
Installation of Tuyere/Vane Separator				■	■	■	■	■	■	■	■	■	■	■	■	■	■							
Installation of Metering Skid				■	■	■	■	■	■	■	■	■	■	■	■	■	■							
36" Tie-ins to Pig Launcher				■	■	■	■	■	■	■	■	■	■	■	■	■	■							
36" Tie-ins Pressure Control System				■	■	■	■	■	■	■	■	■	■	■	■	■	■							
Hydrotesting																	■							
Commissioning																		■						

3.4. Proposed Cannonball Wellhead Protector Platform

3.4.1. Reservoir Description

The Cannonball West gas accumulation is located in the Columbus Basin, approximately 60km offshore of the southeastern tip of Trinidad adjacent to the Cassia, Kapok and Amherstia/Immortelle fields in the central portion of bpTT's Greater Cassia Complex (Figure 3.4 below).

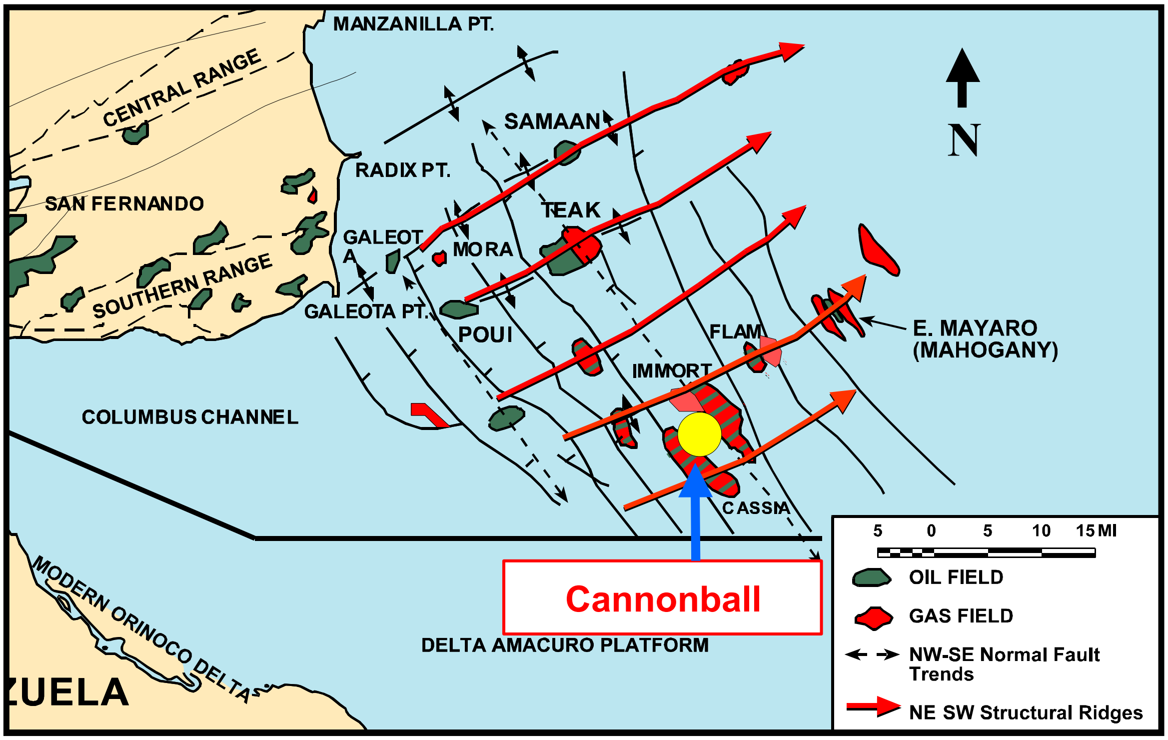


Figure 3.4: Cannonball Project Location with the Columbus Basin

The field was discovered by the IronHorse-1ST1 exploration well drilled in mid-2002 to test for hydrocarbons in an area of distinctive seismic amplitudes that are used as an indicator for the presence of natural gas. The bright yellow and orange area shown on the seismic display in Figure 3.5 represents the gas accumulation. The exploration well found a 289-foot thick gas column in high quality reservoir sands at about 12,500 feet below sea level. Faults and impermeable shales seal the gas accumulation.

The Cannonball West accumulation was mapped using seismic data and correlations between the Iron Horse exploration well and other wells in the area. It is estimated to hold approximately 1 trillion standard cubic feet of gas. Extensive computer modeling of anticipated reservoir performance shows that the planned development should achieve an excellent recovery factor of over 70% of the initial gas in place. Petrophysical and engineering studies indicate that the thick, high quality sand should be capable of high production rates as required to help meet bpTT's gas supply commitments.

The Cannonball platform is considered a Strategic Drill Center within bpTT's long-term basin development strategy. In addition to the Cannonball West gas accumulation, a number of additional future gas supply opportunities exist within range of the platform location. These include both un-drilled prospects and proven, but not fully developed accumulations within the Cannonball East area and deep prospects below the current Cannonball West development.

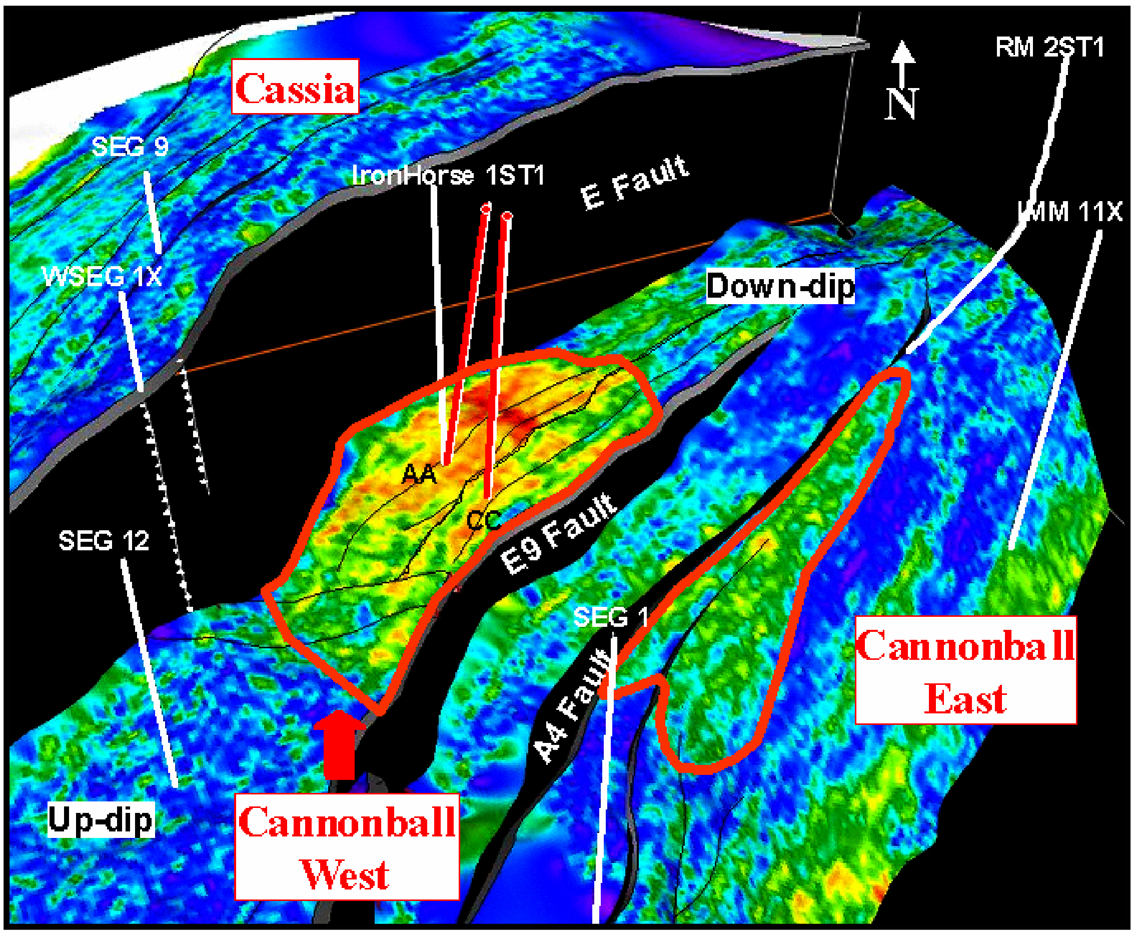


Figure 3.5: 3D View of the Cannonball West 33 Sand showing Structure and Seismic Amplitudes

3.4.2. Proposed Location of Cannonball Platform

Figure 3.2 above gives the overall location of the Cannonball Platform to be installed offshore. The Cannonball Platform will be located offshore 60km southeast of bpTT's Galeota Port Facility. The platform will be installed approximately 3.7km northeast from the Cassia "A" and "B" facilities and approximately 7.2km north-northwest of the Kapok

Facility. The proposed position is 773073.7m E and 1100173.8m N (WGS84, UTM Zone 20). Figure 3.6 below shows the location of the Cannonball Platform in relation to the present Cassia and Kapok Offshore Facilities.

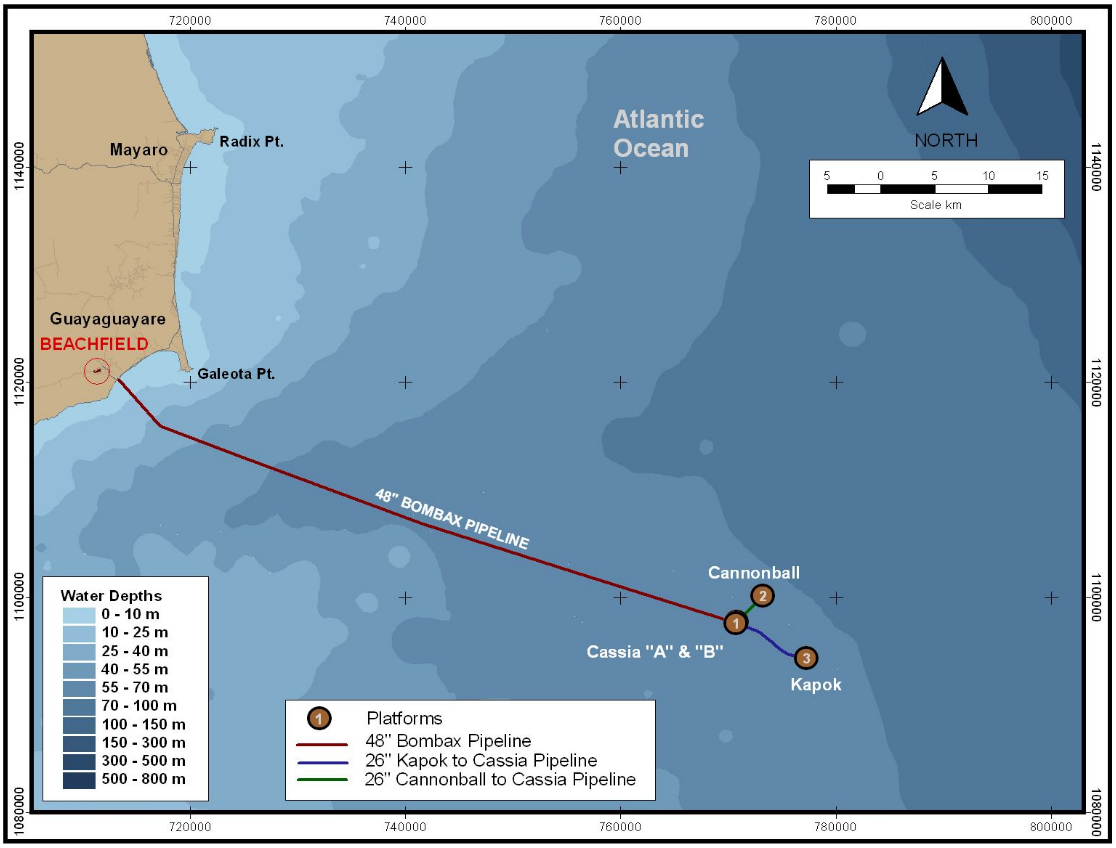


Figure 3.6: Cannonball WPP Location offshore.

3.4.3. Design Basis of Proposed Cannonball Wellhead Protector Platform (WPP)

The purpose of the Cannonball WPP is to access gas and condensate from the Cannonball West and East Offshore reservoir described in Section 3.4.2 above. The Beachfield Gas Receiving Facility in Guayaguayare requires an ongoing supply of gas to satisfy the supply demand agreements that have been established with bpTT. In particular, when Atlantic LNG Train 4 comes on stream in mid - 2006, there will be need for sustained gas supplies to the Beachfield Gas Receiving Facility. As the reservoir life of the existing facilities are projected to begin diminishing in production then planned facilities such as the Cannonball WPP need to be developed and brought on line to replace the deficits and to sustain the supply needs.

The platform is designed to be an automated unmanned facility and will transport its gas to the Cassia B hub, southwest of Cannonball, then onwards to the Beachfield Gas Receiving Facility along the already present 48” BOMBAX Pipeline.

At present the Beachfield Gas Receiving Facility processes approximately 1.8 billion standard cubic feet of gas per day (bcfd). The Cannonball Field Development Project plans to produce an additional 1.1 bcfd to supply Beachfield Gas Receiving Facility bringing the total volume to 2.9 bcfd. The production profile for the field is as shown in Figure 3.7 below.

The design of the Cannonball WPP was governed by the best practice of an inherently safer design. Typical inherently safer design features used include:

- Minimizing inventory;
- minimizing equipment, flanges, fittings and instruments;
- keeping the design and intended operating activities simple;
    - using well proven technology and techniques;
    - minimizing intervention requirements;
    - minimizing manning requirements.

From previous risk studies conducted, the main activities which pose the highest risks are the transportation of personnel offshore and having personnel in close proximity to the processing facility. On this project aligning ourselves with an inherently safer design has led to a decrease in the personnel transportation frequency and the interaction of personnel with the process. As a result, the Cannonball project team has designed a facility with a visitation frequency of once per quarter with up to 10 persons on board during each visit.

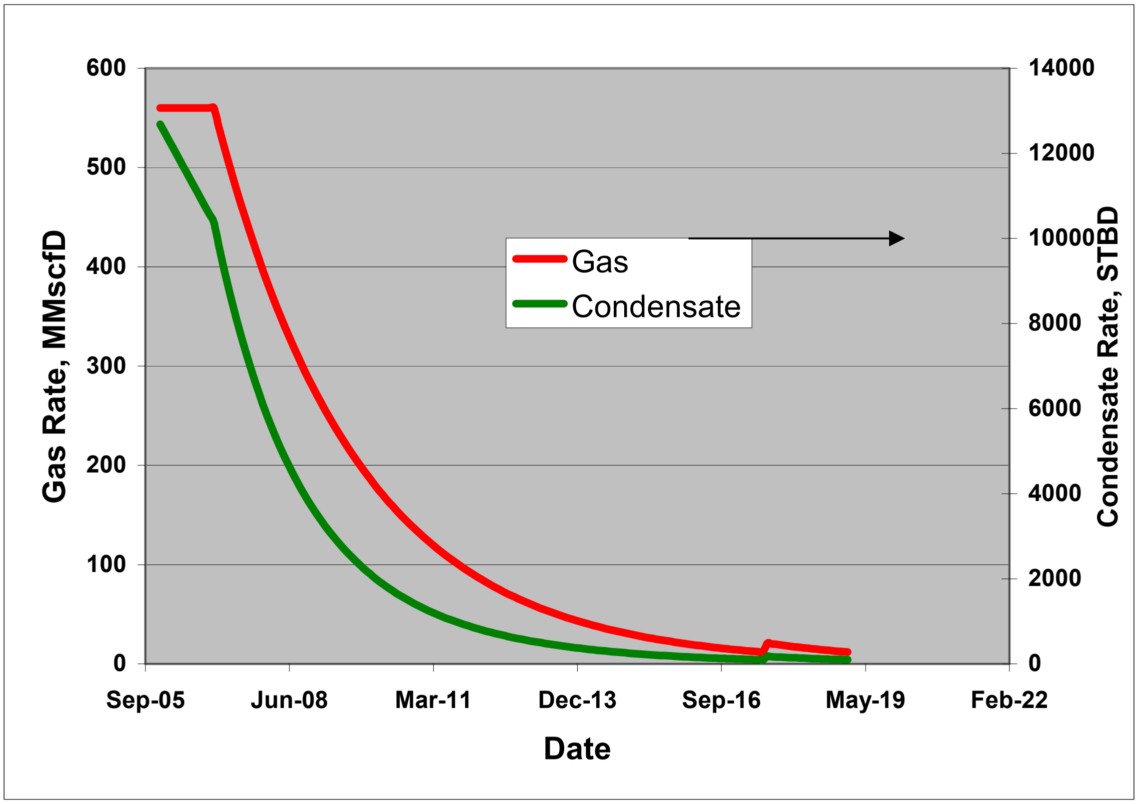


Figure 3.7: Production Profile for the Cannonball Field

3.4.4. Description of Proposed Cannonball Platform

The Cannonball WPP to be installed offshore is a four (4) leg WPP that will be strategically installed to allow for efficient access of the Cannonball West and East reservoirs. The depth of water at the installation location is 235ft (71.6m). The facility will provide for three (3) high flow rate wells, comprising of standard 7 5/8" completions. There will be slots available for up to nine (9) wells for future development.

It is designed as an unmanned facility and operations will occur remotely with functional visits scheduled on a quarterly basis.

Figure 3.8 below shows a 3-D graphic of the Cannonball WPP viewed from the southwest.

Figure 3.9 shows the platform configuration viewed from the northeast while Figure 3.10 shows the platform from the northwest. The major pieces of equipment and machinery to be found on the Cannonball WPP are illustrated in these Figures.

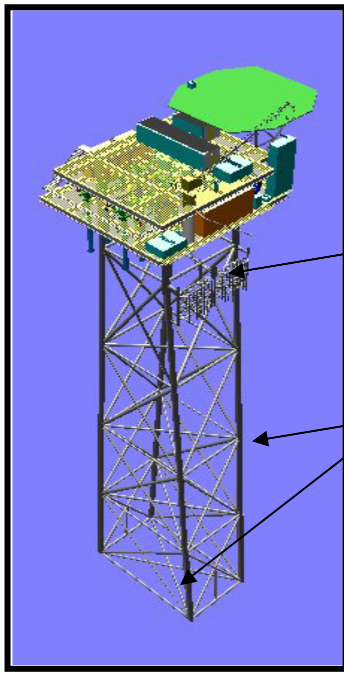


Figure 3.8: Cannonball Platform viewed from southwest

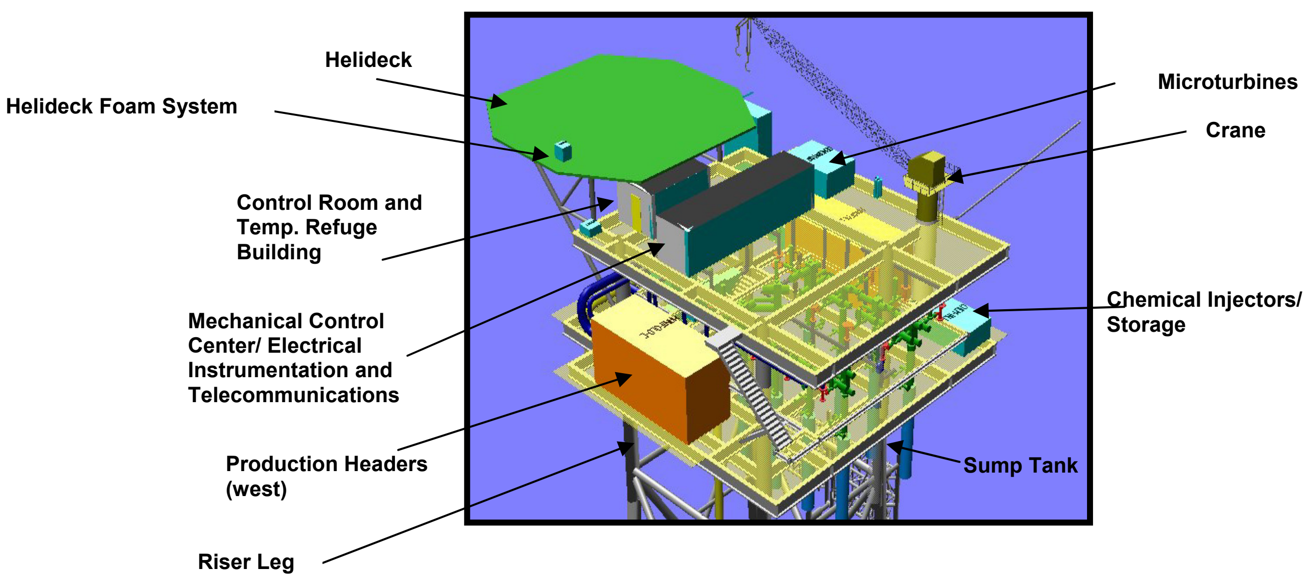


Figure 3.9: Cannonball Platform viewed from the northeast.

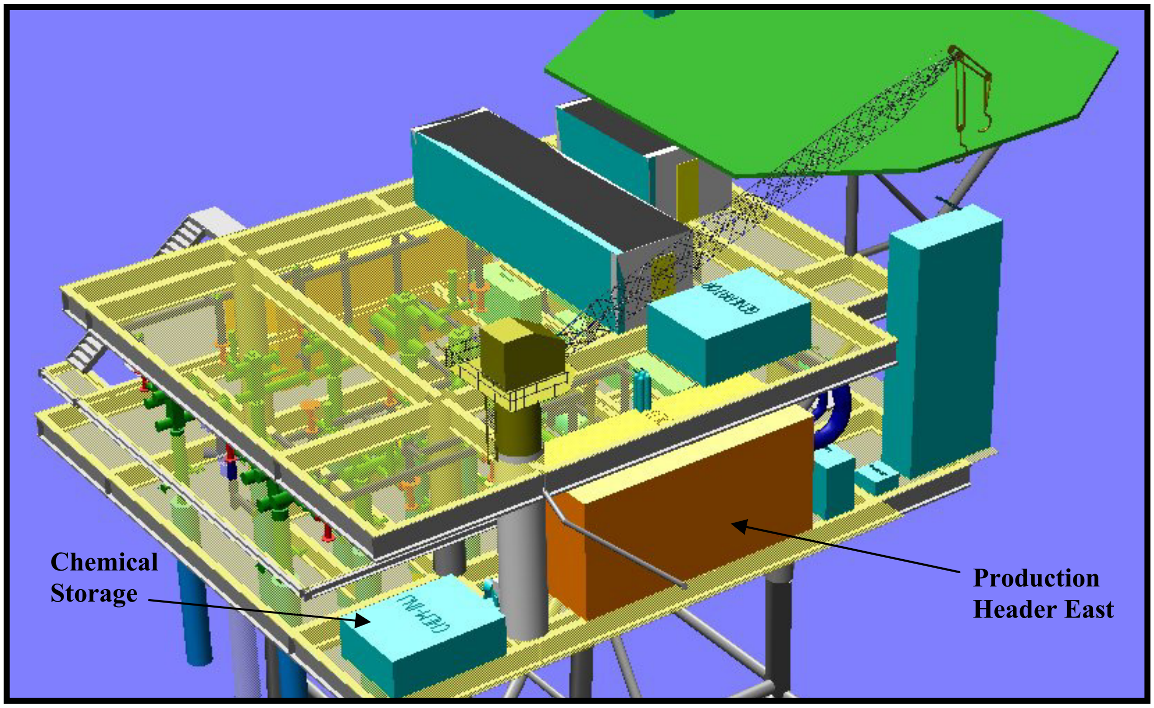


Figure 3.10: Cannonball Platform viewed from the northwest

The major pieces of equipment on the platform consist of:

Table 3.2: Major Platform Equipment	
Equipment	Description
Helideck:	17.4m diameter designed to receive a BELL 412 Helicopter of weight approximately 4,700kg.
Crane Pedestal:	Installed on the west side of platform.
Hydraulic Power Unit:	The hydraulic power unit will consist of an electrically driven 10,000 psi system for controlling the SCSSSV and a 3000 psi system for controlling all other valves.
Pig Launcher:	The gas pipeline holding the full well stream will be designed to allow pigging with an instrumented smart pig.
Power Generators:	Dual micro-turbine units each rated at 60kW, producing 480 VAC, 50/60 Hz will be the prime source with a diesel generator unit for black start and back-up power. Produced gas will used as fuel gas for the micro-turbines.

The jacket for the WPP is a four (4) leg configuration which is arranged in a grid with transverse and longitudinal spacing of 40ft by 45ft at the working point. Leg diameter is expected to be 1.2m. The platform is expected to be installed at the offshore site using a semi-submersible crane vessel. The installation procedure is discussed in Section 3.4.6 below.

The estimated structural weight of the Cannonball WPP is 1,686 tons. The deck's expected lift weight is 866 tons. The estimated weight of the four (4) skirt piles is 968 tons. During installation, the expected penetration depth is approximately 50m into the mudline.

As the Cannonball WPP is normally unmanned, all operating functions will be monitored and controlled from the nearby Cassia "B" Hub (Figure 3.2). Communications will be via microwave radio signal to the Cassia "B" Facility with a redundant link to Kapok Platform. There will be provisions for installing a fiber optics interface as a back up for the radio telecommunications system. There will, however, be a series of planned quarterly visits to the Cannonball WPP to conduct the following functions:

- Platform refueling (e.g. diesel).
- Chemical re-supply (corrosion inhibitor).
- Crane operations.
- Pig launching.
- Mechanical/safety maintenance.
- Cathodic protection survey.
- Reinstating flowing status after a facilities shutdown.
- Potential installation of velocity strings later in field life.

Failure of the downhole completion components may require the intervention of a jack up drilling rig for remedial work later in the field life, such work may comprise responding to failed down hole safety valves (DHSVs), tubing failures and casing leaks. Wireline operations may also be required depending on the nature of the work to be carried out.

Access to the facility will be by means of helicopter. When a Jack up drilling rig is present at the Cannonball WPP, helicopter access will be provided by the Jack up drilling rig helideck.

All Drilling/Completion/Workover operations will be conducted from a jack up drilling rig cantilevered over the Cannonball WPP, as it is not designed to support drilling operations. This is described in Section 3.4.7 below.

3.4.5. Facility Systems Onboard

3.4.5.1. Utility Systems

Utility Water

Utility water is required on the facility for miscellaneous uses such as utility stations. The water quality will be non-treated salt seawater therefore continuous sodium hypochlorite injection will not be required. A single 100 gpm at 50-psig discharge pressure Utility Saltwater Water pump will be installed on the facility. All utility lines around the platform will be fiberglass with maintenance inlets.

Diesel Fuel

Diesel is required as fuel to drive the engine that powers the crane and portable air compressor when on board for maintenance or other uses.

The diesel storage will be in a small tank mounted near the crane. This area will be constructed with appropriate bunding (both primary and secondary containment areas in the event of spills to reduce likelihood of spills to sea).

Fuel Gas

Fuel gas is required on the platform to be used as fuel for the micro-turbine power generators. Production gas from the pipeline will be used as fuel gas. The nominal capacity of the system is 1.0 MMscfd of gas based on the maximum consumption of all micro-turbines simultaneously. Fuel gas will be supplied with produced gas at 1,350 psig directly from the production manifold. A let down pressure skid will reduce the pressure to 200-250 psig. The final pressure of the system will be driven by the micro-turbine requirements.

Utility Air

All instrumentation on the Cannonball WPP will be electrically/hydraulically operated. No pneumatic instruments will be used. A portable diesel driven air compressor will be brought on board for maintenance use if required. No permanent air compressor provision required.

Potable Water

Potable water will not be stored on the platform. Portable eyewash/safety showers and personal eyewash bottles will be provided. Water and emergency overnight supplies will be stored on the facility.

Helicopter Fuel

No helicopter fuel capability will be present on this facility.

Drain Systems

A hydrocarbon/oily water drain system will be designed to capture all oily residual liquids. The closed drain header collects hydrocarbon from equipments such as the pig launcher, diesel storage tank, fuel gas filter that needs to be drained for maintenance. It will also collect the hydrocarbons derived from the fuel gas scrubber as a continuous contribution.

The open drain will collect mostly rainwater and spills or leakage from equipment skidpans. The platform will be grated therefore a large amount of open drain is not expected. Each skid will be equipped with a liquid seal drain to avoid gas contamination on the platform.

The drain Sump Tank will collect both closed and opened drains and shall be designed for one header approximately ½ filled with liquid in addition to the continuous condensate-water mixture from the Fuel Gas Scrubber. The fluid from the Sump Tank will then be pumped back into the pipeline; the total fluid will be exported to Cassia "B". An electric motor-driven plunger pump shall be designed to transfer the total fluid from the Sump Tank to the pipeline at 1,300 psig minimum pressure.

Chemical Injection

Chemical injection will be provided on the facility for corrosion inhibitor. The chemical injection storage shall be designed for three (3) months supply to satisfy the philosophy of unmanned platform with quarterly visits. Chemical will be pumped from a boat to the chemical storage tank on the facility and will be injected on the platform downstream of the choke valves to protect topsides piping as well as the pipeline. Piping upstream of the choke would be stainless steel so injection at this point is not required.

No chemicals to manage hydrate formation are required, as the fluid will operate outside the hydrate formation envelope. The chemical storage tank is a double walled containment tank equipped with sensors which indicates any leakage between the tank walls. The chemical injection area will be constructed with appropriate bunding to reduce the likelihood of spills to sea.

3.4.5.2. Utility Equipment Onboard

Pig launcher

The 26" gas pipeline holding the full well stream will be designed to allow pigging with an instrumented smart pig. The frequency of pigging and levels of automation will be agreed with operations, and will be based on reliability and operability considerations, in order to minimize unmanned platform interventions.

Hydraulic power unit

The hydraulic power unit will be located in the wellbay area and consist of an electrically driven 10,000 psi system for controlling the SCSSSV and a 3000 psi system for controlling all other valves. The hydraulic power fluid chosen will be on the MEEI's approved list of chemicals. All fail-safe valves are spring loaded so in the event there is a loss of hydraulic fluid/pressure, the valves will move into their set failure position. Redundancy will be provided by the means of a pneumatic driven and/or manually operated pump.

Motor Control Center

The Motor Control Center will consist of a dual tiered workstation with the following features: -

- Shutdown capability
- Interlock bypass capability
- Alarm displays and arrays
- Ability to communicate via marine aeronautical radios.
- Microwave link directly to Cassia B or to Cassia B via Kapok
- System is fiber compatible for future LAN connections
- Downhole monitoring displays
- Sand monitoring
- Historized data
- Power monitoring for load shedding and to operate microturbines at maximum efficiency
- Emissions monitoring
- Security monitoring (Fire and Gas, CCTV)

Power Generators

The power required to operate the facility properly is approximately 35 kW unmanned and 85kW manned with everything running. The base case will be using the micro-turbines as the power supply. Dual micro-turbine units are each rated at 60 kW. Produced gas will be used as fuel gas for the micro-turbines.

The platform will be equipped with an Uninterruptible Power Supply (UPS) system that consists of banks of batteries, battery charger, DC/AC converters, and static transfer switch. The UPS will be designed to provide nine (9) hours of rated power output in the event of total loss or failure of normal power to the critical users and 12 hours with load management.

The Nav Aids system will have a dedicated battery charger and will incorporate solar panels.

The Telecom equipment will have a stand-alone battery and charger, separate from the UPS serving process related loads. A breaker will be available for a portable generator connection for backup.

Accommodations

No permanent accommodations will be provided, as this is an unmanned facility. A temporary safe refuge will be provided in conjunction with the Control Building sized to shelter an overnight stay for 4 persons.

HVAC

HVAC will be provided only for the Control Building and the temporary safe refuge. The EIT building will be located in a non-hazardous area.

Communications

Communications will be by microwave radio signal to the Cassia B hub. A fiber optics interface will be designed for future tie-in and as a backup for the radio telecommunication system. Provisions shall be made for a hang off point for the fiber optics umbilical.

Lifesaving Systems

The normal means for access to the platform evacuation will be by helicopter. If helicopters are unable to land due to inclement weather, shelter is provided on board the platform. Operations provisions when manning the platform will take into consideration food and water for overnight stays. A stand by boat will be no more than ten (10) minutes away when the platform is manned.

Two 12 man life rafts will be located near the temporary safe refuge. The life rafts shall meet the requirements of 33 CFR 144 and SOLAS. Life rafts will be throw-over type contained in a storage canister. Life preservers will be worn by all personnel when they arrive on the platform and will meet the requirements of 33 CFR 144 and SOLAS.

A minimum of four (4) life ring buoys will be installed on the platform. One ring buoy will be installed on each side of each deck that is over water, with the exception of the helideck. Life ring buoys will be complete with a water light and meet the requirements of 33 CFR 144 and SOLAS.

3.4.6. Fabrication of the Cannonball Platform

The Cannonball WPP will be fabricated and assembled at the approved LABIDCO fabrication yard in La Brea and at a Gulf of Mexico (GOM) yard in the United States of America. Different stages of work will be carried out at the various sites. The jacket piles will be fabricated in the GOM and shipped by barge to LABIDCO in Trinidad. All jacket pre-fabrication work will also be carried out at the GOM worksite.

The assembly of the base support legs; cellar deck, mezzanine floor, production deck and the main deck will be carried out in Trinidad at the LABIDCO site.

Main activities at the LABIDCO site and Weldfab's fabrication shop in Claxton Bay are:

- Welding
- Pipe Joining
- Blasting (in preparation for painting)
- Painting

The list provided below outlines the pieces of equipment to be located in Trinidad and Tobago for the fabrication:

Table: 3.3: Fabrication Equipment to be used In fabrication

Equipment	Quantity
Crawler cranes	5
Cherry Picker	1
Welding Machine	50
Wire Feed	50
Tractor/trailer	1
Truck HIAB	1
Crane Mats	28
Forklift (10 ton)	1
Sand Blast equipment	4

The Fabrication and Assembly contractor manages the LABIDCO, GOM and Weldfab's sites and is obligated to comply with bpTT's minimum HSE standards as well as Cannonball's Contractor HSE Management Plan (Appendix C).

A bpTT HSE representative will be present at each worksite to ensure that the Fabrication and Assembly activities comply with the bpTT Construction HSE Management Plan. There will be regular audits of the fabrication and assembly areas to ensure compliance.

3.4.7. Transport of the Cannonball WPP to Offshore Location

The fabrication of the Cannonball WPP is expected to occur at the LABIDCO Fabrication Yard which is located at La Brea along the west coast of Trinidad. Fabrication is expected to be completed in March 2005 at which point the platform will be transported to its offshore location site via cargo barges (each of which will be towed using a tug vessel). Figure 3.11 below shows the probable sea transportation route to be taken by the cargo barges.

Figure 3.11: Offshore Transportation Route of the Cannonball WPP

The transportation from La Brea to the offshore site is expected to take approximately 2 days. The transportation plan will be designed in full collaboration with the Maritime Services Division of Trinidad and Tobago and will be accompanied by a program of public awareness via local media. Representatives from bpTT will be sent to the various fish landing sites along the route to inform local fishermen of the transportation of the platform and its duration and route. A "**Notice to Mariners**" will be published in the local media prior to the transportation.

Wastes and emissions from the tugs and cargo barges will conform to local discharge regulations and to bpTT's HSE standards. bpTT will have an HSE representative on board these vessels during the transportation phase to ensure HSE compliance with local and company standards.

3.4.8. Installation of Cannonball Platform

Upon arrival of the Cannonball WPP, at the offshore location, the cargo barges will rendezvous with a lifting crane vessel. This installation vessel will be moored at the site using a 12 anchor spread pattern with a radius of approximately 2,195m. Figure 3.2 above shows the proposed location of the Cannonball WPP.

A site survey of the installation area was conducted by Capital Signal Limited in July 2003. The results of the survey indicate that the depth of water at the proposed installation site was between 70 – 73m. There are no anomalous features within the area of the platform installation point and there is no need for site preparation and dredging.

During the installation procedure, the cargo barges will be moored to the lifting crane vessel. The crane will lift the platform jacket from the cargo barge, which will then be pulled away. The jacket will then be rotated while suspended until vertical and lowered to the seafloor. The cargo barges will then be brought back to be moored to the lifting crane vessel. Each of the four piles will be lifted, rotated to vertical and then inserted into the four jacket legs. The piles will then be driven to the design penetration depth (24.4m below mudline) using a large underwater hydraulic hammer. Upon completion of the pile driving, the piles will be grouted to the pile sleeves.

The cargo barge with the Cannonball WPP will then be moored to the lifting crane vessel. The platform is then lifted onto the jacket by the crane after which the deck section is welded to the jacket. After completion of all structural connections and start up of onboard systems, the lifting crane vessel will pull away from the platform and all anchors will be retrieved.

Figure 3.12 below illustrates the process of using a crane barge offshore to install the Wellhead Protector Platform. The photograph illustrates the installation of the bpTT Cassia “B” hub in August 2003.

Figure 3.12: Installation of the Cassia “B” Hub in 2003

During the installation, the crane lifting vessel, the cargo barges and any support vessels will be required to conform to local discharge regulations and to bpTT’s HSE standards. bpTT will have an HSE representative on board these vessels during the installation phase to ensure HSE compliance with local and company standards.

3.4.9. Drilling Program

Drilling of Cannonball's first two wells is expected to start shortly after platform installation. The expected start of drilling is May 2005 and will continue until November 2005. The drilling plan calls for the first two (2) wells to be drilled with an option to drill a third well in the future. There are nine (9) well slots on the Cannonball WPP for future development.


Figure 3.13: ENSCO 76 Rig

Cannonball wells will be drilled and completed with an 116C Type Jack Up drilling rig. A drilling rig has not been selected as yet for the Cannonball Project however; it will be similar to that used for the drilling of the KAPOK wells which are to the south of the Cannonball. The drilling rig used for KAPOK's drilling operation is the ENSCO 76 Jack-Up Rig with dimensions of 74m x 63m x 8m. The rig is shown in Figure 3.13.

Figure 3.14 below shows a schematic of the drilling rig canter-levered over a well platform. The particular platform being shown is the KAPOK platform whose drilling program will be completed in early 3Q 2004

The typical Cannonball Well will be drilled to approximately 14,377 ft with sections drilled by progressively decreasing diameter drill bits through the rock formations. Figure 3.15 below shows a schematic of the drilling program for the Cannonball Platform. The drilling program can be separated into five (5) intervals.

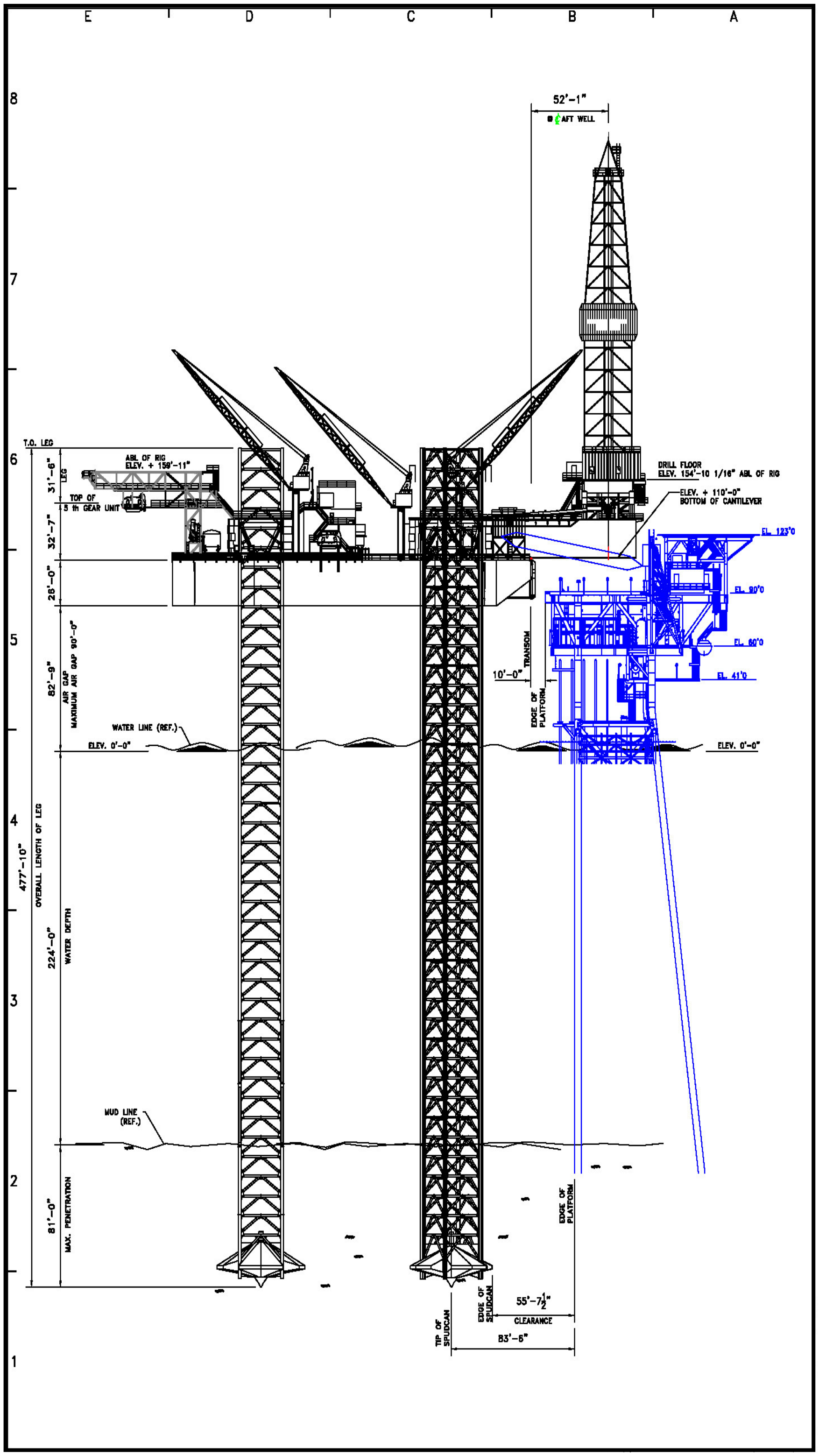


Figure 3.14: Illustration of a Jack-Up Drilling Rig canter-levered over a well platform.

INTERVAL 1: A 30" conductor casing will be driven to a depth of 700 ft MD-RT (Measured Depth – Rotary Table). **INTERVAL 2**: A 26" hole will be drilled and 20" casing will be set at a depth of 2000 ft MD-RT and cemented in place. **INTERVAL 3**: A 17 ½ " hole will then be drilled and 13 5/8- inch casing will be set at a depth of about 7362 ft MD-RT and cemented in place. **INTERVAL 4**: A 12 ¼" hole will be drilled and 10 ¾" casing will be set at a depth of about 12,398 ft MD-RT and cemented in place. Finally, **INTERVAL 5**: an 8 ½" hole will be drilled and a 7"gravel pack liner will be set at a depth of about 12,735 ft MD-RT. The details discussed above may vary as the project progresses.

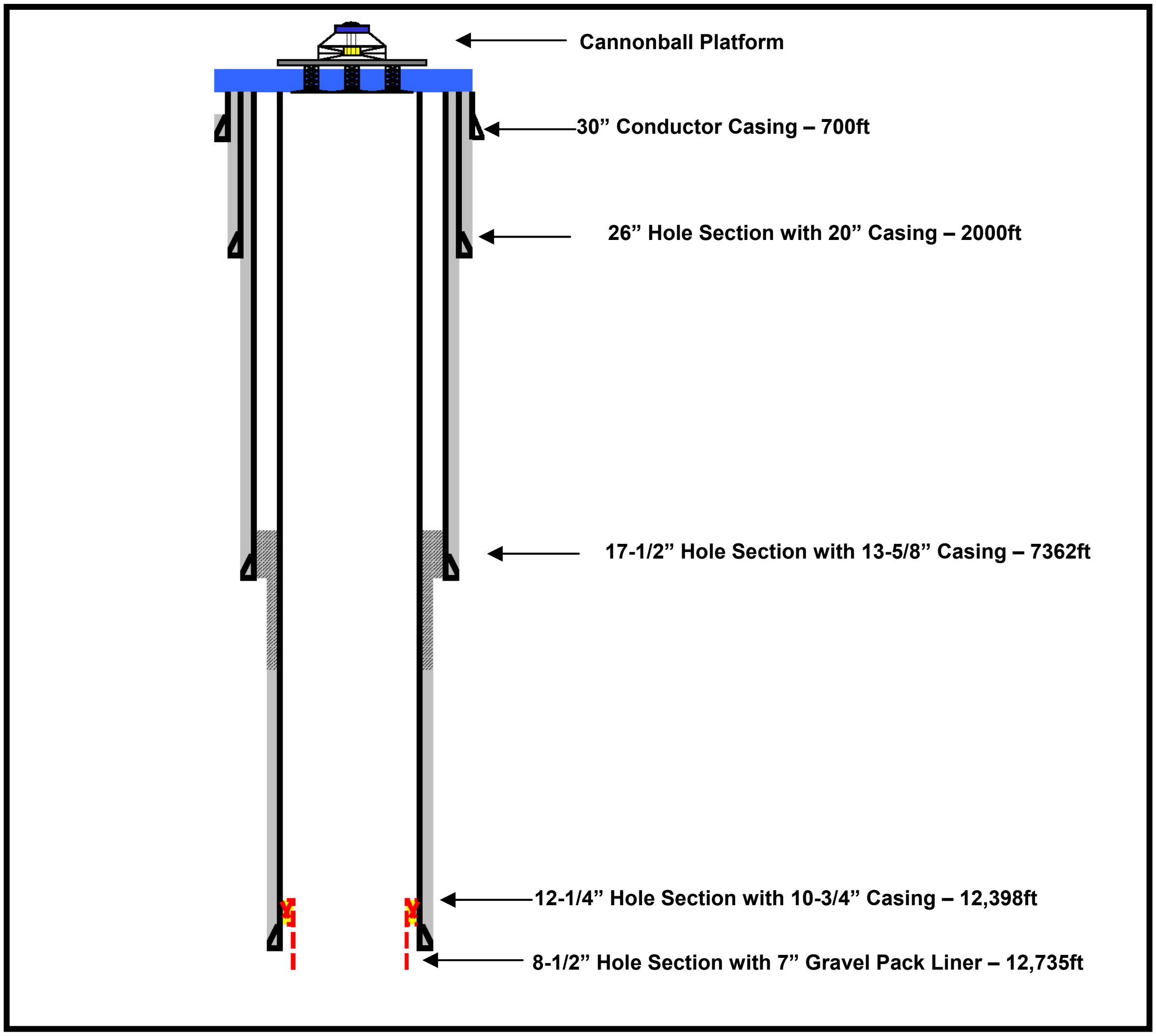


Figure 3.15: Typical Cannonball Well Design

3.4.9.1. Drilling Mud and Cuttings Disposal

During the Cannonball drilling operations, drilling mud will be pumped down the drill string and up through the annulus. Drilling fluids or drilling muds are an essential component of the rotary drilling process used to drill for oil and gas on land and in offshore environments. The most important functions of drilling fluids are to transport cuttings to the surface; to balance subsurface and formation pressures preventing a blowout; and to cool, lubricate, and support part of the weight of the drill bit and drill pipe (Neff *et al.* 1987; Darley and Gray 1988). During drilling, the drilling fluid is pumped from the mud tanks down the hollow drill pipe and through nozzles in the drill bit. The flowing mud sweeps the crushed rock cuttings from beneath the bit and carries them back up the annular space between the drill pipe and the borehole or casing to the surface. The mud is then passed through solids control equipment (an integrated system of shale shaker screens and hydrocyclones) to remove the cuttings. It is then circulated back to the mud tanks where the cycle is repeated. This system is summarised in Figure 3.16 below:

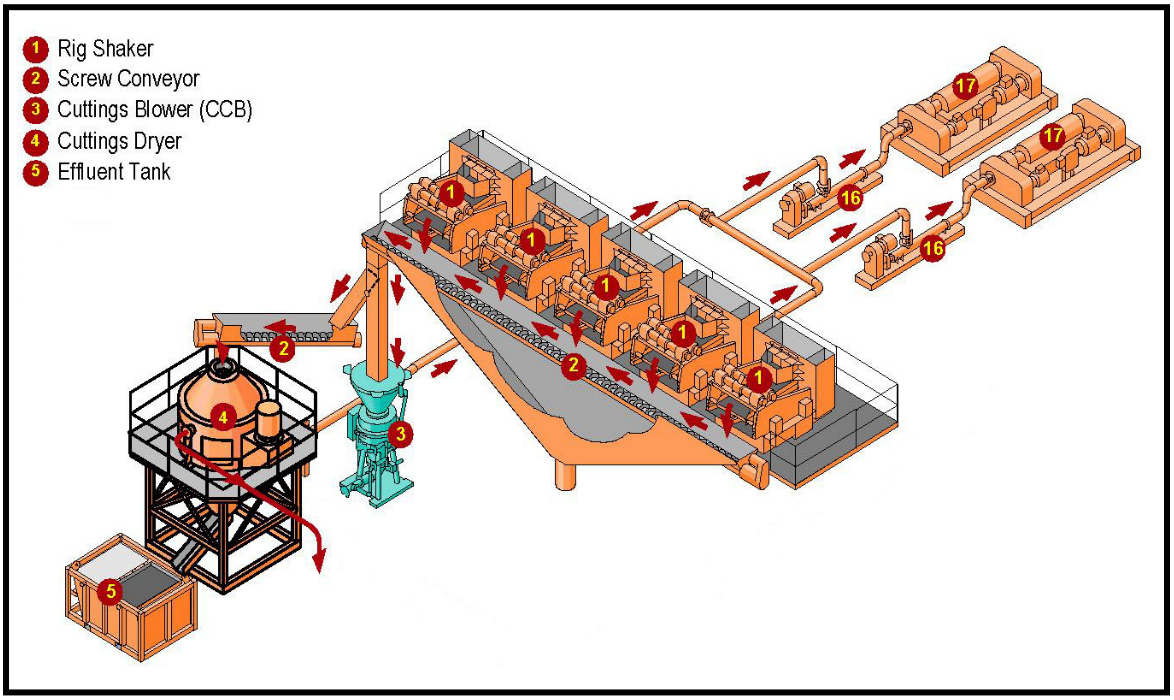


Figure 3.16: Drill Cuttings Separation System for Cannonball Well Platform

The mud being brought back to the surface from the drill hole is sent to the Shakers (1) via the Centrifuge (17) and Centrifuge Feed Pumps (16). The separated cuttings are then transported via the Screw Conveyor (2) system to the Cuttings Dryer (4) after which the cuttings are discharged overboard.

Water Based Muds (WBM) will be used for the surface and intermediate hole sections and the completion interval while low toxicity Synthetic Oil Based Mud (SOBM) will be used for the deeper drilling intervals. WBMs will be discharged at a low rate together with drill cuttings during the drilling process which is primarily a result of adherence of the drill muds to the cuttings. Larger volumes of the WBM are discharged when there is a change in type of drill mud being used and at the end of a well.

Upon completion of drilling a well with SOBMs, muds are separated from the cuttings via the use of shakers and stored for transport to the shore where it is cleaned and reformulated to make new SOBM. Overboard discharge of SOBM will not occur. However, there will be some discharge overboard of SOBM as part of the 6% retained oil on cuttings (ROC). This is well below the Ministry of Energy and Energy Industries (MEEI) requirement of 10% ROC.

Table 3.4 below shows the estimated volumes of drill cuttings and drilling muds being generated and discharged during the Cannonball Drilling Program. The drilling muds and associated fluids being used will be approved by the Ministry of Energy and Energy Industries (MEEI).

Table 3.4: Drilling Mud and Cutting Discharge Program for typical Cannonball Well

Interval	Drilling Mud	Drilling Days	Volume of Drill Cuttings discharged (bbls)	Vol. of Drilling Mud discharged (bbls)
I - Surface	WBM	7	N/A	400
II - Intermediate	WBM	3	2,206	2,644
III - Production	SOBM	8	2,718	-
IV – Completion	SOBM	9	1,558	-
V	WBM	5	99	2,807

3.4.10. Sewage Discharge

The Cannonball WPP is an unmanned facility hence there will be no sewage and habitation wastes generated normally. However, there will be quarterly visits by personnel to conduct operations such as Mechanical/Safety Maintenance, diesel refueling, cathodic protection surveys etc (see Section 3.4.3) which are expected to last approximately three (3) days. A maximum of 10 persons will be onboard during these scheduled periods. At these times there will be generation of some sewage waste. This will be handled by an onboard sewage macerator which will grind the solids to approximately 1/8 of an inch after which it will be discharged to sea.

3.4.11. Garbage and Debris

In accordance with bpTT Waste Management Plan, no discharge of solid wastes such as garbage and debris will be permitted. These will be stored and transported via boats to the ASCO Base in Galeota where they will be disposed on land at an approved disposal site.

3.4.12. Air Emissions

At the Cannonball Wellhead Protector Platform possible sources of air emissions are as follows:

- Combustion gases from natural gas fuelled equipment such as the Microturbine for power generation.
- Hydrocarbon drips from minor spills
- Venting due to a platform blowdown or through relief valves during an emergency
- Minor fugitive emissions from general process related equipment.
- Combustion gases from the diesel fuel crane.
- Combustion emissions from the drilling rig during the drilling programme.

Table 3.5 below shows a summary of the expected CO_2 emissions from the Cannonball WPP , while Table 3.6 shows the emissions from the Cannonball WPP's Microturbine Generators. Table 3.7 shows the projected combustion emissions from the jack up drilling rig during the drilling programme.

Table 3.5: Summary of CO_2 Emissions from Cannonball Platform					
Process	**Vol Vented (SCF)**	**Vol Vented (MMSCF/yr)**	**Vol Vented (Tonnes/yr)**	**CO_2 Equivalent (Tonnes)**	**Notes**
Routine	22,209	0.02	0.42	389.45	Assume pigging 4 times per year
Unplanned (downhole leaks)	23,683	0.02	0.45	9.51	Assuming downhole leaks will not occur more than once in 5 years based on previous experience
Planned Maintenance (non routine)	526,388	0.53	10.07	211.40	For example if an extra valve needs to be added onto the header (ie if another well is to be drilled). So far provisions have been made for the tie in of 3 wells on the headers.
Maintenance (Routine)	293,818	0.29	5.62	118.00	SCSSSV checks require blowdown of Flowline and Tubing 2 times per year. Xmas tree valves require flowline blowdown quarterly.
Planned platform Work (Rig)	306,848	0.31	5.87	123.23	The Platform needs to be blown down when the rig arrives and leaves. Apart from that it is envisioned that the platform should never have to blowdown (98% sure)
Emergency	153,424	0.15	2.93	61.62	

Table 3.6: Summary of Emissions from Cannonball's Microturbine Generators (Vendor supplied)		
Gas Emitted	**Vol. per kW-hr (gm/kW-hr)**	**Per year (Tonnes/yr)**
NO_x	0.223	0.117
CO	0.603	0.317
HC	0.078	0.041
NO_x + HC	0.301	0.158
CO_2	724	380.534
O_2	7,060	3,710.736

Table 3.7: Estimate of CO_2 Emissions from Cannonball Drilling Rig		
Gas Emitted	**No of Days Drilling**	**Volume of Gas Emitted (tonnes)**
CO_2	184	6,312

3.4.13. Produced Water

Produced Water is formation water that is brought to the surface during gas production. Initially as a field is brought into production there will be no produced water, however over the years of production the water content is anticipated to slowly increase up to the design rate of produced water.

The produced water from the Cannonball WPP will be sent to the Cassia "B" hub, 3.7km to the southeast (see Figure 3.2), via the 26" pipeline that is being laid between Cassia "B" and the Cannonball WPP. Please see Section 3.5 for a discussion of the laying of this pipeline.

At present, Cassia "B" serves as the receiving hub for the produced water from four (4) existing bpTT gas platforms. These are:

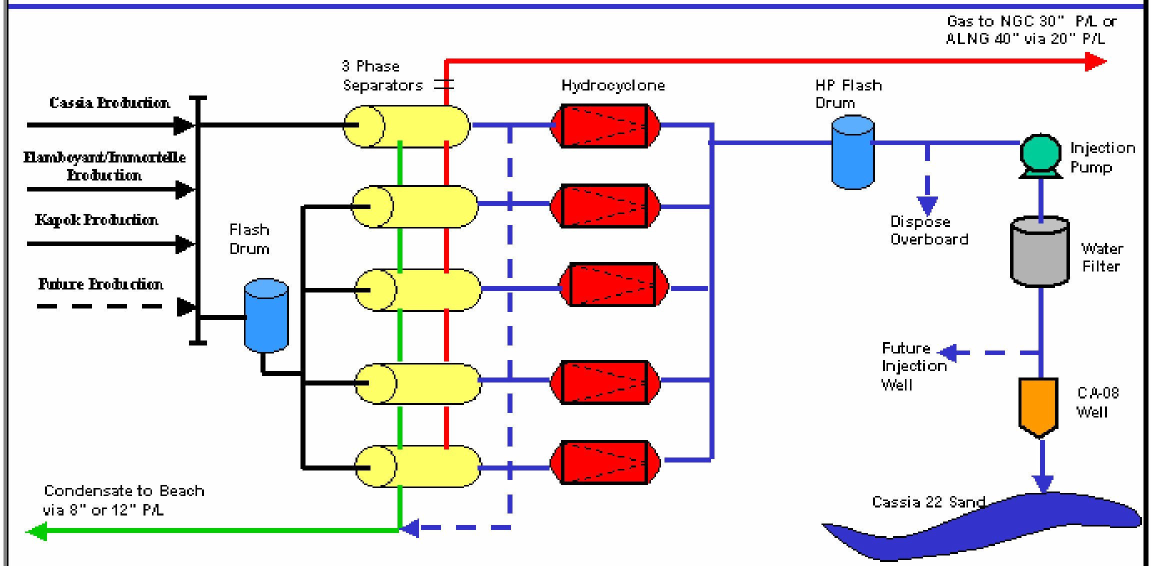
- **C**assia, **I**mmortelle and **F**lambuoyant (CIF)
- Kapok.

The produced water from the Cannonball field will be mixed with the above produced water sent to the Cassia "B" Platform. All the produced water arriving at Cassia "B" is treated by a Produced Water Re-Injection System (PWRI) and then disposed by re-injection into the Cassia "A" Produced Water Injection Well (Well 8).

Figure 3.17 below shows the PWRI Facility on Cassia "B" that will be handling the Cannonball Produced Water. The High Pressure (HP) Produced Water Treating, Pumping and Disposal facilities include five Hydrocyclones, one HP Flash Drum, four Produced Water Injection Pumps and two Produced Water Filters. The system is designed to treat about 25,000 standard barrels per day of produced water from the production separators. It reduces the free oil concentration in the produced water from 1000 ppm to 29 ppm at the outlet of the HP Produced Water Flash Drum. The water is then pressured to 2037 psig, filtered and injected into a well at Well No. 8 located at Cassia "A". The separated oil from the system will be sent to the Closed Drain Sump Vessel for reprocessing.

Table 3.8 below shows the expected Cannonball Produced Water parameters as supplied by bpTT (bpTT, 2003).

PWRI Process Flow Diagram



Equipment	Separators	Hydrocyclone	HP Flash Drum	Water Filter
Inlet		1000 ppm oil	=<40 ppm oil	In
Outlet		=<40 ppm oil	=<29 ppm oil	20 microns

Figure 3.17: Cassia "B" Produced Water Handling System

Table 3.8: Expected Cannonball Platform Produced Water Composition (supplied by bpTT)	
Parameter	**Value**
Temperature (°C)	29.4
Density (kg/m^3)	1004
Oil Concentration before PWRI (mg/l)	1000
Oil Concentration after PWRI (mg/l)	29
Salinity (ppt)	22.6
Sodium (mg/l)	8439
Potassium (mg/l)	151
Calcium (mg/l)	465
Magnesium (mg/l)	71
Barium (mg/l)	4
Iron (mg/l)	<1
Chloride (mg/l)	11209
Bicarbonate (mg/l)	599
Carbonate (mg/l)	-
Sulphate (mg/l)	140
Bromide (mg/l)	67
Iodide (mg/l)	-
Sulphide (mg/l)	-

Although the produced water from CIF, Kapok and Cannonball is not being discharged overboard and therefore should not impact on the environment, it is possible for the Cassia "B" PWRI system to fail. The uptime efficiency of the PWRI system on Cassia "B" was determined to be 98% by a Reliability, Maintenance and Availability (RAM) Study conducted in 2001 (Jardine and Associates, 2001). This means that for 2% of the operating time there can be a system failure resulting in the discharge of produced water over the side of the platform at Cassia "B". The discharge rate calculated is for a maximum outflow from all produced water treated at Cassia "A". This includes a discharge of produced water from Cassia, Immortelle, Flamboyant, Kapok and the Cannonball Field Developments, the resulting discharge will be a total of 1140 barrels/day when produced water at all wells reach their maximum. The produced water discharged would be treated to a TPH level of 29ppm. This discharge was modeled to determine its fate and transport from the Cannonball WPP. The results of the modelling are presented in Appendix E.

To determine the volumes of produced water that can be discharged into the sea from the Cannonball WPP it is necessary to examine the cumulative addition of the Cannonball Produced Water to that of the CIF and Kapok Platforms since they will all be mixed at the Cassia "B" PWRI system.

Table 3.9 below shows the estimated Rate of the Produced water from CIF and Kapok being processed by Cassia "B" until the end of year 2004.

Table 3.9: Estimated Produced Water Rate for CIF and Kapok until 2004

Rate (mbd)	Jan-03	3-Feb	Mar-03	Apr-03	3-May	Jun-03	Jul-03	3-Aug	Sep-03	Oct-03	Nov-03	Dec-03
CIF	15.1	15.4	13.0	13.1	13.2	13.4	12.0	15.4	16.1	17.0	17.9	18.9
Kapok	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.4	0.7	0.9	1.4
Rate (mbd)	Jan-04	Feb-04	Mar-04	Apr-04	May-04	Jun-04	Jul-04	Aug-04	Sep-04	Oct-04	Nov-04	Dec-04
CIF	9.5	10.3	11.1	11.8	9.5	10.3	10.9	11.6	12.3	13.0	13.8	14.7
Kapok	2.0	2.4	2.6	2.9	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0

The Cannonball WPP, however, is not expected to produce water until May 2006. The following graph shows the estimated Cannonball Produced Water Rates from 2006 to 2012.

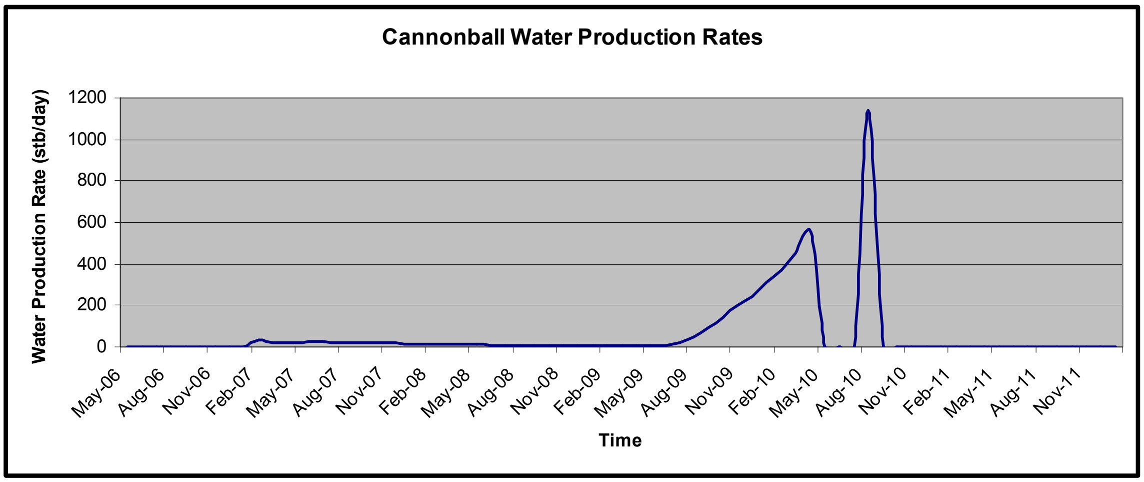


Figure 3.18: Projected Cannonball Produced Water Rates for the years 2006 – 2012.

3.4.14. Staffing involved in Platform Installation and Drilling

Although Cannonball is an unmanned facility and therefore will not have personnel on board during normal operations, there will be personnel involved with the platform's fabrication, installation and drilling operations. The following Table 3.10 summarises the staffing for the Cannonball WPP:

Table 3.10: Staffing of the Cannonball Platform

Operation	Length of Time (days)	Staffing	Percentage Local
Fabrication (Trinidad Assembly)	199	200	30-70%
Installation	13	11	80%
Drilling	183	90	80%

3.5. 26" Pipeline between Cannonball WPP and Cassia "B" HUB

To facilitate the transport of the production of 1 bcfd gas and condensate from the Cannonball WPP, it will be necessary to lay a 26" pipeline from Cannonball to the nearby Cassia "B" Hub. Gas and condensate will then be exported from Cassia "B" to the Beachfield Gas Receiving Facility via the existing 48" Bombax pipeline.

Figure 3.19 shows Cassia "B" proximity to the Cannonball WPP. The pipeline to be laid is approximately 5.0km long and runs to the southwest from Cannonball to Cassia B. Pipeline installation is expected to begin April 2005 and take approximately 21 days.

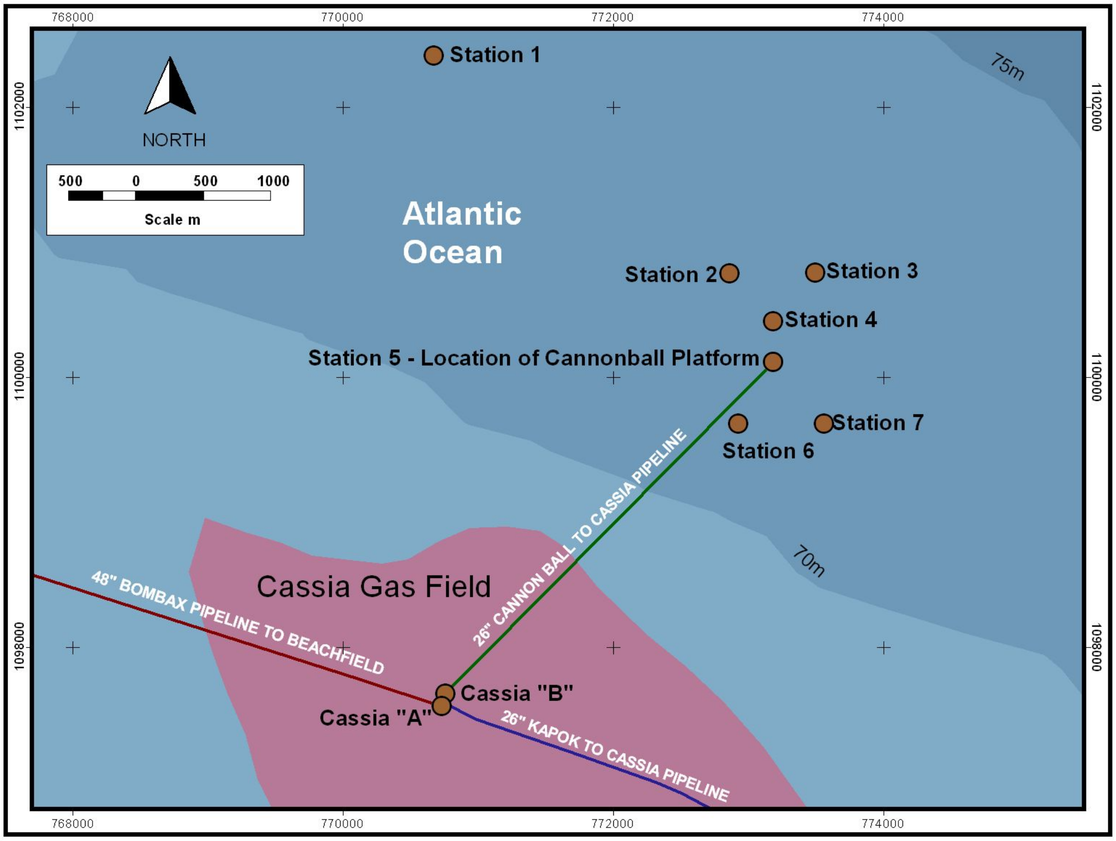


Figure 3.19: Pipeline Route from Cannonball Platform to Cassia "B" (outlined in green)

3.5.1. Pipeline Route

The 26" pipeline route is shown in Figure 3.19 above. A pipeline route survey was conducted in July 2003 by Capital Signal Limited. It showed that along the proposed pipeline route, the seafloor gradient is less than 0.1 percent and the depths are generally 70 – 71m. The surficial sediment on the seafloor is comprised very soft muddy soils (clay and silt) that range in thickness from less than 1 foot to approximately 14 feet (4.2m). While there were some metal anomalies in the area, the survey found that there is no need for any clearance of the pipeline route prior to installation.

3.5.2. Installation of Pipeline

Given the relatively shallow depths along the pipeline route and the seafloor conditions it is expected that the 26" pipeline between Cannonball and Cassia "B" will be laid directly onto the seafloor without burial from a lay barge using the S-Lay Method. The S-Lay is the traditional method for installing offshore pipelines in relatively shallow water and is so called because the profile of the pipe while it moves in a horizontal plane from the welding and inspection stations onto the lay barge and on to the ocean floor it forms an elongated "S". Figure 3.20 below shows a typical S-Lay formation as the pipeline goes overboard from the lay barge. As the pipeline moves across the stern of the lay barge and before it reaches the ocean floor, the pipe is supported by a truss-like structure, which is equipped with rollers and is known as a stinger. The purpose of a stinger is to minimize curvature, and therefore the bending stress, of the pipe as it leaves the vessel (Cranswick, 2001).

The lay barge will have a 12 anchor mooring system, which is maneuvered to pull the barge forwards as the pipeline is laid. Pipe sections are welded and inspected before being lowered to the seafloor and will be covered with the following coatings for protection:

- Cathodic Protection
- External coating of fusion-bonded epoxy (FBE), with a rough coat finish to ensure concrete coating adhesion
- Concrete Coating for protection and stability.

The 26" pipeline will be connected to the Cassia "B" hub via a 40m spool piece which connects to the bottom of the Cassia "B" riser. The spool will be deployed and connected using a Diver Support Vessel (DSV) with a team of "saturated" divers.

During the pipeline installation, the pipeline laying barge as well as any support vessels (including the DSV) will be required to conform to local discharge regulations and to bpTT's HSE standards. bpTT will have a representative on board these vessels during the installation phase to ensure HSE compliance with local and company standards.

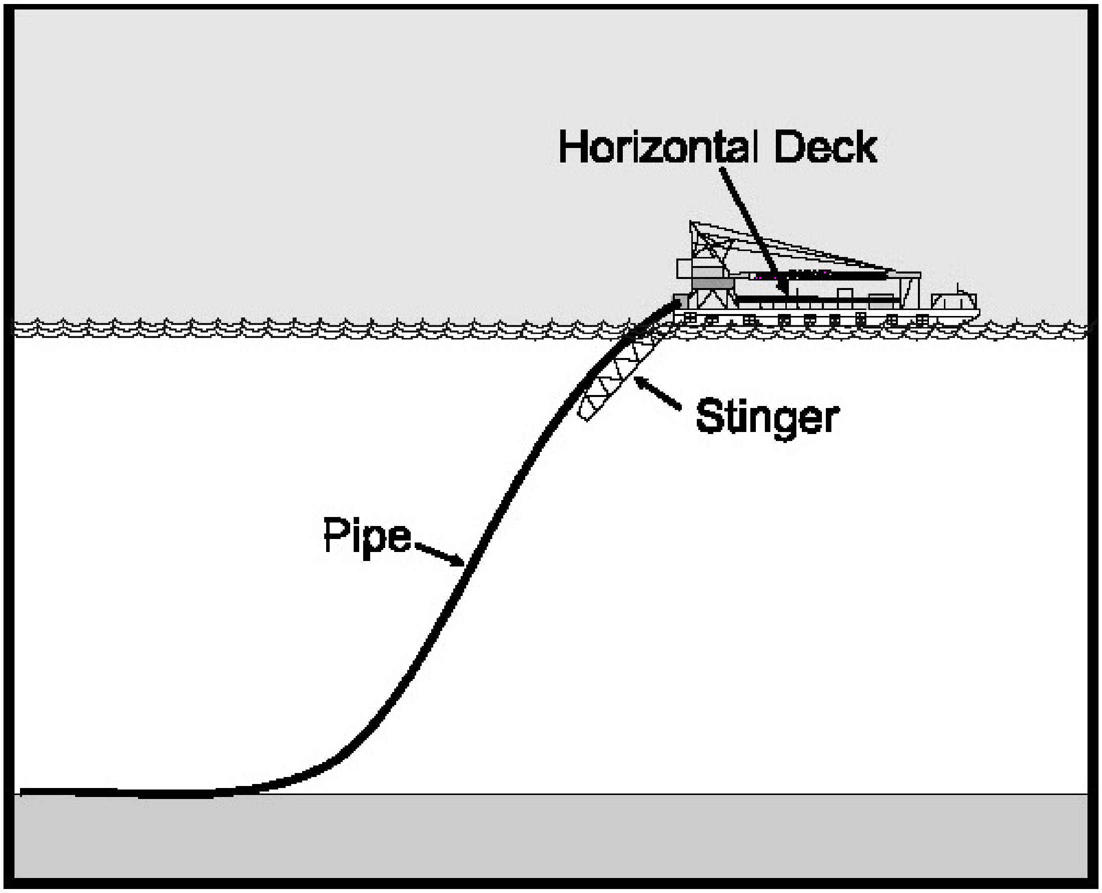


Figure 3.20: Illustration of how the Cannonball Pipeline is to be laid on the seabed (Cranswick, 2001)

3.5.3. Hydrotesting of 26" Pipeline

After the installation of the 26" pipeline, the line will be pressure tested with treated water in a process called **"Hydrotesting"**. It is expected that this will occur in May 2005 after the installation of the 26" pipeline.

Water is pressure filled into the 26" pipeline system to test for leaks. This water will be seawater with a biocide added to eliminate bacterial growth inside the pipeline that will encourage corrosion. The biocide to be used will be approved for hydrotesting by the Ministry of Energy and Energy Industries (MEEI). The Material Safety Data Sheet (MSDS) is present in Appendix D. When the pipeline is filled with this water, it will be allowed to lie in the pipeline for approximately 2 months after which it will be discharged over the side of the Cassia "B" hub. The water will be ejected using a pig launched from the Cannonball WPP. The biocide will naturally decay in the pipeline according to its particular half-life. This will reduce the impact of discharging the biocide overboard at Cassia "B". This will be discussed in **Section 5: Significant Environmental Impacts**.

While the concentration of the biocide will be known, other parameters of the hydrotest water such as salinity and temperature are not known at this time. However, we can estimate these parameters since we know that the hydrotest water will be pumped into the 26" pipeline from the surface and therefore will have the salinity of this surface water. The temperature of the hydrotest water during discharge will be close to the bottom temperature of the water column along the pipeline route since the hydrotest water will be left in the system for 2 months and so the water will be equalised with this bottom temperature. Based on the previous data collected off the east coast of Trinidad, during the Hydrotesting we can expect that the surface salinity is approximately 35ppt and the bottom temperature will by approximately 25°C. Therefore, we estimate that the ejected hydrotest water will have the following expected properties:

Table 3.11: Estimated Hydrotest Water Discharge Parameters

Hydrotest Water Parameter	Value
Volume	1,392 m^3
Biocide Concentration	250ppm
Temperature	25°C
Salinity	35ppt

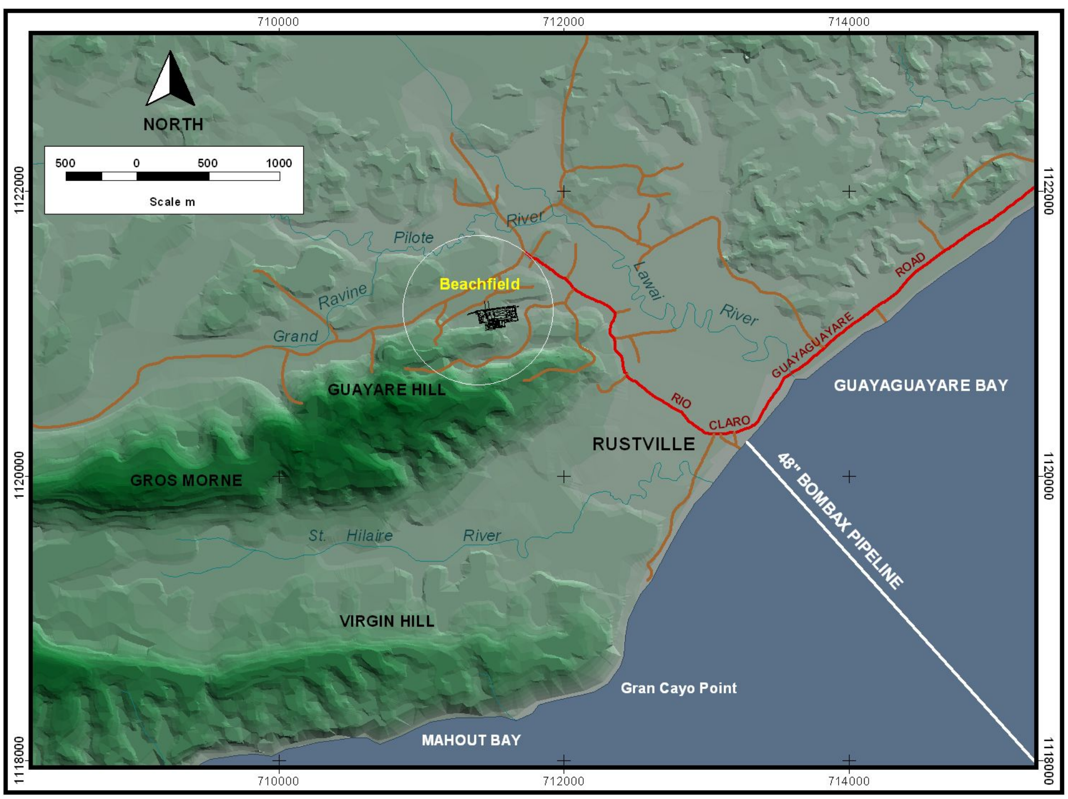
3.6. Beachfield Modifications

It is expected that the Cannonball WPP will produce at start up approximately 550 mmscfd of natural gas which will transported to the west coast of Trinidad to feed industries in Point Fortin, including the Atlantic LNG Company of Trinidad and Tobago's Train 4 LNG plant. This will be in addition to the natural gas already being produced by bpTT assets off the east coast of Trinidad. To accommodate this increased natural gas and condensate supply, the Beachfield Gas Receiving Facility in Guayaguayare will have to be upgraded from 1.8 bcfd to 2.9 bcfd. This section describes the planned modifications.

3.6.1. Existing Facilities

The Beachfield Gas Receiving Facility is located approximately 1.5km northwest from the Guayaguayare Bay coastline. Figure 3.2 in Section 3.2 above shows the general location in relation to Point Galeota and the Cannonball Field. Figure 3.21 below shows a topographical map of the Beachfield area with the Beachfield Gas Receiving Facility identified. It lies at the northeastern foot of the Guayare Hill. 500m to the east is the Lawai River which runs to the Rustville Wetlands along the Guayaguayare Coastline. The main pipeline running into the Beachfield Gas Receiving Facility is the 48" BOMBAX Pipeline which lands in Rustville and runs along a Right of Way (ROW) leading to the Beachfield Gas Receiving Facility.

Figure 3.21: Topographical Map showing the Beachfield Facility



The primary purpose of the Beachfield Gas Receiving Facility is to receive natural gas and hydrocarbon liquids from platforms located offshore and to transport the gas to both the National Gas Company's (NGC) pipeline system and to the Atlantic LNG plants at Point Fortin. Figure 3.22 below shows the present layout of the Beachfield Gas Receiving facility taken from above.

Figure 3.22: Aerial View of the Beachfield Gas Receiving Facility (from the southeast)

A schematic diagram of the Beachfield Gas Receiving Facility is shown in Figure 3.23 below.

The main gas transportation pipelines running into the Beachfield Gas Receiving Facility from offshore are as follows (these are identified in Figure 3.23).:

- **A 48" pipeline, 41 miles long, from Cassia "B" Hub to Beachfield (BOMBAX)**
  This 48-inch pipeline originates at the Cassia "B" hub ties into an offshore sub-sea manifold and continues to Beachfield where it ends at the 48-inch pig receiver. This pipeline will transport the gas and condensate production from the proposed Cannonball WPP.

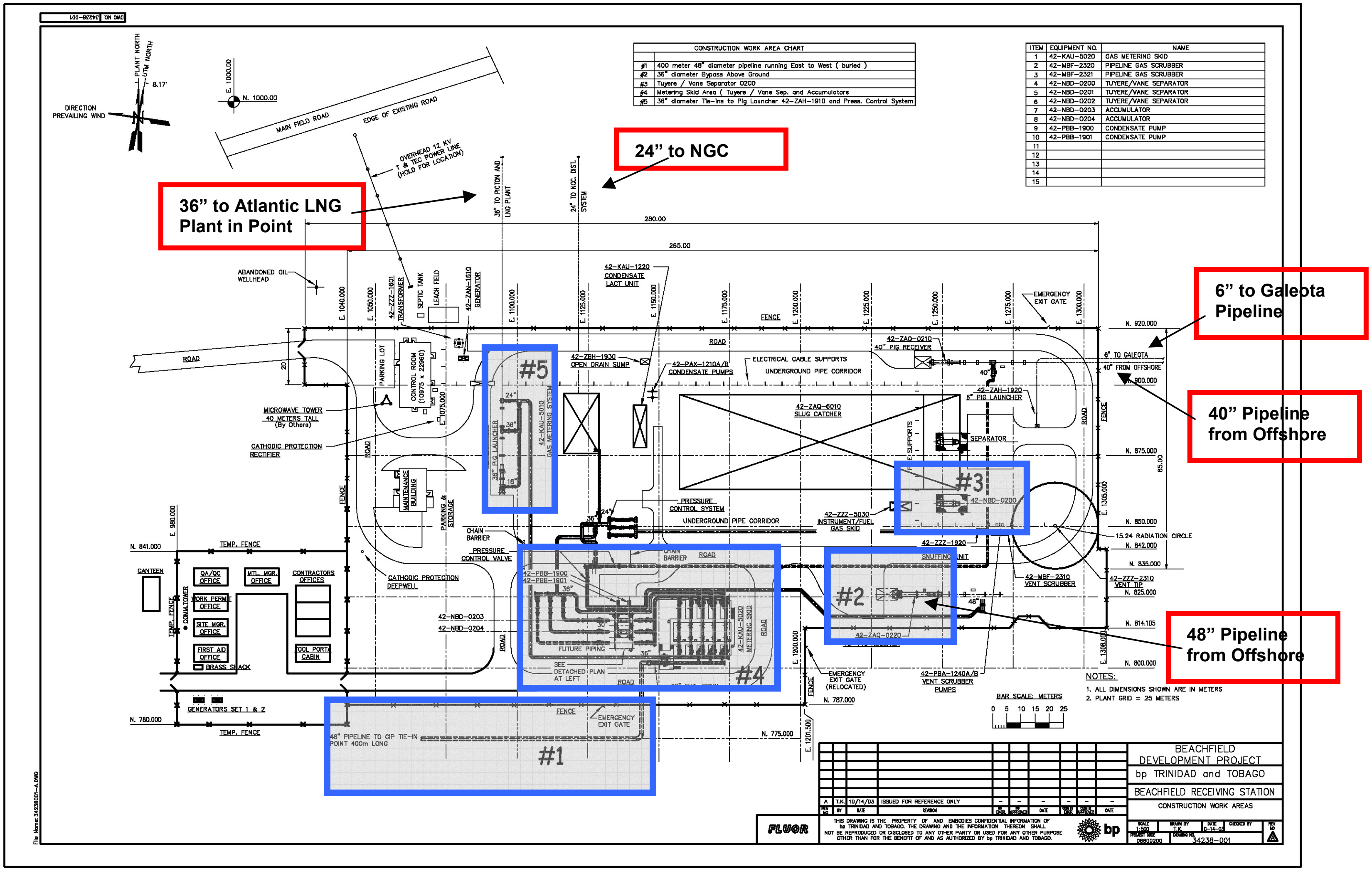


Figure 3.23: Schematic of the Beachfield Gas Receiving Facility

- **A 40" pipeline from the Mahogany 'B' Platform to Beachfield.**
  This 60-mile long, 40" sub sea pipeline originates at the Mahogany B platform and ends at Beachfield 40" pig receiver. The other intermediate platforms that tie into this 40-inch pipeline are the Amherstia and Cassia "A" Platforms. See Figure 3.2 in Section 3.2 above for locations of these platforms.

The overall design capacity of the existing facility and associated pipelines is 1.8 bcfd.

At the Beachfield Gas Receiving Facility a 5000-barrel capacity finger type slug catcher and an elevated horizontal gas separator with a **'Tuyere'** internal device is used to separate liquids from the gas. The gas exiting the elevated horizontal separator passes through a Pressure Control System 'HIPPS'. This Pressure control system 'HIPPS' protects the onshore system from over pressuring by the offshore system. The gas then branches to two alternate destinations:

- **The 24" onshore pipeline from Beachfield to the NGC pipeline network.**

- **The 36" onshore pipeline from Beachfield to the Atlantic LNG Plant at Point Fortin.**

The liquid condensate from the Tuyere Separator is transported to the bpTT Galeota Point Processing Facility via a 6" pipeline.

The schematic shown in Figure 3.23 above shows the existing facility with the above pipelines outlined in Red, It also shows the proposed modifications outlined in blue which are necessary to allow the Beachfield Gas Receiving Facility to handle the increased natural gas entering the system through the 48" Bombax Offshore Pipeline. The modifications are discussed in Section 3.6.2 below.

3.6.2. Proposed Modifications

Figure 3.23 above shows the proposed modifications to be made to the Beachfield Gas Receiving Facility outlined in blue. There are five (5) areas to be modified. The areas in the Figure 3.23 are numbered accordingly. Although there are five (5) areas to be modified, only two (2) are outside of the existing compound and are therefore discussed separately.

3.6.2.1. 48" Pipeline Tie-in to 56" CIP (Outside of Compound)

An underground 48" x 575 meter (1890 ft) pipeline will be installed from the 36" by pass to the future 56" CIP tie-in location. The area to be modified is shown in Figure 3.23 as the blue enclosed area (# 1) and in Figure 3.24 below which shows an aerial photograph of the Beachfield Gas Receiving Facility with the construction site outlined. The construction and pipeline laying areas will extend beyond the present Beachfield Gas

Receiving Facility boundary fence. The Pipeline to be laid is 575m long and will be buried 1.2m (from the top of the Pipe) and is indicated in red on the figure. There will be a 12m wide permanent Right of Way (ROW) cleared along the pipeline route. The pipeline will be made of Carbon Steel and have a design pressure of 1050 psig. The pipe will be supplied by free excess pipe joints previously staged at the construction site. The following is a list of site work to be done in this modification:

- Clearance of existing surplus material at the Beachfield lay down area
- Construction survey
- Clearing and grading of construction workspace
- Ditching/Trenching
- Stringing and Fitting
- Welding and Non Destructive Testing (NDT)
- Lowering pipeline into ditch/trench
- Tie-ins (above and below grade)
- Installing cathodic test and bonding stations
- Backfilling and compacting
- Flooding and cleaning
- Hydrotesting, dewatering, and drying
- Nitrogen gas purge and pack
- Installing all auxiliary features (i.e. pipeline markers, permanent fences, etc)
- Reinstating pipeline right-of-way, temporary workspace, roadways, etc.

The laying of the pipeline will most likely require the clearance of some trees along the route. The eventual route will be determined by the potential for significant environmental impacts discussed in **Section 5: Significant Environmental Impact.**

From Figure 3.24 below, the probable area to be cleared of trees is 575m (length of pipeline) x 12m (average width of tree clearance along pipeline route). This is equivalent to 6,900m^2 of tree area to be cleared. Assuming a tree density of 1 tree per 8m^2, this translates to approximately 863 trees to be cleared.

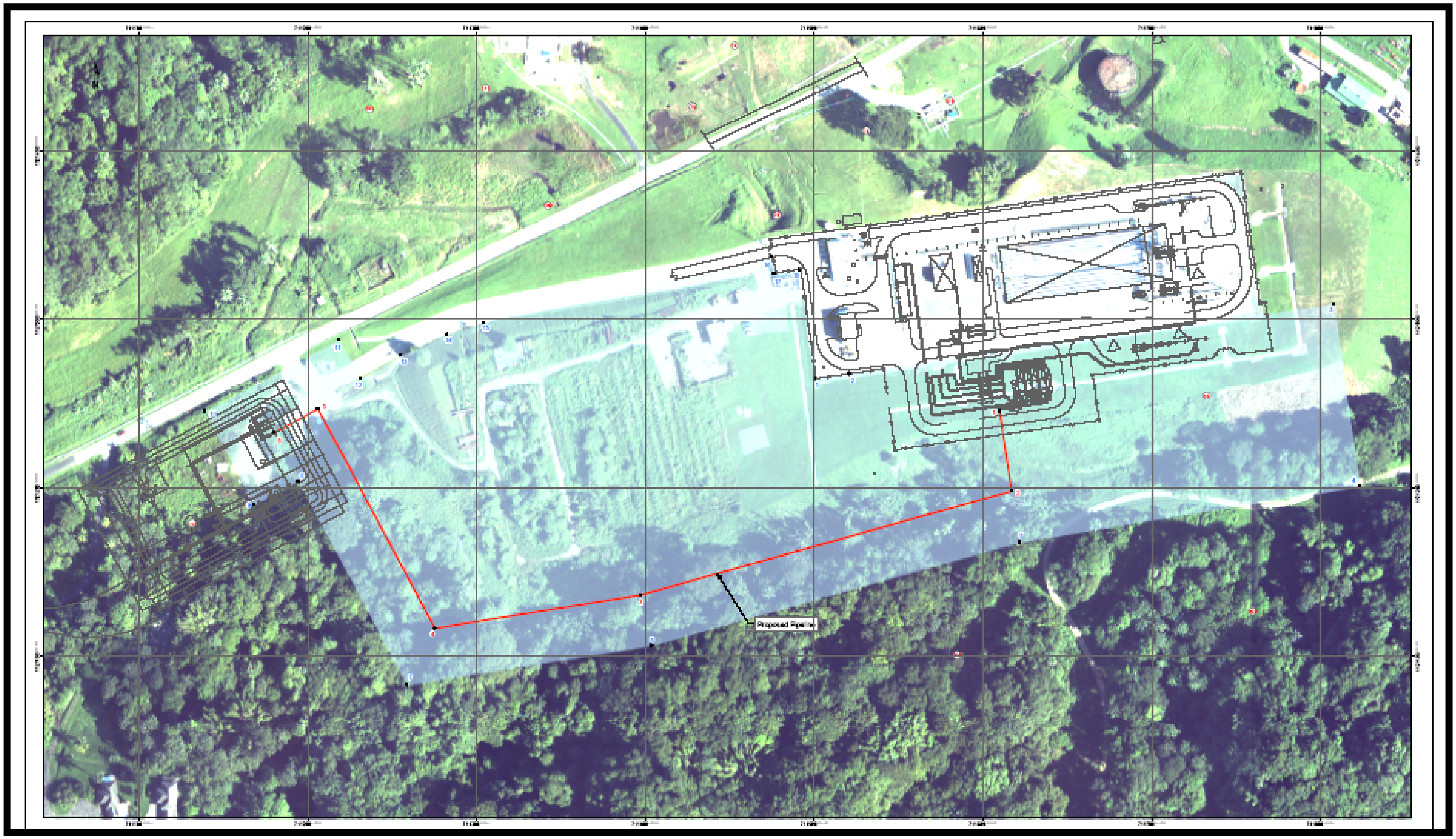


Figure 3.24: Overview of the site clearance needed for connection to 56" Cross Island Pipeline (CIP). Red line indicates route of Pipeline, (Flour Daniel, 2003)

The commissioning of this 575m pipeline will require a pressure test of the pipeline using water pressured in the pipeline. This water is non-chlorinated freshwater and no biocides will be used. After the hydrotest, the water will be discharged via pipelines into the nearby Lawai River. Based on a diameter of 48" (1.22m) and a length of 575m, an approximate total of 672m^3 of hydrotest water will be discharged.

Figure 3.25 below shows the area to be cleared outside the fence of the Beachfield Compound.

Figure 3.25: Area outside Beachfield Compound to be cleared for Pipeline.

3.6.2.2. Installation of a Metering Skid (Outside of Compound)

A new Metering Skid will be added to handle the increased influx of natural gas from the Cannonball WPP. The metering skid controls the amount of flow of the natural gas as well as its pressure and allows the volume of gas flowing through the system to be metered. Figure 3.25 above shows the proposed location of the new metering skid. Please refer to the schematic diagram in Figure 3.23 for the modification area # 4. There will be two (2) small Tuyere Separators installed as part of this modification.

Modification Area # 4: There will be a 36" tie-in to the Pig Launcher and a 36" tie-in to the Pressure Control System. This 36" tie-in will be to the 36' pipeline to Atlantic LNG. The schematic diagram in Figure 3.23 shows the location of this tie-in as Modification Area #5.

The following operations are expected to be carried out in the above modification to the Beachfield Facility compound:

- excavation, grading, paving, fencing, light posts
- the installation of foundations and pipe supports
- piping and structural installation
- crane operations for piping and equipment setting
- the pre-fabrication and / or fabrication of spools
- the pre-fabrication and /or fabrication of steel support structures for the separators, pipe sleepers, pipe supports
- the demolition and removal of existing pipe sections, equipment and foundations, as required
- the installation to existing conduit duct banks and wiring for instrumentation
- the installation of cable trays and electrical power and control cables
- the installation of grounding cables on fencing, structures, and electrical equipment
- the installation of motor starters in the existing MCC and control stations at the motors
- the installation of area lighting and floodlight poles and associated underground cable
- the installation of junction boxes and wiring for instrumentation
- the demolition of some fence grounding
- the testing and checkout of these modifications to mechanical completion.

3.6.2.3. Modifications within the Beachfield Compound.

Modification Area #2: Figure 3.23 above shows the area of modification in the Beachfield Facility identified as Area #2. The modification includes the installation of a 26" bypass from the 48" Pig Launcher.

Figure 3.26 below shows the location of the 48" Pig Launcher to be attached to the 26" bypass.

Modification Area #3: A new Tuyere/Vane Separator identical to the one existing in the Beachfield Facility will be installed. The install location is shown in Figure 3.23 as the area labeled # 3. The Tuyere Separator removes liquid from the natural gas. This liquid is then sent to the Galeota Processing facility via the 6" pipeline.

Figure 3.27 below shows the present Tuyere/Vane Separator and the proposed location of the new one to the south.

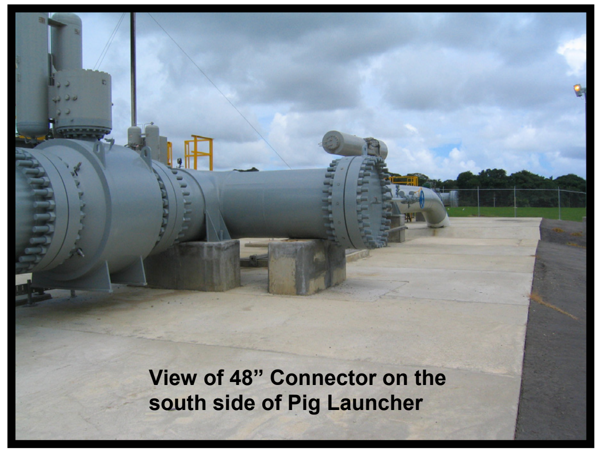


Figure 3.26: 48" Pig launcher to be modified (Modification # 2).

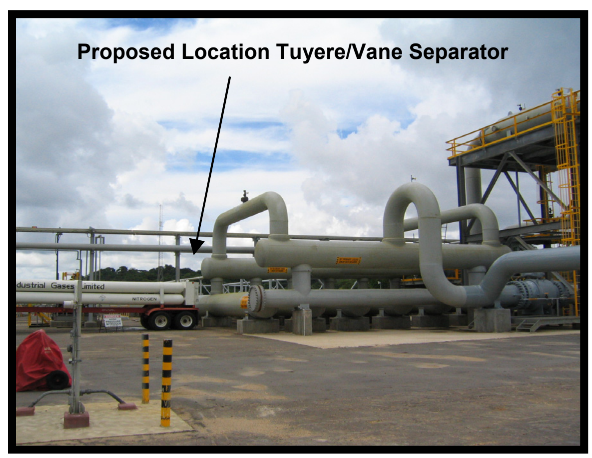


Figure 3.27: Location of Present and Proposed Tuyere Separators (Modification # 3)

3.6.3. Equipment to be used in Beachfield Modification

Table 3.12 below shows the list of equipment needed for the above described Beachfield modifications. The equipment will be mobilized onto site during the initial stages however equipment will be transported onto the construction site when required.

Table 3.12: Expected equipment list for Beachfield Modification	
Item	**Description For Beachfield Location**
1	Grinding Sets including sparkless sets
2	25 ton mobile crane
3	35 ton mobile crane
4	100 ton crawler
5	100 ton crawler
6	200 crane
7	Dump Trucks
8	40' flat bed truck
9	Pick-up trucks
10	AC/DC magnetic yoke
11	Air Compressors
12	Chop Saw
13	Concrete Saw
14	Concrete Vibrators
15	Concrete Batching / Mixing Trucks
16	Conduit Benders
17	All NDT equipment for x-ray, ut, dye penetrant, mpi etc.
18	All post heat / pre-heat equipment including heating consoles
19	Cutting rigs
20	Automatic and manual beveling bands
21	Electric Welding Sets
22	Tractor with front lift
23	Backhoe
24	Forklift
25	Generators
26	Holiday Testers
27	Jumping Jacks
28	Mechanical pipe threading machines and dies
29	Mechanical Screed
30	Megger Insulation Tester
31	Meriam Digital Manometers
32	Motor Rotation Indicator
33	Phase Rotation Meter
34	Picks
35	Pipe Cutters
36	Portable x-ray machine
37	Rigging (slings and shackles)
38	Rigid Threading Machine
39	Instrumentation calibration / test bench
40	Side Boom
41	Holiday Detector
42	Loop Calibrator
43	Vibratory Roller
44	Wacker Machines
45	Wacker Plates
46	Water pumps
47	Water Trucks
48	Welding Machines
49	Site offices for both contractor and bpTT CM Team
50	Security & Temporary Lightening

3.6.4. Construction Schedule

The proposed schedule for the modifications of the Beachfield Gas Receiving Facility is given in Figure 3.3 in Section 3.2. Construction is expected to start in April 2004 and continue until April 2005 (15 months) at which point hydrotesting and commissioning of the Beachfield Facility's modifications will occur.

3.6.5. Staffing and Man-hours involved in Beachfield Modifications

The construction schedule for Beachfield Gas Receiving Facility's modifications calls for approximately 15 months of construction. During that time it is estimated that there will be 100 workers (at peak) on site each day assuming Monday – Friday working days. In all there will be 1402 man months of workers on the job throughout the 15 month construction schedule. Table 3.13 shows the distribution of the areas where skilled workers will be required for the Beachfield Gas Receiving Facility modifications:

Table 3.13: Areas of Construction needed on the Beachfield Construction Project

Area of Construction	Estimated Percentage of Workforce (%)
Civil	18
Concrete	2
Steel	2
Equipment	1
Pipe Field Fabrication	68
Electrical	3
Instrument	5

3.6.6. Wastes Generated by Beachfield Modifications

Table 3.14 below shows an estimation of the wastes generated by the Beachfield Gas Receiving Facility's modifications over the proposed 15 months of construction. bpTT will ensure through its contractor selection process that the chosen contractor for the proposed modifications will have a stringent Waste Management Plan that conforms to bpTT's Waste management plan as well as the Laws of Trinidad and Tobago. There will be regular monitoring of the contractor's waste handling procedures during the construction phase by bpTT personnel.

Table 3.14: Estimated Waste Generated by the Beachfield Modifications		
Waste Type/Description	**Estimated Quantity Produced**	**Handling/Disposal Options**
Sanitary Wastes	42,060 gallons over 14 months	Portable toilets/port-a-cans to be provided at each construction site. Waste to be collected twice per week at a minimum and taken to an approved treatment facility for disposal.
Cooking Wastes	None	Cooking Wastes is nil as canteen on wheels will remove all associated wastes
Construction Solid Wastes: scrap pipes etc	42,060lbs	Store temporarily in lugger buckets. Haul to an approved landfill or recycling facility as appropriate.
Other inert Construction Wastes: concrete etc.	900 tonnes	Segregate debris according to category. Haul to an approved landfill or recycling facility as appropriate. Concrete trucks will wash out residual concrete at the approved disposal site (established for each delivery point) before returning to the batch plant. Concrete will not be washed out into a stream or water body.
Paints/Coatings/Solvents	500 gallons paint, 250 gallons of solvents	Use biodegradable cleaning agents in lieu of petroleum based solvents where practical. Fill used cans and buckets with sand or other inert material (ex. Bentonite) until no free liquid residue is present. Spread rags to allow air dry. Place lids on cans and buckets securely and insure that all hazardous material containers are labeled appropriately to describe contents. Provide a secure, fenced area for temporary storage of waste. Develop and implement a waste manifest for transfer of waste to an approved disposal site (i.e., Solid Waste Management Company Limited, SWMCOL). Use only approved waste transport companies to haul waste.
Hydrocarbon Spills/Waste Oil: oily waste including lubricating oil, hydraulic fluids, transmission fluids, grease, and used oil filters	Based upon equipment quantities but assume the following: 1. 10 each 42 gallon barrels of lubricating oils and grease	Develop and implement a spill prevention, control and countermeasures (SPCC) plan. Keep and maintain spill cleanup equipment at all construction sites where a reasonable potential for spills exists. Position hydrocarbon and fuel containers a reasonable distance away from water bodies. Provide secondary containment (berms or vaults) for fuel storage vessels/tanks and in locations where fuel transfer operations take place. Provide a secure, fenced area for temporary storage of waste. Develop and implement a waste manifest for transfer of waste material to an approved treatment facility or landfarm. Use only approved waste transport companies to haul waste.
Hydrostatic Test Water Discharge	197m^3	Currently there are no plans to provide chemical additives to hydrostatic test water.

3.6.7. Increased Air Emissions by the Beachfield Gas Receiving Facility

There will be air emissions generated by the Beachfield Gas Receiving Facility during its modification and operation. During construction there will be combustion gases emitted by the construction equipment. During normal operations, the Beachfield Gas Receiving Facility will have intermittent emissions of natural Gas due to maintenance emissions from the following equipment (Table 3.15):

Table 3.15: Maintenance Emissions of Natural Gas from Beachfield Gas Receiving Facility

Equipment Maintained	Total Volume Vented (SCF)
1 Tuyere Separator (slug catcher)	14,975
2 Tuyere Separators	29,950
2 Accumulators	10,576
Bypass 36" Line	76,673
5 Meter Runs	29,377
Other	8,105
TOTAL	169,656

Using a 2:1 equivalency ratio, this works out to be approximately 68.1 tonnes of CO_2 released into the atmosphere per year. The above volumes are the incremental increases in the Beachfield Gas Receiving Facility due to the Cannonball Field Development Modifications.

4. DESCRIPTION OF THE ENVIRONMENT

In order to identify the potential environmental effects of the proposed Cannonball Field Development Project, it is necessary to review the existing environment that may be affected. This provides a basis for assessing the potential interactions of the planned development and the environment.

bpTT has commissioned extensive studies of the offshore and onshore environment to establish the pre-development baseline conditions specifically for this Cannonball EIA. It is bpTT's intention to manage the environmental aspects of this project such that it is in keeping with bpTT's stated HSE goal of "no harm to the environment". Therefore, bpTT will be using this baseline environmental survey for the following purposes:

- To establish of the existing environmental conditions before the development takes place
- To assess the potential impacts that the Cannonball Project might have on the environment
- To allow a comparison of the environmental conditions pre-development and post-development
- To establish a specific monitoring plan that records the actual impacts of the Cannonball Field Development Project
- To provide input into the Cannonball Environmental Management Plan that will mitigate the potential environmental impact of the project.

While bpTT is aware that there exists environmental data that has been collected for previous studies in the area, it was decided to conduct extensive field surveys to update this information and to establish a new database of environmental conditions for both offshore and onshore areas. The data collected for this EIA is as follows:

Offshore Area

- Water Quality Survey – surface, middle and bottom depths offshore
- Sediment Quality Survey – Surficial Sediments collected offshore
- Current Speed and Direction data for the offshore area
- Conductivity, Temperature and Density Data for the offshore area
- Macrobenthic Survey of the offshore area
- Meiobenthic Survey of the offshore area
- Video Survey of the offshore seabed

Onshore Area

- Fisheries Survey
- Socio-Economic Survey
- Vegetation and Forest Survey
- Avifaunal Survey
- Butterfly Survey

- Wetland and Sensitive Habitat Survey

This section summarises the results of all the above surveys including a literarture review of the already existing data.

Figure 4.1 below shows the two study areas for this Cannonball EIA.

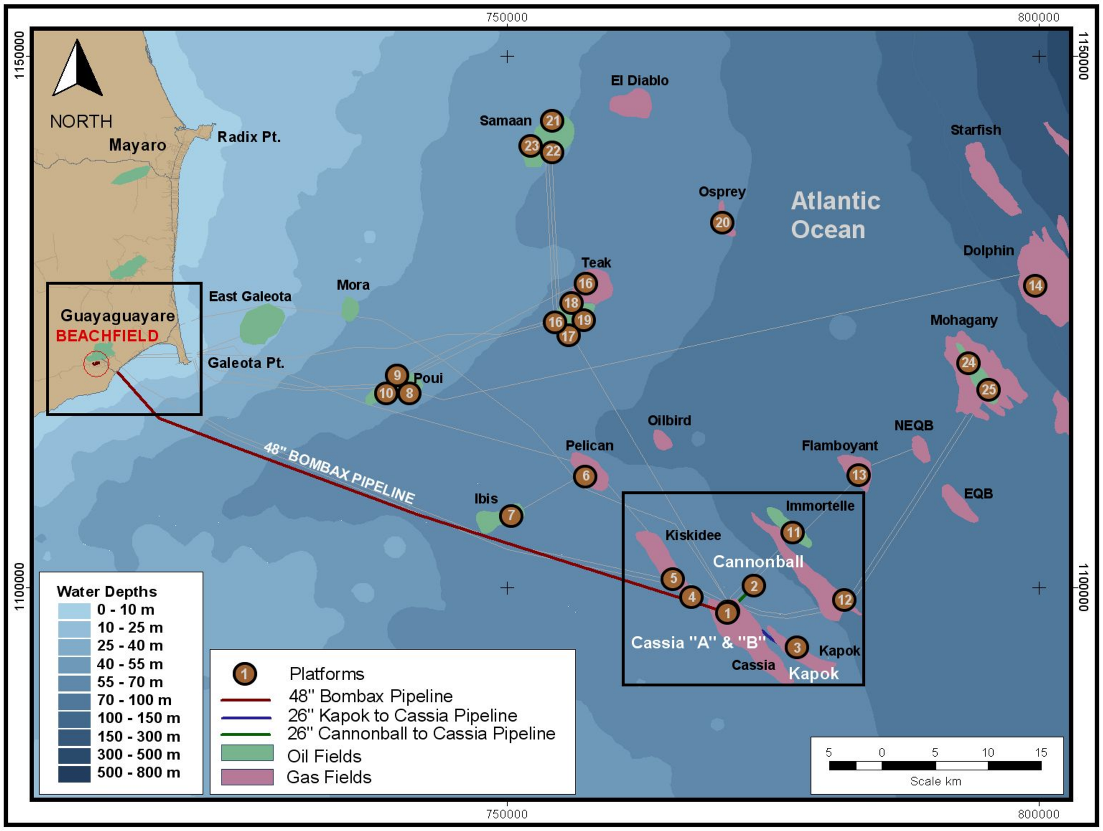


Figure 4.1: Location of the two study areas for Cannonball Field Development EIA

4.1. Methodology for Data Collection

In order to obtain data for these two sites, Coastal Dynamics used the following sources of data:

- Previous studies commissioned by bpTT at both the offshore and onshore sites

- A literature review of data sources that included, but were not limited to, The University of the West Indies, The Institute of Marine Affairs, The Maritime Services Division of Trinidad and Tobago, The Hydrographic Unit of Trinidad and Tobago and The Seismic Unit of Trinidad and Tobago.

- Data libraries of Coastal Dynamics and its consultants.

- In additions to the above data sources, bpTT commissioned two (2) offshore surveys, conducted during October 2003, to collect baseline data for this Cannonball Field Project EIA. The following data was collected at seven (7) stations offshore:
    - Current Speed and Direction throughout the water column
    - Conductivity, temperature, Salinity throughout the water column
    - Water Quality samples for chemical analysis
    - Sediment Quality samples for chemical analysis
    - Benthic Sediment Samples for Macro-Benthic Analysis
    - Benthic Sediment Samples for Meio-Benthic Analysis
    - Sediment samples for Grain Size Analysis
    - Video Imagery of the Seabed
- The following field surveys were conducted at the onshore Beachfield study area:
    - Socio-Cultural Survey
    - Fisheries Survey
    - Vegetation and Forest Surveys
    - Bird Count Surveys
    - Wetland Surveys

The methodology for the onshore field surveys will be discussed in their relevant sections below; however, the next section discusses the methodology of the offshore sampling program executed for this Cannonball Field Project EIA.

4.2. Offshore Field Survey

To supplement the literature review of available data, bpTT commissioned an offshore field survey to collect Cannonball Field Project specific environmental baseline data prior to the proposed installation of the platform. This offshore data collection survey was conducted between 12th October 2003 to 31st October 2003. Seven (7) environmental monitoring stations were chosen which are shown in Figure 4.2 below. Station 1 was chosen outside the immediate study area to act as a control while Station 5 represents the site of the proposed Cannonball Well Protector Platform. The following samples were collected at each Station:

1. Water samples for water quality analysis at surface, middle and bottom depths.
2. Surficial sediment samples for sediment quality analysis.
3. Surficial sediment samples for macro and meio-faunal benthic analysis.
4. Current speed and direction profile data at the Cannonball Field during the survey
5. Conductivity, Temperature and Density (CTD) profile information at the water sample locations.
6. Underwater video images at all offshore stations.

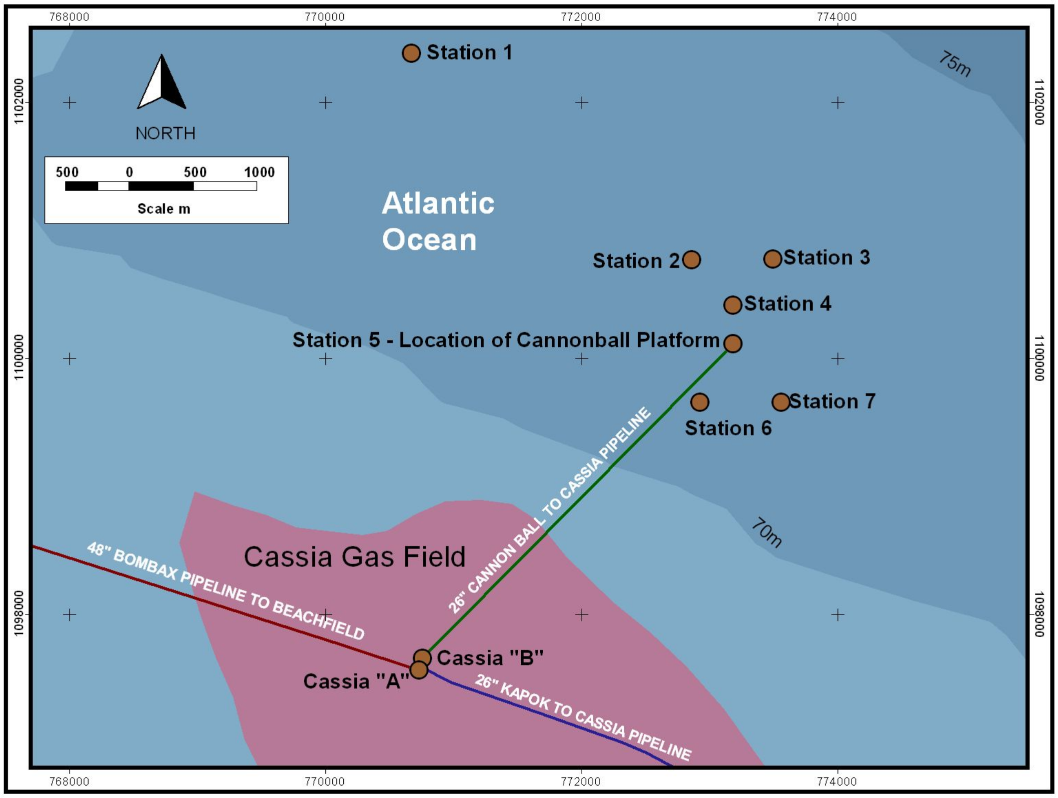


Figure 4.2: Location of the Offshore Data Collection Stations

The UTM co-ordinates of the monitoring stations are given in Table 4.1 below:

TABLE 4.1: Location of Cannonball Environmental Stations (WGS 84)

Station Name	Eastings (m)	Northing (m)
Station 1	770671	1102380
Station 2	772862	1100769
Station 3	773498	1100772
Station 4	773184	1100416
Station 5	773187	1100112
Station 6	772927	1099655
Station 7	773563	1099658

The offshore survey was conducted twice to capture variability in offshore conditions in the Cannonball area. The following is the survey times:

Table 4.2: Survey Times and Sampling Regime for Cannonball EIA	
Survey 1: 12th – 14th October 2003	**Survey 2: 27th – 30 October 2003**
Water samples for water quality analysis	Water samples for water quality analysis
Current speed and direction profile data	Current speed and direction profile data
Conductivity, Temperature and Density (CTD) profile data	Conductivity, Temperature and Density (CTD) profile data
	Surficial sediment samples for sediment quality analysis.
	Surficial sediment samples for macro- and meio-faunal benthic analysis
	Underwater video images at all offshore stations

The individual survey methodologies will be discussed in the appropriate sections below.

4.3. Offshore Environment

4.3.1. Study Area

The study area for the offshore baseline description of the environment is determined by the area of influence of the proposed Cannonball Field Project. The offshore area is an area 20km x 16km centered on the proposed location of the Cannonball Well Protector Platform. This is shown in Figure 4.3 below.

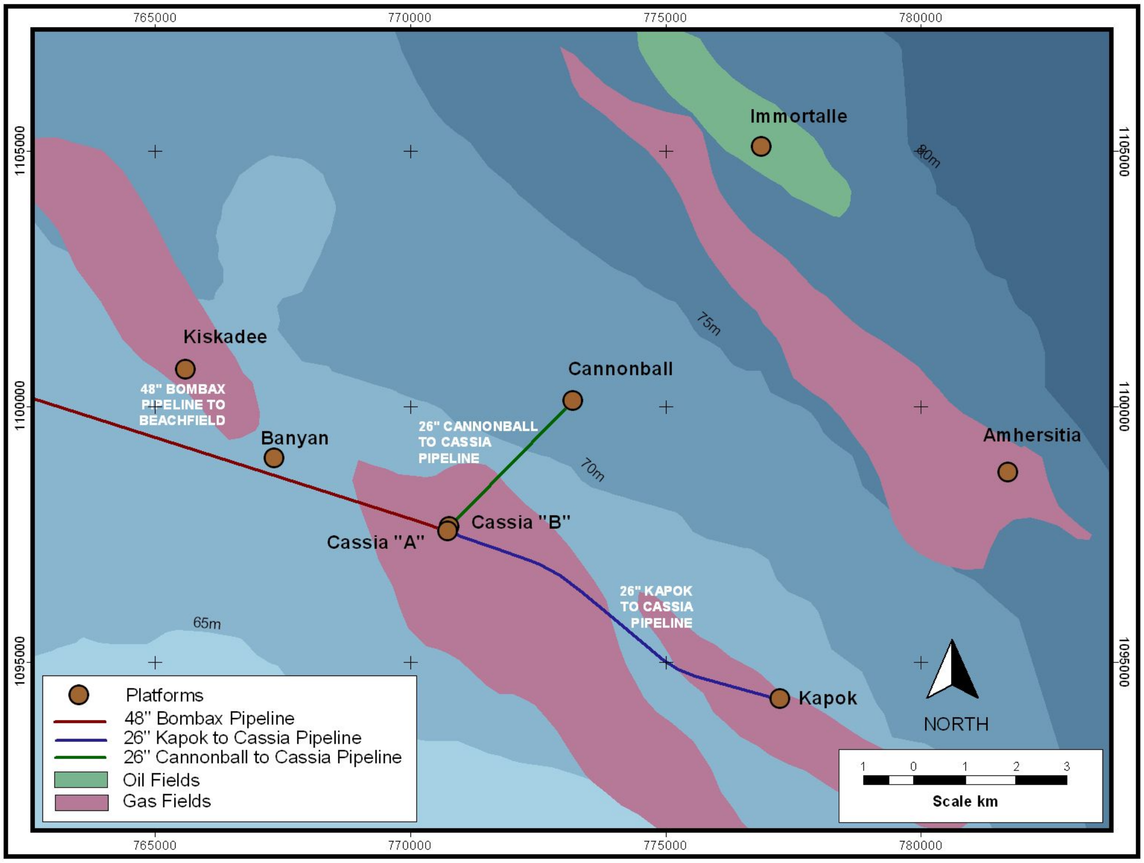


Figure 4.3: Cannonball EIA - Offshore Study Area

4.3.2. Geology

Tectonic Setting

The area of interest is located within the passive margin plate boundary that stretches north from Venezuela to the Lesser Antilles (Robertson and Burke, 1989). According to Matson (1984) the three tectonic elements that influence that the regional geology are identified as the Atlantic Plate to the east, the South American Plate to the south and west and the Caribbean Plate to the north and northwest. It is thought that the relative motions along the plate boundaries are a combination of strike slip deformation between the

Caribbean and South American Plates and convergence between the Atlantic and Caribbean Plates (Speed, 1985). This is shown in Figure 4.4 below.

Offshore Geology

The continental shelf in the study area is approximately 95km wide and gently slopes from the shore to the shelf break in approximately 100m of water depth. The study area is in the geological province of the Columbus Basin, a depositional basin that lies within the Columbus Syncline and forms the eastern extension of the Venezuelan Basin (Leonard, 1983). There are two major structural trends that characterize the basin these are a series of east-northeast trending anticlines and north-northwest aligned normal faults (Persad, 1985). The anticlines were formed in response to right lateral fault displacement along the Los Bajos and El Pilar fault zones during the Miocene and Pliocene (Leonard, 1983). The normal faults are a result of sediment loading from fluvial and deltaic centers in the southwest. The faults are early Pliocence to late Pleistocene in age and are generally older to the west.

During the Pleistocene, transitional marine sediments were deposited in the western portion of the Columbus basin while shelf-slope deposits accumulated to the east. At the east end of the basin, the Plio-Pleistocene deposits exceed 7,500 m. To the west, uplift and erosion has removed much of the Pleistocene section.

Holocene deposition in Columbus Basin has not been extensive. A thin veneer of silty clay from the Orinoco Delta extends across much of the Columbus basin. Although the main discharge from the Orinoco River is to the southeast of the basin, the northwest flowing North Equatorial Current system transports these sediments to the northwest into the Columbus basin (van Andel, 1967).

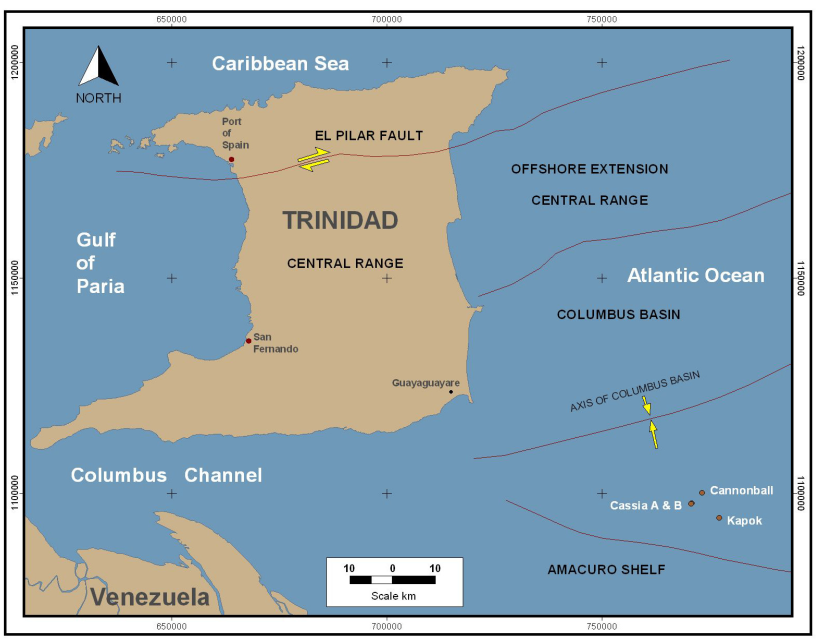


Figure 4.4: Tectonic elements of southeast Caribbean

4.3.3. Bathymetry and Subsurface Conditions

In July 2003 a site hazard survey was conducted along the proposed pipeline between the Cannonball Well Protector Platform and the Cassia "B" Platform by Capital Signal Limited. This survey was to advise the design and engineering of the pipeline laying activity discussed in Section 3.5.2. The discussion of the bathymetry of the study area is based on Capital Signal Limited's report entitled "A Geological Hazards Evaluation of a Pipeline Pre-Lay Corridor from Proposed Cannonball Drill Site to the Cassia 'B' Platform, Offshore Galeota Point, Trinidad" (Capital Signal, 2003).

Bathymetry

The offshore bathymetry is shown in Figure 4.5 below. Regionally, this portion of the East Trinidad Shelf slopes gently to the east. The shelfbreak generally runs along the 100-meter isobath.

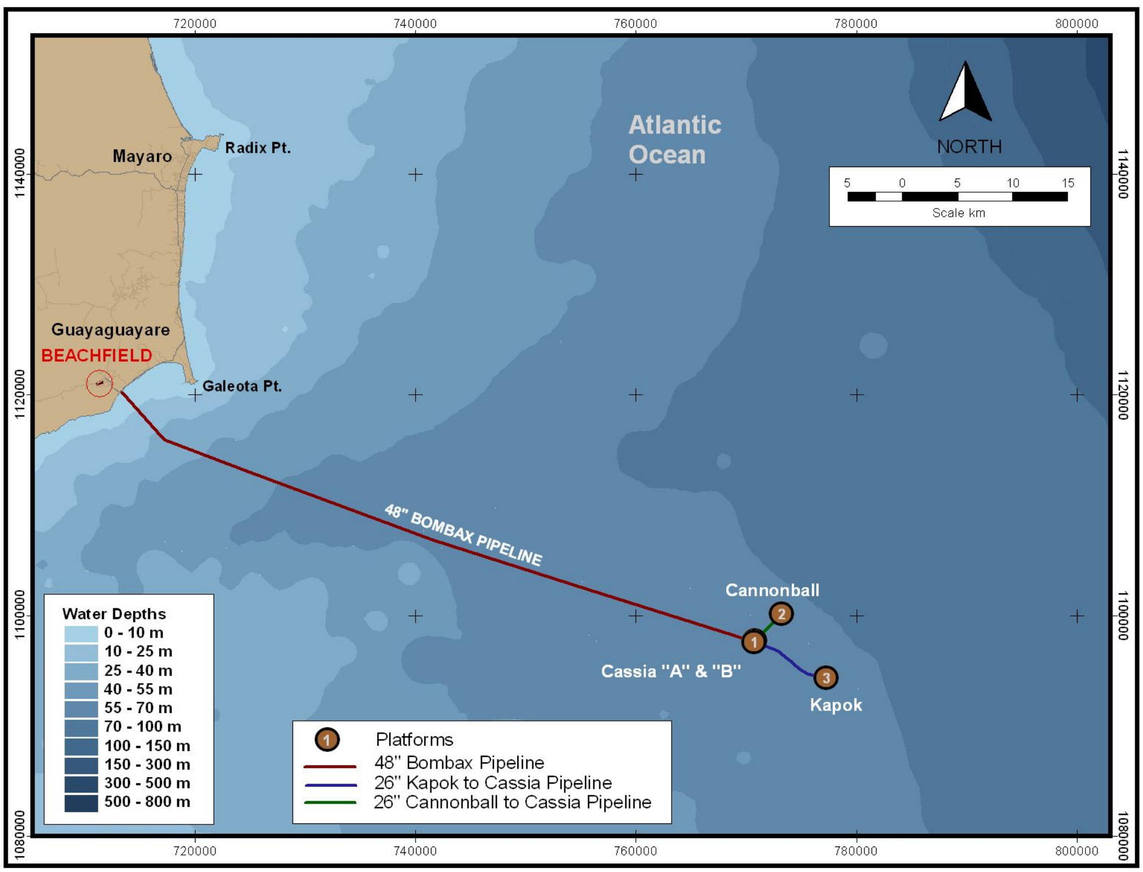


Figure 4.5: Bathymetry of the general offshore area

The water depth at the planned Cannonball WPP location is 71.5 meters. The bathymetry contours are shown on the chart at 15m intervals and run generally parallel to the shoreline. All depths are tide corrected to the LAT tidal datum which is the local chart datum.

Seafloor Topography and Near-surface Geology

Capital Signal Limited also conducted a sub-bottom sonar survey of the Cannonball area. The sonograms collected show a homogenous seafloor with some pockmark in the area. The pockmarks usually form from gas expulsion up through the unconsolidated surficial sediment veneer.

The surficial sediment is a very soft to extremely soft Holocene clay. This material covers an uneven erosional surface that probably dates to the last glacial-related sea level low stand. Figure 4.6 illustrates the nature of the shallow sediment beneath a portion of the seafloor in the vicinity of the Cannonball Well Protector Platform.

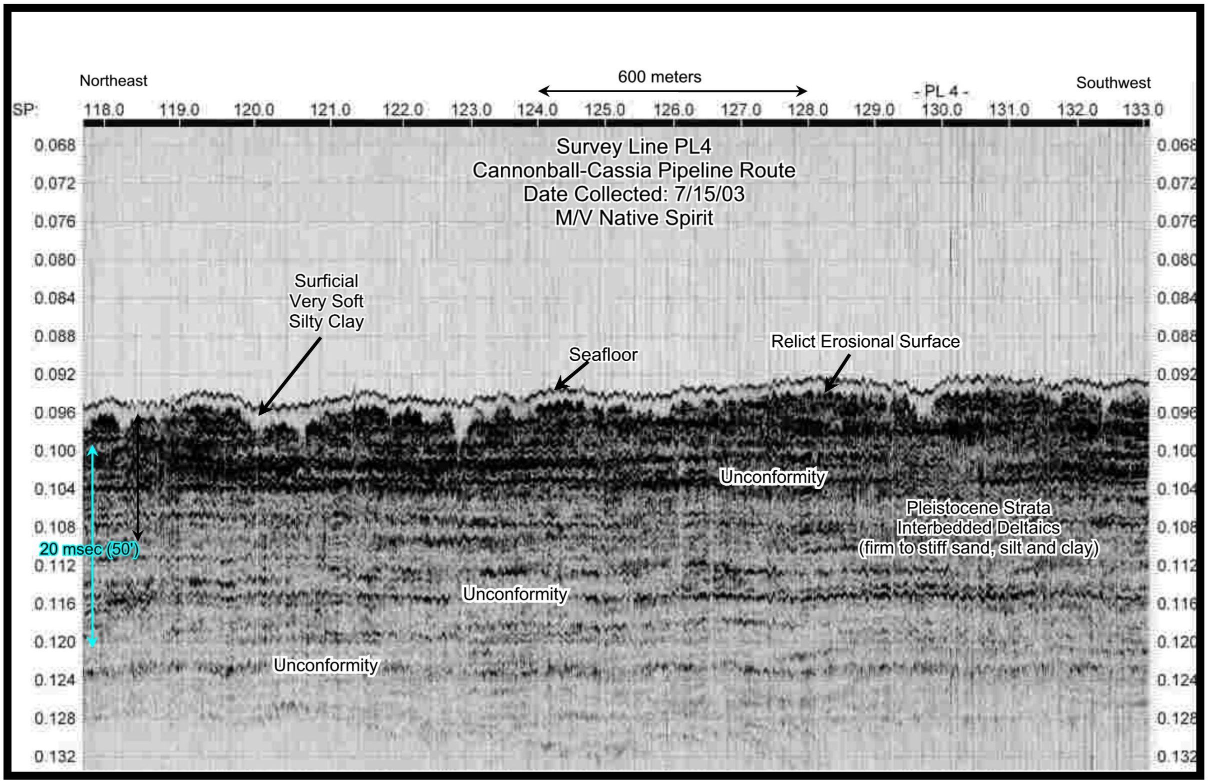


Figure 4.6: Example of a sub-bottom profile line collected at Cannonball Well location offshore (Capital Signal Limited, 2003)

Faulting

Two faults were seen on the seismic data from the related Cannonball drill site investigation; these faults are inactive and do not extend up much higher than 800 feet beneath the seabed. This indicates these faults have probably been inactive since the late Pleistocene in the region between the Iron Horse 1 well location and the proposed Cannonball drill site. The subbottom profiler data lacks evidence that active faults occur farther to the southwest between the Iron Horse 1 well and the Cassia structures

Shallow Gas

Pockmarks indicate that minor concentrations of shallow gas may be present in the near-surface sediment. Any gas present would probably not be under pressures much higher than hydrostatic and potential gas hazards are unlikely for the Cannonball WPP area.

Reefs and hard-bottom

Reef structures do not appear in the survey area. The conditions are unfavorable in this part of the Columbus basin for coralline algae formation. Authigenic carbonate formation cannot be ruled out whenever there is a chance that methane may be seeping through the seabed sediments. The sonograms conducted for Capital Signal Limited"s site hazard survey lack evidence for this however as the sonar reflectivity was homogenous.

The late Pleistocene strata that underlie the very soft surficial clay may comprise firm or even stiff material. Exposures of this older sediment are absent within the survey corridor (it would probably show up as a high sonar reflectivity zone). Because the thickness of the very soft surficial clay is thinner atop the topographic highs, the possibility exists that the proposed 26" pipeline could settle through the surficial mud and eventually contact this older sediment.

4.3.4. Seismic Activity

Previous studies of the area by the Seismic Research Unit (SRU) of the University of the West Indies have revealed that though the area is fairly active, the majority of earthquakes in this region tend to be low magnitude and diffusely spread through out the region, which indicates that from an earthquake perspective there appears to be no major active seismic zone in close proximity to the study area.

An on-line query of the United States Geological Sevice's, National Earthquake Information Center's Database has shown that there have been a total of 30 earthquakes of magnitude 5.0 and greater within a 200km radius of the proposed location of the Iron Horse protector platform. This data is shown in the following Table 4.. The database's records span the period 1973 to the present. Of these 30 earthquakes, there have been four earthquakes of magnitude 6.0 and greater.

In 1988, there was a magnitude 6.6 event off the South coast of Tobago, this event and subsequent aftershock caused moderate damage to structure and buildings in Tobago. In 1997, there was another >6.0 magnitude event off the West coast of Tobago which once again resulted in minor damage to buildings and low amplitude surface deformation. In summary there have been only a few events of magnitude 6.0 and greater recorded in the NEIC database; the closest of these was approximately 32 kilometers (20 miles) from the proposed location of the Iron Horse protector platform in 1988. This was part of the 1988 event off the South coast of Tobago, the effect of this tremor produced no documented damage to any well constructed structures located in the study area.

Recent work by Shepherd (2003) has produced fresh prespective on the seismic hazard distribution in Trinidad and Tobago. Utilising data recorded by the SRU's extensive local network, Sheppard has been able to better constrain attenuation models and has utilised spectral ground acceleration instead of peak ground acceleration to produce more up-to-date seismic hazard maps of Trinidad and Tobago. Shepherd's maps show that the area in the vicinity of the Cannonball Project shows a likelihood of horizontal ground acceleration of >500gals at 0.2sec period with a 2% probability in any 50 year period. See Figure 4.7 below.

TABLE 4.3: USGS/NEIC Database Query: Results for Circular Area 200km radius centered on 60-33W Longitude and 09-55N Latitude, for the Period 1973 to June 2003, earthquakes Magnitude ≥5.0

Year	North Lat (dec. deg.)	West Long (dec. deg.)	Depth Km	Magnitude	Distance of Epicenter Km
1975	9.31	-61.51	47	5.4	124
1976	8.6	-60.41	33	5.3	145
1982	11.22	-60.85	6	5.2	147
1988	10.4	-60.59	56	6.6	53
1988	10.4	-60.58	53	5.4	53
1988	10.39	-60.5	47	5.1	52
1988	10.17	-60.6	53	5.2	28
1988	10.14	-60.57	51	5.7	25
1988	10.21	-60.17	31	5.1	52
1988	10.21	-60.61	56	5.7	33
1988	10.18	-60.6	56	5.2	29
1988	10.21	-60.56	38	6	32
1988	10.31	-60.58	58	5	43
1989	8.45	-61.04	23	5.8	170
1989	9.98	-59.85	47	5.2	76
1990	10.21	-59.8	47	5.2	88
1991	10.62	-62.18	63	5.4	193
1994	10.24	-60.76	36	6.2	42
1994	10.27	-60.6	40	5.1	39
1996	11.23	-61.72	70	5.4	193
1997	11.41	-60.94	45	6.1	170
1997	11.05	-60.78	5	5.5	127
1997	11.11	-60.89	5	6.7	137
1997	11.03	-60.96	5	5.6	130
1997	11.06	-61.17	5	5	142
1997	11.05	-60.84	5	5	128
1997	11.14	-61.02	5	5	144
1997	11.03	-60.97	5	5.5	131
2001	10.72	-61.05	27	5	104
2003	10.67	-59.37	10	5.3	153

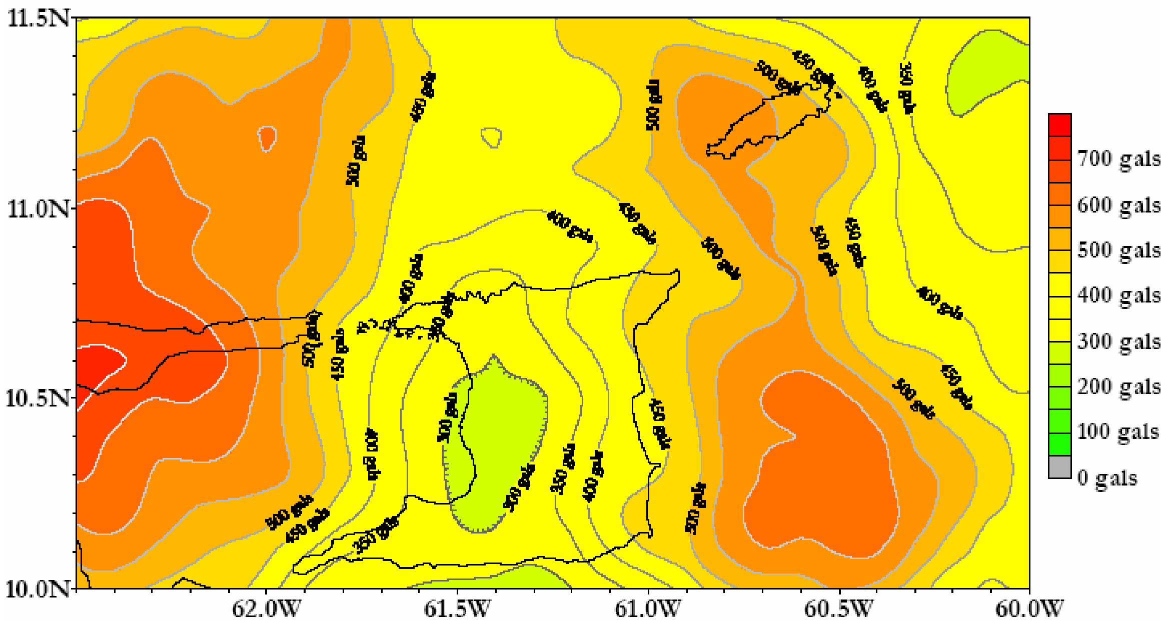


Figure 4.7: Likelihood of horizontal ground acceleration of >500gals at 0.2sec period with a 2% probability in any 50 year period (Shepard, 2003)

4.3.5. Oil and Gas Activity in the Offshore Study Area

bpTT currently operates an extensive network of gas producing facilities offshore of the east coast of Trinidad. Figure 4.8 below shows the location of all platforms within a 35km radius of the Cannonball Well Protector Platform.

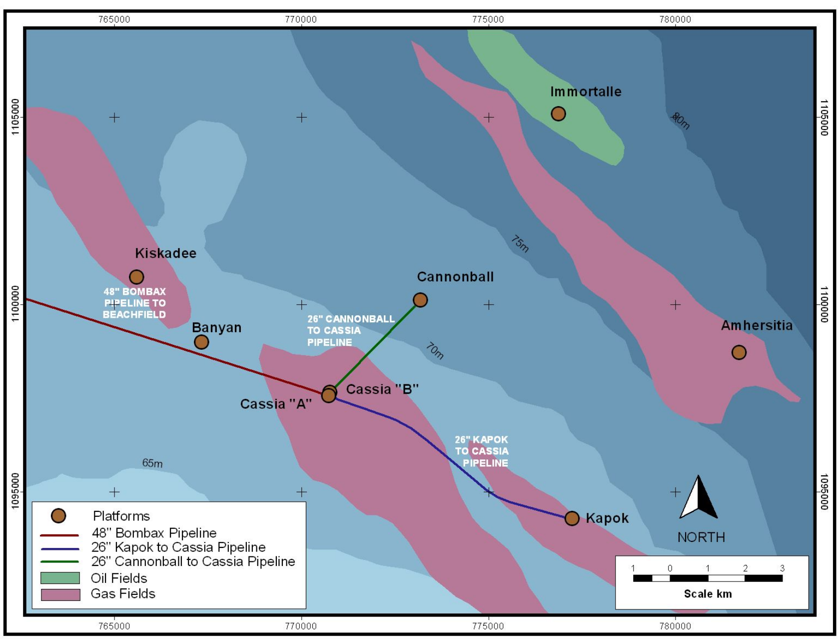


Figure 4.8: Location of all oil and gas facilities within 35km of the Cannonball Well Protector Platform.

4.3.6. Climate, Meteorology and Air Quality

Climate and Meteorology

The climate of the area may be described as tropical with pronounced dry (January to April) and wet (June to November) seasons. May and December are transition periods between seasons. Dry season is characterised by low rainfall with high daily air temperatures, wet season by high rainfall and lower air temperatures. The occurrence of the wet season coincides with the overhead passage of the Inter Tropical Convergence Zone (ITCZ). A short break in the wet season frequently occurs during September to October, the period is characterised by dry season-like weather, and is locally referred to as the 'Petit Careme'. A summary of climate and weather in Trinidad and Tobago can be obtained in Henry (1990).

The area lies under the influence of the northeast Trade Winds for most of the year, with Southeast Trades in August-October. Henry (1990) summarised the winds in the region as having a marked directional stability, particularly from October through to June when almost all winds are from the east or northeast. The wind speeds are typically less than 10 m s^{-1}. In July and August there is usually one or two pronounced westerly events. The strongest winds occur between January and April when the ITCZ is at its furthest south, and the northeast Trade Winds dominate.

There are two main permanent weather recording stations located within the region at Crown Point Airport, on the southwest coast of Tobago and at Piarco Airport in North Trinidad, refer to Figure 4.9. The total mean rainfall recorded at Crown Point is 1.415 m per year, 84% of which occurs during the wet season, based on rainfall statistics for Crown Point from 1969 - 1978 (CMI, 1982). The mean annual air temperatures over land varies between 22.5 °C at night and 28 °C during the day, daily maxima and minima will exceed these mean values. Piarco data show similar trends to Crown Point, and for cases where data are not available for Crown Point, Piarco data may be used. Climate statistics for Piarco are summarised by Henry (1990) and show a strong similarity to Crown Point Airport data. The total average rainfall recorded at Piarco is 1.456 m per year, 81% of which occurs during the wet season. Data on rainfall for the Mayaro area from the Water Resources Agency shows that the mean annual rainfall is approximately 2000mm per year (Water Resources Agency, 1990).

The mean relative humidity varies between 70% and 85% and mean air temperatures between 19 °C and 35 °C. The coolest months are between December and April.

4.3.7. Winds

The area lies under the influence of the NE Trade Winds for most of the year, with SE Trades in August-October. Henry (1990) summarised the winds in the region as having a marked directional stability, particularly from October through to June when almost all winds are from the east or north of east. The wind speeds are typically less than $10ms^{-1}$.

In July and August there are usually one or two pronounced westerly events. The strongest winds occur between January and April when the ITCZ is at its furthest south, and the NE Trade Winds dominate.

The local (Trinidad and Tobago) meteorological offices at Piarco, Trinidad and Crown Point, Tobago are the only permanent recording facilities within the islands. Since winds at sea tend to be stronger than winds blowing over the land (US Army Corps of Engineers, 1984) winds derived from the meteorological office at Piarco or Crown Point are sometimes not very useful in describing the offshore winds. While the wind directions may be similar, some deviations in wind direction and strength are expected, the quantification of these variations however are beyond the scope of this report. Figure 4.9 shows monthly averaged wind speeds for Piarco and Crown Point. The wind speeds at Crown Point are always higher than those for Piarco, this may be a function of the proximity of Crown point to the sea when compared to Piarco. The graphs show that winds are highest between January and May and attain their maximum during the month of May. There is a rapid decrease of wind speeds over June to August, followed by a slow increase to December. These results are based on averages over at least 20 years.

Data on winds at sea are available from three main sources for the Atlantic Coast of Trinidad: Herrera et al. (1984), CCC (1988) and (bpTT, 2003). Of these data no measurements were conducted within the study area. Since no other published data are available for the study area, information on winds was compiled from these three data sources. Since the data describe open water conditions for the East Coast of Trinidad and Tobago these variations are expected to be negligible.

The data obtained from CCC (1988) is for a region between Tobago and Grenada (2° x 1.5°) for offshore conditions. The Canadian Climate Center (CCC) collected ship observations of wind and wave data from 1855 to 1987 for the area shown in the inset of Figure 4.10. The report indicated that winds were consistently from the east-northeast during most of the year, there are periods when the winds are from the southeast, mostly during June to September.

From January to May (Dry Season) 70% of winds are in the range 10 knots – 20 knots (5 m s^{-1} - 10.0 m s^{-1}), while 10% of the time it was 20 knots – 34 knots (10 m s^{-1} - 17 m s^{-1}). The remaining 20% percent of the times the winds were less than 10 knots (5 m s^{-1}).

During the Wet Season (June to December) the winds were lower and more variable most of the times. Wind speeds were greatest during the months of December to June, with a marked reduction of wind speeds during July to November (CCC, 1988). Figure 4.10 shows a summary of the wind speed data. The average wind speed was generally 13 knots (6.5m s^{-1}) during the December to June months and 10 knots (5m s^{-1}) during the months July to November. Wind directions were generally from the east, when they were strongest and from the northeast at other times.

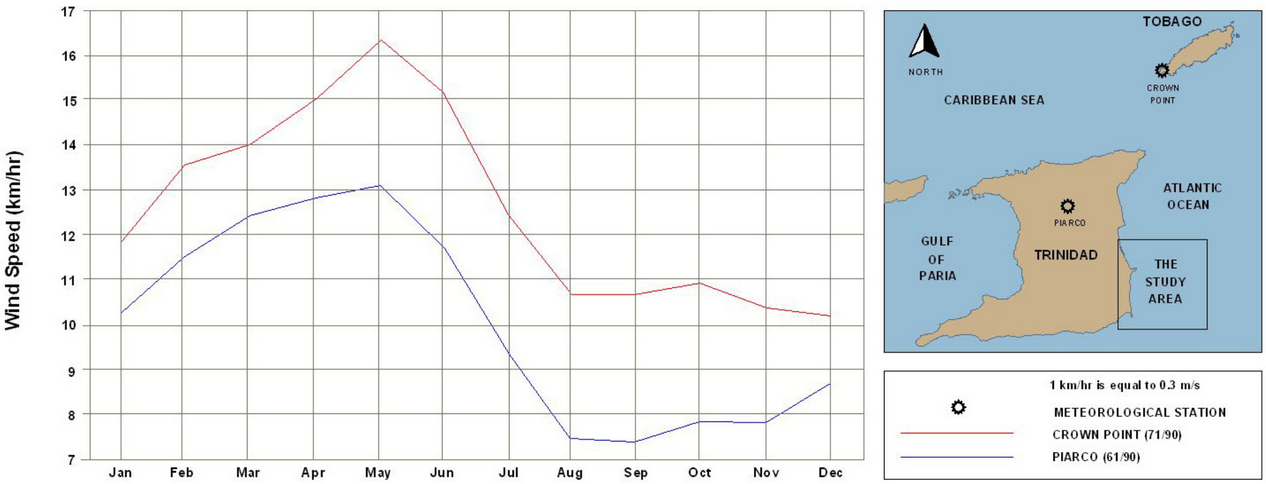


Figure 4.9. Monthly averaged wind speeds at Piarco, Trinidad and Crown Point, Tobago. Monthly averages for the period 1961-1990.

Extreme Winds – Tropical Cyclones

In general, Trinidad lies south of the Atlantic Hurricane Track, although occasionally a tropical cyclone will pass further south than usual. Daniel and Maharaj (1987) discussed all tropical cyclones affecting Trinidad and Tobago from 1725 to 1986. All tropical cyclones passing within the region bounded by 10°N to 12°N and 60°W to 62°W were included in this study. The Atlantic Hurricane Season extends from June 1 to November 30. Daniel and Maharaj (1987) summarise the hurricane activity passing through the Lesser Antilles. They estimate that in any year ten tropical storms form during the Atlantic Hurricane Season

Prior to 1990 the statistics for tropical cyclones affecting Trinidad was 34.7 years return period for hurricanes and 17.3 years for tropical storms (Daniel and Maharaj, 1987). Since 1990 however, with the occurrence of two tropical storms (Arthur and Fran), the statistics have been affected and Maharaj (1990) gives return periods of hurricanes for the region of 34.7 years, with a return period of 13.1 years for hurricanes and storms. These return periods are based on statistics over the period 1886 to 1990. Hurricane Flora was a category 3 storm (winds in the range 210 km hr^{-1} to 248 km hr^{-1}) which passed over Tobago in 1963, the recurrence interval for Category 3 hurricanes is 200 years.

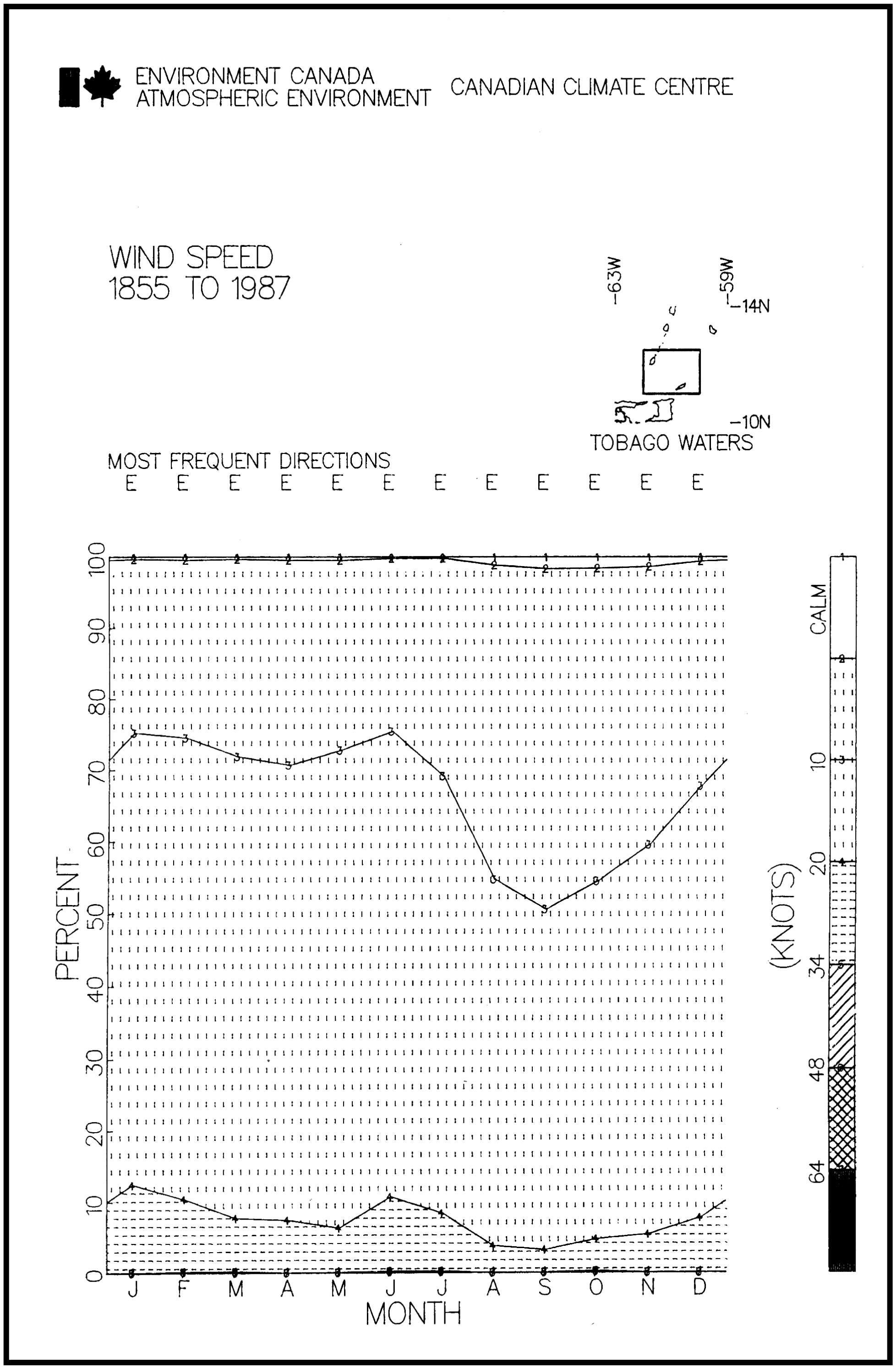


Figure 4.10. Monthly averaged wind speeds and direction based on ship observations (1855-1988).

The impact of a hurricane lies not only in the intensity of its winds but with the attendant storm surge. Storm surges are produced as a result of winds usually associated with tropical cyclones. The intensity of the storm surge is related to the central pressure of the tropical cyclone and the approach of the cyclone. Storm surge heights are calculated based on land mass topography and orientation, bathymetry, wind speed and direction. The Saffir-Simpson Hurricane Scale (WWW, 1988) provides estimates of storm surge heights for various hurricane intensities, see Table 4.5. Storm surge effects are expected to be very small for remote offshore locations.

Wind data for extreme events were also obtained from METOCEAN Criteria for the Eastern Coast of Trinidad (bpTT, 2003). This data is shown in Table 4.4 below.

Table 4.4. Extreme winds near the Cannonball site, East Coast, Trinidad. After (bpTT, 2003).

RETURN PERIOD (years) →	10	25	50	100
	Wind Speed (m/s)			
1-hour @10m	17.0	18.5	24.2	29.3
1-minute @ 10m	20.4	22.2	29.2	35.2

Table 4.5: Saffir-Simpson Hurricane Scale. After World Weather Watch (WWW, 1988).	
CATEGORY	**DESCRIPTION**
One:	Winds 119 – 153 km/hr or storm surge about 1.5m above normal.
	No real damage to building structures: damage primarily to unanchored mobile homes, shrubbery, and trees; also, some coastal road flooding and minor pier damage.
Two:	Winds 154 – 177 km/hr or storm surge about 2 – 2.5m above normal.
	Some roofing, door and window damage to buildings; considerable damage to vegetation, exposed mobile homes, and piers; coastal and low-lying escape routes flood two to four hours before arrival of centre. Small craft in unprotected anchorage's break moorings.
Three:	Winds 178 – 209 km/hr or storm surge about 2.6 – 3.7m above normal.
	Some structural damage to small residences and utility buildings with minor amount of curtainwall failures; mobile homes are destroyed. Flooding near the coasts destroys smaller structures and large structures damaged by floating debris. Terrain continuously lower than 1.5m may be flooded inland 13km or more.
Four:	Winds 210 – 249 km/hr or storm surge about 4 – 5.5m above normal.
	More extensive curtainwall failures with some complete roof structure failure on small residences; major damage to lower floors or structures near the shore; terrain continuously lower then 3m flooded inland as far as 10km.
Five:	Winds greater than 249 km/hr or storm surge about 5.5m above normal.
	Complete roof failure on many residences and industrial buildings; some complete building failures with small buildings blown over or away; major damage to lower floors of all structures located less than 4.5m above sea-level and within about 455m of the shoreline.

Summary

The climate of the area is tropical with a pronounced dry (January to April) and wet (June to November) seasons. May and December are transition periods between seasons. Dry season is characterised by low rainfall with high daily air temperatures, wet season by high rainfall and lower air temperatures. The occurrence of the wet season coincides with the overhead passage of the Inter Tropical Convergence Zone (ITCZ). A short break in the wet season frequently occurs during September to October, the period is characterised by dry season-like weather with clear skies and hot days, and is locally referred to as the

'Petit Careme'. A summary of climate and weather in Trinidad and Tobago can be obtained in Henry (1990).

Daily air temperatures over land vary between 19°C and 35°C with relative humidity between 70% and 85%. The mean annual rainfall is approximately 2000mm.

Winds are generally from the northeast for most of the year, frequent southeasterly winds are observed during June to September. The average wind speed was generally 6.5m s^{-1} during the December to June months and 5m s^{-1} during the months July to November. The highest wind speeds tended to be from the east. Winds of greater intensity are expected during tropical cyclone events, the occurrence of such extreme events is: 1:13.1 years for tropical storms or hurricanes and 1:34.7 years for hurricanes.

4.3.8. Oceanographic Currents

Prevailing Currents in the General East Coast Area

Circulation in the area is influenced by the branch of the North Brazil Current that flows parallel to the East Coast of Trinidad, referred to as the Guiana Current. Historically, the Guiana Current has been spelt as "Guiana", however, some authors choose the form "Guyana" reflecting more contemporary views. This report will use the form "Guiana Current", which for the purposes of the reader is the same as "Guyana Current". Recent studies by Richardson and Walsh (1986), Muller-Karger and Castro (1993), Richardson and Schmitz (1993), Richardson (1993), Richardson *et al.* (1994), Stansfield *et al.* (1995) and others have shown that anticyclonic eddies of varying scales close to the North Brazil Current become detached and migrate to the north, towards the Caribbean Sea, see Figure 4.11. The Guiana Current exhibits some variability as these eddies flow past the islands during part of the year, Stansfield *et al.* (1995) found that the local velocities within these eddies can result in current speeds as large as 0.80m s^{-1}. Richardson *et al.* (1994) describes the phenomenon as a migrating train of eddies with diameters in the order of 200 km for most of the year, refer to Figure 4.11 and Figure 4.12.

Other studies have been conducted south of the study area, in particular a study by Herrera and Masciangiolo (1984) was undertaken to determine the contributions to the total flow by geostrophy (currents generated by sea level and Coriolis force), tides and the mean current (Guiana Current). In general, the current speeds were found to be greatest during February and April and lowest between August and October, with currents predominantly to the north-northwest (NNW) at most depths. The near-bed velocity at some times deviated from northwest.

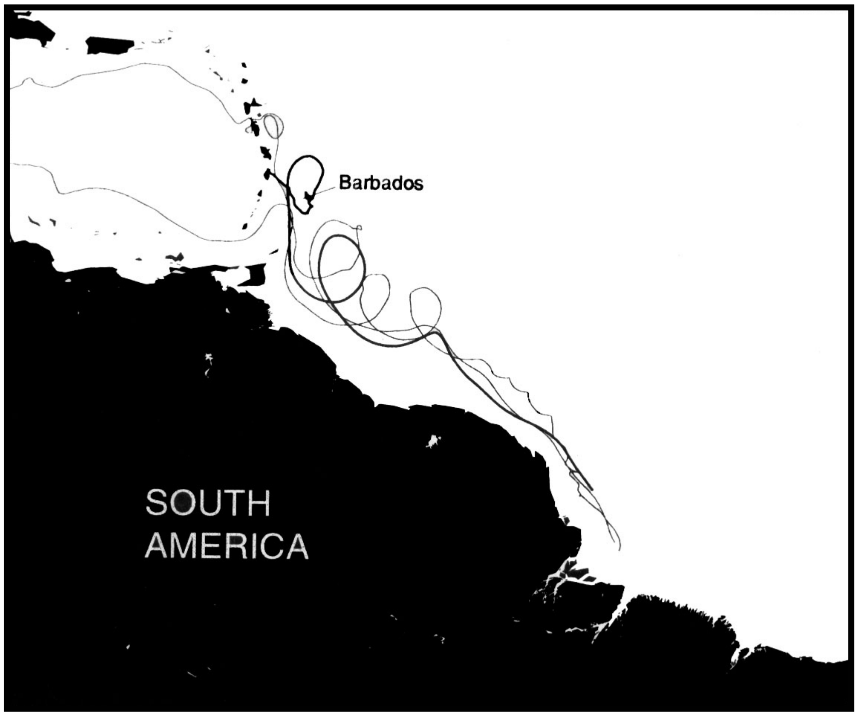


Figure 4.11: Drifter Tracks from a release point near the Amazon River. After Stansfield et.al. (1995)

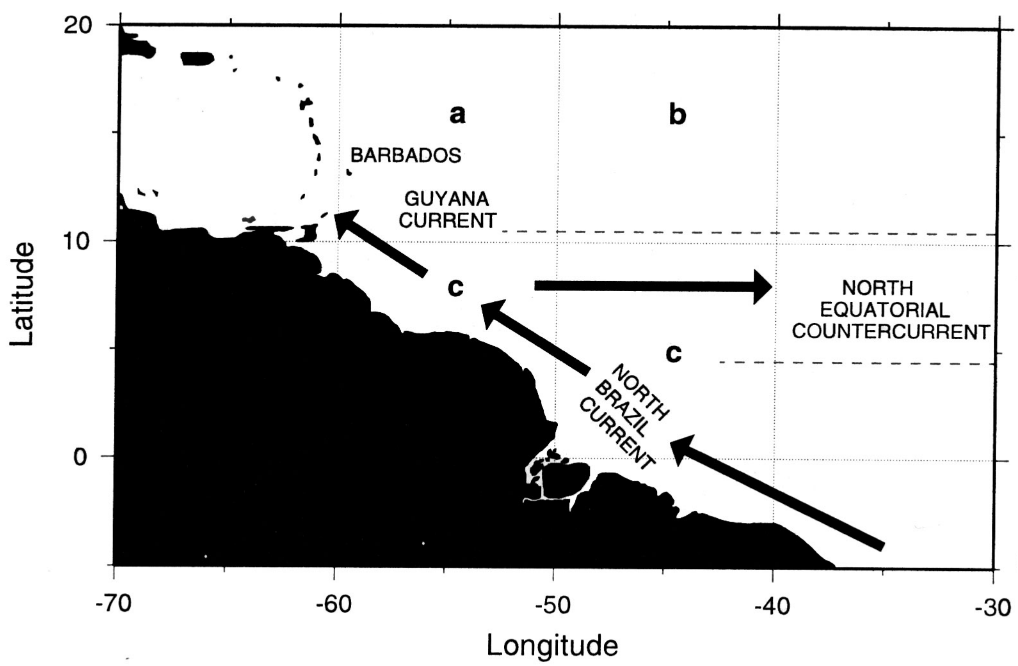


Figure 4.12: Large Scale Circulation Patterns around Trinidad and Tobago. After Stansfield et.al. (1995)

Studies by Herrera *et al.* (1981) indicated that the surface current speeds (6.5m below surface) at a station in a water depth 200m varied between 0.07 m s^{-1} and 1.36 m s^{-1} with currents showing little or no tidal variation, the mean current speed was 0.42 ms^{-1} to the northwest during the dry season. The current direction varied between west and northeast, with almost no periods of currents travelling to the south during April 1978 (dry season). The mid-depth measurements showed an increase in tidal influence with currents varying between northeast and northwest with speeds in the range 0.02m s^{-1} to 0.69m s^{-1}, and a mean flow to the northwest at a rate of 0.18m s^{-1}. The currents at a depth of 150m show tidal variations, with rising tide currents to the southeast and falling tide currents to the northwest, current speeds varied between 0.02m s^{-1} and 0.63m s^{-1} with a mean current of 0.03 m s^{-1} to the east.

Of these observed currents, the main component is the background or mean flow due to the Guiana Current. The maximum current speeds occur during the months April and May (mean current speed of 0.48m s^{-1} to the northwest), with lesser values in current speed during the latter half of the year (mean current speed of 0.34m s^{-1} to the northwest) (Herrera *et al*., 1979). The eddies which form along the eastern coast of Guyana travel northwards along the East Coast of Trinidad in water depths greater than 200m, these eddies cause significant variations in the circulation patterns. The seasonal variation in the Guiana current can be related to the variations in forcing due to winds, river outflow and water density. The findings of these surveys are consistent with other observations within the study area, specifically Hydrographer of the Navy (1983).

<u>Prevailing Currents Within the Cannonball Field Study Area</u>

Only a few datasets were available for the immediate study area. The only sources of data within the study area are Hydrographer of the Navy (1983) and Acoustic Doppler Current Profiler (ADCP) data collected by Coastal Dynamics (present study) and bpTT (2000). The Hydrographer of the Navy (1983) estimates that currents can attain rates between 0.5 and 1.0 m s^{-1} (1 and 2 knots) to the northwest off the East Coast of Trinidad. Inshore, the currents can travel to the south and can be strong (Hydrographer of the Navy, 1983). Within the study area tidal reversal of currents may be uncommon because of the strength of the Guiana Current. This will be even more apparent during the wet season when the Orinoco flow is at its peak.

ADCP data was collected by (bpTT, 2000) at three sites off the East Coast of Trinidad. The deployment information is shown in Table 4.6.

The ADCP data was not available for this study; however, a summary of the data is as shown in Table 4.7. Figure 4.13 shows the location of the current monitoring stations.

The data showed that higher current speeds were found at the shallowest deployment (75m), off the East Coast of Trinidad. Station 1 has similar water depths to the study area at the Cannonball WPP Site. Maximum current speeds were typically near the sea surface. Currents attained maximum speeds of up to 1.46 ms^{-1} at Station 1 (75m). The mean current speeds were in the range 0.26 ms^{-1} to 0.65 ms^{-1} for Station 1.

Table 4.6: Summary of (bpTT, 2000) ADCP current measurements, East Coast, Trinidad.						
Location	**Nominal Depth (m)**	**Date**		**Duration (Days)**	**Instrument Type**	**Sampling Interval (minutes)**
		Start	**End**			
East Manzanilla	75	Oct 9th, 1996	December 14th, 1997	430	ADCP	20
East Mayaro	92	October 9th, 1996	March 15th, 1997	155	ADCP	20
Block 5B	500	March 30th, 1997	May 1st, 1998	360	3 Recording Current Meters and ADCP	20

Table 4.7: Summary of current speeds with depth for three stations. After bpTT, 2000								
Station 1			Station 2			Station 3		
Height (m)	Mean ms^{-1}	Maximum ms^{-1}	Height (m)	Mean ms^{-1}	Maximum ms^{-1}	Height (m)	Mean ms^{-1}	Maximum ms^{-1}
75 (surface)	-	-	92	-	-	500	-	-
67	0.65	1.42	83	0.53	1.33	462	0.34	0.72
63	0.60	1.41	79	0.57	1.39	438	0.26	0.69
59	0.57	1.38	71	0.52	1.39	422	0.23	0.64
55	0.54	1.42	59	0.45	1.27	398	0.21	0.52
47	0.48	1.45	51	0.40	1.2	374	0.18	0.39
39	0.43	1.46	43	0.34	1.13	350	0.16	0.34
31	0.38	1.42	35	0.3	1.03	318	0.14	0.31
23	0.33	1.25	27	0.26	0.87	203	0.10	0.24
19	0.30	1.16	19	0.23	0.72	109	0.10	0.26
15	0.26	1.03	15	0.21	0.7	15	0.09	0.19

Coastal Dynamics conducted two 4-hour, ship mounted ADCP surveys on October 28 and 30th 2003, during neap tide conditions. The results of this survey are summarised in Figure 4.14. The ADCP is configured to "look" downwards, mounted off the side of the ship. A 300kHz RD Instruments Workhorse ADCP was used to conduct the survey. ADCP data are represented as bin-averaged (1m binned) currents over the water column. Bins are numbered from 1 at the seabed to 80 nearest the instrument (3m from surface). The figure shows that the current profiles in water depths of 66m attained speeds of up to 0.5 ms^{-1} moving to the north and northwest. The surveys conducted were rising tide conditions on October 28 2003 and from rising to falling tide (October 30 2003).

The ADCP results confirm the existence of persistent northwesterly currents. Current speeds were generally higher in the upper part of the water column and showed no tidal influence during the survey.

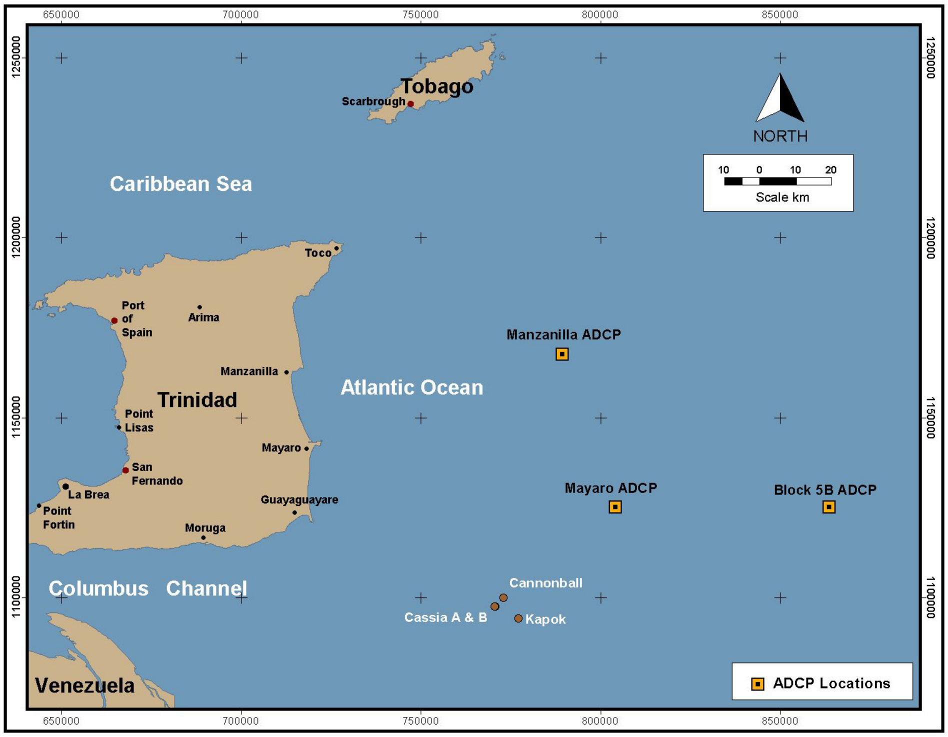


Figure 4.13: Location of the ADCP Current Meters discussed in the bpTT 2000 report

Figure 4.14: Illustration of Current Flow off the East Coast of Trinidad.

Summary of Current Flow

Figure 4.14 above shows the general flow of currents off the east coast of Trinidad. The currents in the immediate Cannonball WPP location generally flow to the north-northwest. The upper flow can reach as high as 1.4 m s^{-1} reducing as you go down the water column. Bottom currents are in the order of 0.5 – 0.1ms^{-1}. There appears to be little tidal influence in the surface currents which are mainly affected by the persistent Guiana Current flowing from the southeast.

4.3.9. Waves

A description of the deep water wave climate for the study area is derived from work by Herrera *et al*. (1979), CCC (1988) and (Cannonball Design Basis – bpTT, 2003). Although these sources describe wave climates to the north and south of the study area, it will be representative of the study area since they describe general East Coast deep water wave conditions.

The wave regime off the East Coast of Trinidad consists of wind seas and swell. These are wind waves, which are generated by local Northeasterly Trade Winds, and swell waves generated by distant pressure systems (high and low) in the North Atlantic during the Northern Winter period. The wind wave periods are usually 1-7 seconds and the swell periods are usually 9-15 seconds. Generally, in deep water, waves are from the northeast (25 - 40°) with a period of 8 - 10 seconds with a deepwater significant wave height of 0.5m - 0.8m. The significant wave height usually denoted as H_s represents one-third (1/3) of the highest waves observed in a sample set, as opposed to the maximum wave height which could refer to the single highest wave in a set of observations.

The only available comprehensive data set for the region is available for Tobago waters, however, it can be applied to the study area since the winds blowing over the adjacent areas are similar and are affected by the same weather systems. Statistics obtained from the compilation of ship observed wave data, the Comprehensive Ocean Atmosphere Data Set (COADS) (CCC, 1988) showed that waves in the region of Tobago generally approach from the east with some waves coming from the northeast during the winter months, December to January. The data showed that during November to March, waves are generally higher. During this period, which coincides with winter storm weather in the North Atlantic, 30 percent of the significant wave heights observed were between 2m and 4 m in height while 70 percent were 0.5m - 2 m. During the months of April to October, the contributions were 20 percent (2m - 4 m) and 80 percent (0.5m - 2 m). There appeared to be an increase in wave heights during the months of January to February (Winter Swell) and June to July possibly due to the hurricane season. Figure 4.15 shows the summary of combined sea and swell wave height data. The average wave height during the winter months (November - March) was 1.75 m from the northeast (25° - 40°) with periods of 10s -15s. The maximum wave heights observed for this region are between 5m to 7m from the east (CCC, 1988).

Herrera *et al.* (1979) conducted a study of tides, currents, winds and waves for several stations near the Orinoco delta during the period December 1977 to November 1988. The results of Herrera *et al*. (1979) showed that the patterns in the most frequent, maximum significant wave height $H_{s\ max}$ were as shown below:

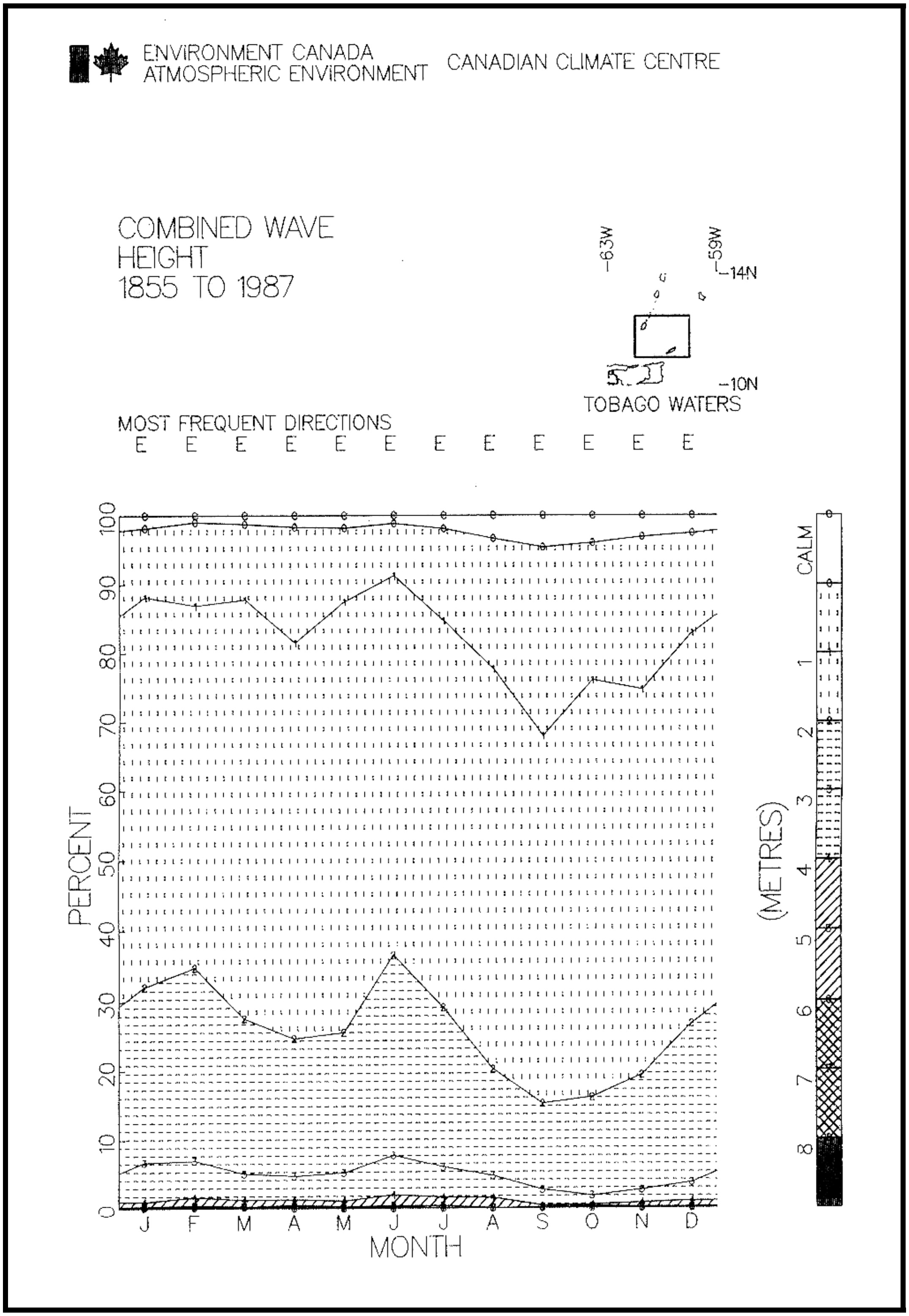


Figure 4.15. Combined sea and swell wave height data. After CCC, 1988.

January to March	2.9 to 3.0m
April	2.1 to 2.2m
May	3.1 to 3.2m
June to July	2.6 to 2.7m
August to September	1.7 to 1.8m
October to November	2.3 to 2.4m
December	2.7 to 2.8m

The average significant wave periods observed were between 5.3s and 6.4s. The range of significant wave heights are similar to those observed by CCC (1988), it is important to note that Herrera et al (1979) is based on one year data, while CCC (1988) is based on 132 years of ship observed data.

The maximum significant wave heights observed for these months were approximately 2m higher than these values; this gives an estimated maximum significant wave height during the study period of approximately 5m. Herrera *et al*. (1979) gave an estimate of the 50 to 100 year extreme wave height of 8m, this value was based on a mathematical model using extreme wind conditions for the region southeast of the study area.

The Cannonball Design Basis Report (bpTT, 2003) gives estimated 100- year storm wave conditions for the study area. The maximum expected significant wave height and maximum wave height are shown in Table 4.8 below.

Table 4.8. 100-year storm wave conditions. After (Cannonball Design Basis, bpTT, 2003)

Parameter	Wave Height (m)	Wave period (second)
Maximum Wave Height (m)	13.4	10.9
Significant Wave Height (m)	7.8	8.5

The 100-year maximum significant wave height is similar to the Herrera et al. (1979) estimates for the area.

4.3.10. Tides

Tides in the region are of a mixed semi-diurnal type with a pronounced semi-diurnal inequality. The range is micro-tidal, with tidal ranges of about 0.9m at the northern end of the Gulf of Paria (Port of Spain) and 1.9m in the Columbus Channel (Chatham Bay). The principal lunar constituent (M_2) provides, on average, more than 70% of the tidal amplitude for different locations in the region. There are two permanent tidal stations in the Trinidad coast of the Gulf of Paria, Port of Spain and Point Fortin. The Port of Spain station is a Standard Port. This gauge has been in place since 1939, but the tidal record is not continuous.

Recently a tide gauge has been deployed at Galeota Point, East Coast, Trinidad by CPACC (Caribbean Planning Adaptation to Global Climate Change) as part of the Global Sea Level Observing System (GLOSS). Data from this instrument is expected to become available in the near future. At present estimates of the tides can be found in the local Tide Tables for the current year. The Tide Tables published by the Hydrographic Unit of Trinidad and Tobago states that the high tide at Guayaguayare Bay (immediately west of Galeota Point) is 39 minutes earlier than the corresponding High Water at Point Fortin. Low Water is 42 minutes earlier than the Point Fortin equivalent.

Data for Point Fortin and Port of Spain suggest that the mean sea level is higher during the wet season months with the level in September/October about 0.15m higher than in February. This level has not been referenced to any datum.

4.3.11. Salinity, Density and Temperature

The salinity and temperature of the waters surrounding Trinidad and Tobago, including the study area, are affected annually by the Orinoco and Amazon River discharges. The Orinoco has a greater long term effect on the water column salinity and temperature (density) within the study area since much of the Amazon River outflow is confined to the regions east of the 200m contour in the form of eddies. During the dry season, when Orinoco flow is low, most of its discharge flows northward along the South American Coast. There is a separation in flow south of the southeastern tip of Trinidad, with one branch of the Guiana current travelling north along the east coast of Trinidad on route to the Caribbean Sea (Muller-Karger *et al.*, 1988). During the wet season, even larger volumes travel north along the East Coast of Trinidad towards the Caribbean Sea. The Orinoco River has a mean discharge of 33,950m^3/s (Lerman, 1980).

Salinity and temperature have been measured at a several hydrographic stations along the east coast of Trinidad, most notably during the "Guaigueri" research cruises in 1960 and 1961 (Gade, 1961), the cruise by R.V. Dr. Fridtjof Nansen in 1988, cruises by the R.V. Malcolm Baldrige as part of the Subtropical Atlantic Climate Studies in 1989 and by the R.V. Sagar Kanya during the project CORE in 1990. A research project was also conducted by the Institute of Marine Affairs (IMA, unpublished data) at an offshore site near prospector patch on the east coast of Trinidad during a 25 hour oceanographic station on October 26th, 1994 (wet season).

The data show that there is a general increase in sea surface temperature along the east coast waters during the wet season (from 27°C to as high as 29°C), a scenario confirmed by surface temperature distribution data collected by Gade during the "Guaigueri" cruises in 1960 and 1961 (Gade, 1961). In water depths greater than 50m, the bottom temperature shows a maximum in the wet season month of August and a minimum in the dry season month of February. The surveys referenced above indicate a decrease in near surface salinity during the wet season with salinity varying between 30ppt near the surface and approximately 37ppt near the seabed. The changes in sea surface temperature do not vary significantly, and are in the range 25°C to 29°C near the surface and in relatively shallow waters (less than 30m).

Results from a study by Febres-Ortega (1974) showed that the salinity profiles to the southeast of the study area varied between 30ppt (surface) and 37ppt during April of 1972, with a corresponding range in temperature between 5°C (>1000m) and 27°C (at the surface). During the wet season the corresponding ranges in salinity and temperature were: 31ppt (surface) to 37ppt for salinity, 5°C (> 1000m) to 29°C (surface) (Hydrographer of the Navy (1983), IMA (unpublished data), Gade (1961), Febres-Ortega (1974)).

The sea water density typically varies between 1020 kg m^{-3} and 1024 kg m^{-3}, throughout much of the water column for the year. However, it must be noted that there is variability in density structure, especially in the upper water column due to the increase in Orinoco River water influence during the wet season (July - December). At present, this variation is not quantifiable due to lack of long term records for the study area.

4.3.12. Water and Sediment Quality

4.3.12.1. Literature Review

The study area (Cannonball Field) is situated at approximately 60km from nearest land (Trinidad) and well within an area in which there are a number of commercial concerns involved in the exploration and production of oil and gas (Figure 4.16). The study area lies in the open Atlantic in fairly deep water (>20m) and is strongly influenced by the Guiana current which generally flows to the north. It is therefore expected that the effect of anthropogenic activities derived from land based activities in Trinidad or from oil and gas installations located to the north of the study area will have little if any direct influence on the environmental quality of the Cannonball WPP site. The Guiana current is strongly influenced by the discharges of the Orinoco and the other large South American rivers (van Andel and Postma, 1954) and, as a result, water quality with respect to the levels of nutrients (NO_3^-, NO_2^-, NH_3, PO_4^{3-}) would be higher than that typically reported for open oceanic conditions. On the other hand, salinities would be lower particularly in the wet season, when riverine discharges are high.

There are two producing gas/condensate platforms located in close proximity to the study area, namely Kapok and Cassia (A) and (B), which may directly influence the environmental quality of the study area as discharges would be carried to the north (study area) by the Guiana current, although the Cassia (A) and (B) platform, located to the southwest, may have less of an impact on environmental quality at the Cannonball WPP site.

The general area surrounding it is actively under oil exploration and production activities, for this reason the general area has been well documented in terms of baseline environmental quality. Additionally the Institute of Marine Affairs has extensively monitored the nearshore areas of the east coast petroleum hydrocarbons and trace metals (Cu, Cd, Cr, Pb, Hg and Zn).

Nutrients

The nutrients ammonia (NH_3), nitrates (NO_3^-), and nitrites (NO_2^-) are forms of nitrogen which are typically derived from the breakdown of organic matter, agricultural runoff and from sewage treatment facilities. In the study area the main sources of the nutrients would be from rigs and other installations with sewage treatment facilities, vessel discharges and from the Orinoco River. Nutrients, in areas that have abundant sunshine

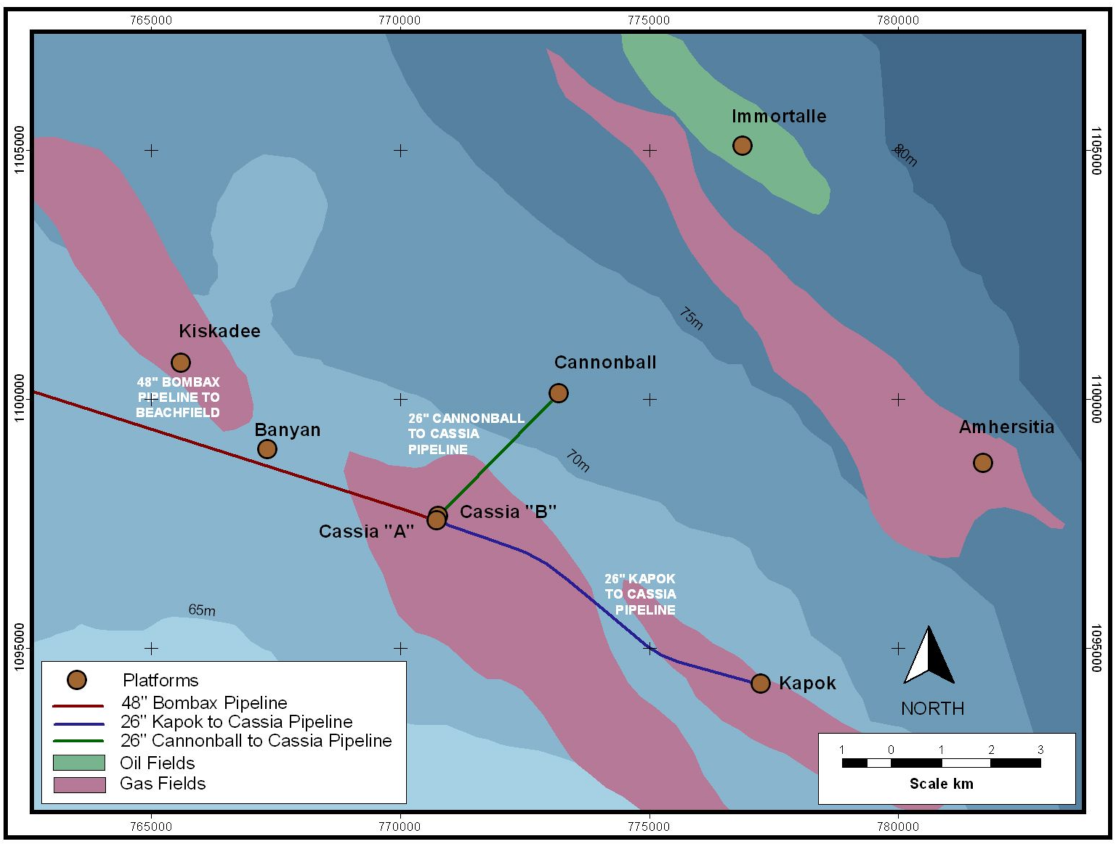


Figure 4.16: Location of Cannonball Study Area

and waters which have low turbidity and are highly oxygenated, are rapidly utilised by plant matter and typically have low residence times in the environment and pose no accumulation threat.

The ranges in the levels (µM) reported for the areas of Trinidad's east coast in a close proximity to the site were Ammonia (NH_3) 0.205 – 0.540; Nitrates (NO_3^-) 0.035 – 5.99; Nitrites (NO_2^-) 0.02 – 0.10 and Phosphates (PO_4^{3-}) Not Detected. - 0.11 (Ecoengineering

Consultants, 2000a,b; Ecoengineering Consultants, 2001; Continental shelf Associates, Inc. 1997, 1998). It can be concluded that the levels of nutrients reported for the area are low (< 1μM) and representative of open oceanic conditions.

Trace Metals

The trace metal levels reported for the general area has been quoted as being below the method detection limits of 1 μg L^{-1} for The trace metals nickel (Ni), copper (Cu), chromium (Cr^{3+} and Cr^{6+}), cadmium (Cd), lead (Pb); below the 0.1 mg L^{-1} detection limit for iron (Fe) and below the detection limit of 0.025 μg L^{-1} mercury (Hg) (Eco Engineering Consultants, 2000a,b; Eco Engineering Consultants, 2001; Continental shelf Associates, Inc. 1997, 1998).

Rajkumar *et al.,* (1992) reported metal level (μg L^{-1}) ranges for the nearshore areas of Mayaro Bay of 0.05 – 1.33 for Cd; 0.5 – 3.49 for Cu; 0.05 – 3.84 for Pb; 219.89 – 2961 for Fe whilst Cr was not detected. The levels reported were below the USEPA criteria for the protection of marine aquatic life with the exception of copper which exceed the limit of 2.9 μg L^{-1}(USEPA 1986).

Oil and Grease and Total Petroleum Hydrocarbons

Oil and grease has been reported below the detection limits of 0.5mg L^{-1} (Ecoengineering Consultants, 2000a,b; Ecoengineering Consultants, 2001; Continental shelf Associates, Inc. 1997, 1998).

Total petroleum hydrocarbons (chrysene equivalents) reported for the area ranged between 0.29 – 1.00 μg L^{-1} for offshore areas of the east coast (Ecoengineering Consultants, 2000a,b; Ecoengineering Consultants, 2001; Continental shelf Associates, Inc. 1997, 1998). The levels reported for nearshore areas of Mayaro and Guayaguayare Bays were 0.04 – 18.67 μg L^{-1} (IMA Archival Data). The levels of TPH reported for waters of the east coast of Trinidad are lower than that reported of areas of the Gulf of Paria (Agard and Gobin 1993, Agard *et al.,* 1988) but significantly higher than the 0.01 μg L^{-1} reported by Atwood et al., (1987) for marine waters of the Wider Caribbean Region.

Petroleum Hydrocarbons and Total Oil and Grease

The ranges of oil and grease and petroleum hydrocarbons reported for offshore areas of the southeast coast of Trinidad were 0.021 – 0.239 mg g^{-1} and 0.22 – 6.29 μg g^{-1} on the other hand levels of petroleum hydrocarbons reported for nearshore sediments of Mayaro and Guayaguayare Bays were with the range of 0.10 – 64.58 μg g^{-1}. The levels reported for the east coast of Trinidad are however much lower than that reported for other areas in the Gulf of Paria (Agard and Gobin, 1993, Agard *et al*., 1988).

The levels of petroleum hydrocarbons in the nearshore sediments were higher than that found in the offshore areas and are due to the reported high levels of tar stranding which incorporate tar on sand grains and thus accumulation in the nearshore area (following a trend opposite to that reported for the trace metals) (Persad, 2003; Georges and Oostdam, 1988).

Sediments Quality

Trace Metals

The levels of trace metals (µg Kg) reported for the surficial sediments of general study area were 17.6 – 57.5 for Cr, 3.2 – 13.5 for Cu, 0.06 – 0.11 for Cd, 7.1 – 20.5 for Pb, 0.003 – 0.021 for Hg with Fe ranging between 0.93 – 5.34% by weight (Eco Engineering Consultants, 2000a,b; Eco Engineering Consultants, 2001; Continental shelf Associates, Inc. 1997, 1998).
The ranges reported of the nearshore sediments of Mayaro and Guayaguayare Bays were 0.98 – 3.04 for Cr, 0.09 – 1.13 for Cu, 0.01 – 0.22 for Cd, 1.19 – 7.36 for Pb with Fe range of 1061.8 – 18934.39 (IMA archival Data).

The levels of the metals are lower for the nearshore sediments due to the high sand content and lower Fe content which implies a lower retention capacity for trace metals (Chester and Voutsinou, 1983). The levels of the trace metals for both the offshore and nearshore areas were below the levels quoted by Kennicutt *et al.,* (1994) to evoke toxic responses in aquatic organisms.

Summary

In general, the water and sediment quality of the east coast, as identified in the literature survey, is good as evident by the low reported levels and the quality criteria quoted by the USEPA for water (1986) and Kennicutt *et al.,* (1994) for sediments.

4.3.12.2. Offshore Baseline Survey

As discussed in Section 4.2 above, a comprehensive water and sediment quality baseline survey was conducted for this EIA. Please refer to Section 4.2 for a description of the sampling regime.

Figure 4.17 below shows the location of the seven sampling stations for this assessment of water and sediment quality in the immediate study area. The stations locations were selected such that they spatially encircled the project site to assess baseline conditions. Station 1 was located approximately 4 km north west off the Cannonball WPP site and was placed to assess baseline conditions further off from the immediate study area and to serve as a control station. The other six sampling stations were located in a roughly circular pattern around the site. The parameters selected for monitoring were a combination of those which typically assessed for general environmental quality (Trace metals, hydrocarbons, nutrients and the physico-chemical parameters).

Two samplings of water were done over a two week period to determine variability in water quality. Water samples were also collected at three depths, 1m below the surface, mid depth and 1m above the sea floor. Surficial sediment quality, being less labile than water quality, was only collected once at each of the seven locations.

The waters of the east coast are influenced, to a great extent, by the discharge of the Orinoco and other large South American rivers located on the northern tip of the continent with the Guiana Current moving the water mass in a general northerly direction at about 2.5 cm s^{-1} along Trinidad east coast. The strong current speed coupled with the distance and bearings of the study site from closest land (Point Galeota) would suggest that land based sources of pollution from Trinidad are unlikely to affect the project area. The relatively strong predominant northerly flow of the current also suggest that the site environmental conditions would be greatest influenced by activity located to the south and south east of the site. Such activities include, oil exploration and production, shipping activity and discharge of ballast waters and pollutants transported by the South Equatorial and Guiana currents. There have also been accounts published on the occurrence of natural oil seeps along the east coast of Trinidad which could influence the baseline conditions at the site.

Physico-Chemical Parameters - Salinity, Dissolved Oxygen, Temperature and Suspended Solids

Table 4.9 presents the levels of salinity, dissolved oxygen (DO), temperature and total suspended solids (TSS) detected at each of the sampling stations. In general the results suggests that, as expected, the entire water column is well oxygenated and the pH, salinity and temperature are within the norms which have been published for the general area (van Andel and Postma, 1954; Ecoengineering Consultants, 2000a,b).

Nutrient Quality

The levels of the major nutrients (nitrates (NO^{3-}), nitrites (NO^{2-}), ammonia (NH_3), sulphides (S^{2-}) and phosphorus (total (P) and reactive (PO_3^{2-})) detected at each of the seven stations for the two sampling events are presented in Tables 4.10 and 4.11.

Sulphides were not detected at any of the stations sampled for each of the two sampling events. The levels of the other nutrients (NO_3^-, NO_2^-, PO_3^{2-} and total P) were very low in micro molar (μM) concentrations and within the range reported for areas off Trinidad's east coast. The levels are also typical of those reported in the general area and are characteristic of oceanic conditions with minimal impacts from anthropogenic activities USEPA (1986).

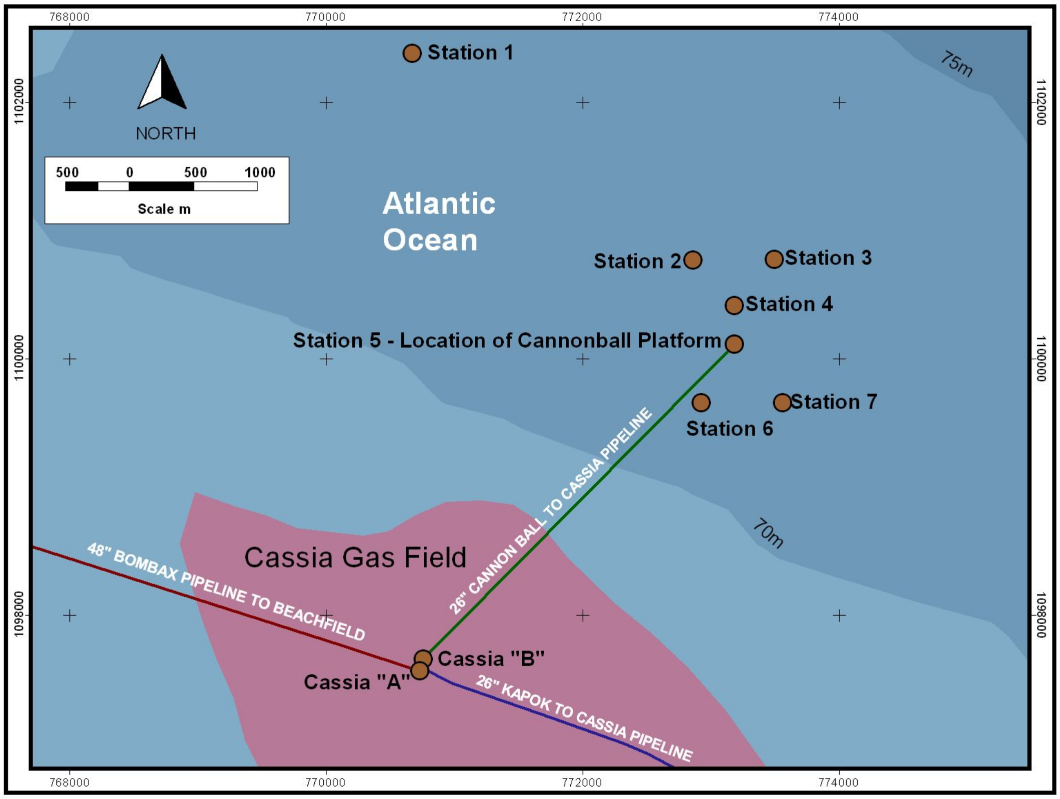


Figure 4.17: Location of the Water and Sediment Quality sampling points

Table 4.9: Physico-Chemical Parameters for Marine Waters (Surface, Mid and Bottom)									
Station Number		Parameter							
		Temperature °C		Salinity ‰		Dissolved Oxygen mg L^{-1}		pH	
	Depth	14/10/03	28/10/03	14/10/03	28/10/03	14/10/03	28/10/03	14/10/03	28/10/03
1	Surface	29.1	26.72	16.71	38.47	7.09	7.02	8.15	7.77
	Mid	27.26	28.73	37.29	37.22	6.12	NA	7.88	7.87
	Bottom	26.19	25.67	37.49	37.39	5.89	NA	7.83	7.83
2	Surface	28.86	27.68	16.9	37.54	6.88	6.93	8.12	7.95
	Mid	28.14	28.72	37.23	37.26	6.17	NA	7.93	7.88
	Bottom	26.27	25.24	37.54	37.33	5.7	NA	7.87	7.81
3	Surface	28.17	27.44	22.78	36.96	6.6	7.01	8.13	7.95
	Mid	27.52	28.73	37.19	36.57	6.24	NA	7.93	7.87
	Bottom	25.91	25.06	37.55	36.44	5.18	NA	7.87	7.78
4	Surface	28.56	27.51	24.42	36.86	6.55	7.29	8.1	7.92
	Mid	27.79	28.73	37.36	36.59	6.28	NA	7.96	7.87
	Bottom	26.25	25.82	37.55	36.52	5.63	NA	7.9	7.83
5	Surface	28.66	27.92	17.03	37.37	6.73	NA	8.12	7.83
	Mid	27.8	28.73	37.33	37.27	6.22	NA	7.95	7.86
	Bottom	26.29	25.59	37.57	37.48	5.6	NA	7.89	7.81
6	Surface	28.56	28.05	21.19	37.23	6.5	NA	8.02	7.9
	Mid	27.8	28.72	37.35	37.28	6.12	NA	7.94	7.86
	Bottom	26.47	25.71	37.57	37.38	5.71	NA	7.9	7.82
7	Surface	28.86	28.35	16.9	37.09	6.88	NA	8.12	7.88
	Mid	28.14	28.61	37.23	37.25	6.17	NA	7.93	7.86
	Bottom	26.27	25.71	37.54	37.39	5.7	NA	7.87	7.81

Table 4.10: Levels of the major nutrients for the Cannonball Site (Surface, Mid and Bottom) -14 Oct 2003							
Station Number	Parameter						
	Depth	S^{2-} (µM)	NO_3^- (µM)	NO_2^- (µM)	NH_3 (µM)	PO_3^{2-} (µM)	Total P (µM)
1	Surface	BDL	0.131	0.083	1.588	0.037	0.066
	Mid	BDL	0.035	0.150	1.824	0.000	0.022
	Bottom	BDL	1.273	0.067	2.529	0.133	0.318
2	Surface	BDL	0.058	0.039	3.412	0.024	0.081
	Mid	BDL	0.134	0.126	2.765	0.013	0.051
	Bottom	BDL	0.013	0.059	3.000	0.168	0.663
3	Surface	BDL	0.173	0.046	3.294	0.048	0.099
	Mid	BDL	1.850	0.046	3.588	0.157	0.406
	Bottom	BDL	0.316	0.046	2.882	0.048	0.157
4	Surface	BDL	0.115	0.035	2.765	BDL	0.043
	Mid	BDL	0.234	0.117	3.588	BDL	0.056
	Bottom	BDL	1.726	0.054	3.059	0.037	0.133
5	Surface	BDL	0.058	0.035	2.235	0.024	0.044
	Mid	BDL	0.077	0.200	2.706	0.013	0.032
	Bottom	BDL	0.556	0.030	2.412	0.048	0.089
6	Surface	BDL	0.013	0.046	3.471	0.013	0.044
	Mid	BDL	0.042	0.183	3.588	BDL	0.025
	Bottom	BDL	1.598	0.054	2.824	0.168	0.278
7	Surface	BDL	0.013	0.054	2.588	0.037	0.048
	Mid	BDL	0.013	0.200	1.882	0.000	0.030
	Bottom	BDL	1.452	0.050	2.412	0.181	0.373

Table 4.11: Levels of the major nutrients for the Cannonball Site (Surface, Mid and Bottom) -28 Oct 2003

Station Number	Parameter						
	Depth	S^{2-} (µM)	NO_3^- (µM)	NO_2^- (µM)	NH_3 (µM)	PO_3^{2-} (µM)	Total P (µM)
1	Surface	BDL	0.192	0.120	2.118	0.061	0.132
	Mid	BDL	0.811	0.107	2.588	BDL	0.027
	Bottom	BDL	1.345	0.270	2.294	BDL	0.044
2	Surface	BDL	0.042	0.120	1.824	0.048	0.120
	Mid	BDL	0.061	0.074	2.412	0.000	0.032
	Bottom	BDL	0.511	0.285	2.824	0.037	0.108
3	Surface	BDL	0.048	0.089	3.000	0.037	0.144
	Mid	BDL	1.390	0.089	2.294	0.013	0.077
	Bottom	BDL	0.023	0.130	2.824	0.205	0.448
4	Surface	BDL	0.035	0.093	2.647	0.037	0.106
	Mid	BDL	0.029	0.083	2.294	BDL	0.028
	Bottom	BDL	0.108	0.120	3.000	0.205	0.537
5	Surface	BDL	0.361	0.048	2.529	0.061	0.139
	Mid	BDL	0.061	0.052	2.412	0.048	0.127
	Bottom	BDL	1.800	0.102	3.235	0.205	0.468
6	Surface	BDL	0.089	0.074	2.588	0.192	0.570
	Mid	BDL	0.029	0.115	2.294	0.037	0.127
	Bottom	BDL	1.579	0.083	2.824	0.266	0.658
7	Surface	BDL	0.029	0.048	1.824	0.037	0.076
	Mid	BDL	0.023	0.048	2.647	BDL	0.057
	Bottom	BDL	1.455	0.102	3.412	0.615	1.019

Trace Metals

The levels of trace metals detected at the seven stations at the three depths monitored for the two sampling events are presented in Tables 4.12 and 4.13 below.

The levels of Chromium VI (Cr^{6+}), Arsenic (As), Mercury (Hg) and Vanadium (V) were all below the method detection limit for each of the stations for the two sampling events.

The levels of the other trace metals monitored (Copper, Chromium, Cadmium, Lead, and Nickel) were marginally lower in the first sampling event that that found in the second sampling event. Cadmium (Cd) was only detected in the bottom waters for station 6 for the two sampling events at sub parts per billion levels (µg L^{-1}). There were no spatial trends observed as it pertained to major differences in detected levels of the trace metals at each of stations sampled which suggests that there is minimal impacts on the site for nearby anthropogenic activities (Oil exploration and production – Ministry of Energy and Energy Industries, 2003)

In general, the levels of total chromium (Cr), copper (Cu), lead (Pb), and nickel (Ni) were generally very low (in the low µg L^{-1} levels) with the levels of Cu being the highest. For stations 4, 5 and 6 the levels of metals in the water column were highest for the bottom waters whilst for stations 1, 2, 3 and 4 there were little differences between top and bottom waters. The levels of iron (Fe), although higher than that found for the other metals at each of the stations (1 – 7), was also low and representative of the general levels reported for the area (Ecoengineering Consultants, 2000a,b; Ecoengineering Consultants, 2001; Continental shelf Associates, Inc. 1997, 1998).

Station Number	Depth	Fe (µg L⁻¹)	Cr6+ (µg L⁻¹)	Cr (µg L⁻¹)	As (µg L⁻¹)	Cd (µg L⁻¹)	Cu (µg L⁻¹)	Pb (µg L⁻¹)	Hg (µg L⁻¹)	Ni (µg L⁻¹)	V (µg L⁻¹)
Table 4.13: Trace Metal Concentrations for Cannonball Site (14 Oct 2003)											
1	Surface	45.2	BDL	BDL	BDL	BDL	13.1	1.4	BDL	8.5	BDL
	Mid	32.8	BDL	2.8	BDL	BDL	22.1	2.3	BDL	6.5	BDL
	Bottom	37.2	BDL	3.6	BDL	BDL	5.6	1.5	BDL	8.2	BDL
2	Surface	22.4	BDL	1.1	BDL	BDL	14.1	2.2	BDL	2.8	BDL
	Mid	40.7	BDL	2.9	BDL	BDL	8.5	3.5	BDL	1.5	BDL
	Bottom	35.8	BDL	2.5	BDL	BDL	9.7	6.2	BDL	5.2	BDL
3	Surface	21.1	BDL	2.8	BDL	BDL	11	1.4	BDL	2.5	BDL
	Mid	36.9	BDL	1.8	BDL	BDL	8.9	2.6	BDL	2.5	BDL
	Bottom	45.2	BDL	1.9	BDL	BDL	10.8	1.1	BDL	3.6	BDL
4	Surface	23.1	BDL	0.9	BDL	BDL	11.2	1.2	BDL	4.5	BDL
	Mid	25.8	BDL	2.2	BDL	BDL	12.1	0.9	BDL	3.6	BDL
	Bottom	18.9	BDL	1.8	BDL	BDL	20.8	1.5	BDL	7.2	BDL
5	Surface	16.2	BDL	0.9	BDL	BDL	6.3	0.7	BDL	6.3	BDL
	Mid	25.8	BDL	BDL	BDL	BDL	8	1.5	BDL	5.4	BDL
	Bottom	37.8	BDL	1.1	BDL	BDL	8.2	1.9	BDL	6.8	BDL
6	Surface	24.5	BDL	BDL	BDL	BDL	8.2	2	BDL	1.2	BDL
	Mid	16.9	BDL	BDL	BDL	BDL	12.2	2.3	BDL	2.5	BDL
	Bottom	44.8	BDL	1.1	BDL	0.2	15.2	1.1	BDL	2.9	BDL
7	Surface	15.4	BDL	0.5	BDL	BDL	15.5	0.3	BDL	4	BDL
	Mid	32.8	BDL	BDL	BDL	BDL	18.6	1.1	BDL	5.5	BDL
	Bottom	45.3	BDL	0.9	BDL	BDL	22.9	0.9	BDL	6.3	BDL

Station Number	Depth	Fe (µg L⁻¹)	Cr6+ (µg L⁻¹)	Cr (µg L⁻¹)	As (µg L⁻¹)	Cd (µg L⁻¹)	Cu (µg L⁻¹)	Pb (µg L⁻¹)	Hg (µg L⁻¹)	Ni (µg L⁻¹)	V (µg L⁻¹)
Table 4.14: Trace Metal Concentrations for Cannonball Site (28 Oct 2003)											
1	Surface	44.1	BDL	2.1	BDL	BDL	15.5	3.1	BDL	1.2	BDL
	Mid	25.8	BDL	1.5	BDL	BDL	14.1	2.1	BDL	3.1	BDL
	Bottom	30.4	BDL	3.6	BDL	BDL	25.1	3.6	BDL	2.8	BDL
2	Surface	16.1	BDL	2.2	BDL	BDL	7.2	1.5	BDL	3.6	BDL
	Mid	21.2	BDL	1.5	BDL	BDL	11.8	1.8	BDL	2.5	BDL
	Bottom	28.9	BDL	1.6	BDL	BDL	8.9	1.3	BDL	5.8	BDL
3	Surface	31.9	BDL	2.5	BDL	BDL	8.8	0.8	BDL	5.2	BDL
	Mid	23.1	BDL	0.9	BDL	BDL	7.8	1.1	BDL	6	BDL
	Bottom	51.8	BDL	1.5	BDL	BDL	8.2	1.6	BDL	8.9	BDL
4	Surface	22.4	BDL	2.5	BDL	BDL	3.3	BDL	BDL	2.3	BDL
	Mid	31.6	BDL	0.9	BDL	BDL	8.1	0.9	BDL	4.5	BDL
	Bottom	38.8	BDL	1	BDL	BDL	10.3	2	BDL	4.8	BDL
5	Surface	24.5	BDL	2.5	BDL	BDL	18.2	2.2	BDL	4.8	BDL
	Mid	29.1	BDL	2.9	BDL	BDL	17.2	3.6	BDL	5.2	BDL
	Bottom	35.1	BDL	2.3	BDL	BDL	19.9	2.8	BDL	6.1	BDL
6	Surface	25.1	BDL	1.2	BDL	BDL	4.3	1.5	BDL	0.9	BDL
	Mid	27.4	BDL	1.6	BDL	BDL	2.2	1	BDL	2.1	BDL
	Bottom	38.1	BDL	2.2	BDL	0.4	7.9	2.3	BDL	2.6	BDL
7	Surface	16.5	BDL	2.2	BDL	BDL	2.6	3.3	BDL	4.7	BDL
	Mid	25.8	BDL	5.6	BDL	BDL	5.5	5	BDL	5	BDL
	Bottom	42.5	BDL	9.5	BDL	BDL	24	4.8	BDL	6.1	BDL

In general, the levels of trace metals found at the site were lover than those quoted by the [1]USEPA and are also well within the range reported for the general area (USEPA 1986).

[1] USEPA (1986) Quality Criteria for Protection of Aquatic life In Marine Water in

Hydrocarbons and total phenols

The hydrocarbons monitored were total oil and grease (hexane extractable), total petroleum hydrocarbons (TPH) and Benzene, Toluene, Ethyl Benzene and Xylene (BTEX). Tables 4.15 and 4.16 presents the data collected for the two sampling events. No total oil and grease TPH and BTEX was detected at any of the seven stations sampled; the detection limits of the methods were: 0.05 mg L^{-1}, 0.05 mg L^{-1} and 0.002 mg L^{-1} respectively. It should be noted that the average levels of petroleum hydrocarbons reported for the Wider Caribbean region is 0.01 μg L^{-1} while that reported for waters in Trinidad is 0.1 μg L^{-1}.

Phenols were detected at some of the stations sampled, See Tables 4.15 and 4.16, however the levels detected were very low generally below 0.02 mg L^{-1} and is not indicative of contamination (USEPA, 1986).

Table 4.15: Hydrocarbon and Phenol levels for Cannonball Site – 14 Oct 2003

Station Number	PARAMETER				
	Depth	Total Oil & Grease (mg L^{-1})	TPH (mg L^{-1})	BTEX (mg L^{-1})	Phenols (mg L^{-1})
1	Surface	BDL	BDL	BDL	0.0151
	Mid	BDL	BDL	BDL	0.0204
	Bottom	BDL	BDL	BDL	0.0351
2	Surface	BDL	BDL	BDL	0.0155
	Mid	BDL	BDL	BDL	0.0201
	Bottom	BDL	BDL	BDL	0.016
3	Surface	BDL	BDL	BDL	BDL
	Mid	BDL	BDL	BDL	BDL
	Bottom	BDL	BDL	BDL	0.0114
4	Surface	BDL	BDL	BDL	BDL
	Mid	BDL	BDL	BDL	BDL
	Bottom	BDL	BDL	BDL	0.021
5	Surface	BDL	BDL	BDL	0.0151
	Mid	BDL	BDL	BDL	0.0184
	Bottom	BDL	BDL	BDL	0.0222
6	Surface	BDL	BDL	BDL	BDL
	Mid	BDL	BDL	BDL	BDL
	Bottom	BDL	BDL	BDL	0.0144
7	Surface	BDL	BDL	BDL	BDL
	Mid	BDL	BDL	BDL	0.0142
	Bottom	BDL	BDL	BDL	0.0189

μg L^{-1} (**Chronic**: Cd (43), Cr^{6+} (1100), Cr^{3+} (10,300), Cu (2.9), Pb (140), Hg (2.1), Ni (75), Zn (95); **Acute** Cd (9.3), Cr^{6+} (50), Cu (2.9), Pb (5.6), Hg (0.025), Ni (8.3).

Table 4.16: Hydrocarbon and Phenol levels for Cannonball Site – 28 Oct 2003					
Station Number	PARAMETER				
	Depth	Total Oil & Grease (mg L^{-1})	TPH (mg L^{-1})	BTEX (mg L^{-1})	Phenols (mg L^{-1})
1	Surface	BDL	BDL	BDL	0.008
	Mid	BDL	BDL	BDL	0.012
	Bottom	BDL	BDL	BDL	0.018
2	Surface	BDL	BDL	BDL	0.008
	Mid	BDL	BDL	BDL	0.011
	Bottom	BDL	BDL	BDL	0.015
3	Surface	BDL	BDL	BDL	BDL
	Mid	BDL	BDL	BDL	0.008
	Bottom	BDL	BDL	BDL	0.013
4	Surface	BDL	BDL	BDL	0.009
	Mid	BDL	BDL	BDL	0.021
	Bottom	BDL	BDL	BDL	0.011
5	Surface	BDL	BDL	BDL	BDL
	Mid	BDL	BDL	BDL	0.011
	Bottom	BDL	BDL	BDL	0.017
6	Surface	BDL	BDL	BDL	BDL
	Mid	BDL	BDL	BDL	0.012
	Bottom	BDL	BDL	BDL	0.024
7	Surface	BDL	BDL	BDL	0.014
	Mid	BDL	BDL	BDL	0.026
	Bottom	BDL	BDL	BDL	0.045

Sediments

The trace metals determined in the surficial sediments collected at each of the seven stations are presented in Table 4.17. Chromium VI and arsenic were not detected at any of the stations sampled. Mercury was detected at low concentrations (sub parts per million levels) at six of the stations sampled. The other trace metals monitored (Cr, Cu, Cd, Ni, V, Fe, Hg and Pb) were all at low levels and much below the concentrations quote by [2]Kennicutt *et al*., (1994) to evoke toxic responses in marine organisms. The results also compare favourably with other work conducted in the general area. There were no observable spatial trends in trace metals found in the sediments collected at each of the seven stations suggesting that impacts from nearby anthropogenic activities in oil

[2]Apparent Effects Threshold (AET) ppm: Cd(5), Cu(300), Pb (300), Hg (1)
100% silt and clay: Cd(1.3), Cr (230), Cu(87), Hg (0.5)
100% sand: Cd(0.13), Cr(23), Cu(8.7), Pb(8.7), Hg(0.05).
(Kennicutt *et al*., 1994)

and gas exploration and production (Ministry of Energy and Energy Industries, 2003) are minimal.

The levels of oil and grease, total petroleum hydrocarbons and benzene, toluene, ethyl benzene and xylene are presented in Table 4.18 . The levels of hydrocarbons in the sediment are low and are with the ranges reported for the east coast of Trinidad and lower than those reported for the Gulf of Paria (Agard *et al*., 1988; Agard and Gobin, 1993; IMA, 1996)

Table 4.17: Trace Metals levels for Surface Sediment at Cannonball Site

Date Sampled: 28/10/2003	Station Number						
Parameter	1	2	3	4	5	6	7
Iron (µg g^{-1})	3.652	4.564	5.881	3.892	8.258	6.589	4.897
Chromium VI (Cr^{6+}) (µg g^{-1})	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total Chromium (µg g^{-1})	46.03	45.716	41.6	49.903	41.554	46.504	48.824
Total Arsenic (µg g^{-1})	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total Cadmium (µg g^{-1})	0.159	BDL	0.111	BDL	0.08	0.141	0.076
Total Copper (µg g^{-1})	21.682	11.59	11.04	13.125	12.772	18.618	13.77
Total Lead (µg g^{-1})	13.523	11.561	11.752	14.301	15.918	16.54	12.748
Total Mercury (µg g^{-1})	0.078	0.09	0.028	0.071	BDL	0.082	0.058
Total Zinc (µg g^{-1})	84.155	75.446	67.587	83.252	75.054	82.466	81.298
Nickel (µg g^{-1})	27.472	26.001	26.466	28.869	25.661	26.005	21.027

Table 4.18: Hydrocarbon levels for Surface Sediment at Cannonball Site

Date Sampled: 28/10/2003	Station Number						
Parameter	1	2	3	4	5	6	7
Total Oil and Grease (mg/Kg)	45.68	39.84	22.45	26.56	32.11	24.55	35.95
TPH (mg/Kg)	27.52	15.56	12.25	10.58	22.2	12.85	16.25
BTEX (µg/Kg)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Total Organic Carbon (%)	0.905	0.866	0.756	0.721	0.705	0.723	0.821

Summary of Findings

1. The environmental quality (chemical pollutant parameters) of the study area compares favourably with other areas of Trinidad's offshore east coast environment.

2. The levels of pollutants in the water column and surficial sediment (with the exception of copper in water) are below quality criteria USEPA quoted by the USEPA (1986) and Kennicutt *et al*., (1994).
3. The levels of copper are within the range reported for marine waters off Trinidad's coast (IMA archival data).

4. The environmental quality of the study area can be considered "non-impacted" in terms of chemical pollution parameters.

4.3.13. Surficial Seabed Type

The sediment samples at the seven (7) Cannonball Sediment stations discussed above were also analysed for Grain Size Characteristics. They were all consistently grey mud with some fine shell fragments. Figure 4.18 below shows a chart of the offshore area around the Cannonball WPP site location with a description of the seabed types. The area around the Cannonball WPP is characterised by grey muds while the area to the north has some hard substrate and coral.

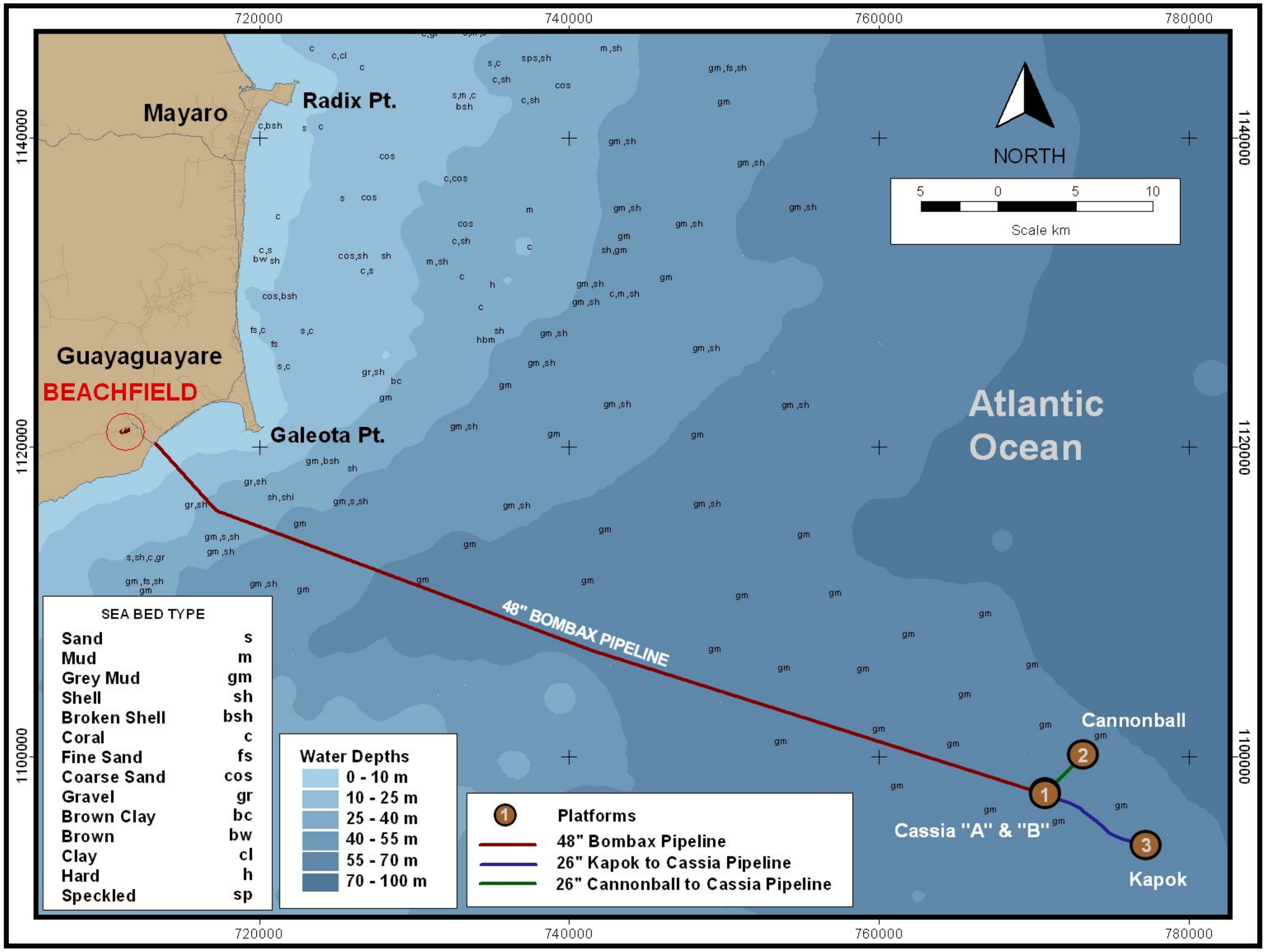


Figure 4.18: Seabed Types in the offshore areas around the Cannonball WPP site.

4.3.14. Macro Benthic Communities

Organisms living in the bottom sediment (benthic fauna) play a major role in the marine environment since they are components of the food chain. In the sediment, they act as integrators of the effects of a variety of "disturbances" and are therefore good indicators of the status or "quality" of the environment.

Due to the importance of the status of the benthic communities at the Cannonball WPP site, bpTT commissioned a study of the benthic communities by collecting benthic samples during the field surveys of 28th October 2003. The purpose of this study is to establish the state of the benthic communities at the Cannonball WPP site before the proposed installation of the platform. This data will then be compared to benthic data that will be collected after the installation of the platform and regularly after that. In this way it would be possible to identify directly the impacts of the Cannonball WPP on the surrounding benthic communities.

Literature Review of Macrobenthic communities offshore East Coast, Trinidad

The marine benthic fauna of the East Coast has to date been described in general terms as parts of larger surveys (and reports) which were carried out by international research vessels. The earliest benthic information for Trinidad was gathered from a number of stations around Trinidad and Tobago, during a deep-water research cruise. This was carried out by the Research Vessel RV Pillsbury in 1969 (Staiger, 1971). The data set (which included East Coast stations) has been used for comparison with much later studies since it provides valuable, pre-petroleum exploitation information. The survey described benthic organisms from depths of between 55m to 1800m, which included Molluscs, Crustaceans (crabs, shrimps), Echinoderms – crinoids, holothurians (sea cucumbers) and *Astropecten* sp. (starfish), Coelenterates (sea fans), sea pansies, bryozoans and sponges.

Since that time there have been only two major macrobenthic field surveys associated with exploratory drilling offshore on the East Coast; both in the southern offshore area. The first was conducted by Continental Shelf Associates and Barry A. Vittor & Associates for British Gas (CSA, 1994) and the second by Institute of Marine Affairs for AMOCO Trinidad Oil Company (IMA, 1996). Both surveys described diverse benthic communities consisting mainly of polychaetes, crustaceans, echinoderms and coelenterates. Some new and undescribed species of organisms were also identified in the latter survey.

More recently, Environmental Impact Statements and Baseline Reports by Oil companies such as SHELL (1998), ENRON (1998) and EXXON (1999) have produced some additional, but limited benthic information. These surveys contain proprietary data sets and therefore cannot be used in this study.

The marine benthos in the overall East Coast and the southerly offshore area appears to be maintaining healthy and diverse communities containing a wide range of taxa (especially crustaceans, echinoderms, and coelenterates). This diversity is corroborated by other studies (e.g. Hubbard *et al*. 1991 and Agard *et al.* 1996) which suggested the presence of high diversity of phytoplankton and high biomass of zooplankton (values of which were among the highest for the Caribbean). It is these organisms which provide the rich food source that ensures the production of a healthy benthic fauna (on which other macrofauna and fish feed).

<u>Baseline Field Survey conducted on 28th October 2003</u>

Surficial sediment samples were obtained offshore at the Cannonball WPP site at the same seven (7) stations sampled for the water and sediment stations. The location of the stations is shown in Figure 4.16 above. At each station, three (3) replicate sediment samples were collected using a 0.25 m^2 van Veen grab sampler.

Each sample was washed through a 0.5 mm^2 sieve and all organisms retained were preserved in a 10% formalin buffered seawater solution. Additionally, the organisms were stained using a proteinaceous dye (Rose Bengal) and securely stored in plastic containers for transport to the laboratory. In the laboratory, all samples were gross sorted into two groups – marine worms (Phylum Annelida) and all other macrofauna. All organisms collected were counted and identified as far as possible to the taxonomic level of species, using relevant taxonomic literature.

For the 21 samples collected, 167 individuals belonging to 26 species and belonging to five (5) phyla (Annelida, Arthropoda, Gastropoda, Echinodermata and Mollusca) were recorded. A species list of all macrofaunal species is presented in Table 4.19 below. The non-polychaete organisms dominated the fauna (62.4 %) which is typical of coarse substrates (Gray 1970), while the polychaetes accounted for the rest (37.6%). Some of the species observed appear to be first records for present day-polychaete collection. This is however yet to be confirmed.

A species diversity index- (SWI) Shannon-Weiner Index (Shannon and Weaver 1963) was calculated for each station. This simple index is a measure of the species richness of a sample and takes into account the spread or the number of individuals per species. Overall, this will give an indication of the diversity of benthic macrofaunal species in the oil field area.

The highest species diversity was recorded at station 4 while the lowest was at station 5. Overall species diversities were low (range of 0.66 to 1.73) which has been typically described for the area (bpTT, 2001). The substrate was composed mainly of coarse sand, shells, rubble and little clay or silt.

Table 4.19: Shannon Wiener Index (SWI) for each station (replicates combined)	
Station	**SWI**
1	1.56
2	1.07
3	1.43
4	1.73
5	0.66
6	1.30
7	1.70

The East coast of Trinidad is considered productive from an ecosystem point (Hubbard et al 1991, Agard et al 1996) and it supports a “healthy” benthic infauna (on which macrofauna and fish feed). In turn, this supports a very rich fishery resource (Heileman 1991, Fisheries Vessel Census 1991, Fabres and Kuruvilla 1992,).

The East coast is also very productive in terms of oil and gas fields. Few earlier surveys (IMA archival data, CSA/IMA 1997) suggest that there are elevated levels of total petroleum hydrocarbon levels in some inshore areas of the east coast while the offshore areas (to date) do not appear to be “contaminated”. Overall though, benthic community structure in this survey appears to be largely correlated with the natural environmental variable of sediment quality. The coarseness of the substrate seems to be the main parameter responsible for the sparse fauna present.

Results of this survey suggest that this offshore marine area is similar to earlier surveys (carried out in the general marine area), in terms of a relatively low benthic biological diversity. This may be attributed to natural environmental parameters such as the coarseness of sediment in which the fauna live.

Table 4. 20: Species list for the Macrobenthic Survey for Offshore Cannonball WPP Site – 28th Oct 2003
Phylum Annelida
Class Polychaeta
Amphinomidae
Paramphinome sp.a
Capitellidae
Notomastus sp.a
Capitella sp.a
Streblospio sp.a
Cirratulidae
Cirratulid sp.a
Eunicidae
Onuphis sp.a
Glyceridae
Glycera sphyrabrancha
Lumbrineridae
Lumbrineris sp.
Magelonidae
Magelona sp.a
Maldanidae
Maldanid sp. a
Nephtyidae
Aglaophamus sp.
Orbinidae
Scoloplos sp.a
Sigalionidae
Sthenolepis sp.a
Spionidae
Prionospio sp.
Trichobranchidae
Terebellides stroemi
Phylum Arthropoda
Class Crustacea
Order Amphipoda
Ampelisca parapanamensis
Order Copepoda
Copepod sp.
Order Decapoda
Paeneus sp.a
Decapod sp.a
Order Isopoda
Isopod sp.
Phylum Mollusca
Class Bivalvia
Bivalve sp.a
Bivalve sp.b
Corbula sp.a
Phylum Gastropoda
Gastropod sp.a
Phylum Echinodermata
Echinoderm sp.a

4.3.15. Benthic Meiofaunal Communities

The macro faunal survey discussed in Section 4.4.14 above examined the benthic communities of the Cannonball Field offshore site to down to a 500micron size. The benthic faunal community (< 500micron size) was also examined to provide an indication of the baseline conditions prevailing at the Cannonball site before the installation of the Well Protector Platform and to suggest how the installation of the platform might impact on the fauna.

This section is a summary of the Benthic Meiofaunal Report. Please refer to Appendix N for the comprehensive report.

For this meiofaunal survey, surficial sediment samples were collected at the seven (7) Cannonball Offshore stations discussed above (Figure 4.16). The same methodology of the sediment sampling was used i.e. use of a Van Veen Grab lowered over the side of the survey vessel. The sample times for this survey are the same for the Macrofaunal Survey discussed in Section 4.4.13 above.

Two (2) separate grabs were taken for meiofaunal analysisat each of the seven (7) Cannonball Stations. For these samples the top grid of the Van Veen Grab was removed and the surface 1cm layer carefully extracted. The resultant sample (approximately $11cm^2$) was then stored in a ziplock bag and stained with a proteinaceous dye (Rose Bengal) and preserved in a 10% formalin buffered seawater solution. The fourteen samples were then stored and for analysis.

The samples were numbered as Station 1 - 7, and the two samples from each were designated A and B respectively. The depth of sample was approximately 72m for each sample. The samples comprised grey to brownish-grey clays with a little (<1%) fine sand. They were washed over a 63-micron mesh to remove clay and silt, then air-dried.

The residues were picked for stained foraminifera. Perhaps due to the weak solution of rose Bengal, few specimens were brightly stained. However, quantities of specimens were found to contain isolated pink blebs, or to be stained pale pink. These were concluded to be the remains of either recently deceased foraminifera, the pale pink specimens perhaps being coated with bacteria that had been feeding on dead protoplasm. All specimens showing any staining were picked, and comprise the main subject of this report. Because both bright red and pale pink specimens were picked, it is possible that the foraminiferal numbers overestimate live foraminifera. The broad nature of the dead fauna was also noted, but not studied quantitatively.

<u>**Foraminiferal Database**</u>

Most of the samples yielded a large volume of >63-micron residue that comprised foraminiferal tests (both planktonic and benthonic), ostracod valves, pteropod, gastropod and pelecypod shells, and fine quartz sand. The sand grains were sub-angular.

Stained benthonic foraminifera were picked from the >180-micron fraction only: scanning of the <180-micron fraction showed that this contained very few stained foraminifera. Due to the large amount of residue in most samples, half only was picked for all samples expect Station 7 A, for which the whole was picked.

Species were identified using standard references (Cushman, 1918-1931; Drooger and Kaasscheiter, 1958; Todd and Bronnimann, 1957; Mikhalevich, 1983). The stained foraminiferal meiofauna for each of the 14 samples is listed in Table 4.20. For analytical purposes species were placed into three groups according to wall type (see Loeblich and Tappan, 1964):

- *agglutinated*, with tests comprising foreign particles held together by cement secreted by the foraminifera
-
- *porcellaneous*, with tests constructed of randomly oriented calcite lathes that appear white and opaque under reflected light

- *hyaline*, with glassy walls that appear transparent to translucent under reflected light.

Discussion

Although the stained fauna in each sample was dominated by only a few species, the dominant species differed from sample to sample. *Saccammnna difflugiformis* was dominant in all expect three samples (Station 2A and Station 2B, co-dominant *S. difflugiformis* and *Eponides antillarum*: Station 5A, co-dominant *Eponides antillarum* and *Hanzawaia concentrica*).

Sample Station 5A was the only one in which *S. difflugiformis* was neither dominant nor subdominant (i.e., did not form >10% of the stained assemblage). The associated replicate Station 5B contained too few specimens for meaningful analysis. However, the contrasts between Station 5A and Station 5B and the remaining samples imply that conditions here differ from those at the other sample stations.

Associations between those species forming >1% of the total recovery were examined using Pearson's product moment correlation coefficients for absolute specimen counts in all samples (Table 4.22). Few significant correlations were noted. *Saccammina difflugiformis* was positively correlated with *Cancris sagra* (r = 0.5414, p = .045) but negatively correlated with *Cibicidoides* ex gr. *floridanus* (r = -0.5915, p = .026). In turn, *Cibicidoides* ex gr. *floridanus* was positively associated with:

- *Eponides antillarum* (r = 0.7351, p = .0026)

- *Quinqueloculina lamarckiana* (r = 0.6621, p = .009)

These groupings contrast an association tolerant of a high carbon flux (*S. difflugiformis*, *C. sagra*) with a hard substrate-dwelling association (*C. floridanus*, *E. antillarum*, *Q. lamarckiana*).

The similarity of the assemblages from the samples was compared using Pearson's product moment correlation coefficients on the raw data (Table 4.23). All the correlation coefficients were significant at a level of $p<.05$ except that between Station 4B and Station 5A ($r = 0.247$, $p = .084$). Exceptionally low correlations ($r < 0.4$) were noted between:

Station 4A / Station 4B
Station 4A / Station 6B
Station 4A / Station 7B
Station 5A / Station 4B
Station 5A / Station 6B
Station 5A / Station 7B

These data, together with the low abundance of stained foraminifera in sample Station 5B, suggest that conditions at sites Station 4B and Station 5B (the latter the site of the proposed platform) differ from those in the remainder of the sampled area.

The Cannonball Field, which lies offshore from the Orinoco Delta, is subject to an influx of freshwater from the Orinoco River. There have been few studies of the diversity of foraminifera in the vicinity of deltas. However, two allow some comparison:

- Gibson and Buzas (1973) examined total (live + dead) assemblages around the coastline of North America, and noted that diversities are depressed in the vicinity of the Mississippi Delta. At depths of <80 m, near the delta, the value of the Information Function for the total assemblage was $H' = 0.5 – 1.0$. The value rose to ~3.0 at ~200 m, and thereafter remained constant. Thus, the values of H' for the stained assemblage from the Cannonball Field exceed those for the total (stained + unstained) assemblage at equivalent depths (~72 m) off the Mississippi Delta.

- de Rijk et al. (1999) studied the distribution of stained benthonic foraminifera in the eastern Mediterranean Sea, including a transect off the Nile Delta. They reported (op. cit., fig. 2) that the species richness S per sample ranged at ~70 m between ~14 to ~31 species per sample. Values for the Cannonball Field samples are comparable, the mean value for the Cannonball Field of ~18 species lying towards the lower limit of the range off the Nile Delta. de Rijk et al., (1999, fig. 3) recorded that the percentage of agglutinated specimens in the Mediterranean range between ~4 to ~10%. This is considerably lower than the percentage in the Cannonball Field (mean percentage stained agglutinants = 40.4%).

Thus, faunal diversities in the Cannonball Field area are comparable with those off other deltas, but agglutinated foraminifera are more abundant than would be anticipated.

Summary and Conclusion

Stained (= live?) benthonic foraminifera were examined in 14 samples (paired replicates from 7 sample stations) of grey to grey-brown sandy-clay collected in October 2003 from the Cannonball Field of the East Coast Marine Area off Trinidad. Stained specimens were picked from the >180-micron fraction, and the unstained (dead) assemblage was scanned to discern any indicators of sediment transport and relict sediments.

The samples yielded 2508 stained foraminifera belonging to 50 species. However, most species were rare, only ten, which collectively formed ~91.0% of the total stained assemblage, forming >1.0% of the total recovery. The four most abundant species were, in relative order: *Saccammina difflugiformis* (agglutinated wall type); *Eponides antillarum* (15.7%, hyaline); *Cancris sagra* (11.5%; hyaline calcareous wall type); and *Hanzawaia concentrica* (8.1%, hyaline). Both *C. sagra* and *H. concentrica* are indicative of a high flux of organic carbon (>10 g m^{-2} yr^{-1}).

Two of the common species (*S. difflguiformis* and *Bombulina spinata*) were not recorded during a 1958 survey of the shelf around Trinidad, though both were recorded from the Gulf of Paria in 1957. Both were rare in a 1974 survey. Using the foraminifera as proxies for environmental conditions, this implies that environmental conditions on the shelf around Trinidad have changed considerably over the past 50 years. Although diversities are comparable to those found off the Mississippi and Nile deltas, the proportion of agglutinants is in the Cannonball Field area much higher. It is suggested that, should the installation of a pipeline across the Cannonball Field area stress the environment further, it would be marked by a decrease in diversity of the fauna, and further increases in the populations of *Saccammina difflugiformis* and *Bombulina spinata*. However, should the appearance of these two species east of Trinidad be part of an on-going trend, it might prove difficult to distinguish between the effects of this and the effects from the installation of a hydrocarbon production platform. It is suggested that, should the bpTT wish to monitor the effects of this platform, consideration be given to the use of control sites located up-current from it.

4.3.16. Marine Mammals

To determine the possible impacts to the population of marine mammals and sea turtles by its proposed Cannonball Field Development and the cumulative impact of its east coast activities, bpTT commissioned an study of available data for the east coast of Trinidad.

The term *marine mammal* is purely descriptive and is not a taxonomic designation, encompassing mammals from three orders (Cetacea, Sirenia, and Carnivora) (Jefferson*, el al* 1994). Marine mammals are an integral part of the marine and coastal fauna of Trinidad & Tobago, the tropical and subtropical waters of the Caribbean Sea and the Gulf of Mexico. For many species, these waters serve as primary habitat for a range of critical activities including feeding, mating, and calving. The reported occurrence of marine mammals species in the wider Caribbean and the water within Trinidad & Tobago is reviewed by (Wardand Moscrop, 1999.) and (Ward *et al,* 2001). These species are listed in Table 1- 7 below, a secondary review incorporated findings found in (Eco Report No: 10/2000.) & (Eco Report No: 17/2000. 2000.)

Several species of marine mammals found in the Wider Caribbean are listed in Annex 1 to Article 64 of the United Nations Law of the Sea (UNCLOS, 1982) and are also listed as endangered or vulnerable in the annexes of several multilateral treaty agreements, including UNEP's Specially Protected Areas and Wildlife Protocol (SPAW, 1990), The Convention on International Trade in Endangered Species (CITES, 1973), The Convention on the Conservation of Migratory Species of Wild Animals (CMS, 1979), also known as the Bonn Convention and the International Convention on the Regulation of Whaling (ICRW, 1946), as well as on the International Union for the Conservation of Nature (IUCN) red data list of threatened animals.

4.3.16.1. Marine Mammal's Habitat

Knowledge of movements and habitats of marine mammals is a perquisite for estimating their home range along with data on the temporal and spatial distribution of their different activities, e.g. breeding and foraging in order to identify breeding and foraging habits.

The characteristic marine mammal habitats for species listed above are not eventually distributed. Marine mammals are highly mobile and capable of traveling long distances. Some species undergo seasonal migrations while others may follow prey species in offshore-onshore seasonal migrations patterns. Some species, despite their capacity for migration, are resident in relatively small areas through the year. These species are dependent on continuous availability of food with their local habitats. Possible shifts and/or displacements in distributions of marine mammals occur not related to annual migrations, with these events reflecting changes in the quality or availability of their preferred habitats.

The marine mammals that can occur within the study region are classified under two Orders the Cetacea (whales, dolphins and porpoises, which is divided into two groups, the Mysticetes (which are generally much larger more than 10m in length) they have fringed plates of keratin or baleen which are used to filter feed organisms such as plankton and small fish; and the Odontocetes, (which are mostly less than 10m in length with the sperm whale being an exception) have jaws which often extended as a beak-like snout behind which the forehead rises in a round curve or 'melon', and they possess teeth The Order Sirenia contains the manatee, which are primarily herbivorous.

Under the Mysticetes, the baleen whales comprise the majority of large whale species. As a group, the baleen whales are characterised by the series of baleen plates that are used to filter small organisms from the sea water..

The toothed whales or odontocetes include porpoises, dolphins, and all toothed-whales. They feed mostly on squid, fish, and occasionally other marine mammals.

There is only one species of Sirenian within the Caribbean, the West Indian manatee–sub species Antillean manatee (*Trichechus manatus manatus*), are primarily herbivorous but have been reported as having a limited omnivorous diet. It is listed as a rare and endangered species. They are coastal animals and therefore inevitably come into contact with humans over much of their range. Manatees occupy a specialised niche in the ecosystem, which makes them susceptible to over-exploitation.

4.3.16.2. Marine Mammal Habitats off the East Coast of Trinidad

The environmental conditions of the coastal systems of the east coast of Trinidad such as, the high nutrient rich primary productivity and diversity of biodiversity, are highly favourable factors for the occurrence of marine mammal species. For example Humpback species observations by (Swartz *et al,* 2003) of female-calf pairs of humpbacks reports that it confirms that the Lesser Antilles and the Caribbean coast of Venezuela (inclusive of Trinidad & Tobago north and east coast) serve as serve nursing, mating and possibly calving grounds today.

It is highly probable that the waters within the study region still serve as a habitat for marine mammal species. Historically the waters of Trinidad's & Tobago have been reported with concentrations of Cetaceas and Sirenia populations with depletions historically resulting from direct anthropologic impact of over harvesting especially for whales from shore and ship whaling of specifically targeting species especially humpback species which were heavy exploited on the western coast of Trinidad in the Gulf of Paria, was reported as a major gathering ground for humpbacks (Reeves 2001a,2001b) and (Romero *et al,*2002).. It has been reported that dolphins are also harvested directly and incidentally in fish nets (Kenny and Bacon. 1981)

Indirect sources of decline of whales due to anthropogenic effects is reported by (Swartz *et al,* 2003) who suggested that population declines of species in the wider study area due to more recently from noise disturbance from the oil and gas exploration activities and increased heavy levels of commercial marine shipping traffic.

Manatees populations on the west and south coast of Trinidad and in southwest coast of Tobago are extirpated due historical direct impacts of harvesting and indirectly by habitat changes with only small concentrations reported within limited east coast habitats which are direct impacted by illegal harvesting, incidental fish net capture and indirectly by habitat changes. (UNEP, 1995), (IMA /UNEP CEP/RCU. 1999), and (Romero *et al,* 2002).

Overall, natural habitat changes , with a higher degree of anthropogenic effects direct and indirectly have significant impacted to the region marine mammal habitat quality. The degradation and alteration of favorable habitat quality especially for the relatively closed waters of the Gulf of Paria have been reported, where as the open waters of the Atlantic ocean.. Current potential anthropogenic threats to marine mammals are limited, with direct impacts occurring from harvesting of manatees and dolphins from direct capture and incidental capture fish net (UNEP, 1995), (Kenny and Bacon, 1981.) and (Romero *et al.*2002), with indirect impacts possibly from acoustic noise from marine traffic and off shore platforms and localized and transnational chemical and solid waste pollution and/or over fishing of prey populations serve as possible negative impacts to habitat.

4.3.16.3. Cannonball Project Site

Ward *et al* (2001), establishes the most recent authoritative working guide of reported distribution and possible occurrence of species along the coastal waters of Trinidad, which would include the baseline area. There are 4 mysticete and 19 odontocete species that have been recorded in the offshore waters and 1 sirenian species reported from the east coast of Trinidad (Table 4.24).

There is only one contemporary survey of marine mammals (only for cetaceans) within the proposed project development area, by (Swartz *et al,* 2000.) and (Swartz *et a,l* 2003). This was a study of humpback whales involving an acoustic and visual survey of Humpback Whale *(Megaptera novaeangliae*) distribution in the Eastern and Southeastern Caribbean Sea. It established a confirmed presence of humpback whales as being a common occurrence off the north, northeast and east coast of Trinidad (via visual sightings and acoustic reports). Overall, seventeen humpback sightings occurred north and east of Trinidad and south of Tobago (26 individuals including one calf). Humpback sightings were primarily in close proximately to the north of the Cannonball Field Project development area. Singing male humpback whales were detected acoustically in this area, eight (8) during one survey and six (6) during another in February and March, all in waters 50m to 100m deep. No singing male hump-back whales detected acoustically from the Trinidad survey region in the south east coast and south coast of Trinidad close to the Cannonball Project area.

Another recent siting of marine mammals close to the study area occurred on October 12, 1999 when 25 adult short-finned pilot whales (*Globiocephala macrorhynchus)* stranded themselves at Cocos Bay, Manzanilla which is located in the northern coastal region of the proposed development area (ECCN, 2000).

4.3.16.4. Marine Mammals found at Cannonball Project Site

Ward *et al* (2001), establishes the most recent authoritative working guide of reported distribution and possible occurrence of species along the coastal waters of Trinidad, which would include the baseline area. There are 4 mysticete and 19 odontocete species that have been recorded in the offshore waters and 1 sirenian species reported from the east coast of Trinidad (Table 4.21).

There is only one contemporary survey of marine mammals (only for cetaceans) within the proposed project development area, by (Swartz *et al,* 2000.) and (Swartz *et a,l* 2003). This was a study of humpback whales involving an acoustic and visual survey of Humpback Whale *(Megaptera novaeangliae*) distribution in the Eastern and Southeastern Caribbean Sea. It established a confirmed presence of humpback whales as being a common occurrence off the north, northeast and east coast of Trinidad (via visual sightings and acoustic reports). Overall, seventeen humpback sightings occurred north and east of Trinidad and south of Tobago (26 individuals including one calf). Humpback sightings were primarily in close proximately to the north of the Cannonball Field Project development area. Singing male humpback whales were detected acoustically in this area, eight (8) during one survey and six (6) during another in February and March, all in waters 50m to 100m deep. No singing male hump-back whales detected acoustically from the Trinidad survey region in the south east coast and south coast of Trinidad close to the Cannonball Project area.

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4.3.16.5. Manatees

No confirmed sightings of the West Indian manatee Antillean manatee occurrences in the project development region. Local population distribution, migratory behavior and offshore activities are not available for the project development area. The West Indian Antillean manatee is reported to occur in the central and northern sections of the east coast such as in Ortoire River, Nariva river lagoon and drainage canals, North Oropouche River and Salybia Bay(Gyan and Boodoo, 2002) Apart of the local east coast manatee breeding population a subset which may be part of a migratory distribution influenced by possible seasonal exchanges with the Orinoco river delta population especially during the rainy season (CEP Technical Report No. 35, 1995), (IMA /UNEP CEP/RCU. 1999)

TABLE 4.21. Marine mammals reported within the waters of Trinidad & Tobago and which possibly occur in the specific project study region

Common Name	Scientific Name	Range	Status IUCN
The Rorquals Whales			
Fin whale	*Balaenoptera physalus*	Cosmopolitan.	Vulnerable.
Sei whale	*Balaenoptera borealis*	Uncommon in the tropics.	Vulnerable.
Bryde's whale	*Balaenoptera edeni*	Tropical.	Insufficiently known.
Humpback whale	*Megaptera novaeangliae*	Cosmopolitan.	Vulnerable.
The Spem Whales			
Sperm whale	*Physeter macrocephalus*	Cosmopolitan.	Insufficiently known.
Pygmy sperm whale	*Kogia breviceps*	Cosmopolitan.	Insufficiently known.
Dwarf sperm whale	*Kogia sima*	Cosmopolitan.	Insufficiently known.
The Beaked Whales			
Cuvier's beaked whale	*Ziphius cavirostris*	Cosmopolitan	Insufficiently known..
Gervais' beaked whale	*Mesoplodon europaeus*	Endemic to Atlantic.	Insufficiently known.
The Oceanic Dolphins			
Killer whale	*Orcinus orca*	Cosmopolitan.	Insufficiently known.
Pygmy killer whale	*Feresa attenuata*	Cosmopolitan.	Insufficiently known.
False killer whale	*Pseudorca crassidens*	Tropical.	Insufficiently known.
Pilot whale	*Globicephala macrorhynchus*	Tropical.	Insufficiently known.
Pan-tropical spotted dolphin	*Stenella attenuata*	Tropical.	Insufficiently known.
Atlantic spotted dolphin	*Stenella frontalis*	Endemic to Atlantic.	Insufficiently known.
Spinner dolphin	*Stenella longirostris*	Tropical.	Insufficiently known.
Clymene dolphin	*Stenella clymene*	Endemic to Atlantic.	Insufficiently known.
Common dolphin	*Delphinus delphis and Delphinus capensis.)*	Cosmopolitan.	Insufficiently known.
Bottlenose dolphin	*Tursiops truncatus*)	Cosmopolitan.	Insufficiently known.
Striped dolphin	*Stenella coeruleoalba*	Tropical.	Insufficiently known.
Risso's dolphin	*Grampus griseus*	Cosmopolitan.	Insufficiently known.
Rough-toothed dolphin	*Steno bredanensis*	Tropical.	Insufficiently known.
Tucuxi	*Sotalia fluviatilis*	Tropical.	Insufficiently known.
The West Indian manatee			
West Indian mantee Antillean manatee	*Trichechus manatus manatus*	Endemic to Caribbean.	Vulnerable.

Sources: (Kenny, J.S. Bacon. P. R. 1981.), (Kenny, J., *et al* 1997.) & (Ward, N., Moscrop, A., and Carlson, C. 2001)

4.3.17. Turtles

Sea Turtles fall into one of two families. Family *Cheloniidae* includes sea turtles which have shells covered with scutes (horny plates). Family *Dermochelyidae i*ncludes only one modern species of sea turtle, the leatherback turtle. They are protected by law in Trinidad and Tobago (1984) under the Convention on International Trade in Endangered species (CITES) and by the SPAW Protocol (under the Cartagena Convention). The leatherback turtle *(Dermochelys coriace*a) is also completely protected in Trinidad under the Conservation of Wildlife Act (amended 1963) and by the Protection of Turtles and Turtle eggs Regulation (1975).

Of the five living genera containing six species, four species nest on the beaches of Trinidad & Tobago. Sea turtles spend nearly all of their lives in the water and only depend on land (specifically sandy beaches) as nesting habitat so most of the species determined are caught incidental by fishermen and records are directly made. The sightings of various species differ widely due to their seasonal movements, geographical ranges, and behavior.

Sea turtles have been reported nesting beaches of the east coast of Trinidad; four species in particular have been identified. They inhabit different biotopes in their life stages from estuaries, bays, and near shore waters coastal, adult foraging areas, may vary among species or populations, and are geographically distinct from their juvenile habitats. Biotopes that adult sea turtles might forage in include coral reefs, bays, estuaries, near shore waters, infra-littoral, circa-littoral, and oceanic waters are habitats for species. Sea turtles spend nearly all of their lives in the water and only depend on land (specifically sandy beaches) as nesting habitat.

Though there is limited base line field data on the numbers and species of sea turtles for the study area the species of sea turtles that may be present in the area of study are described below:

Green sea turtle (*Chelonia mydas*)
Green sea turtles nesting take place in the coastal waters of Trinidad and Tobago but is reported as rare (Bacon 1970); and later (Bacon 1981) listed Trinidad nesting beaches within the wider development area for this species as Mayaro, Manzanilla and Matura bays.

Hawksbill sea turtle (*Eretmochely imbricata)*
Hawksbill sea turtles, like the Green sea turtles, nesting occur along the east coast of Trinidad but is reported as occasional (Bacon 1970); and later (Bacon 1981) listed Trinidad nesting beaches within the wider areas of Mayaro and Manzanilla bays.

Leatherback sea turtle (*Dermochelys coriacea*)
Leatherback sea turtle nesting does occur but is reported as common (Bacon 1970); and later (Bacon 1981) listed Trinidad nesting beaches within the wider development area for this species as Mayaro, Manzanilla, Matura bays.

Loggerhead sea turtle (*Caretta caretta*)
Loggerhead sea turtle nesting does occur but is reported as occasional; (Pritichard and Trebbau 1984); no specific data is available for listed Trinidad nesting beaches within the wider development area for this species, though (Bacon 1981) reports that the species is known to forage in the waters off Trinidad's northern coast.

Olive ridley sea turtle (*Lepidochelys olivacea)*
Olive ridley sea turtle nesting does occur but is reported as rare; (Bacon 1981) listed Trinidad nesting beaches within the wider development area for this species as Mayaro, Manzanilla, Matura bays. The olive ridley is a small turtle, usually less than 100 pounds. The overall color of this turtle is olive green. This is an omnivorous turtle which feeds on crustaceans, mollusks and tunicates. An average clutch size is over 110 eggs which require a 52 to 58 day incubation period. The olive ridley inhabits tropical and subtropical coastal bays and estuaries.

There is limited base line field data on the numbers and species of sea turtles for the study area, restricted to the confirmed occurrence of Loggerhead sea turtle (*Caretta caretta*), in the study area (Little 1996, Eckert 1996) and would be considered as a inter nesting period, migratory and feeding. The sea turtles occurring in the waters of Trinidad & Tobago are listed in Table 4.22, below.

Table 4.22: Sea Turtles occurring off East Coast of Trinidad

Common Name	Scientific Name	STATUS	
		USFWS	CITES
Green sea turtle	*Chelonia mydas*	E	L
Hawksbill sea turtle	*Eretmochely imbricata*	E	L
Leatherback sea turtle	*Dermochelys coriacea*	E	L
Loggerhead sea turtle	*Caretta caretta*	E	L
Olive ridley sea turtle	*Lepidochelys olivacea*	E	L

E = IUCN Status Endangered, L = Listed on CITIES Appendix I endangered under CITIES Appendix 1

4.3.18. Photos of the Cannonball WPP Site Seabed

To obtain a visual record of the seabed before the installation and operation of the Cannonball WPP, video footage of the seabed was obtained during the field survey of the 28th October 2003. This was obtained using a SIMRAD Video System lowered over the side of the surveying vessel at each of the seven (7) Cannonball Sample Stations (Figure 4.16 above). The video provides a record of the seabed before the installation of the Cannonball WPP and allows a comparison of the baseline condition with video data that will be collected during the monitoring program outlined in Section 7.0. Figures 4.18 – 4.20 shows some representative photographs of the seabed.

The photos show that the seabed throughout the Cannonball WPP site is homogenous with the seabed being soft clay with some bio-turbation shown in all photos. Figure 4.19 shows a photograph of the seabed at the Cannonball WPP with a Brittle Star being seen.

Figure 4.19: Photo of Seabed at Cannonball WPP Site showing a Brittle Star. (2003)

Photos 4.20 (a) below shows the bio-turbation that exists at all seven (7) stations while Figure 4.20 (b) shows the presence of a Tube Worm.

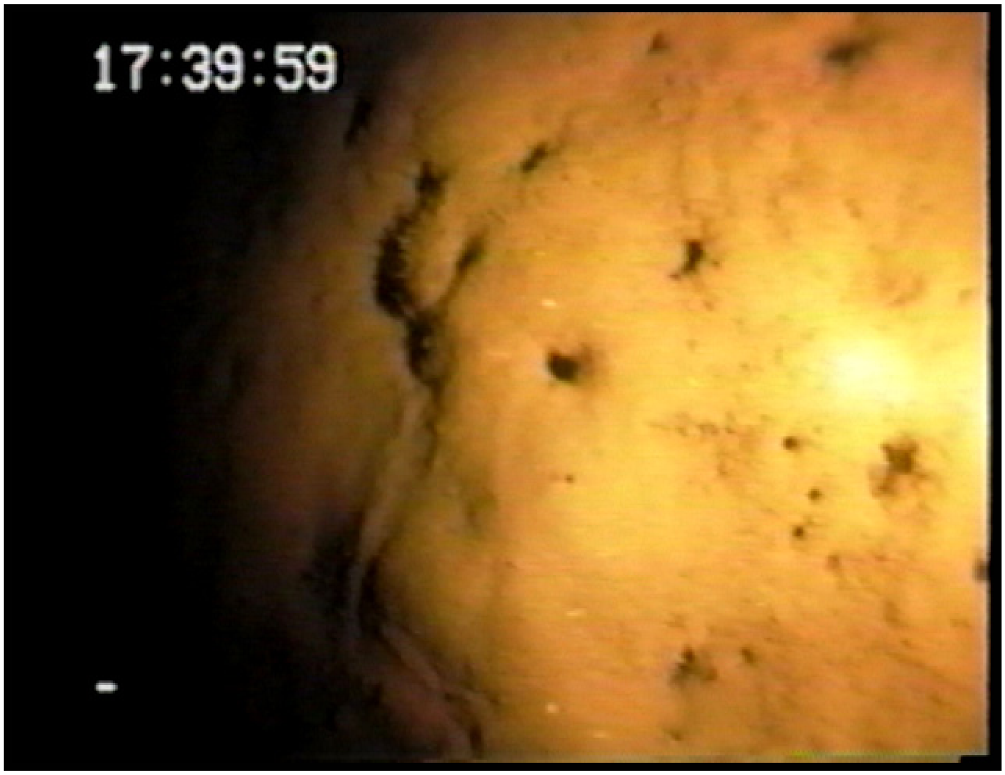

Figure 4.20 (a): Seabed Photograph at Cannonball WPP site (2003)

Figure 4.20 (b): Photograph of Seabed at Cannonball WPP site showing Tube Worm

4.3.19. Marine Traffic

The Cannonball WPP site is 60km southeast of Galeota Point in Trinidad. It is approximately 3km northeast from the Cassia "A" and "B" hubs and 6 km northwest from the Kapok Platform. Marine traffic in the area would consist of bpTT workboats moving between Galeota Point and Cassis "A" and "B" platform and the Kapok Platform. The marine traffic is controlled by bpTT's ASCO Base in Galeota

There are no commercial shipping lanes in the vicinity of the Cannonball WPP site, however, there are some fishing activities that take place in the area, mainly line and gillnetting. See Section 4.6 for a description of these fishing activities. These fishing vessels are mainly artisanal fishing boats e.g. prirogues (30ft – 40ft) with a crew of approximately 2 -5 persons. They usually have no electrical running lights or GPS systems for navigation. They will have gas lanterns for lighting the vessels as well as the positions of fishing equipment in the water. With gillnetting and palange fishing techniques, the fishermen have little control over the direction of drift of the nets and lines relying on picking up the equipment before it interferes with the platforms. There will be an increase in fishing traffic during the annual "Crop Season" which is from November – April.

4.4. Onshore Environment

The proposed Cannonball Field Project includes in its project scope some modifications of the Beachfield Gas Receiving Facility in Guayaguayare, South East Trinidad. Therefore, there is potential for the Cannonball Project to impact on the surrounding onshore environment. The following Section describes the baseline environmental conditions of the onshore component of the Cannonball Project beginning with a discussion of the delineation of the onshore study area.

4.4.1. Study Area

Southeast Trinidad has been established as the land-based focal point for the oil and gas exploration and production activities in the marine fields off Trinidad's east coast. Southeast Trinidad contains the only existing oilfield and industrial development along the eastern coastline of the island. This includes facilities at Galeota (north-eastern Guayaguayare Bay), established during the 1970's to provide shore-based support and infrastructure for operations of the offshore oil and gas industry east of Trinidad. Guayaguayare Bay is an area that has had land-based oil production with some of the first commercial oil wells to be drilled in Trinidad located in this part of Trinidad. The area known as Rustville (southwestern Guayaguayare Bay) has been associated with commercial land-based oil production since 1902.

The Guayaguayare area, particularly the southwest and northwest, contains a number of existing wellheads, pumping-jacks, pipelines, gathering stations, oil storage tanks and related infrastructure, supporting the land-based operations of Petrotrin and Well Services Ltd. Additionally, the central and southwest portions of Guayaguayare Bay contain gas pipeline landfalls, utilized by the National Gas Company of Trinidad & Tobago (NGC), bpTT and BHP Billiton (under construction) to transport crude petroleum and natural gas from offshore fields east and northeast of Trinidad to LNG processing facilities at Point Fortin, southwest coast and crude oil storage facilities at Rustville in Guayaguayare.

Figure 4.21 below shows the extent of the onshore study area for Cannonball Field Project EIA. The Beachfield Gas Receiving Facility is located approximately 1.5km northwest from the Guayaguayare Bay coastline. It lies at the northeastern foot of the Guayare Hill. 500m to the east is the Lawai River which runs to the Rustville Wetlands along the Guayaguayare Coastline. The main pipeline running into the Beachfield Facility is the 48" BOMBAX Pipeline which lands in Rustville and runs along a Right of Way (ROW) leading to the Beachfield Facility.

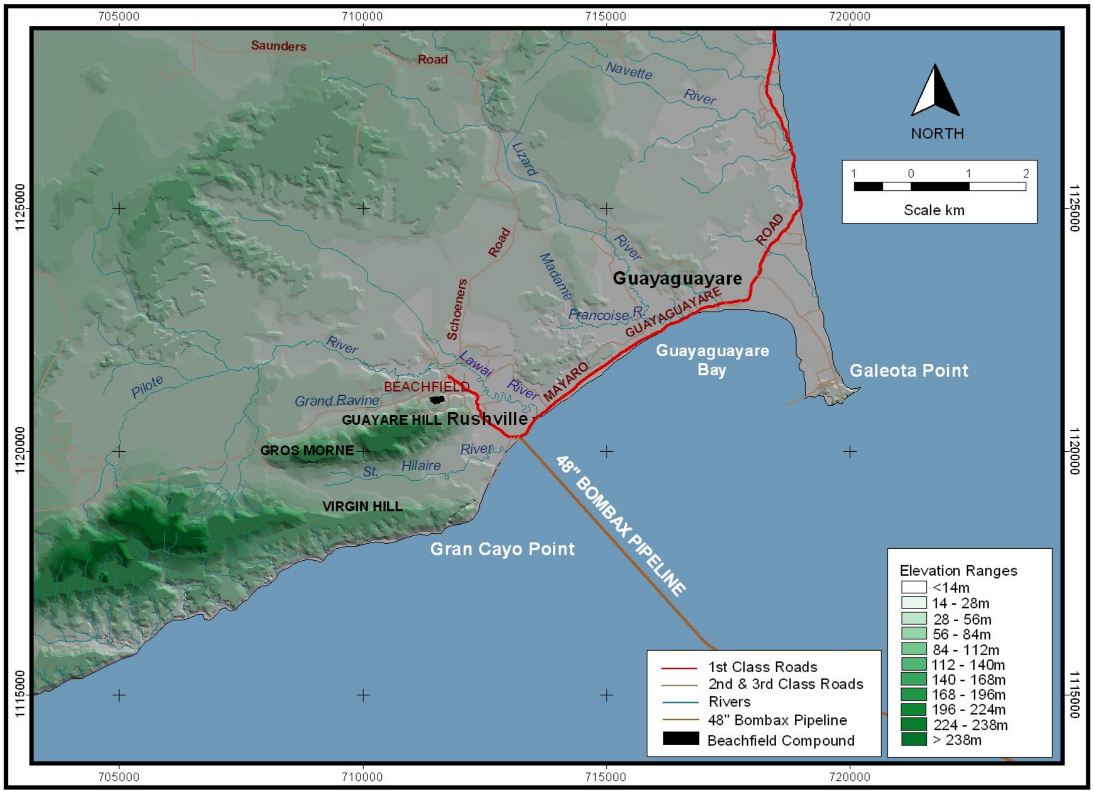

Figure 4.21: Cannonball Field Project Onshore Study Area

The main hills in the area are the Trinity Hills to the southwest of the Beachfield Facility and the Guayare Hills immediately to the south of the facility.

There are two bays in the study area: Guayaguayare Bay to the south and Mayaro Bay to the east. Due to the location of the Beachfield Facility, Guayaguayare Bay is more important as a possible recipient of any environmental impacts.

4.4.2. Guayaguayare Bay –Physical Characteristics

Guayaguayare Bay is located in the southeastern section of Trinidad. It can be described as a shallow concave bay running approximately in a northeast-southwest direction. To the east is Galeota Point which extends southwards and separates the Atlantic Ocean from Guayaguayare Bay. At the tip of Galeota Point is the port facility of bpTT. The port includes a dredged approach channel and turning basin. In the west, there is the Grand Cayo Headland. The beach located within these two headlands is fine to coarse grained and is backed by mangroves, cliffs and a raised beach which is composed of layers of sand, gravel and shells of the bivalve Donax spp. forming layers. Figures 4.22 (a) and (b) shows some aerial photographs taken of the bay for this EIA.

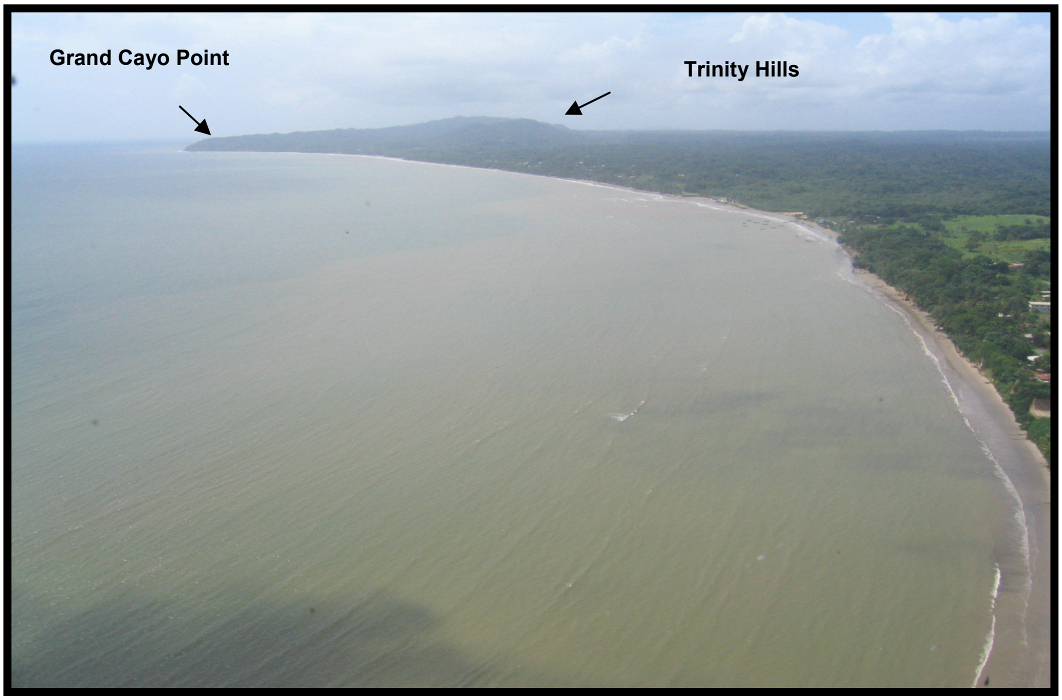

Figure 4.22 (a): Aerial Photograph of Guayaguayare Bay looking West.

Figure 4.22 (b): Aerial Photograph of Guayaguayare Bay looking East.

Guayaguayare Bay is generally shallow at the eastern end with the 5m contour being approximately 2.5km from the shoreline. The western end is deeper with the 5m contour being approximately 750m from the shoreline (See Figure 4.23 below).

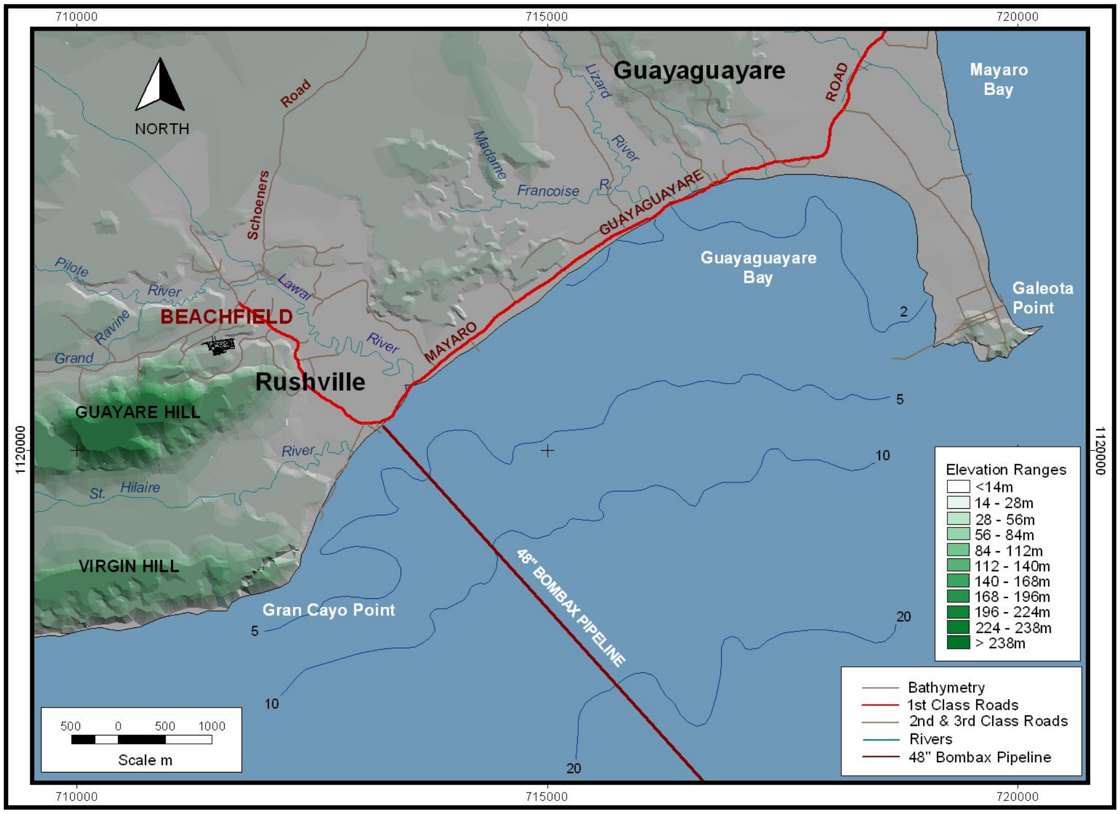

Figure 4.23: Bathymetry of Guayaguayare Bay

4.4.3. Mayaro Bay

Information for this section is taken primarily from Lands and Survey Department, Ministry of Land, Agriculture and Marine Resources, Government of Trinidad and Tobago, topographic maps and aerial photos. The coastline along Mayaro Bay is basically oriented in a north-south direction, between Pt Radix in the north to Pt Galeota in the south and forms the southeastern coastline of the island of Trinidad bounded by the Atlantic Ocean. Mayaro Bay is approximately 22 kilometers long. The coastline of Mayaro Bay is characterised by an almost unbroken stretch of sandy beach over its entire length. The following sections will describe the major coastal features of Mayaro Bay. Figure 4.24 below shows the locations of Mayaro Bay.

<u>Pt Radix to Mayaro Village</u>

The coastline between Pt Radix and Mayaro Village is oriented in a north northeast-south southwest direction and is approximately 5 km long. This section of coastline is characterised by the floodplain of the Ortiore River to the west. The sandy coastal plain is wide (approximately 800m) and flat and consists almost exclusively of cultivated coconut plantations. There are no watercourses to speak of that enter the bay in this area.

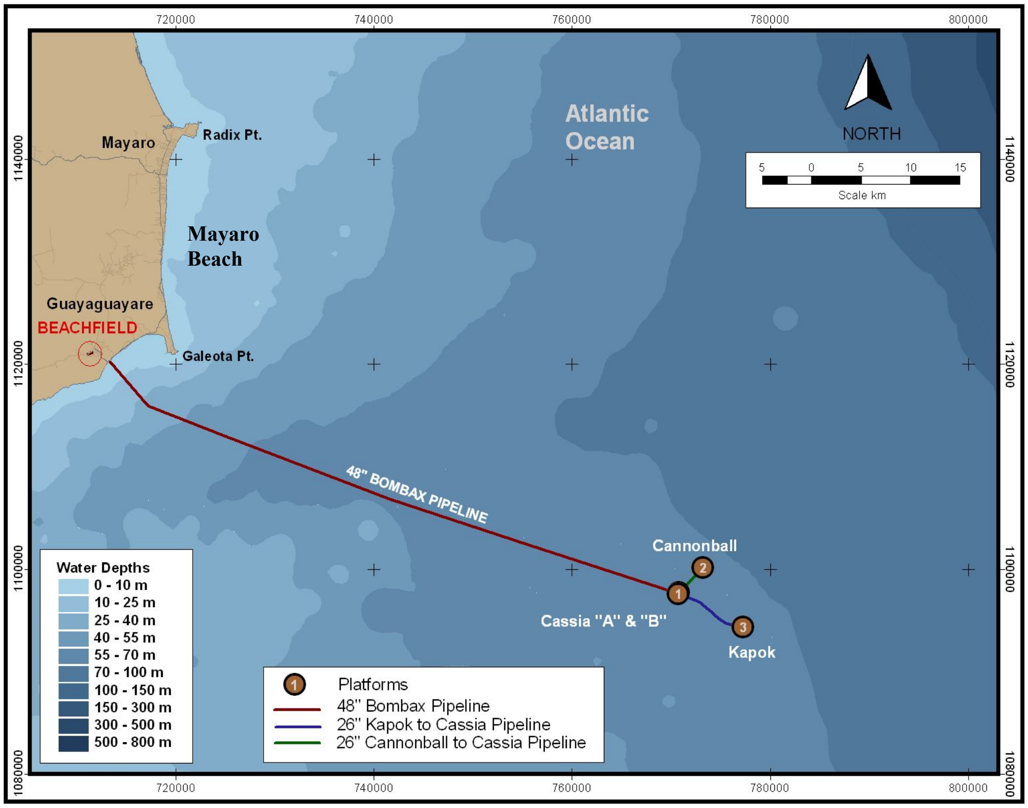

Figure 4.24: Location of Mayaro Beach

Mayaro Village to St Margaret

The coastline between Mayaro Village and St Margaret changes orientation to a north-south direction and is characterised by the narrowing of the coastal plain from 700m at Mayaro Village to approx. 300m at the mouth of the Grand Lagon River just South of St Margaret. This is caused by the encroachment of the low coastal hills (30m elev) to the west. There are four major watercourses entering the bay along this stretch of coastline and several minor watercourses as well. The major rivers are, from the north, the Mahaut River, the Radix Lagon River, the Lagon Deux River and the Grand Lagon River.

St Margaret to Pt Galeota

The coastline between St Margaret and Pt Galeota is slightly arcuate in shape, though still in a north-south orientation, and is characterised by the encroachment of the low-lying hills to the west and the disappearance of the coastal plain. The dominant feature of this portion of the coastline is low coastal cliffs and bluffs. The beach along this stretch is considerably narrower than the northern part of the Bay. There are four major watercourses that enter the bay along this portion of the coastline. They are, from the north, the Palmiste River, the Tavia River, the La Brea River and the Navette River. They are also a few minor un-named watercourses that enter the bay.

4.4.4. Terrestrial Ecology – Non Wetlands

The description of the terrestrial ecology of the general study area and the specific Beachfield site was done using a combination of literature review of previous studies and a field data collection exercise.

As part of the ecological survey, areas along the coastline (non-wetlands) and an area south of the existing bpTT facility in Beachfield were surveyed. The assessment involved Point Counts where the dominant plant species were identified, floral structure was assessed and habitat sensitivity ascertained. The assessment of vegetation characteristics did not utilise a 'fixed radius', as this constrained the determination of floral interactions and connectivity. Rather the characteristics that best captured long-term ecological processes (natural and human-derived) that could be used to assess past trends and predict future trends (and impacts). The Point Counts conducted south of the bpTT facility were arranged to act as a transect through the area proposed for the plant expansion. In addition, areas further south were assessed for similarity to the areas proposed for clearing. Figure 4.25 below shows the location of the terrestrial stations around the Beachfield Gas Receiving Facility.

Coastal areas of Trinidad, particularly the north and east coast, are described by Beard (1946) as having littoral woodland. This vegetation type is dominated by wind that deposits a fine spray of salt on plants. The plants (including trees) in the vegetation associations possess both physiological and physical adaptations to these xerophytic conditions. As a result littoral woodland does not extend far from the coast. While, the areas of southeast Trinidad (which includes Guayaguayare) are not described as having extensive areas of littoral woodland, enough components of this vegetation type are present to suggest that it is a significant part of coastal vegetation in Guayaguayare Bay.

Littoral woodland includes two plant associations: Seagrape-Manchineel (*Coccoloba uvifera-Hippomane mancinella*) which starts at the high water mark, and the Palmiste-Balata (*Roystonea oleracea-Manilkara bidentata*) formation which can be found further inland. The *Coccoloba* association can be present for several chains inland, for a distance varying with exposure, until less extreme conditions enable the *Roystonea-Manilkara* association to take over. The latter merges into inland forest after 20-400 m (1 to 20 chains), the distance varying with exposure (Beard 1946).

Figure 4.25: Locations of Terrestrial Ecology Stations around Beachfield

The coastal location of this vegetation type results in it being subjected to periodic damage by strong winds and gales, so that the structure is never consistent. Depending on the level of exposure to wind, structure may be a windswept thicket a few meters high to a closed stand of trees 12 m (40 ft) high with emergent palms rising to 30 m (100 ft). The *Roystonea-Manilkara* association is usually found as littoral forest with closed stand of trees 10-20 m (30-60 ft) high and medium sized girths (girths over 1.2 m rare), or as a Palm stand with a pure stand of Roystonea Palms up to 20-30 m (60-100 ft). The *Coccoloba-Hippomane* association is often found as a littoral hedge consisting of windswept trees 0.5-3 m (2-10 ft) high and extremely dense, or a littoral thicket 3-10 m (10-30 ft) high and not as windswept (Beard 1946).

Along the eastern shoreline of the Galeota Peninsula the vegetation is dominated by *Coccoloba uvifera* (Sea Grape) in parts, *Hibiscus pernambucensis* along the edge of the mangrove, and thickets dominated by *Myrsine guianensis*, *Randia aculeata Desmoncus sp*., *Cordia curassavica*, *Pisonia fragrans*, *Diospyros inconstans*, *Senna baillaris*, *Senna bicapsularis* and *Coccoloba coronata* (Ramjohn 2002). This coastal vegetation structure is that of a short wind-swept thicket, especially along the ridges, within small pockets among the grass. Other areas along this coastline contain shorter scrubby vegetation dominated by *Rhabdadenia biflora* (usually a vine, but can grow as a low shrub), *Solanum stramonifolium* and *Smilax cumanensis*.

Within Guayaguayare Bay there are several areas of interspersed vegetation types where *Coccoloba* thickets exists with coconut plantations. In the area south of St Hilaire River a semi-abandoned Coconut Estate in southwest Guayaguayare, the Sea Grape community exists more as an understorey thicket in the coastal margin of the more dominant Coconut interspersed with secondary forest vegetation (Figure 4.26 below). The Coccoloba dominates the understorey at the shoreline but the vegetation becomes dominated by secondary growth, scrub and grasses further inland.

Further south of this area, at Gran Cayo Point, the vegetation consists of coconut palms at the shoreline and *Roystonea* palms growing on the higher slopes (Figure 4.27 below). These palms show the typical growth patterns where their stature as emergents in palm forest is obvious.

The presence of coconut (*Cocos nucifera*) on the beaches of Trinidad has come about by the creation of estates where coconut is grown for the extraction of oil from the copra. Trees have also been spread to isolated bays by natural dispersal of the seeds of this plant via the sea. These seeds, which are buoyant in seawater, remain viable after months in the water. The coconut trees located at the base of the slopes of Gran Cayo Point are most likely the result of natural dispersion of these plants.

Figure 4.26: *Coccoloba* trees among Coconut

The creation of coconut estates has been at the expense of littoral vegetation. The persistence of littoral vegetation on the coast is as a result of isolation of bays by physical barriers, steepness of the beach (thus preventing colonisation) and adaptability of individual species. In Guayaguayare, much of the original littoral woodland on the coastline was cleared for the development of coconut (*Cocos nucifera*) plantations. Even where some of the former Coconut Estates are no longer actively managed, the Coconut trees still form the predominant vegetation type (Photograph 3). Active coconut estates still exist, such as at the St. Mary's Estate where coconut is harvested for copra at a less intensive level. Where estates have been abandoned, small-scale harvesting of dry nuts is still carried out by residents from nearby areas.

Figure 4.27: ***Roystonea*** **and Coconut palms at Gran Cayo Point**

Figure 4.28: Coconut trees along beach

Areas of the Guayaguayare coastline, such as the eastern side of Galeota and the areas just north of Gran Cayo Point, are covered by either *Sporobolus virginicus* or *Paspalum vaginnatum*. These two grasses have a primarily coastal distribution and are present in some areas along the Guayaguayare Bay. Various herbaceous vines including *Passiflora foetida* and *Ipomoea setifera* occur among the grasses. *I. setifera* occurs among scrub and abandoned coconut as a very visible component of the vegetation as it is often covered in flowers that provide nectar to hummingbirds and butterflies.

Where the coastline has been altered through the construction of houses and guesthouses, the vegetation is more indicative of agriculture or disturbed areas. Among the houses at Guayaguayare tree crops are planted and other crops may be planted in open areas or abandoned house lots. Citrus, *Mangifera indica* (mango), *Cajanus cajan* (pigeon peas), *Manihot esculenta* (cassava), *Carica papaya* (pawpaw) and *Musa sp*. (banana) were some of the crops observed. In areas such as Guayaguayare it is not uncommon that houses are surrounded by tree crops such as coconut and mango, pioneer trees such as Bois Canot (*Cecropia peltata*), roadside weeds and short crops such as peas.

Figure 4.29: Human-impacted landscape and vegetation

Human alteration of the landscape (Figure 4.29) leads to vegetation indicative of disturbed areas, poor soil and roadsides. The vegetation of these (urban and rural) areas can be dominated by these hardy species. Common weed and shrubs such as *Bidens pilosa* (Railway Daisy), *Mimosa pudica* (Sensitive Plant), *Stachytarpheta cayennensis* (Vervine), *Senna obtusifolia*, and *Senna occidentalis* (Senna) are prominent members of these plant communities.

INLAND FOREST

Direct impacts of fragmentation are related to the creation of "edges" (interfaces between areas of forest and non-forest). Many of these "edge effects" are a consequence of the increased penetration of wind and sunlight into the forest. The penetration of wind into the forest alters the microclimate, reducing the vapour pressure of water under the canopy and drying out the forest understorey. Drying may increase the mortality of trees, seedlings, understorey plants and invertebrates. Increased incidence of sunlight raises temperatures, which also has a desiccant effect. Elevated light levels also allow the penetration of light-demanding weedy species into the forest floor, and the proliferation of epiphytes and vines along the edges.

Historically, the areas inland of Guayaguayare Bay were comprised of the *Mora* association and the *Crappo-Guatecare-Carat* association (Marshall 1939). The area under consideration would have most likely been under the latter association due to physical and climatic conditions. The dominants of this association would have been *Carapa guianensis* (Crappo), *Eschweilera subglandulosa*,(Guatecare), *Spondias mombin* (Hogplum), *Sterculia caribea* (Mahoe), *Pachira insignis* , *Mimusops balata* (Balata), *Trichilia oblanceolata* (Acurel) and *Terminalia obovata* (Locust). These species would have dominated the canopy together with individuals of many other canopy trees. The forest would have a well-developed understorey with trees such as *Brownia latifolia* (Cooperhoop) and *Swartzia pinnata* (Bois Pois) accompanied by palms such as *Maximiliana caribea* and *Sabal glaucescens*.

BEACHFIELD AREA

The wider area south of the bpTT facility has historically been the site for oil exploration and production. There is a network of oilfield roads, production wells and abandoned wellheads, pipelines and oil storage tanks. As such the area can be viewed as a latticework of forest cover that is composed of forest fragments at the macro level but part of a wider forest cover at a landscape level. Within the area there are varying levels of ecological integrity and species diversity.

By contrast to the *Crappo-Guatecare-Carat* association described by Beard (1939) the study area south of the bpTT facility shows a very impoverished flora with the canopy dominated by *S. mombin*, *Hura crepitans* (Sandbox) and *Sapium glandulosum* (Milkwood). These trees accounted for most of the species encountered along the transect. These species, with the exception of *H. crepitans*, are components of the

Crappo-Guatecare-Carat association. However, this can be viewed as a considerably impoverished canopy community. Among these species were few individuals of *Inga laurina* (Sackysac), *Clusia palmicida* (Matapal), *Virola surinamensis* (Wild Nutmeg), *Clathrotropis brachypetala* (Blackheart), *Zanthoxylum martinicense* (L'Epinet). These sub-dominants within the study area were almost all entirely young trees with a DBH of <20 cm and while important members of this plant association, obviously recently regenerated through natural dispersal by avifauna and mammals. The canopy of these areas ranged from 10 – 25 metres and structurally represents forest cover, Figures 4.30 and 4.31 below.

The relatively impoverished nature of the area, with a notable absence of most of the common canopy dominants appears to be a result of the forest being high-graded (i.e. the selective extraction of commercial timber species) in the past (over 50 yrs ago). Species richness is extremely low at all the sites. Nonetheless, these fragments appear to be relatively old given the size of the stems in the plots, and the forest appears to be recovering from past disturbance as the vegetation in the plots exhibits some of the vertical stratification expected from less disturbed forest systems nearby. It is expected that this area serves a similar ecological role to nearby forest in providing resources to the fauna in the area. This is supported by the presence of avifauna that can be considered as forest and forest edge species such as Scaled Pigeon, Rufous-breasted Wren and Silver-beaked Tanager (see Section 4.4.6).

Table 4.23 summarised the forest vegetation recorded in plots at the proposed plant expansion site. The location of the stations are given in Figure 4.25 above.

Figure 4.30: Beachfield Gas Receiving Facility

Figure 4.31: Aerial View of Beachfield Vegetation

Table 4.23: Forest Vegetation recorded in plots at the proposed Beachfield Expansion Site					
Species	**1**	**2**	**3**	**4**	**5**
Bactris sp.					Y
Casearia guianensis	Y				
Cecropia peltata				Y	
Cedrela odorata.					Y
Ceiba pentandra.					Y
Clathrotropis brachypetala			Y		
Clusia palmicida		Y			
Coccoloba latifolia	Y				
Desmoncus sp.	Y				
Erythrina poeppigiana				Y	
Heliconia sp.	Y	Y			
Hura crepitans.	Y	Y		Y	
Inga laurina		Y			
Psidium sp.			Y		
Roystonea oleracea		Y			
Sabal mauritiiformis	Y				
Sapium glandulosum	Y	Y	Y		
Spondias mombin.	Y				Y
Virola surinamensis		Y			
Zanthoxylum martinicense.			Y		
Canopy height	< 20 m	20 - 25 m	10 m	25 m	< 15 m

4.4.5. Wetlands and Sensitive Habitats

The description of the wetlands and sensitive habitats of the Guayaguayare Study area has two components: A literature Review of previous studies of the area and a field survey examining the wetlands of the area particularly the Rustville Wetlands as this is the area most likely to be impacted by the proposed Beachfield Modifications.

Literature Review

The east coast of Trinidad is characterized by a series of large sandy bays separated by wave resistant headlands, except in the northern section of the coast where rocky formations predominate. The bays and headlands have been formed through the differential erosion of soft and hard geologic formations, in which the softer sections form the bays and small inlets, separated by the harder, more resistant formations. The most prominent examples of the harder formations along the coast are Manzanilla, Radix and Galeota Points (Barr, 1981).

In some places along the coast the sandy formations form protective beach barriers to coastal wetland systems, the largest of these wetlands being the Nariva Swamp. The system is also the largest wetland in Trinidad and Tobago covering an area of approximately 6000 ha (Bacon *et al*, 1979). The wetland is a highly diverse ecosystem consisting of an association of estuarine and basin mangroves, freshwater swamp forest, palm swamp forest and freshwater marsh. There are also small sections of upland or terrestrial forests interspersed within the wetland (Alleng, 1994; Bacon, 1988, 1990, 1993; Bacon *et al*, 1979). The hydrology of the wetland is dependent on the balance that exist between a number of inlets or rivers flowing into its western boundary from the Central Range of Trinidad and its main outlet, the Nariva River on its eastern side. The Nariva River also acts as an inlet for saltwater intrusion into the wetland. In addition, there is saltwater seepage through the protective beach barrier during high tides (Bacon *et al*, 1979). As a result of the diversity of wetland ecotypes, species diversity of fauna and flora is high within the wetland, which includes the occurrence of some rare or endangered species such as the anaconda (*Eunectes murinus gigas*), manatee (*Trichecus manatus*) and blue and gold macaw (*Ara ararauna*) (James *et a*l, 1986).

Other wetland systems along the east coast are listed in Table 4.24. Of concern for the study area would be the Mouville wetland, which is the largest system found within the Guayaguayare Bay area, occupying an area of approximately 22 ha. Figure 4.32 below shows the location of the wetlands in the study area.

Table 4.24. List of wetlands located on the east coast of Trinidad			
Wetland Name	**Location**	**Size**	**Dominant Wetland Type**
Matura river	10° 39′ N, 61° 02′ W	15 ha	Estuarine mangrove
Balandra river	10° 43′ N, 60° 59′ W	<1 ha	Estuarine mangrove
Salybia	10° 43′ N, 61° 02′ W	4 ha	Freshwater swamp forest
North Oropuche\ Fishing Pond	10° 35′ N, 61° 02′ W	170 ha	Estuarine / basin mangrove
North Manzanilla	10° 31′ N, 61° 02′ W	<1 ha	Estuarine mangrove
Manzanilla Windbelt	10° 32′ N, 61° 01′ W	44 ha	Estuarine mangrove
Mouville	10° 09′ N, 61° 00′ W	22 ha	Estuarine mangrove
L' Ebranche	10° 31′ N, 61° 03′ W	47 ha	Estuarine mangrove
Ortoire river	10° 20′ N, 61° 00′ W	110 ha	Estuarine / basin mangrove
Sources: Alleng, 1997; Bacon, P.R., 1993.			

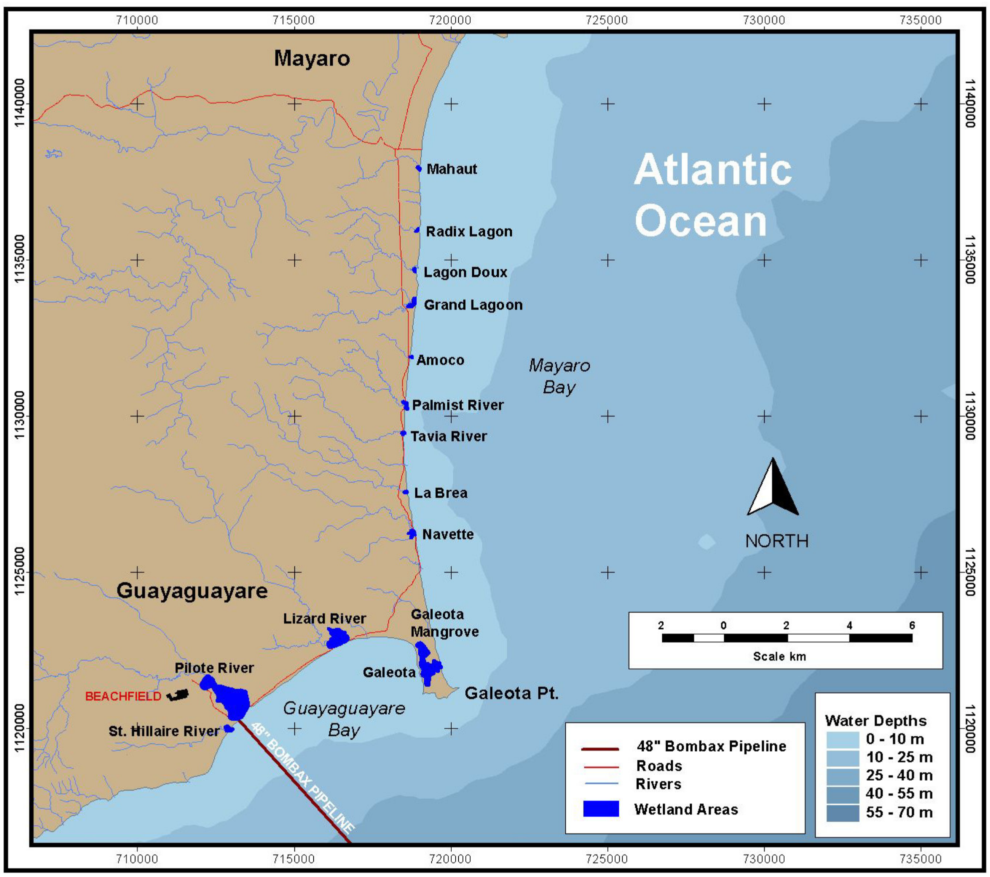

Figure 4.32: Location of the Wetlands in the study area

There a few mangrove wetlands within the Guayaguayare Bay area occupying a small percentage of the coastal zone. There is limited information on these systems as they are relatively small, with no mention being made of them in a national inventory of the large wetlands in Trinidad and Tobago (James *et al*, 1986). However Ramcharan *et al* (1982) provided some information on a mangrove swamp along the banks of the Lawai River, which he refers to as the Guayaguayare swamp. It was a mangrove system dominated by *Rhizophora mangle* (red mangrove), interspersed with sections of *Acrostichum aureum* (mangrove fern) and *Scleria* sp. The presence of the mangrove fern indicated that the some alteration had occurred in the area. Bacon (1993) renamed this wetland system as the Rustville mangrove swamp, describing it as an estuarine mangrove community type, dominated by red mangrove with the occasional white (*Laguncularia racemosa*) and black mangrove (*Avicennia germinans*) species present. Its size was recorded as 23 ha. In spite of these two reports on the system, no reference is made of the fauna of the area but a baseline survey report by the Institute of Marine Affairs (1996) produced a species list of a few crustaceans and avifanua in the system. The status of the wetland is given as healthy but impacted by road development and oil exploration.

Other wetlands in the Guayaguayare Bay area include Mouville, St. Hilaire River and the Guayaguayare Bay mangrove systems (Table 4.25). An inventory of the components of each system is given in Alleng (1997).

TABLE 4. 25: WETLANDS PRESENT WITHIN GUAYAGUAYARE BAY			
Area	**Size**	**Type of wetland**	**Reference**
Guayaguayare Bay	23 ha	Estuarine mangrove	Bacon (1993); Alleng (1997)
Mouville	22 ha	Fringe mangrove	Bacon (1993); Alleng (1997)
St. Hilaire River	<10 ha	Estuarine mangrove	IMA (1997); Alleng (1997)

Field Surveys

An inventory of the wetland systems within the Guayaguayare Bay area was undertaken (Figure 4.32 above, with particular attention focused on the Rustville system because of the potential of impacts from the proposed Beachfield development affecting this wetland. The status of the wetlands was determined using categories of impact (Table 4.26) as defined by Bacon *et al* (1989).

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TABLE 4.26: CATEGORIES FOR DESCRIBING THE STATUS OF COASTAL WETLANDS IN THE CARIBBEAN
1. Pristine
2. Impacted
- slightly modified
- moderately modified
- greatly modified, but apparently healthy
- greatly modified, and showing sign of damage
- severely damaged
3. Destroyed

Adapted Bacon *et al* (1989).

A general survey of the flora and fauna, including the avifauna was undertaken within this ecosystem. The "Point counts Without Distance Estimation" method as described in Wunderle (1994) was used to detect the various avifauna species in the area.

Structural elements of the Rustville system were investigated using a methodology adapted from CARICOMP (2001).
Five 10 m x 10 m plots were established in the forest and their locations fixed with a hand-held GPS where it was possible because of interference of the signals from the forest canopy cover. Basic structural element of heights and circumference at breast height (Cbh) of the trees within the plot were taken (Figure 4.33). The Cbh measurements were converted to diameters at breast height (Dbh) measurements. The systems were mapped using 1998 aerial photographs.

Figure 4.33: Surveying Wetlands Trees in Rustville

4.4.5.1. Description of Wetlands in Study Area

The following is a description of the wetlands found in the study area. Please refer to 4.32 above for the locations of the wetlands being discussed.

RUSTVILLE

The Rustville wetland is an estuarine mangrove community approximately 102 ha in area that has developed along the lower banks of the Lawai River.

Forest structure:

The system is a mixed mangrove forest that is dominated by both *Rhizophora mangle* (red mangrove) and *Laguncularia racemosa* (white mangrove). *Avicennia germinans* or black mangrove occurs occasionally within the system. There is some measure of a zonation pattern existing within the forest as areas that are frequently inundated, where the muds are softer than more landward areas and salinities are low (e.g. river bank and channels), these areas are covered by relatively pure stands of red mangrove.

Figure 4.34: Rustville Wetlands

White mangrove **Red mangrove**

Figure 4.35 Types of Mangrove in the Rustville Wetlands

In less hydro-dynamic areas where the sediment is more compact and interstitial salinities are high (e.g. landward sections of wetland) pure stands of white mangrove persist.

The forest is a mature system with the average height of trees at 11.4 m, an average diameter at breast height of 9.49 cm and mean density of 46 / 0.1 ha (Table 4.27).

Associated Wetland Flora:
Along the landward fringes of the wetland particularly in the southern sector, there are pure stands of the mangrove fern, *Acrostichum aureum*, the occurrence of which is indicative of some form of disturbance to the system. This is not unexpected as the area has been modified with the construction of the road and bridge along its eastern boundary.

Associate habitats of the wetland include secondary forests and scrub vegetation, primarily in its southern, western and northern boundaries.

TABLE 4.27: STRUCTURAL MEASUREMENTS OF RUSTVILLE MANGROVE FOREST

Plot No.	Species density (No. of trees / 0.1ha)	Average height (m)	Average Dbh (cm)
1	Laguncularia : 21	14.3	13.75
2	Laguncularia : 56	9.9	7.29
3	Laguncularia : 62 Avicennia : 4	13	8.34
4	Laguncularia : 7 Rhizophora : 19	10	10.76
5	Laguncularia : 58 Rhizophora: 3	9.7	7.33
Average	46 trees/0.1 ha	11.4	9.49

Acrostichum

Fauna:
A list of the fauna occurring in the wetland is presented below:

A list of the birds occurring in the forest obtained from the bird counts is provided in Table 4.28 below.

Table 4.28: List of Fauna occurring in Rustville Wetlands	
Species Name	Common Name
Invertebrates:	
Cardisoma guanhumi	Blue crab
Ucides cordatus	Hairy crab
Aratus pisonii	Mangrove tree crab
Goniopsis *cruentata*	Mangrove crab
Uca sp.	Fiddler crab
Melampus coffeus	Coffee bean snail
Vertebrates:	
Caiman sclerops	Spectacled caiman

Socio-economic use: Crab catching is the main socio-economic use in the system as about 30% of the Guayaguayare village utilize the area for this purpose. Additionally some recreational use of the wetlands takes place in the area (7%).

Status:
The status of the wetland can be described as healthy but impacted by road construction.

OTHER WETLANDS IN THE GUAYAGUAYARE AREA
The following are general inventories of the other wetlands within Guayaguayare Bay, which are not expected to be impacted by the modifications to the Beachfield Gas Receiving Facility but make up part of baseline information for Guayaguayare Bay.

GUAYAGUAYARE BAY

LOCATION: East of Guayaguayare village, at the mouth of Lizard River.

SIZE: 23 ha

TYPE: Estaurine mangrove

WETLAND FLORA: *Rhizophora mangle* (red mangrove), *Avicennia germinans* (black mangrove), *Laguncularia racemosa* (white mangrove) and *Conocarpus erectus* (Button mangrove).

FAUNA: No information available at the time of the study.

GENERAL COMMENTS: The wetland has developed along the lower banks of the Lizard River. It is a mature mixed forest that is bounded by secondary forest growth.

STATUS: It is moderately modified by road construction and a recent land reclamation scheme, in which a large section of the wetland has been destroyed by infilling with dumped soil.

TABLE 4.29: BIRD COUNTS AT RUSTVILLE WETLAND, OCTOBER 2003.

Species	Nos./ 15 minutes
Count 1	
Psarocolius decumanus (Crested oropendola)	1
Molothrus bonariensis (Shiny cowbird)	1
Sakesphorus canadensis (Black-crested antshrike)	2
Thraupis palmarum (Palm tanager)	2
Glaucis hirsuta (Rufous-breasted hermit)	1
Dryocopus lineatus (Lineated woodpecker)	2
Count 2	
Seiurus novehoracensis (Northern waterthrush)	2
Pitangus sulphuratus (Great kiskadee)	1
Sakesphorus canadensis (Black-crested antshrike)	1
Thraupis palmarum (Palm tanager)	2
Actifis macularia (Spotted sandpiper)	I
Count 3	
Sakesphorus canadensis (Black-crested antshrike)	2
Seiurus novehoracensis (Northern waterthrush)	1
Icterus nigrogularis (Yellow oriole)	I
Thraupis palmarum (Palm tanager)	2
Amazilia tohaci (Copper-rumped hummingbird)	1
Thryothorus rutilus (Rufous-breasted wren)	2
Count 4	
Icterus nigrogularis (Yellow oriole)	2
Pitangus sulphuratus (Great kiskadee)	1
Glaucis hirsuta (Rufous-breasted hermit)	1
Count 5	
Sakesphorus canadensis (Black-crested antshrike)	2
*Coereba flaveola (*Banaquit)	2
Amazilia tohaci (Copper-rumped hummingbird)	1
Thraupis palmarum (Palm tanager)	2
Myrmotherula axillaris (White-flanked antwren)	1
Count 6	
Sakesphorus canadensis (Black-crested antshrike)	1
*Coereba flaveola (*Banaquit)	2
Amazilia tohaci (Copper-rumped hummingbird)	1
Seiurus novehoracensis (Northern waterthrush)	1
Myrmotherula axillaris (White-flanked antwren)	1
Conirostrum bicolor (Bicolored conebill)	1
Species observed within wetland during the general survey of the wetland, outside the time period of the point counts	
Tyrannus melancholicus (Tropical kingbird)	1
Chloroceryle americana (Green kingfisher)	1
Pitangus sulphuratus (Great kiskadee)	1
Coragyps atratus (Black vulture)	5

MOUVILLE

LOCATION: Southeast peninsula, west of Galeota Point along the northern section of Guayaguayare Bay.

SIZE: 22 ha

TYPE: Fringe mangrove.

WETLAND FLORA: *Rhizophora mangle* (red mangrove), *Laguncularia racemosa* (white mangrove), *Avicennia germinans* (black mangrove), E*leocharis sp.*(sedge), Cyperus sp. (sedge), *Fimbristylis sp.*(sedge).

FAUNA: No information available at the time of the study.

GENERAL COMMENTS: The system is a fringe wetland forest that has developed along the northern boundary of Guayaguayare Bay. The system is a mature mixed forest.

STATUS: Greatly modified and showing signs of damage

ST HILAIRE RIVER

LOCATION: South- east of Rustville in the western section of Guayaguayare Bay along the mouth of the St. Hilaire River.

SIZE: < 10 ha

TYPE: Estaurine mangrove.

WETLAND FLORA: *Laguncularia racemosa* (white mangrove), *Rhizophora racemosa* (red mangrove), *Rhizophora mangle* (red mangrove) and *Avicennia germinans* (black mangrove).

FAUNA: See Alleng, 1997.

GENERAL COMMENTS: The system is a thin fringe of mangroves that has developed along the banks of the St. Hilaire River near Rustville. The area is bordered by scrub forest and old coconut groves.

STATUS: Healthy but impacted by road construction across river course.

4.4.6. Birds

Activities that lead to the fragmenting of habitats and creating "edge" conditions can result in the displacement of more sensitive forest-specialist species. Avifauna was characterised as one of the representative faunal taxa because they are highly visible, readily counted and tend to have specific, well-researched habitat requirements that can be used to predict environmental conditions in an area, and the effects of development impacts. They also have important ecological roles in the community as pollinators and dispersers of flora.

For this EIA, avifauna was sampled using the Point Count Method, with points of 5-minute duration conducted within the study area. The point counts were conducted during hours of peak bird activity (6:00 to 9:00 am; 3:00 to 6:00 pm). The rationale was to ensure that a high proportion of the birds present were recorded, and that variation between points as a result of heat and bird inactivity, were kept to a minimum. Birds were detected both visually (using a pair of high-resolution 7 x 42 binoculars) and aurally (through detection of species-specific vocalisations). Identification of species was aided, where necessary, by published field guides for Trinidad & Tobago and Venezuela. The purpose of the avifaunal surveys was to ascertain:

- The sensitivity of species that occur;
- The occurrence of rare or endangered species;
- The responsive stability of the species present (i.e., the ability to resist habitat disturbance and colonise new niches); and
- The overall habitat quality and ecological health of the area

As part of the assessment of an area using avifaunal communities, great enough sampling effort is required to determine a comprehensive community structure. Shy and elusive members of communities can easily be overlooked if too small an area or too little sampling time and effort is used. While the most common or conspicuous members of communities drive most community interactions, it is the rare or less common species that determine community structure.

For the purposes of the information in this Section and in Appendix L, "abundance" of a species is based on habitat requirements. Thus, "common" denotes that a species is frequently recorded in the habitats indicated, and does not necessarily imply that the species is commonly found or widespread throughout Trinidad & Tobago. "Localised" implies restriction to a particular habitat, and suggests a high level of site dependence. The classification of species as "resident" or "migrant" is also based primarily on ffrench (1992).

As part of the development within Guayaguayare Bay in the last decade, EIAs were conducted for projects within the area, which contain assessments of avian communities. These avian surveys (where data collection involves field surveys) have been conducted along the coastal environment, landward of mangroves and the forest interior. An EIA submitted in 1996 to TCPD for a natural gas pipeline from Rustville to Point Fortin (ECO

Report No. 15/1995), contained as part of the baseline assessment, field surveys of avian communities. The avian survey (conducted between August 1995 and January 1996) involved areas of the coastline at Rustville and the edge of the Guayaguayare Forest (north of Rustville), and two pipeline ROWs (from Beachfield to Abysinia and Beachfield to Picton). A total of 78 Fixed Radius Point Counts were conducted over several habitat types of this large spatial study area. The study revealed 45 species of birds in the Rustville and (southern areas of the) Guayaguayare Forest. The species composition of this area revealed waders (such as Lesser Yellowlegs and Semi-palmated Sandpiper), aggressive species adapted to impacted areas (Great Kiskidee and Ruddy Ground Dove) and forest edge species (such as Rufous-breasted Wren). The Point Counts along the two ROWS recorded a total of 80 avian species (to give a total of 141 avian species). The species composition of these communities showed a greater dominance of forest species as the ROWs passed through areas of intact primary forest and contiguous secondary forest.

An EIA submitted in 2002 to EMA for the granting of a CEC for an Oil Storage Terminal site and a pipeline ROW (Ramjohn et al 2002) contained as part of the baseline assessment, field surveys of avian communities. The areas investigated included the Galeota Peninsula, coastal areas of Guayaguayare Bay to Rustville, the Rustville forest areas and an Amoco 6’’ Gasline ROW at Galeota to Beachfield (conducted between March - September 2002). A total of 61 Point Counts were conducted over the large spatial study area. The area at the Rustville coastline, abandoned estate and forest edge north of Rustville revealed a total of 30 species of avifauna. Similarly to the study in 1996, the species composition of this area revealed shorebirds (such as Little Blue Heron), aggressive species adapted to impacted areas (such as Blue-gray Tanager and Tropical Kingbird) and forest species (such as Squirrel Cuckoo and Little Hermit). The Point Counts along the Galeota to Beachfield recorded 81 avifauna species with the great many of the species forest or forest edge dependent. During the course of the ecological surveys a combined total of 104 bird species were recorded at the areas investigated.

A comparison of these two studies show a similarity in the number of species recorded in the wider Guayaguayare area. This suggests that species composition of the habitat types may be highly resilient to change once there is enough of the habitat type to support populations of individual species.

For the present study a much smaller geographical area was investigated, specifically, the coastal areas of Guayaguayare (that did not contain mangroves) and the areas that are proposed for the bpTT Facility expansion. The habitat types covered along the coastline included urban-derived areas, coconut plantations (active and abandoned) and sandy beach areas. The areas south of bpTT facility were investigated where areas in close proximity to the facility may be converted. A total of 15 Point Counts were conducted in these areas (between the 15th –17th November 2003) and recorded a total of 42 species of birds (see Appendix *). Figure 4.25 above shows the location of the survey area and the Point Count locations in relation to the Beachfield Gas Receiving Facility.

The species recorded along the coastline included several Semi-palmated Sandpipers near the mouth of the St. Hilaire River, and a juvenile Common Black Hawk. The Common Black Hawk can be found in environments where water is present as its main prey item is crabs. Point Counts within the human-derived environment recorded species that were the aggressive members of the avifaunal community that are able to tolerate human presence. These species are often intolerant of forest conditions and rarely seen outside of urban, agricultural, scrub or forest edge. Species such as the House Wren, Tropical Mockingbird and Smooth-billed Ani are the conspicuous members of urban faunal communities (Appendix L).

The area south of the bpTT facility, as described earlier, contains degraded forest that structurally provides the functions and some of the resources of more intact forest areas.

The Point Counts within this area, not surprisingly, recorded a significant number of forest and forest edge species. Species such as the Scaled Pigeon, Plain-brown Woodcreeper and Little Hermit are species that can be considered 'forest specialists', species that require canopy closure in order to persist in areas. These species would be considered dependent on the forest cover provided. However, the degraded nature of the forest (Photograph 4.36) suggests that these species may show some resilience to impacts to forest quality. More likely, these areas of degraded forest act as 'satellites' of potential habitat that forest species can utilise in foraging, roosting and nesting. In the areas that are closer to Petrotrin facilities, the aggressive species such as the Barred Antshrike, Cattle Egret and Great Kiskadee were found in the Point Counts. These species are able to enter these areas as they are tolerant of open areas or scrub and demonstrate 'edge effects' amongst a taxonomic group. The areas of smaller forest fragments or where the edge penetrates deep into forest are most likely to be dominated by these species.

Table 4.30 below summarises the results of the avifaunal survey around Beachfield Facility.

Figure 4.36: Degraded forest south of bpTT Beachfield site

Table 4.30: Avifauna recorded during Point Counts in Guayaguayare Bay and the proposed plant expansion site

SPECIES	RESIDENTIAL						bpTT Site			FOREST				COASTAL	
	CD 1	CD 2	CD 3	CD 4	CD 5	CD 6	V 7	V 11	V 12	CD 7	CD 8	CD 9	CD 10	CD 11	CD 14
Bananaquit										Y	Y		Y		
Barred Antshrike	Y					Y				Y		Y	Y		
Black Vulture	Y	Y			Y										
Black-crested Antshrike						Y						Y	Y	Y	
Blue-black Grassquit			Y	Y	Y						Y				
Blue-gray Tanager	Y		Y	Y											
Brown Pelican					Y										
Buff-throated Woodcreeper												Y			
Carib Grackle		Y													
Cattle Egret				Y						Y					
Common Black Hawk															Y
Crested Oropendola			Y												
Eared Dove													Y		
Golden-fronted Greenlet						Y					Y	Y		Y	
Gray-rumped Swift									Y						
Great Kiskidee	Y			Y							Y				
House Wren		Y	Y	Y								Y			
Lineated Woodpecker							Y								
Little Hermit												Y			
Long-billed Gnatwren											Y	Y	Y	Y	
Magnificent Frigatebird					Y										
Northern Waterthrush											Y	Y			
Orange-winged Parrot				Y											

Table 4.30: Avifauna recorded during Point Counts in Guayaguayare Bay and the proposed plant expansion site

SPECIES	RESIDENTIAL						bpTT Site			FOREST				COASTAL	
	CD 1	CD 2	CD 3	CD 4	CD 5	CD 6	V 7	V 11	V 12	CD 7	CD 8	CD 9	CD 10	CD 11	CD 14
Pale-vented Pigeon											Y	Y	Y	Y	
Palm Tanager	Y					Y									
Plain Brown Woodcreeper						Y	Y								
Ruddy Ground Dove				Y		Y									
Rufous-breasted Hermit						Y				Y					
Rufous-breasted Wren	Y					Y	Y				Y				
Rufous-browed Peppershrike												Y		Y	
Scaled Pigeon													Y		
Semi-palmated Sandpiper														Y	
Shiny Cowbird									Y						
Silver-beaked Tanager													Y		
Smooth-biled Ani				Y				Y							
Tropical Kingbird	Y			Y	Y					Y	Y				
Tropical Mockingbird			Y												
Tropical Peewee										Y					
Turquoise Tanager													Y		
White-lined Tanager											Y				
White-tipped Dove													Y		

4.4.7. Lepidoptera (Butterflies)

Cross-taxon Bioindicator Data Verification

Where various ecosystems components are at work, the determination of environmentally sensitive areas cannot be ascertained by the use of single taxa. The use of other taxonomic components can verify the efficacy of the species data that has been generated. The composition of Lepidopteran communities has been used to document habitat changes and predict landscape level impacts (Ramjohn et al 2003).

The use of Lepidoptera (butterflies and moths) to assess ecosystem function and habitat quality is possible for a number of reasons, including ready identification (through the use of available taxonomic keys) and the availability of records of distribution and habitat requirements. Thus, Lepidoptera are used in the present study as biological indicators of present ecosystem integrity and habitat quality.

Butterflies and moths (Order: Lepidoptera, Class: Insecta) are conspicuous members of the invertebrate communities of ecosystems. Butterflies in particular, which are day flying and often brightly coloured, generate interest from the public and can be considered a “charismatic” species. The separate life stages have different requirements, in particular the larval stage can be very specific in its requirements (with a close link between a caterpillar and a particular host plant) for successful development. As a result, species may be site dependent at one or other stage and may also move between habitats during their life cycle.

In comparison to other insect groups butterfly taxonomy is relatively well known (Wood & Gillman, 1998), particularly in Trinidad where many insect species have not been adequately catalogued, occurrence determined and status ascertained. The level of isolation of habitat fragments can be determined by assessing the composition of Lepidopteran populations. Some butterflies show limited dispersal by an inability to cross barriers such as different habitat types or cleared areas. Forest butterflies are especially vulnerable to such restrictions due to their adaptation to specific ranges of microclimate conditions, which may not allow movement through non-forest habitat (Srygley and Chai 1990, Spitzer *et al* 1997).

Butterflies were sampled at the same area where avian Point Counts were conducted. At each Point butterflies were observed and captured over a 20-minute period using a butterfly net, in an approximately 50-metre radius around the point. Species that could be identified in the field were noted and the others captured and preserved for later identification. Hesperids (Family: Hesperidae) are not included, as the group has not been properly catalogued in Trinidad and identification was beyond the scope of this study.

For the purposes of the data verification Lepidopteran communities were separated into residential-rural (which includes human-derived landscapes such as coconut plantations) and forest communities and comparison of the two environments determined to investigate habitat requirement and specificity. The determination of the species assemblages demonstrates a strong dissimilarity of the ecotypes. Of the 21 species recorded within the Point Counts, 3 species were recorded in each habitat type, 9 species were recorded in coastal and human-derived environments, and 9 species located in forest areas (see Table 4.31).

The strong dissimilarity illustrates the habitat specificity of these taxa with groups such as the Ringlets (Genus: *Euptychia*) and the Night (*Taygetis penelea*) only recorded in forested areas. This group of drab brown butterflies use camouflage as a means of defence against predators and rarely venture far from forest or forest edge. Similarly to this trend the species found in human-derived environments were the aggressive species that are fast fliers or unpalatable to predators such as birds.

The trends seen in the Lepidoptera fauna mirror the patterns observed in the avian fauna with high habitat specificity among community members. However, among the Lepidoptera it was observed that 'edge effects' were observed among the communities. The Cow Shoemaker (*Anaea marthesia*), a forest butterfly was observed (at a coastal point) just past the St Hilaire River, where it was flying between coconut and sea grape trees. In the forested areas, the Monarch, a 'sun loving' species was observed flying into the forested areas on an oilfield access road. The presence of these species in 'alien' environments does not negate the data verification but rather demonstrates the importance of assessing areas using various taxa which may have varying sensitivities to habitat change. The patterns observed clearly shows that the past history of the Guayaguayare area has resulted in fragmentation of the landscape and the edge effects associated with habitat alteration.

Table 4.31: Lepidopteron Species recorded during Point Counts in Guayaguayare Bay and the proposed plant expansion site

SPECIES	RESIDENTIAL					bpTT SITE		FOREST			COASTAL
	CD 2	CD 3	CD 4	CD 5	CD 6	V 9	V 12	CD 7	CD 8	CD 9	CD 12
Blue Grecian					Y				Y		
Caroni Flambeau					Y						
Cattleheart		Y									
Cocoa Mort Bleu								Y			
Common Blue	Y										
Common Yellow							Y				
Cracker	Y										
Gold Rim					Y						
Monarch								Y			
Night						Y					
Painted Lady	Y										
Postman				Y				Y		Y	
Purple Mort Bleu					Y						
Red Anartia			Y				Y			Y	
Red Shoemaker											Y
Ringlet 1									Y		
Ringlet 2								Y			
Ringlet 3								Y			
Sweet Oil										Y	
Tiger								Y		Y	
White Peacock		Y									

4.5. Fisheries

The marine area along the east and southeast coasts of Trinidad is the site of natural gas, oil and fisheries economic activities. These activities share this marine area as a common natural resource used to access the rich natural gas/oil reserves beneath the seabed and commercially important fish stocks in the waters. Both of these economic activities have a long history of development spanning more than 100 years.

Both activities also contribute to the social and economic well-being of the citizens of Trinidad and Tobago. Exploitation of natural gas/oil has and continues to be a significant contributor on a macro socio-economic level. Exploitation of fisheries resources is an important source of income and contributes to social cohesion at the community level in coastal fishing villages (IMA Nov. 1999).

Arriving at and maintaining harmonious co-existence and sustainable co-development of these two important economic activities requires an understanding of each other's activities and how they are interrelated. The significance of this is amplified since they both share the marine area along Trinidad's east and southeast coasts as a common resource. Harmonious co-existence is in the best interest of bpTT, fishers, their fisheries and the wider Trinidad and Tobago community, who all depend upon these activities for their sustenance. To ensure that all potential impacts of the Cannonball Field Project on both the fishermen and the fisheries resources that they depend on are recognized as part of this EIA, bpTT commissioned an extensive fisheries study. The fisheries component of this EIA seeks to provide relevant information and guidelines to enable bpTT, its natural gas development operations in the Cannonball Field, fishers and the fish resources comprising the fisheries on the east and southeast coasts, to harmoniously co-exist throughout the entire lifetime of the project.

The following is a summary of the results of the fishing baseline survey. The complete survey is presented in Appendix J

4.5.1. Methodology of Fisheries Study

The following activities were conducted as part of this fisheries study:

- **<u>Literature review:</u>**
  - Fisheries statistics, data and information from Ministry of Food Production & Marine Resources, Fisheries Division
  - Review of all existing reports and articles on the fisheries in the study area

- **<u>Review of relevant maps:</u>**
  - Ministry of Housing and Settlements, Lands & Surveys Division
  - Ministry of Food Production & Marine Resources, Fisheries Division
  - Sourced from existing scientific reports and articles

- **<u>Frame Survey of the fish landing sites in the study area</u>**

Reconnaissance visits to identify and determine the fish landing sites within the study area were conducted on 21 September 2003 and 28 September 2003. These visits were used to locate the landing sites, identify the landing sites with fishers using the study area, quantify the number of vessels at each site, identify community leaders and conduct a preliminary assessment for development of survey questionnaires.

A Frame Survey (Caddy & Bazigos 1985) of the fish landing sites along Trinidad's southeast and east coasts, from Moruga to Ortoire, was conducted over a 3-week period from 10 to 25 October 2003. The survey aimed to capture a 10% sample of the fishing vessels and vendors servicing each landing site. The data and information obtained was compared with and used to update existing information from the literature review.

Two questionnaires were used in the survey:

1. Fisheries Survey Questionnaire (Appendix J) used to gather information on:
   a. Value of the fisheries (number of persons dependent on income earned from exploited resources, indigenous use of the fisheries, value of equipment)
   b. Characteristics of the fisheries (types of vessels, types of gear, seasonal fishing activities, areas fished, types of fish caught)
   c. Qualitative changes in the fisheries (diversity of fish species caught, quantity of fish, changes in the number of fishers)
   d. Perceived impacts of oil/gas activities on the fisheries (fishers, fish resources, fishing areas)
   e. Likely impacts of fisheries activities on the Cannonball Field Development Project

2. Vendors Survey Questionnaire (Appendix J)
   a. Value of the fisheries (number of persons dependent on income earned from exploited resources, vendors' investment in the fisheries, local and foreign markets)
   b. Qualitative changes in the fisheries (diversity of fish species, quantity of fish, changes in the number of fishers/vendors)
   c. Perceived impacts of oil/gas activities on the fisheries (fish resources, market dynamics)

Table 4.32 indicates the number of fishers interviewed for this baseline survey:

Table 4.32: Number of Fishers interviewed for the Fisheries Baseline Survey

Fishing Port	FD estimate of boat numbers (2002)	Survey estimate of boat numbers (2002)	No. interviewed
Ortoire	17	25	14
Plaisance	25	20	6
Guayaguayare	53	14	9
Grand Chemin	47	40	3
La Retraite	28	--	10
TOTAL	170	98	42

4.5.2. Description of the east and Southeast Coast Fisheries

This section provides a description of the physical characteristics, socio-economic characteristics and fisheries for the Ortoire, Plaisance, Guayaguayare Seawall, La Retraite and Gran Chemin fishing ports on Trinidad's east and southeast coasts. Figure 4.37 below shows the location of these fishing ports. In this study a fishery is defined as the interrelations between fishers, exploited fish stocks and the exploited fishing areas (Charles 2001).

Fishing areas around Trinidad and Tobago are delineated based on the type of fishing gear used. There are five general categories of fishing gear, each characterized by 1 or more different of types of fishing activities (Fisheries Division Jul. 2002; Table 4.33). There is extensive overlap between the fishing areas for each type of fishing gear as well as with oil and gas operations off Trinidad's east and southeast coasts.

Table 4.33: Categories of Fishing Gear and Fishing Practices

Category of Fishing Gear	Fishing Activities
Fish pot	Fish pots • Various sizes and types of construction materials; mainly 'arrowhead' pots used in the east and southeast coast fisheries
Seine	Multifilament gillnetting from the beach
Line	• Palangue • Trolling • Switchering • A-la-vive • Banking
Gillnetting	• Monofilament, transparent gillnetting (locally known as 'Transp') • Multifilament gillnetting (locally known as 'Fillet')
Trawl	Types I, II and III industrial trawlers

4.5.2.1. Types of Fishing Gear used by Fishers in the study area

Banking: Type of hook and line consisting of 3 to 8 baited hooks attached to a weighted line of 80 to 140 lbs test strain. The hooks are baited with bonito and the gear is set at the sea bed where it targets demersal species. Each boat may carry between 3 and 9 lines.

Trolling lines: Type of hook and line consisting of un-weighted surface-set lines that use artificial bait. Each boat may carry 4 troll lines

Palangue: Type of hook and line consisting of longlines with 300 hooks or more. Each boat carries one longline, which is set at the surface

Fillet: Multifilament gillnet usually set at night at the water's surface. A single fillet may weigh 300 to 325 lbs and have a depth of 100 holes. Each boat carries one fillet.

Trans-p net: Monofilament gillnet usually set on the seabed. This gear is usually operated during the daytime. Each boat carries one trans-p net.

Fishpot: Arrow-head (or hat-frame) fish traps made of wire mesh over a wood or metal frame. The most common mesh used is 16-guage chicken wire or 'BRC'. Some BRC pots may be made without a frame

4.5.3. Fishing Areas off the East Coast for each type of fishing technique

Fish pot fishing areas are mainly located on the east coast. It consists of 4 main areas extending from Toco on the northeast coast to Guayaguayare on the southeast and Gran Chemin on the south coast (Figure 4.37).

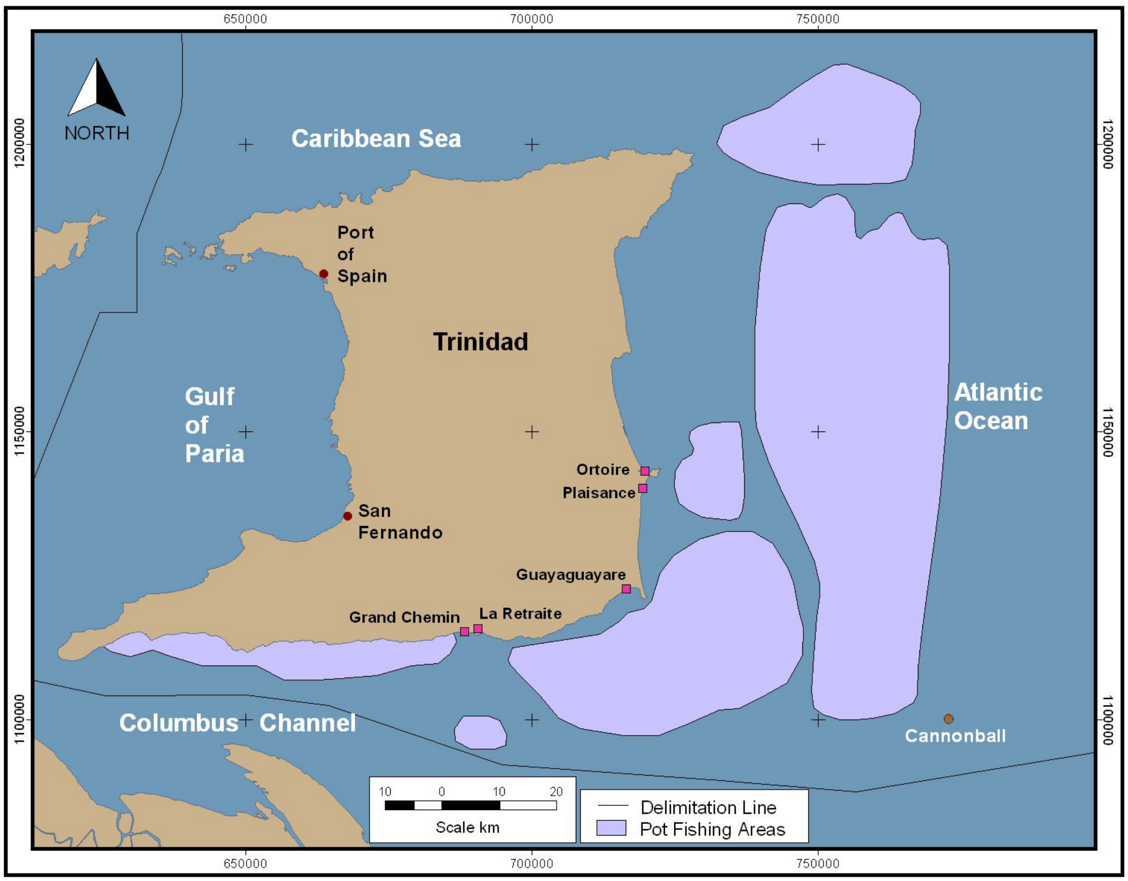

Figure 4.37: Fish Pot Fishing Areas on the East Coast of Trinidad (Fisheries Division, 2002)

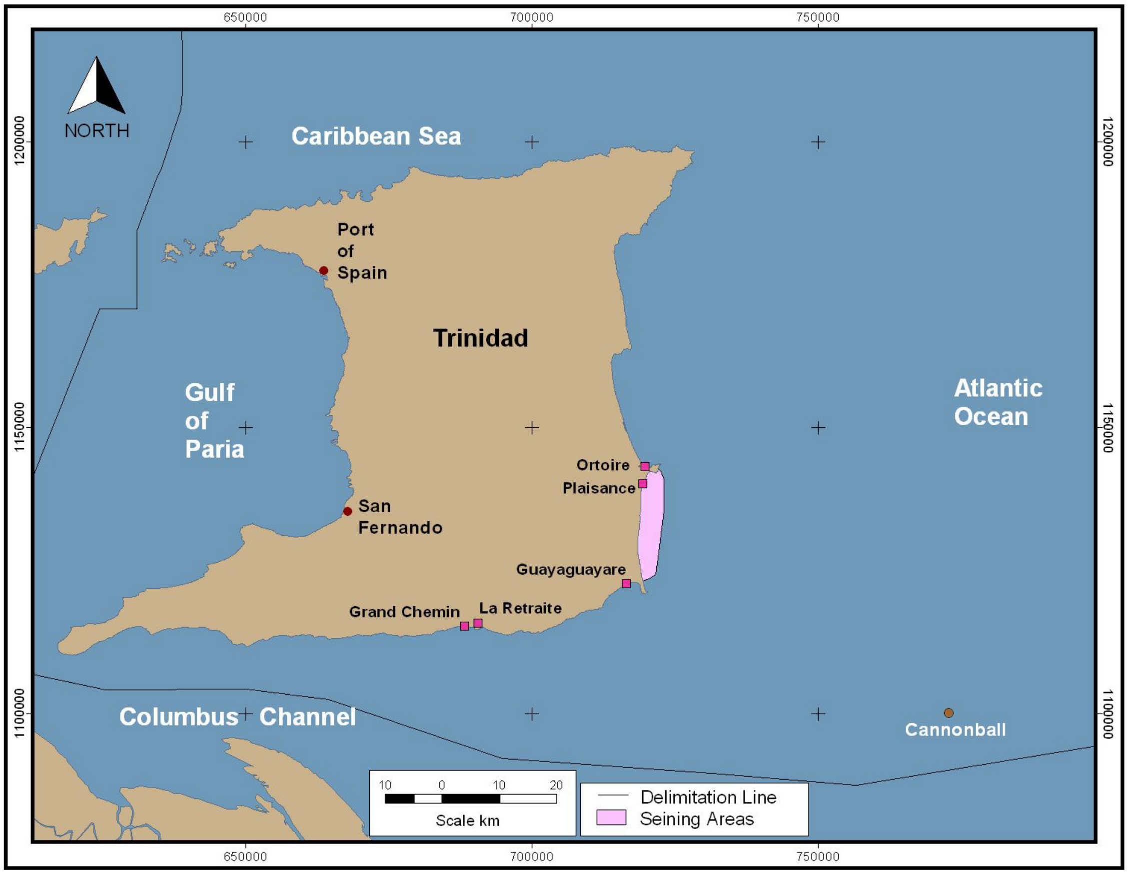

Figure 4.38: Seining Areas (Fisheries Division, 2002)

Seining is practiced along the beaches between Plaisance to Guayaguayare. Fish are caught in the nearshore within the first 10m to 15m of water from the shoreline (Figure 4.38).

Line fishing is concentrated on the east coast between Pt. Cumana in the north to Plaisance south of Pt. Radix (Figure 4.39). There are also several smaller pockets of areas scattered along the south coast up to Gran Chemin and in deeper waters off Pt. Galeota.

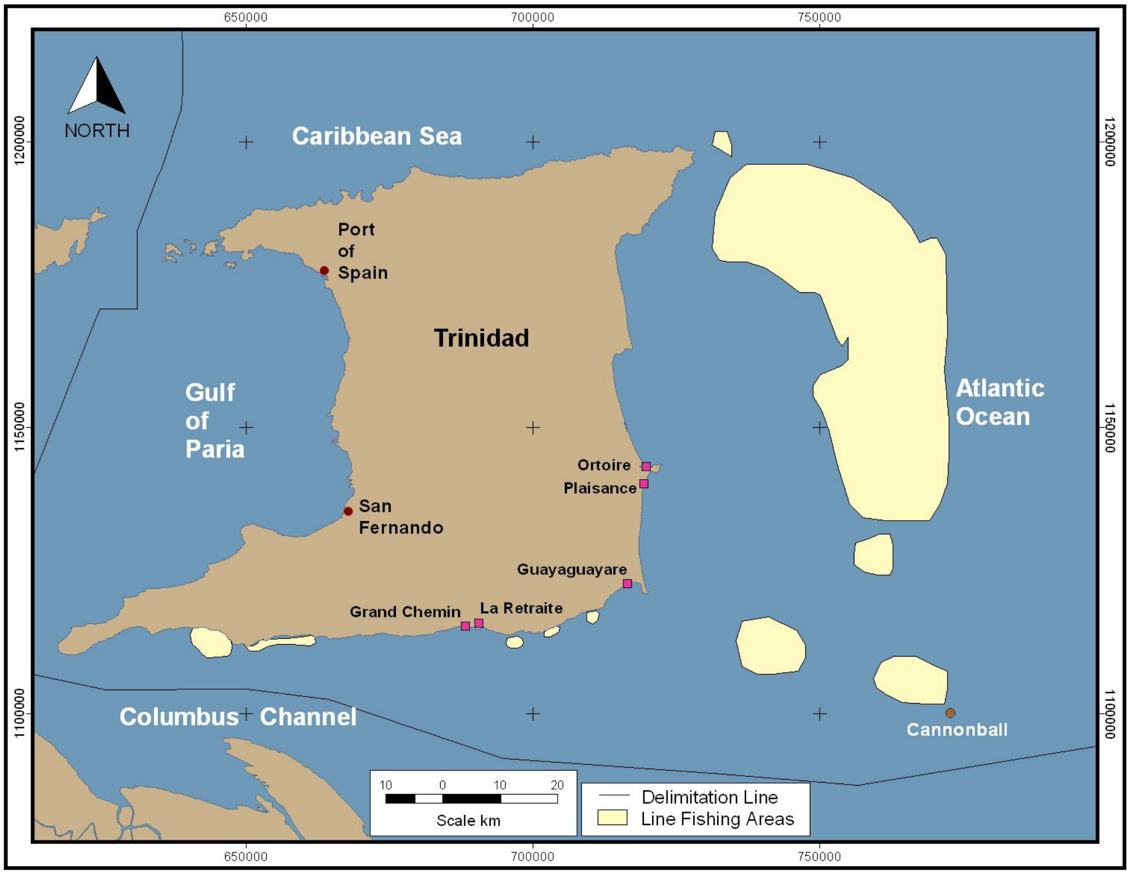

Figure 4.39: Line Fishing Areas off the East Coast of Trinidad (Fisheries Division, 2002)

Gillnetting is concentrated mainly along the northern portion of the east coast extending from Toco in the north to Plaisance south of Pt. Radix (Figure 4.40). There are also several smaller pockets located between Plaisance and Guayaguayare and in deeper waters off Pt. Galeota.

With the exception of beach seining, there is direct overlap between many parts of these fishing areas and oil/gas activities along the east and southeast coasts. Overlap is more extensive between the gillnetting fishing areas in the deeper waters located off Pt. Galeota, line fishing areas along most of the east coast and the deeper waters off Pt. Galeota, and fish pot fishing areas. Although by law trawling should not be taking place along the east coast, many interviewees indicated sightings of Venezuelan trawlers, particularly in the deeper waters off the southeast and south coasts of Trinidad (Fisheries Survey 2003).

Table 4.34 below shows the commercially exploited species for the east and southeast coast of Trinidad.

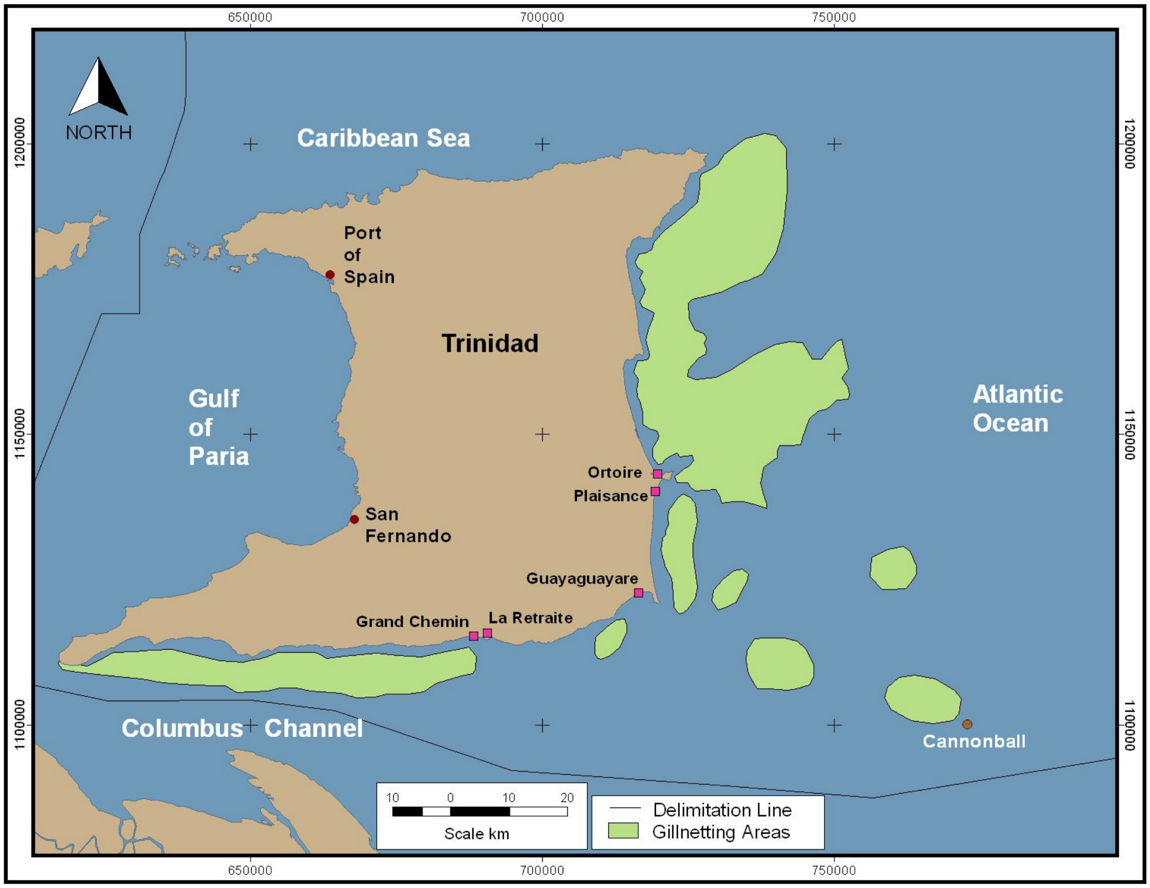

Figure 4.40: Gillnet Fishing Areas for the East Coast of Trinidad (Fisheries Division, 2002)

Table 4.34 :Species List of Commercially Exploited Species in the East and Southeast Coast Fisheries

Family	Scientific name	Local common name	Source
Finfish			
Ariidae (D)	*Arius or Bagre spp*	Catfish	bpTT 2003; FD 2002
Batrachoididae (D)		Crapaud fish	bpTT 2003
Carangidae (P)	*Caranx hippos*	Cavali	bpTT 2003; FD 2002
Carangidae (P)	*Selene spp.*		Stromme & Saetersdal
Carangidae (P)	*Chloroscombrus chrysurus*	Plato	bpTT 2003; Stromme & Saetersdal
Carangidae (P)	*Elagatis bipinnulata*	Salmon	bpTT 2003; FD 2002
Carangidae (P)	*Decapterus spp*		Stromme & Saetersdal
Carangidae (P)	*Oligoplites saurus*	Zapate	bpTT 2003
Carangidae (P)	*Selene brownii*	Moon shine	bpTT 2003; FD 2002
Carangidae (P)	*Selene setapinnis*	Moon shine	bpTT 2003; FD 2002
Carangidae (P)	*Trachinotus spp*		Stromme & Saetersdal
Carangidae (P)	*Trachinotus cayennensis, T. falcatus*	Pompano	bpTT 2003; FD 2002
Carangidae (P)	*Trachinotus goodei, T. lathami*	Jack, pompano, zelwon	bpTT 2003; FD 2002
Carcharihinidae (P,D)		Shark	bpTT 2003; FD 2002
Clupeidae (P)	*Pellona harroweri, Chirocentrodon bleekerianus; Opisthonema oglinum; Harengual jabuana; Sardinella aurita*	Sardine	Stromme & Saetersdal
Engraulidae (P)	*Anchoa spp.; Anchoviella spp.; Engraulis spp*	Sardine	Stromme & Saetersdal
Haemulidae (D)	*Haemulon plumieri*	grunt	bpTT 2003
Haemulidae (D)	*Haemulon sp.*	Grunt	bpTT 2003; Stromme & Saetersdal
Lutjanidae (D)	*Lutjanus griseus, L. jocu*	Pargue	bpTT 2003
Lutjanidae (D)	*Lutjanus spp*	snapper	bpTT 2003; FD 2002
Lutjanidae (D)	*Lutjanus synagris*	Lane snapper	Stromme & Saetersdal
Lutjanidae (D)	*Lutjauns purpureus*	Redfish, red snapper	bpTT 2003; FD 2002
Pomatomidae (P)	*Pomatomus saltator*	Ancho	bpTT 2003; FD 2002
Sciaenidae (D)	*Micropogon furnieri*	Cro cro, Racando, Whitemouth croaker	bpTT 2003; FD 2002
Sciaenidae (D)			Stromme & Saetersdal
Scombridae (P)	*Euthynnus alletteratus*	Bonito	bpTT 2003; FD 2002
Scombridae (P)	*Katsuwonus pelamis*	Bonito	bpTT 2003; FD 2002
Scombridae (P)	*Scomberomorus brasiliensis*	Carite	bpTT 2003; FD 2002
Scombridae (P)	*Scomberomorus cavalla*	Kingfish	bpTT 2003; FD 2002
Serranidae (D)	*Epinephelus itajara*	Grouper	bpTT 2003; FD 2002
Sphyraenidae (D)	*Sphyraena guachancho*	Bechine	FD 2000
Trichiuridae	*Trichiurus lepturus*	cutlassfish	bpTT 2003
		Conger eels	bpTT 2003
		Mix fish	bpTT 2003; FD 2002
Shellfish			
Panularidae (D)	*Panularis sp.*	lobster	bpTT 2003; FD 2002
Portunidae (D)	*Callinectes danae*	Crab	bpTT 2003
Reptiles			
		Turtle	bpTT 2003

D = demersal; P = pelagic

4.5.4. Description of Fishing Port in the Study Area

From the results of the survey, fishers from five fishing ports use the study area. These fishing ports are:

- Along Trinidad's east coast:
  - Ortoire
  - Plaisance
- Along Trinidad's southeast coast:
  - Guayaguayare Seawall
  - La Retraite
  - Gran Chemin

Please refer to Figure 4.37 to see the locations of these fishing ports.

Each fishing port was investigated through a series of interviews with the fishermen there. The following information was obtained regarding each fishing port:

1. The Physical Characteristics
2. The Socio-Economic Characteristics
3. Number of vessels and description
4. Type of fishing practiced at this port
5. Reported Value of the fishing gear
6. Reported Schedule of the vessel activity
7. Targeted Fish Species

A comprehensive report of the above fishing port investigations is given in the complete Fisheries Report in Appendix J.

4.5.5. Fishermen's Perception of bpTT and the general oil and gas industries

Fishers spoke of the interaction between the petroleum and fishing industries based on their experiences. The fishers have experienced positive, negative and neutral interactions with activities associated with the offshore oil and gas industry (Table 4.35).

Table 4.35: Summary of Fishers' Reported Perceptions of the Interrelations with Oil/Gas Operations and Operators – Positive Perceptions

Nature of Interaction	Description
Positive	**Oil/gas platforms act as fish attracting devices (FADs)**
	▪ Platform infrastructure provides extensive surface are for attachment of 'food organisms', which are fed upon directly by targeted species such as groupers and red fish ▪ Shoals of smaller fish aggregate under platforms to feed and shelter providing food for larger fish such as sharks ▪ Food and other garbage thrown into the water from the platforms also provides food, which attract fish ▪ Lights and flares from the platforms attract fish, particularly at night
	Interaction: Fishers have developed a tradition of fishing around platforms to take advantage of the abundant fish populations found there
	Oil/gas platforms provide refuge in the event of adverse circumstances
	▪ Contractors/platform employees provide assistance (food, water) to fishers in distress ▪ Platforms are used as shelters in the event that fishers are caught at sea in inclement weather conditions ▪ For fishers operating without GPS devices, platforms are used as marine markers to guide fishers safely during their operations
	Interaction: Fishers depend on platforms or personnel on platforms to facilitate their safety at sea
	At least one oil/gas operator coordinating with fishers to develop standard identification markers for artisinal fishing vessels and gear
	▪ Joint fishers and oil/gas operator committee formed to assess reasons for occurrences of accidents between vessels operating with oil/gas operators and artisinal fishing vessels ▪ Opening communication lines and re-establishing a 'healthy' relationship between fishers and the oil/gas operator ▪ Oil/gas operator providing fishers with specialized lighting devices to enable identification of fishing vessels and gear (especially at night) to minimize occurrence of accidents
	Interaction: Relationship building between oil/gas operator and fishers at 3 fishing ports – Ortoire, Plaisance and Guayaguayare

Table 4.36: Summary of Fishers' Reported Perceptions of the Interrelations with Oil/Gas Operations and Operators – Negative Perceptions

Nature of Interaction	Description
Neutral	None reported
Negative	**Enforcement of "no access zone" within a 750 m radius around offshore oil/gas installations**
	▪ Areas around platforms, which usually attract high densities of prime commercial species (red fish, shark, grouper, kingfish) are not accessible to fishers
	Interaction: Fishers must increase their catching effort, including time at sea, distances traveled, expenses for fishing trips
	Accidents between fishing vessels or fishing gear and large vessels associated with oil/gas activities
	▪ Supply boats or seismic surveying vessels damage fishing gear, particularly fish pots and surface set gillnets ▪ Supply boats operating on autopilot, particularly at night, collide with fishing vessels or fishing gear resulting in damage or loss of property
	Interaction: Loss of fishers property; risk of injury or loss of human life
	Fishers not held in high regard
	▪ Unfriendly attitude (including spraying down with water, verbal abuse, assault with garbage and other objects) of platform personnel when fishers approach platforms
	Interaction: Fishers not held in high regard
	Traditional fishing grounds reduced by development of offshore oil/gas industry
	▪ Oil/gas installations are being developed in areas historically known to be rich fishing grounds ▪ Each additional oil/gas installation increases the size of the no access area within the fishery effectively reducing traditional fishing grounds ▪ No alternatives are developed (e.g. construction of artificial reefs) to encourage fish to move to other areas that remain accessible to fishers ▪ Shipping lanes cross natural fish migration paths, often giving rise to risk to accidents between fishers following a school of fish and larger vessels operating within the area
	Interaction: Gradual displacement of fishers by oil/gas operations
	Oil spills or other chemical spills for oil/gas installations
	▪ Oil spills or other chemical waste outputs for oil/gas operations soil fishing gear, often making them visible to targeted fish species resulting in reduced catch; contaminating catch already in the gear making them unsuitable for markets; and causing 'additional' cost to fishers for repair/replacement of gear ▪ Reports of oil spills, other chemical spills and fish kills result in reduced revenue to fishers and fish vendors as consumer demand falls ▪ Oil spills or other chemical waste outputs causes fish to migrate to other areas, sometimes resulting in fishers needing to increase catching effort
	Interaction: Loss of income to fishers as a result of increased cost from loss of property; reduced revenue earnings from increased catching effort or reduced market demand

5 SOCIO-CULTURAL AND ECONOMIC IMPACT ASSESSMENT

5.1 INTRODUCTION

5.1.1 Rationale

An assessment of the socio-economic conditions in the study area is an integral part of the environmental impact assessment process. This assessment will determine the direct and indirect impacts or implications of project activity on the socio-cultural and economic activities in the study area. More importantly, it allows *a priori* for the identification of mitigatory measures if any adverse impacts are identified.

The study area for the Socio-Cultural Resources Section includes the immediate study area, of the five villages of Guayaguayare, La Savanne, Grand Lagoon, Radix and Mayaro. These villages were closest to the project site and the wider study area of the Mayaro/Guayaguayare Region which include the 14 villages, from Ortoire in the north to Guayaguayare in the south and Union Village in the west.

The study area is situated in the County of Nariva/Mayaro within parts of the wards of Trinity and Guayaguayare. The area is under the administrative jurisdiction of the Rio Claro Regional Corporation. Refer to Figure 5.1.

5.1.2 Terms of Reference

The Environmental Management Authority (EMA) in accordance with the requirements for an application for a Certificate of Environmental Clearance (CEC) for an oil and gas project provided the Terms of Reference (TOR) for this project. bpTT is about to establish an offshore platform for the production of natural gas from the southeast Galeota Block off the East Coast of Trinidad and to modify the gas receiving facility at Beachfield.

The TOR requires a detailed study on the Socio-cultural environment which includes:

- Employment and labour market – indicate opportunities for employment generation and the availability of such employment in the nearby coastal communities.
- Proximity of communities to the project site - this information must be mapped.
- Customs, aspirations and attitudes – indicate the acceptability of the proposed project to nearby communities.
- Road, bridges, traffic in relation to ongoing and future activities.
- Noise and aesthetics.

The TOR also requires the study to determine the potential impacts of the proposed project on human beings (health, safety and employment), infrastructure and utilities.

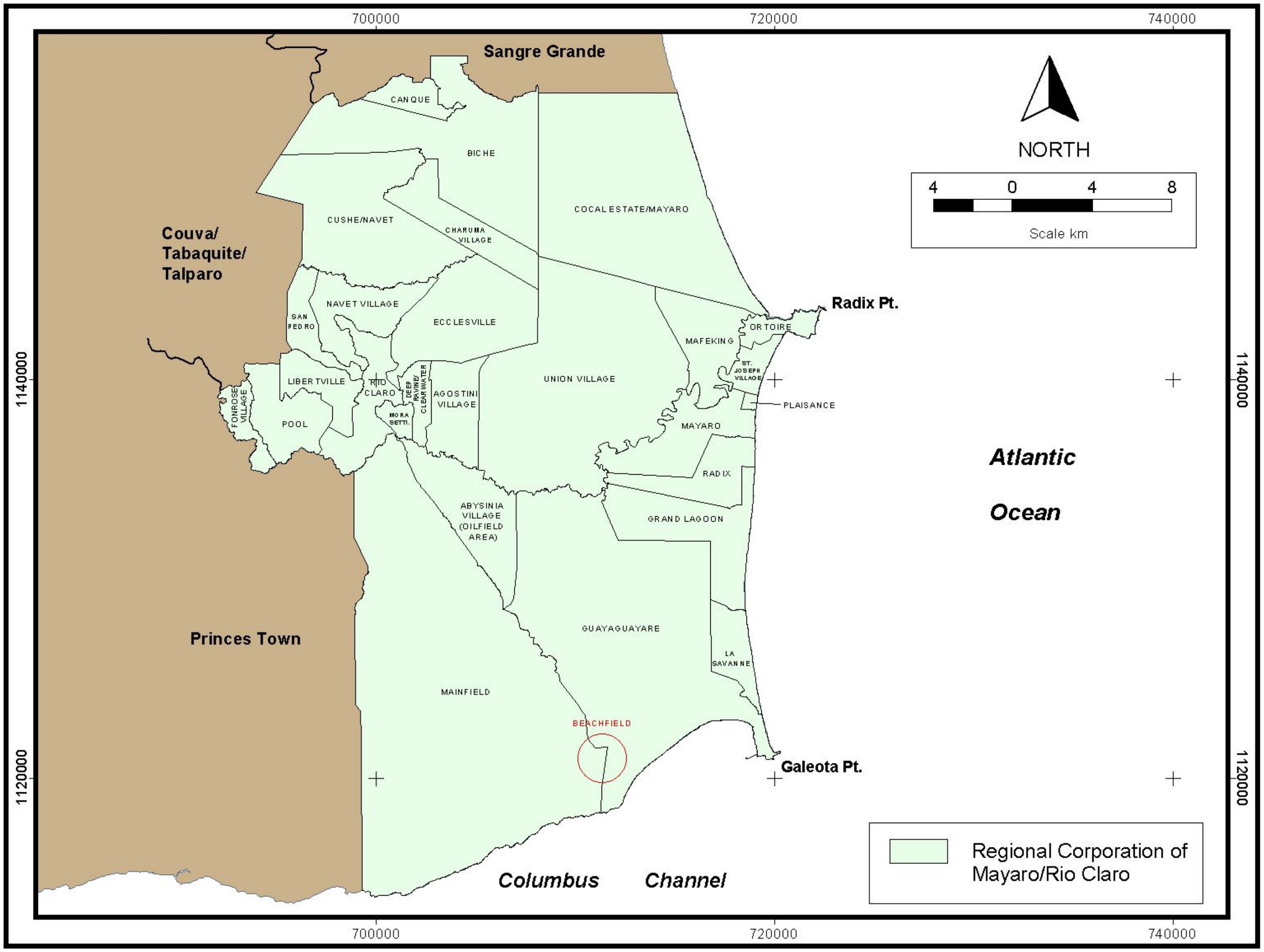

FIGURE 5.1. Description of the Study Area.

5.1.3 Methodology

5.1.3.1 Approach to the Study

The main phases in the conduct of this study were:

- An assessment and analysis of the local environment.
- An evaluation of key resources such as human, social, economic and financial.
- The identification of potential impacts of project activities on the local environment and resources.
- The provision of recommendations to mitigate any adverse impacts identified.

5.1.3.2 Method of Data Collection

In order to complete this socio-economic assessment both primary and secondary data collection methods were used to collect data for the study.

A coastal reconnaissance field trip was conducted to Mayaro/Guayaguayare during the month of October 2003 for the project team to familiarize themselves with the area. This visit allowed the team to make observations and note the quantity and quality of households and institutions in the study area.

A review of the existing literature was carried out to collate documented and published data on the socio-cultural and economic conditions in the Mayaro/Guayaguayare area. Available reports, plans and proposals of various agencies were reviewed. The data collected were used to define the socio-cultural and economic environment, determine the developmental plans for the area and identify potential impacts of project activities on the socio-cultural and economic condition of Mayaro/Guayaguayare.

Interviews and meetings were conducted with a number of representatives from Government and Non-Governmental agencies, commercial and industrial interests. In addition, a number of project meetings were held to discuss the progress of this report and also to discuss any issues pertinent to the socio-economic conditions in the study area.

In the main, these interviews and meetings were formal using an unstructured questionnaire. Appointments were made with officials or representatives from the various agencies to conduct interviews. These interviews were guided by the use of a list of prepared questions. Questions were asked on a number of issues and recorded by the interviewer. It should be noted that the questions on the list guided the interview and as such were not necessarily asked in the same sequential order.

In order to determine the perceptions and attitude of the population in the immediate study area towards the project, a **Systematic Random Survey** was conducted with households in that area. This survey was conducted over an eight-day period from October 13-20, 2003 and included households from Guayaguayare, La Savanne, Grand Lagoon, Radix and Mayaro. A 25% sample was surveyed from the villages in the immediate study area. The head of the household or an adult from one in every five households was interviewed. The data collected was entered on a spreadsheet and statistically analysed.

5.1.4 Limitations

The major limitation encountered in the fieldwork aspects of this study is the lack of dis-aggregated information on social and economic variables on the study area. In most instances, government agencies collected data at the regional or county level as such this data was used in the study. This problem was aggravated by the fact that the various government agencies did not used the same geographic boundaries to define the study area.

5.2 Description of the Study Area

5.2.1 Historical Development of Mayaro/Guayaguayare

5.2.1.1 Mayaro

Although Mayaro's historical roots can be traced to an Arawak settlement[1], it was in the years immediately following 1783 that many parts of the island developed as villages. The Spanish King Carlos III issued a royal proclamation or *Cedula of Population*[2], which had a profound impact on the development of villages in Trinidad. In the aftermath thousands of Caribbean French planters and their slaves settled and developed estates in Trinidad including estates along the Mayaro Coast.

Mayaro was isolated from the rest of the country as there were no roads, bridges or tracks leading to this area. The area was covered with virgin forest. The settlers travelled to and from the area by sea; the sea was also used to transport items produced in the area. In 1849 Lord Harris introduced a system of counties and wards with commensurate rates. Mayaro started to develop with limited facilities such as schools, post offices and churches. By the end of 1889, a police station was established in Mayaro. Radix developed as the village centre of activity with a settlement developing on the St Joseph Estate and Plaisance Estate. Although there were these two settlements Radix remained the centre of population and focal point of Mayaro.

By the end of the century, many coconut estates developed in Mayaro. Coconut plantations flourished along the coast. Evidence of this palm-fringed signature of Mayaro coast can still be seen today. Fishing was also a main activity in the area.

In the early 19th century Pierreville or 'Quarters' was fast becoming a village. By 1917, many of the Government buildings were located in Pierreville. Another significant

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[1] The name Mayaro is an Arawak name referring to the place where the Maya plant grew in abundance.

[2] The *Cedula* granted 32 acres of land to each white person of either sex or half that quantity of land for each slave the settlers shall induce. Free Negroes and persons of colour were to receive 16 acres each with an additional half for each slave introduced by them. Anthony, M. (1975) Profile Trinidad - A Historical Survey from the Discovery to 1900. Macmillan Education.

development, which contributed to Pierreville being the central location at that time, was the widening of the Mayaro Trace into the Naparima-Mayaro Road and the construction of the Mayaro-Guayaguayare Road and the Manzanilla Road. By the completion of this development Pierreville had grown significantly and developed as the focal point of Mayaro.

During the years, and in the more recent past there has been limited development in the area. There has been the construction of some new government buildings including the Civic Centre and Administrative Headquarters. Pierreville remains the focal point of Mayaro.

5.2.1.2 Guayaguayare

It is argued that Guayaguayare holds a unique place in the early history of Trinidad as the part of the island that was first sited by Christopher Columbus. He had promised to name the first land sited after the Holy Trinity (La Trinidad).

Much of the early village of Guayaguayare developed between two rivers (the Lizard River and the Pilote River) and the along the coastal strip. Guayaguayare was almost completely isolated by land with the only route out being along the Mayaro Beach.

Guayaguayare was also well known for its coconut estates and trade. The introduction of the ward system did not have the same developmental effect on Guayaguayare as it may have had on other villages in Trinidad. In fact, two wards were created within the County of Mayaro: Guayaguayare and Trinity. It is noted that the village of Guayaguayare did not fall within the ward of Guayaguayare.

It was not until the end of the 19th Century with one of the most significant discoveries in the country that the village became known. Although there was evidence, of deposits of oil in the forest in Guayaguayare from as early as the 1870s it was not until Randolph Rust began to prospect for oil that the possibility for commercial drilling began.

5.2.2 Historical and Archaeological Sites

According to an inventory of archaeological sites conducted by the University of the West Indies[3], there are some twelve (12) archaeological sites identified in the wider study area. The location of these sites is along the coastline. The proposed project will not impact on any of the archaeological sites located in the study area.

5.2.3 Social Demography

The Central Statistical Office 2000 Population Census data revealed that there were 32,143 persons in the Mayaro/Rio Claro Regional area with 16,642 (51%) of the population male and 15,501 (49 %) female. This population is housed in some 8,514

[3] University of the West Indies, Department of History and Inventory of Archaeological Sites in Trinidad and Tobago

households. The immediate study area comprises 2,158 households or 25% of the Mayaro/Rio Claro area. There are 7,851 persons of which 3,976 or 51% are male and 3,818 or 49% are female. This reflects an almost even distribution of the sexes in this region.

TABLE 5.1: Population and Number of Households in Mayaro/Guayaguayare Area

COMMUNITY DESCRIPTION	NO. OF HOUSEHOLDS	POPULATION		
		Both Sexes	Male	Female
Mayaro/Rio Claro	8514	32143	16642	15501
Mayaro/Guayaguayare*	3000	11000	5610	5390
Grand Lagoon	324	1174	622	522
Guayaguayare	467	1659	862	797
La Savanne	258	919	461	458
Mayaro	683	2558	1249	1309
Radix	426	1541	782	732
	2158	7851	3976	3818
			51%	**49%**

* Population and Household data for the wider study area
Source: CSO, Population and Household Census 2000.

The population of the study area is relatively young. The dependent population, which comprises of persons between the ages of 0-15 years old and persons over 65 years old, represents about 43% of the population. In fact, there are 13,119 or 36% of the population between the age groups 0-15 years and 2,591 or 7 % over 65 years. These figures[4] were not available in a disaggregated form for each of the villages in the immediate study area but were assumed to be representative of the area.

Generally this area is under-populated, with a population density of 40 persons per square kilometer. This figure is significantly lower than the average population density of 237 per square kilometer for Trinidad and Tobago. This relatively depressed rural area has a lower than average national standard of living. Again it is noted that data on the economic welfare indicators were not available in a dis-aggregated form for the immediate study area. The most recent official statistics were available for the county of Nariva/Mayaro. The data revealed that the average gross monthly income of TT$ 2, 438 is marginally higher than the average monthly expenditure of TT$ 2, 097, both of which are below national average which are recorded at TT $ 3, 850 and TT $ 3, 157 respectively.[5]

The county of Nariva/Mayaro was reported among the geographic areas in the country with the lowest average monthly household income. This situation is exacerbated by the fact that households where the head of the household worked as an agricultural, forestry

[4] CSO, Annual Statistical Digest 1999
[5] CSO, 1997/98 Household Budget Survey Report Volume II

or fishery worker had the lowest incomes nationally. Households where the head was unemployed experienced even greater disparity as these households reported incomes 58.3 % below the national average. Given these findings it can be deduced that the communities of the immediate study area are among the poorest rural communities in Trinidad and Tobago.

There is a high correlation between the unemployment and poverty. In a paper[6] examining poverty in Trinidad and Trinidad this was clearly illustrated in a geographical map of the poor and the unemployed. The study recorded an unemployment rate for Nariva/Mayaro at that time (1994) of 18.1% with a corresponding poverty rate of 38.7%. Although, more recent poverty statistics are not available and given that there has been limited changes in the region, this correlation is still expected to exist in the area. It is noted however, that many of the poor in Trinidad and Tobago are considered terminally[7] poor and as such with changing circumstances, their state can be reversed. Thus in an attempt to treat poverty, it becomes necessary to reduce the level of unemployment.

Living conditions and the standard of living of the members of the community were also determined by the quality of their household and access to basic amenities. The 1997/1998 Household Budget Survey Report showed that most of the households in the Mayaro/Guayaguayare area are constructed from wood. In addition, 86% of the population receives a supply of electricity to their households while only 37 % had access to telephone and 44 % receives pipe-borne water.

A high level of illiteracy among the population and the continuous rural-urban drift of the working age population (as they seek to avail themselves of better opportunities in the urban centres) aggravate the socio-economic conditions in the study area.

5.2.4 Economic Conditions

5.2.4.1 Overall Economic Conditions in Trinidad and Tobago

The Social and Economic Policy Framework 2004 indicated that the Energy Sector is the main engine of growth and development and a key source of investment funds and business opportunities. The economic conditions in the Trinidad and Tobago appears to be strong with the energy sector characterized by favorable developments, new oil and gas discoveries and expansion in downstream industries accounting for its strength.

The economy is projected to grow by 6.7 percent due to Liquefied Natural Gas (LNG) operations supplied by bpTT to Atlantic LNG.[8] This projected growth rate of 6.7 percent is strong compared to growth rates of the previous years 2002 (4.6 percent) and 2001 (2.8

[6] Ragoonath, Bishnu. Administering to the Poor: Reconciling the Poverty Crisis in Trinidad and Tobago, Latin American Studies, 15 1997. Page 37.

[7] The terminally poor group includes persons whose poverty can be terminated with instances of changing circumstances in the economy or society as defined in Ragoonath, Bishnu. Administering to the Poor: Reconciling the Poverty Crisis in Trinidad and Tobago, Latin American Studies, 15 1997. Page 32.

[8] Review of The Economy 2003

percent). It was also highlighted that the overall decline in the rate of unemployment was a significant contributor to the development of the economy. There was a marginal increase in the unemployment rate from 10.8 percent in 2001 to11 percent in 2002 but by the third quarter of 2003 it declined to 10.3 percent. This overall fall can be directly related to jobs created in Community Services, Social and Personal Services and Petroleum and Gas Sectors.

The Energy sector with a significant contribution of 25% to GDP is one of the major sectors to stimulate growth in the economy and hence the Government has decided to use this sector to create the conditions necessary for long-term development for the people of Trinidad and Tobago.

Government's Plans for the Energy sector includes:

- Implementing of a new fiscal regime for the Oil and Gas Sector.
- Inviting international oil companies to bid for exploration and producing of hydrocarbons locally.
- Promoting local participants in the Energy Sector so that they will continue to stimulate oil production from existing wells located both offshore and onshore.
- Transforming the economy from an oil-based to a gas-based economy.
- Using downstream industries to create sustainable employment e.g. construction of a new ammonia and methanol plant.[9]

5.2.4.2 Economic Conditions in Mayaro/Guayaguayare

The administrative area of Nariva/Mayaro is a hub of economic activity in Trinidad and Tobago. The town of Mayaro is the main commercial centre, with limited administrative activities. The main economic activities in this area are the production and distribution of oil and gas, commercial fishing, agriculture, domestic tourism and commercial activities (small and micro enterprises). It was highlighted in The Review of the Economy 2003 that the Energy sector had a growth rate of 10 percent in 2002 and 9.5 percent in 2003. This resulted in a marginal decline in revenues from this sector. However, the overall contributions from this sector are increasing.

The Mayaro/Guayaguayare communities accommodate about five (5) oil and gas companies, which specialize in exploration, production and distribution of oil and gas. bpTT is the major player among the large enterprises in the area. Recent discoveries by the company in the Red Mango, Kapok and Flamboyant fields accounts for 7 trillion cubic feet of natural gas. bpTT supplies most of the country's demand for natural gas.

There are also about 35 service contracting companies in the study area, which supply oil and gas companies with the necessary skills for labour and ancillary services. It is noted that Mayaro residents own 9 of these companies[10]. In most instances these companies are

[9] Social and Economic Policy Framework 2004
[10] SBDC\OAS. Community Assessment Number One Page 20.

sub units of companies based outside the area and are located mainly in the New Lands village and Galeota areas. The companies provide employment for the communities' limited skilled and largely unskilled labour force. Although it is recognised that these companies employ residents from the area, the exact number or the percentage of those employed is not available.

Mayaro/Guayaguayare is also well known for commercial fishing. A sample survey of the population revealed that about 23% of the population earns a living from fishing, thus fishing is considered to be one of the main economic activities of Mayaro/Guayaguayare. Refer to Appendix J - Fisheries Survey.

Prior to the 1970s agriculture and specifically coconut cultivation was the most important contributor to the development of the area. At that time the agriculture sector was the major employer in the area. However, with higher wages offered by the oil sector, there was a shift of workers to the oil sector with little hope to return to agriculture.

The most recent data available indicate that there is 443 farmers in Mayaro/Guayaguayare involved in coconut, citrus, cocoa, watermelon and vegetable production[11]. There are a number of abandoned coconut estates and undeveloped agricultural lands in the area. There have been some attempts at rehabilitation but this has been on a small scale. There are still a few large estates in the area under coconut production, although there has been a steady decline in the industry for a number of years. In many instances these large estates target the fresh coconut water market.

There has been a resurgence of the level of domestic tourism activities in the area. A direct result of this interest has been increased construction of new homes, guesthouses and restaurants. There is also a planned resort development for the area. Outline planning approval was received to build a 5 star, 300-room, all-inclusive resort.

The economic activities in the area have generated some additional spin-off activities in the service sector in particular. This increase economic activity is seen in the increase number of resident owned businesses. Recent data revealed 142 businesses are located along the major road network. These businesses tend to be involved in retailing of alcohol and food and the restaurant business. In addition, a few members of the communities engage in house rental as a major source of income. Overall, there has been an increase in economic activity in Mayaro/Guayaguayare for the past five years. However, this increase in economic activity has not filtered down to members of the community on a whole.

[11] SBDC\OAS Community Assessment

5.2.4.3 Level of Employment

The unemployment rate in the economy for 2001/2002 was 10.12 percent with the highest rate recorded among 20 - 24 age group. The rate for males increased from 7.48 percent to 7.53 percent from 2002 to 2003 while the rate for females increased from 14.19 percent to 14.25 percent[12].

The unemployment rate in Nariva/Mayaro was recorded at 15 % in 2002/2003 with the highest rate recorded among the 20-24 age group. It is noted that the female population in the area experience a consistently higher rate of unemployment than their male counterparts. Although the unemployment data for the five communities in the study area is not readily available, the rate of unemployment in these communities is anticipated to be consistently higher than the national average. The survey results also revealed an unemployment rate of 11% in the Mayaro/Guayaguayare area that is above the national average.

5.2.4.4 Sources of Income

The main source of income identified from the survey was from self-employment. The persons who fell into this category represented fishermen, farmers and business owners (shop-keepers, land-lords, restaurant owners). Approximately 27% of the persons surveyed were self-employed while 22% worked for a monthly income. Monthly income earners were mainly public servants. The rest of the surveyed population either worked for wages and salaries, other sources of income or received social benefits.[13]

The Household Budgetary Survey 1998, on the other hand revealed that the main source of income from Nariva/Mayaro was monthly with the average income earned recorded at TT $2834. It was also revealed that wages and salaries was the second major source of income in the district. This variation in the statistics implies that the majority of the monthly paid working population came from communities in the wider study area Mayaro/Guayguayare.

The Socio-Economics variables are presented in summary tables in Section 5.6.

[12] Review of The Economy 2003
[13] Other sources of income were pensioners, painters and masons.
Source: Questionaires

TABLE 5.2: Sources of Income of Households in the Immediate Study Area						
	Total	Guayaguayare	La Savanne	Grand Lagoon	Radix	Mayaro
Population	540	117	81	59	119	164
Self-employed	134	28	32	18	23	33
Wages & Salaries	95	18	7	6	29	35
Monthly	108	12	11	17	26	42
Social Benefits	9	6	2	0	1	0
Other	81	25	7	5	26	18

Source: Survey data, October 2003

5.2.5 Social Services and Infrastructure

5.2.5.1 Education

The study area is served by 5 primary schools. At the secondary level there is one school: The Mayaro Composite School.

5.2.5.2 Health

The study area is serviced by 2 health centers. These health centres provide primary health care services to children and adults. Some of the more common services provided by these centres include pre-natal, ante-natal, child welfare, dental services and chronic diseases.

In addition to the health centres there is the Mayaro District Hospital Facility, which provides an outpatient clinic. This facility provides a wider range of services and handles more severe causalities than the health centres. Some of the more common services provided by this facility include accident and emergency, x-ray and maternity services. Interviews held with officials at the hospital identified their capabilities. The hospital official noted that there is a staff complement of two doctors and four nurses on day shift while the night shift is operated with a staff complement of one doctor and four nurses. In addition there is always one doctor on call (*personal communication*).

It was also revealed that in cases where the facility cannot handle the severity of injury the patient would be stabilized and/or transferred directly to the Sangre Grande Hospital. The facility is equipped with two ambulances but their roadworthiness is questionable.

The hospital official expressed views that bpTT is well equipped with emergency services having safety as number one on their list of priorities. The official concluded by saying that the hospital response to any crisis in the industry is minimal but if they were ever called upon there is a disaster plan that can easily be activated.

5.2.5.3 Emergency Service

5.2.5.3.1 Police Stations

There is one police station that serves the wider study area Mayaro/Guayaguayare. The Inspector interviewed did not reveal information on the size of staff and the number of vehicles. He noted that the crime rate in the area is very low and as such his staff can deal with the level of crime in the community. He further noted that systems were in place to deal with any sudden outburst of crime. However, an earlier report[14] indicated that on any one shift there is at least 1 corporal and 6 constables. There is also a Criminal Investigative Department (CID) unit, which has 1 sergeant, 1 corporal, and 6 constables.

5.2.5.3.2 Fire Stations

There are no fire stations in the Mayaro/Guayaguayare area. The closest fire station is Rio Claro and this serves the entire region of Mayaro/Guayaguayare. The Rio Claro fire station is situated about 22 km from the town of Mayaro with a response time of approximately ½ an hour to 45 minutes. The strength of the Station is 1 officer and 5 firefighters with a working crew of 1 officer and 4 firefighters and 1 water tanker with a capacity of 10,000 litres of water.

However, it was also revealed that Sangre Grande, bpTT and Petrotrin facilities could provide back-up units. The Sangre Grande Fire Station is located approximately 35 km from the town of Mayaro with a response time of 1 hour to the town of Mayaro and 1½ hours to Guayaguayare. The strength of the Sangre Grande Station is 1 officer and 7 firefighters with a working crew of 1 officer and 6 firefighters, 1 ambulance (at present out of service) and 1 water tender.

bpTT has extensive facilities located at Galeota to service its offshore operations. The facilities include an emergency room, which has 6-8 stretchers, a fire tender, and an ambulance with 2 stretchers. In addition, there is a helicopter service which is normally used to transport employees to the rig platforms but which can be used to fly emergency cases to the general hospital.

Petrotrin also has fire and emergency facilities in Guayaguayare. Petrotrin has a rapid response unit and 1 back-up resource tank at its disposal. Both Petrotrin and bpTT make these services available to the community in cases of extreme emergency.

5.2.5.3.3 Other Service

The financial institutions in the wider study area provide a range of financial products to the community and the business sector. There are 2 banks and the Guayamay Credit Union (formerly Amoco Employees Credit Union). The credit union facility provides services to its members, employees of bpTT, their family and the community. In addition, there is the micro credit facility-Micro Enterprises Loan (MEL) Facility that provides access to a fund for business startup and expansion to micro-entrepreneurs in the

[14] UWI , Institute of Business Breaking the Cycle of Poverty: Opportunities for Sustainable Development of the Mayaro/Guayaguayare Community.

community up to a maximum of $10,000. In addition, there is the bpTT sponsored Mayaro Initiative for Private Enterprise Development (MIPED) which administers a US 1 million dollar fund aimed at building entrepreneurial skills in the region.

There are also a number of governmental agencies located within the study area; this includes the Mayaro Magistrates Court, TTPOST, Mayaro Revenue Office and Valuation Departments, Ministry of Works and a branch of the Mayaro/Rio Claro Regional Office.

The other main organizations that are located in the study area include: Mayaro Public Library, Community Centres, Lion's Civic Centre, Mayaro Public Courts, Mayaro Learning Resource Centre, Mayaro Youth/Sport Facility, and the bpTT financed Mayaro Resource Centre. The bptt Sporting Complex was converted into a resource centre for the community with programmes from the National Energy and Skills Centre (NESC), Metals Industries Company (MIC), the University of the West Indies School of Continuing Studies and the Trinidad and Tobago Hospitality and Tourism Institute (TTHTI).

The majority of available social services are located in the town of Mayaro. The smaller villages are lacking many of these services having access mainly to health centers, recreational grounds and community centers. The village of Guayaguayare recently opened a homework and computer center funded by the Community Development Fund, the Ministry of Community Development and Culture.

5.2.6 Physical Infrastructure

The area is accessible by an existing road network from the major towns of Rio Claro and Sangre Grande. It was observed during the fieldwork that major repairs and resurfacing works were taking place along different parts of the main road for Mayaro to Guayaguayare.

The main hub of transportation in and around the area is provided by taxis, private cars and maxi-taxis servicing the longer route. There is a limited bus service in the area.

The area is served by an electrical supply. Although a large proportion of the population receives an electric supply, reports from community members have indicated that this service is unreliable.

Water supplied to this area is via boreholes. There is a limited scheduled supply to the area with residents receiving water on average 4 days per week. There are 4 main sources of supply of water, one of which is located in the Petrotrin fields. In the area, there is 1 well which provides approximately 900,000 litres per day. This is supplied through a joint arrangement between bpTT and the Water and Sewerage Authority (WASA) where the latter supplies labour required for the operation and maintenance and the former supplies parts and equipment required to maintain the plant.

The area is supplied with telecommunication services. Most of the Government agencies and businesses are equipped with telephones and internet access. However, only 37% of the households in the area have access to the use of telephones. It should be noted that there are public and private institutions such as the Mayaro Public Library, the Mayaro/Guayaguayare Distance Learning Resource Centre and the newly constructed Guayaguayare Homework Centre, which provides access to these services to the community.

The Rio Claro Regional Corporation is responsible for the collection and disposal of solid waste in the study area. The waste is disposed of at the Forres Park Landfill some 50 km away. There is no central sewerage treatment plant in the area. The main method of sewage disposal is via pits.

Overall, there are limited beach facilities in the study area. The existing facilities leave much to be desired in terms of maintenance and upkeep.

5.2.7 Developmental Plan

The Local Area Concept Plan and the Planning Assessment and Scoping Report for Mayaro/Guayaguayare identified the following strengths, weaknesses, opportunities and threats for the area[15].

Strengths

- Off-shore oil and gas resources including 91.4 trillion cubic feet of natural gas reserves could provide the impetus for enhanced industrial activities in the Guayaguayare/Galeota area.
- Established base of oil and gas service companies.
- Available land for developmental purposes.
- Natural beauty and landscape variability.
- Established small-scale local tourism.
- Rich history and sites of archeological importance, which could be incorporated as part of the tourism product.
- Existence of a vibrant community network.

Weaknesses

- Low level of academic attainment and skills.
- Lack of opportunities for training/skills development.
- High level of unemployment.
- Decline in agriculture.
- Limited capability of agricultural lands owing to the nature of the soils.
- Insufficient water resources to meet current and projected needs.
- Poor road infrastructure and linkages outwards to San Fernando and Sangre Grande.
- Lack of appropriate facilities for the treatment and disposal of solid, faecal and oily waste.

[15] As quoted in the SBDC\OAS Community Assessment No 1 pages 16-18

- Environmental problems.

Opportunities
- Development of Galeota as a growth pole for oil and gas based industrial activities, with significant economic benefits accruing to the local population.
- Proposed resort development by Mayaro Business Developers.
- Revitalization of the agricultural sector.
- Sustainable development of the forestry resources and the forging of linkages with the building construction sector.

Threats
- Potential conflict between tourism and industrial development requirements.
- Increase potential for pollution along the coast line arising from oil and gas expansion.
- Downturn of the United States economy, which could result in, reduced demand for oil and gas in the short to medium term.
- Depressed oil and gas prices over a sustained period of time could stifle development potential of the area.

There was limited documented data on the development plans for the area. Although several attempts were made to contact the relevant government agency, limited comprehensive documentation was available. Notwithstanding, there is the Local Area Concept Plan and many of the other private companies and developers have individual development plans for the area.

bpTT has embarked on a comprehensive multi-faceted approach for the development of Mayaro. The Community Economic Development seeks to change the structure of the community and built permanent institutions within the community. bpTT has identified five main ingredients for the successful implementation of their plans. These are Planning and Research, debt or risk capital, equity, human resource development and infrastructure. This has resulted in the company implementing a number of intervention strategies including the commissioning of a number of studies, investment in the Ortoire Mall Project for Fishermen, MIPED, academic, social and vocational training for the community, scholarship programmes and the establishment of a steering committee.

5.3 Discussion of Results

5.3.1 Results of the Survey

The survey data revealed that most households from the five main communities lived at their present homes for over 10 years. A total of 413 of the 491 or 84% of the population interviewed lived at their present homes for more than 10 years. La Savanne had 83% of its population living at their present location while Radix had the smallest number of 69% residing at their present homes for over 10 years.

Most (60.9%) of the residents interviewed from the various communities did not belong to a community organization. Of the community groups identified the Mayaro/Guayaguayare Unemployment Organisation of Concern Citizens (MGUOCC) had the largest membership of 85 out of the 187 persons belonging to organisations. This represented 45% of the population. This group seemed to be the most popular among community members, maybe as their major objectives are seeking employment for the unemployed and addressing issues of concerned citizens.

The major source of income for most of the villagers was self-employment with La Savanne being identified as the village with the largest number of self-employed persons. The self-employed included fishermen, farmers and business owners and represented 44% of the population interviewed in La Savanne. This is high when compared to 26% working for wages and salaries and a monthly income while the rest of the population being either on social benefits, pension or unemployed. This statistic appears even more disturbing as it is noted that over 30% of the household in La Savanne had more than 6 persons living in them.

Mayaro on the other hand had the largest number of households working for a monthly income. Of the total interviewed, 26% worked for a monthly income while 21% worked for wages and salaries and 20% were self-employed. The average number of persons living in a household in Mayaro was 3-4. On the contrary, most households in Guayaguayare (24%) were self-employed with an average size family of 3-4. It was also recorded that a total of 26% of the households worked for either wages and salaries or a monthly income while 34% were either on social benefits, pensioners or unemployed.

Guayaguayare Bay is popular with residents of the five communities for sea bathing, fishing and the collection of chip-chip. Over 80% of the users of the bay in Guayaguayare used it for sea bathing, while 36% used the bay for fishing and chip-chip collection and 22% for recreational activities such as walking and exercising. The largest number of non-users of the bay came from Mayaro and Radix. Fifty-one percent (51%) of the villagers from Mayaro and 58% of the villagers from Radix did not use or had no interest in the use of the bay. This is not surprising given that these villages are further away from Guayaguayare Bay and members of the communities use beaches that are in closer proximity. Overall a total of 53% of the population interviewed used Guayaguayare Bay while 38% did not use it at all.

Residents' knowledge on development plans in the various communities is quite limited. Members of the community seem to have very little interest in what is taking place in their community. A total of 62% of the population interviewed had no knowledge of any developmental plans for the area while the remaining 38% had a basic knowledge, mainly of construction and renovation of community buildings and infrastructural developments.

Their level of awareness of bpTT past projects showed a similar trend as only a small percentage could identify some projects led by bpTT in their community. The projects identified fell into five (5) broad categories namely financial contributions, oil and gas, refurbishing and development of recreational facilities, educational assistance and infrastructure developments. While only 32% of the population was aware of these projects, 68% were not aware of any projects led by bpTT. Of the 32% that were aware, less than half felt that these projects have some minimal impact on their households, way of life, recreation, community and business activities.

The creation of jobs from these projects was highly significant for the community to identify a positive impact on households, way of life and business activities. On the contrary, it was believed that some past projects had a negative impact on recreation and community activities since it led to infrastructural damages mainly to the roads and erosion of the shoreline.

Most households, over 70% were unaware of the Cannonball Field Development Project while an average of 24% was aware. Of the 24% more than half felt that the project will have a positive impact on their households, way of life and business activities while others believed that there would be negative impacts on the community. Among the negative impacts identified were impacts on the livelihood of fishermen, erosion of the shoreline, safety and damage to recreational facilities.

In spite of all the concerns identified about 60% of the community were hopeful of employment and income generation while about 22% thought there would be no benefits to derive from such a project because of its geographical location.

Households in the study area viewed the presence of the bpTT in a variety of ways. Over 36% of the household interviewed believed that bpTT's presence was good in each of the communities since the company assisted with scholarships, recreational activities, transport (bus service), educational, sporting activities and infrastructural developments. However, 24% felt that the company could do much more for the communities and another 2% felt that the company was only interested in its own affairs, depleting the resources and damaging the shore line and another 15% believed that the company is not interested in the community.

Members of the community also pleaded for bpTT to generate more employment opportunities and invest in infrastructural development. In addition there was also an outcry for the company to provide emergency services such as a fire station, the provision of an ambulance, upgrading of police station and a health centre.

5.3.2 Results of Interviews with Stakeholders

This section of the document reports on the consultations and interviews, which were held by bpTT and the Consultants. Generally, at meetings, the attendees were introduced and informed of the Cannonball Field Development Project through a non-technical description of the project followed by an open discussion around the project.

In accordance with the requirements of the Environmental Management Act 2000 and in a bold move beyond compliance of the said Act, bpTT conducted a series of public consultations consistent in line with World Bank Standards specifically to ensure that most, if not all the issues likely to occur as a consequence of the project could be identified and mitigated. bpTT indicated that the EIA would have a strong social assessment component. There would be proper interaction with the stakeholders in a way that's meaningful and sustainable and the company wished to build the capacity of groups to aid the EIA process.

There were some common issues raised at the meetings, which included:

- The Emergency Response Plan
- Disruption of Seabed
- Chemical usage and discharges
- The effects of the project on Marine Life
- Reforestation
- Coastal Erosion
- Length and quality of employment
- Increase in marine traffic
- Disturbance of breeding grounds for fish
- Loss of opportunities for employment owing to unmanned platforms
- Additional Clearance of areas near Beachfield
- Type of Skills
- Contractor management
- Replication of HSE standards by contractors
- Quantitative Risk Assessment
- Lifespan of Pipeline
- Use of Radio Active materials
- Reinstatement of roads, bridges etc.
- Wages in the Industry (must be standardized)
- Cost of project and profits as opposed to community benefits from the project
- Making the ESIA results available to the community in writing

The issues most raised by the stakeholders that were of particular concern:

- **Emergency Response Plan**. In both the individual meetings with groups and the public consultations the stakeholders identified the high health and safety risks the community is continuously exposed to with the laying of gas pipelines, in particular if there are blowouts and the increased risks at Beachfield. In addition, the community identified the lack of adequate health facilities and the absence of a fire station in case there is such a disaster.

- **Creation of employment**. This was another concern raised by the stakeholders. The community was concerned about the implications for employment creation on the unmanned platform. They requested additional information on areas of employment to be created as well as the length and quality of the employment available for community members.

- **Upgrading Of Skills.** Stakeholders further raised the issue of upgrading of skills in the community to access work in the industry. The community questioned the role that bpTT can play in upgrading skills of members of the community so that the can be in a position to be employed by the company or contractors on projects.

- **Environmental Concerns.**
  - **the impact of clearing an additional area at Beachfield,**
  - **impact on the marine life,**
  - **chemical and other discharges during drilling and**
  - **erosion at the coastline.**

The stakeholders were concerned about the likely impacts the project will have on the above-identified areas. Members of the community requested additional information on the drilling process and the use of drilling muds and the likely impact this will have on the marine environment.

The community repeatedly raised the issue of erosion of the coastline and its impact on their property and social activities (beach use).

Fishermen concerns were unique. They identified issues pertinent to the fishing community:

- Employment creation for fishermen during the collection of data by the consultant.
- The increase in sea traffic during the project and potential for damaging nets.
- The disturbance of the breeding grounds for fish.

bpTT's meeting with the **Government Agencies and Statutory Bodies** concentrated on adherence of the company industry standards and on the likely impact of project activities on the natural as well as human environment. The main questions raised by representatives of these agencies were as follows:

- What are the reasons for changing from manned to **unmanned platforms?**
- Will there be need to clear **additional areas** around Beachfield to accommodate the work there?
- Would the **anti-corrosion and hydro-static testing** be done in Trinidad.
- Would there be a separate **Quality Risk Assessment** undertaken?
- Would there be adequate **contractor management** as it relates to Health and Safety Issues?
- Would bpTT ensure that **its standards are replicated** by contractors?
- What is the l**ifespan** of the pipeline?
- Would there be **increase traffic** on sea during the installation of the platform?
- Would there be use of **radioactive** material?
- Has the project catered for the **reinstatement of roads, bridges etc**, after the project is completed?

At both the individual group meetings and the consultations the company provided a response to questions asked or concerns raised. In some cases, where an answer was not readily available the company promised to supply a response to the community at the subsequent meeting, for instance the concerns about chemicals used during drilling. A drilling expert was sourced by the company to address the final consultation.

Further the consultations and stakeholder meetings highlighted that there are problems and issues to be addressed by bpTT, which are beyond the scope of this project. These issues are potential risks to the project.

5.4 Impact of the Cannonball Field Development Project

The Socio-cultural and Economic impacts of this project were assessed using results from review of government documents and technical reports, interviews with community groups and other experts in the field and a systematic random survey on 25 per-cent of the population of Mayaro/Guayaguayare from five communities.

5.4.1 Overall Impacts on the Economy

- Data supplied by bpTT indicated that the project cost an estimated US$136 million and should generate revenue in excess of US $976.4 million over its life. (2006-2020). It is anticipated that these revenues will be realized from 2006 declining significantly over the last 5 years or so.

  On a macro-economic level increase gas finds is expected to increase bpTT's revenue over the life of the project, which would impact positively on the contribution to Government's revenue and GDP. Government's main form of revenue would be from Royalties and Taxes. The increases in government revenue would impact positively on the overall national economy, through government's re-investment into social, economic and infrastructure projects and programmes.

5.4.2 Overall Impacts on the Community

- It was found that the major impact of the project on the community related to the anticipation of the creation of employment for the unemployed members of the community. The announcement of the project to the community tends to create anxiety among members of the community as they anticipate the creation of jobs.

- There is the perception that the project activities will increase the rate of erosion of the shoreline especially along Guayaguayare Bay. This in turn will impact on the many users of Guayaguayare Bay. The survey results revealed that about 53% of the population used Guayaguayare Bay for sea bathing, fishing, collecting chip-chip and recreational activities.

5.4.3 Impacts During Construction Phase

The on-shore (land) activities will be concentrated at Beachfield.

- The construction activities at Beachfield are expected to have a direct impact on the economic conditions of the communities since it is expected to generate employment during the construction phase. It should be noted that the employment created would be on a temporary basis.

- During the construction phase, Beachfield will create approximately 100 jobs (skilled and unskilled) over a 15-month period. The company indicated that the contractor would require 25% to 33% of non-skilled to skilled labour as part of the Beachfield work force. This labour is expected to be sourced from the surrounding communities. Jobs will be created in Civil, Concrete, Structural Steel, Equipment/Mechanical, Piping, Electrical, and Instrumentation[16].

  This increased number of workers, in turn will tend to lead to increased business activity through increasing sales in the shops and parlours, restaurant, local transport, taxi services and housing accommodation.

- The activities of the project were assessed and found to have little or no impact on the social services in the study area during normal conditions. There may be increased demand for financial (banking) services on payday.

- However, under extreme conditions, if a disaster were to take place, the Health and Emergency Services will be impacted on negatively. These facilities do not have the capacity to handle extreme situations. bpTT indicated in cases of serious injury on the site, the company will medi-vac the injured to one of the two general hospitals.

- During the construction phase, there will be temporary disruption of traffic on the roads. The contractor indicated that the equipment would be moved from three points: Port of Spain, San Fernando and Galeota Point. This movement of the heavy equipment is anticipated to start between February and May 2004. There will be a one time mobilization and demobilization of the construction equipment.

[16] Civil: performs grading, excavation for foundations ditch digging for pipeline, outfalls, water catch basins, restoration. Concrete: set concrete forms, install rebar, set anchor bolts, set expansion, joints, pours, grades, finishes and cures concrete. Structural Steel: performs steel layout, fabricates, assemblies, and erects steel structures or components, levels and plumbs the erected steel. Equipment/Mechanical performs equipment installation, leveling and preventive maintenance of the equipment including pre-commissioning of the equipment. Piping : performs piping layout, cutting, fitting and wild out of pipe spools or pipe sections, erects and tie-in the pipe spools, test and make secure the piping configurations. Electrical: performs electrical installation of electrical system including but not limited to cable tray, cable, pre-commissioning the installed electrical system including resistance, continuity and meggar test. Instruments: performs installation of instrumentation system including but not limited to instrument tray, instrument cable and tubing, calibrate all installed electrical system including loop checks and instrument/process control systems check out and functionality.

- The project does not expect to increase demands for utility services in the area. However, it should be noted that the quality of the service of utilities in the area is poor.

- Approximately twelve (12) archaeological sites were identified in the study area. The location of these sites is along the coastline. However, the activities of the project would have no impact on these sites because of the location of the project.

- The major developmental plans in the area consist of the development of the oil and gas industry by bpTT and other oil and gas companies, road construction and repair and the development of Resort in Grand Lagoon. These projects do not seem to be incompatible with the project activities involved in the Cannonball Field Development Project.

5.4.4 Impacts During Operational Phase

The project is not expected to have any adverse impacts on the Socio-Cultural and Economic resources of the study area during the operational phase of the project because the major activities will be offshore.

5.4.5 Cumulative Impact

- There is a negative perception by some members of the community on the number of projects and the limited benefits to the communities over the years. This has translated itself into a negative image by members of the community of the company; therefore, there is limited interest in the projects of the company unless these projects address community needs and expectations. Further, in some quarters the community is suspicious of the company's intent.

- The increasing number of projects in the area by bpTT and other oil and gas companies has brought with it a number of legal/administrative requirements, e.g. the public consultations requirement of the EIA process. While the communities welcome these discussions and the opportunity to be part of the decision making process, information from the preliminary consultation of this project suggests the communities are becoming frustrated by these consultations which in many instances seem to be *a talk shop* and not a *bona fide* avenue to address their concerns.

- At the consultation members of the community raised issues that were not directly related to the Cannonball project but are of importance to the company. In many instances, community members believe it an effective public forum to raise issues and long standing concerns and even to "publicly embarrass or reprimand" the company.

- There will be negligible impact on the overall demands for utilities and social services, in the area. In particular in the case of an extreme condition, the services most likely impacted on negatively are the health and emergency services.

5.5 Recommendations

The following are recommendations provided to mitigate against concerns and adverse impacts.

- BpTT should lobby Government to implement mechanisms and systems to manage the increase revenue so that it can impact on the community. Thus there is need for a government led development plan for the Mayaro/Guayaguayare Region.

- To address the perceptions of members of the community bpTT must continue to have transparent, honest and open dialogue with the communities and community groups. The company needs to develop a plan to address their relationship with the community. bpTT needs to have regular meetings with the community. Supply the community with relevant data in a non-technical form to deal with issues such as the erosion of the coastline.

- bpTT has to advise the contractors to hire labour for the project from the surrounding communities. Contractors can be encouraged to adopt this practice and also be provided with an up-to-date copy of the skills bank list from MGOUCC, the Lions Club and any others that are available.

- The company has to develop a comprehensive emergency response plan and an effective mechanism through which to communicate the plan to the community. This should be a collaborative effort among the oil and gas companies operating in the area.

- A geographic area of greatest risk should be identified and a database on the number of households with special characteristics (in particular households with disabilities and elderly) should be developed and mapped as part of the Emergency Response Plan. The disaster plans of other agencies, especially the Mayaro Regional Health Centre should also be incorporated into the Plan.

  bpTT should lobby Government and other oil and gas companies to up-grade the present health and fire facilities that service the community.

- bptt should insist that the contractor develops a Traffic Management Plan for the movement of equipment to Beachfield and the removal of waste. The details of this plan should be communicated to the community. The requirements should be written into the contract document.

- The Project Manager must have continuous dialogue with the utilities companies in the study area to determine the impact on demand or change in demand for the services during the construction phase of the project.

- bpTT needs to address the concerns of the communities, which are not directly related to this project, especially the legacy and long outstanding issues. bpTT needs to establish a register of the projects, issues and promises associated with their projects and appoint a committee to monitor the company's commitment to resolving the identified concerns, issues and promises

- Given the remote location of Beachfield and the anticipated spin-off impacts on economic activities, the company can sponsor a temporary food court area which adheres to all the public health and safety requirements for a pre-determined number of community based catering companies.

- bpTT should develop a monitoring and evaluation program to monitor the impacts of the project during its Construction Phase, as such, if any unanticipated impacts emerge the company will be able to take corrective measures in a short time frame.

- Given the company's commitment to developing the area the company can:
  Identify areas where persons from the community can be trained to monitor impacts during the project.

- Given the strengths and the opportunities identified for the area by the Local Concept Development Plan especially for oil and gas and tourism, the company should develop a long term sustainable development plan for the community which clearly identifies the areas of intervention by the company for instance projects which will directly impact on employment and the aesthetics of the community. In addition, the company needs to implement short term projects which will address the community's immediate needs.

Other miscellaneous recommendations:

- bpTT should place 2 computers in the Mayaro Resource Learning Centre with the data and the GIS information from the project.

- Train members of the community to understand and use the GIS system.

5.6 Summary of Socio-Economic Variables in the Study Area

GUAYAGUAYARE	
POPULATION	1659
Male	862
Female	797
NUMBER OF HOUSEHOLDS	467
AVERAGE SIZE OF HOUSEHOLD	3 to 4
MAIN SOURCE OF INCOME	Self Employed
MAIN ECONOMIC ACTIVITY	Agriculture, Fishing, Services
NUMBER OF BUSINESSES	78
LEVEL OF UNEMPLOYMENT**	15%
COMMUNITY NEEDS*	Investment in Education
DEVELOPMENT PLANS*	Construction & Renovation of Community Buildings
MAIN COMMUNITY ORGANIZATIONS	MGUOCC , Village Council

* represents data collected from field surveys
*NB. **This figure represents the Nariva/Mayaro District*

LA SAVANNE	
POPULATION	919
Male	461
Female	458
NUMBER OF HOUSEHOLDS	258
AVERAGE SIZE OF HOUSEHOLD	>6
MAIN SOURCE OF INCOME	Self Employed
MAIN ECONOMIC ACTIVITY	Agriculture
NUMBER OF BUSINESSES	24
LEVEL OF UNEMPLOYMENT**	15%
MAJOR COMMUNITY NEEDS*	Infrastructural Developments
DEVELOPMENT PLANS*	Infrastructural Developments
MAIN COMMUNITY ORGANIZATIONS	MGUOCC , Village Council

* represents data collected from field surveys
*NB. **This figure represents the Nariva/Mayaro District*

RADIX	
POPULATION	1514
Male	782
Female	732
NUMBER OF HOUSEHOLDS	426
AVERAGE SIZE OF HOUSEHOLD*	3 to 4
MAIN SOURCE OF INCOME*	Wages & Salaries
MAIN ECONOMIC ACTIVITY*	Agriculture
NUMBER OF BUSINESSES	33
LEVEL OF UNEMPLOYMENT**	15%
COMMUNITY NEEDS*	Educational Investment
DEVELOPMENT PLANS*	Infrastructural Development
COMMUNITY ORGANIZATIONS*	MGUOCC

* represents data collected from field surveys
*NB. **This figure represents the Nariva/Mayaro District*

MAYARO	
POPULATION	2558
Male	1249
Female	1309
NUMBER OF HOUSEHOLDS	683
AVERAGE SIZE OF HOUSEHOLD*	3 to 4
MAIN SOURCE OF INCOME*	Monthly
MAIN ECONOMIC ACTIVITY*	Agriculture, Fishing, Commercial,
NUMBER OF BUSINESSES	99
LEVEL OF UNEMPLOYMENT**	15%
COMMUNITY NEEDS*	Educational Investment
DEVELOPMENT PLANS*	Construction & Renovation of Buildings
COMMUNITY ORGANIZATIONS*	MGUOCC

* represents data collected from field surveys
*NB. **This figure represents the Nariva/Mayaro District*

GRAND LAGOON	
POPULATION	1174
Male	622
Female	552
NUMBER OF HOUSEHOLDS	324
AVERAGE SIZE OF HOUSEHOLD	5 to 6
MAIN SOURCE OF INCOME	Self Employed
MAIN ECONOMIC ACTIVITY	Agriculture, Domestic Tourism
NUMBER OF BUSINESSES	27
NUMBER OF INSTITUTIONS	
LEVEL OF UNEMPLOYMENT**	15%
COMMUNITY NEEDS*	Infrastructural Developments
DEVELOPMENT PLANS*	Infrastructural Developments
MAIN COMMUNITY ORGANIZATIONS	MGUOCC , Village Council

* represents data collected from field surveys
*NB. **This figure represents the Nariva/Mayaro District*

5.7 Stakeholders Interviewed During October 2003 to January 2004

1. Council of Protection of the Environment (COPE)
   October 6 2003

2. Mayaro/Guayaguayare Unemployment Organisation for Concern Citizens (MGUOCC),
   October 9 2003

3. Habitat for Humanity
   October 30 2003

4. LIONS Club,
   October 22 2003

5. Guayaguayare Village Council,
   October 27 2003

6. Ortoire Advisory Board and
   November 05 2003

7. The Fishing Community.
   October 27 2003

8. Government Agencies/ Statutory Bodies including
   - Environmental Management Authority (EMA)
   - Ministry of Environment
   - Ministry of Labour,
   - Ministry of Agriculture, Land and Marine Resources,
   - National Emergency Management Authority (NEMA**)**

   November 06 2003

9. Public Consultation in Guayaguayare Community Centre
   - October 30 2003
   - December 16 2003
   - January 13 2004

10. L. Gairy
    Manager District Health Facility
    November 14 2003

11. K. Gairy
    Training Officer
    Learning Resource Centre Regional Health Authority
    November 14 2003

15. Inspector Submike
    Mayaro Police Station
    November 14 2003

16. W. O'Brien
    Community Development Officer- Mayaro/Guayaguayare District
    Ministry of Community Development and Culture

17. Arrow 1
    Town and Country Planning Division (South)
    Ministry Planning and Development

6. ANALYSIS OF ALTERNATIVES

bpTT considered several potential development alternatives for the Cannonball Field Development Project. The proposed concept chosen for this development is a normally unmanned wellhead protector platform with a 5km long, 26" diameter pipeline connecting to the Cassia "B" Central Processing Hub with onshore modifications to the Beachfield Gas Receiving Facility.

The objective of the Cannonball Project is to deliver the expected gas demand increase associated with 2005 start up of Atlantic LNG Train 4. As we moved through the various project stages, more definition was developed around the alternatives.

The stages discussed here are:

- Appraise Stage
- Select Stage

6.1. Appraise Stage

During the Appraise stage the focus was on the identification of viable reservoirs, which could sustain this deliverability. The options were as follows:

- Interim Options
- Compression
- Develop a new field

Interim Options:

Options from existing infrastructure were identified and evaluated however the main issue was the ability to deliver the gas volumes within the specified time frame

Compression

Compression was not a viable option, as it could not be installed on any of the existing platforms other than the Cassia "B" hub.

New Field Development

Develop a New Field from the current inventory of discoveries. Several criteria were used to evaluate the preferred reservoir, options coming out of this evaluation were:

- The Red Mango and Cashima reservoirs
- The Ironhorse reservoir

6.2. Select

In the select stage, a preferred development concept was identified. An important objective of this stage is to demonstrate that all credible and feasible development scenarios have been considered and methodically assessed in order to develop a clear, comprehensive roadmap for concept selection.

Each Team Leader ranked the concept options according to the following categories:

- Health, Safety and Environment
- Production uptime/Availability
- Operability and Maintainability
- Drilling/Wells
- Subsurface
- Local Capabilities
- Other issues and comments

For each Strategy, the building block options were ranked relative to each other, according to "Low", "Medium" or "High" risk. This ranking was only comparative.

The strategies identified are as follows:

- Drilling Rig
- Cuttings Disposal
- Well Intervention
- Production Well Rates
- Normally Unmanned
- Processing Facilities
- Materials for the fabrication of the Wellhead Protector Platform
- Power
- Overpressure protection
- Blowdown/Purging
- Export: 1 platform vs. 2 platforms

  (Details on the methodology outlined in Appendix F)

The Key issues were:

- Export: Number of platforms
- Normally Unmanned Installation: Visitation Frequency
- Muds and Cuttings Disposal
- Power Generation
- Blowdown
- Sewage Treatment

Export: Number of Wellhead protector platforms

Table 6.1: Number of Wellhead Protector Platform Alternatives		
Options	**Potential HSE Impacts**	**Ranking**
1 platform	• Less pipeline exposure • Low footprint due to minimal infrastructure • Lower emissions and discharges	L
2 platforms	• Increased pipeline exposure • Increased footprint due to increase in infrastructure • Increased emissions and discharges	M

The option chosen for export is a single wellhead protector platform (WPP). Initially when the project kicked off two reservoirs were being considered however one reservoir has been chosen to deliver the required reserves. A single platform will also have a lower impact on the environment as highlighted above.

Operations: Normally Unmanned Installation (NUI) Visitation Frequency

Table 6.2: Normally Unmanned Installation (NUI) Visitation Frequency		
Options	**Potential HSE Impacts**	**Ranking**
Monthly Visits	Higher exposure of personnel to the facility	M
Quarterly Visits	Lower exposure of personnel to the facility	L

The option chosen for visitation frequency is quarterly. This is in accordance with bp's Inherent Safety in Design guidelines, which is aligned to the project's goal of removing personnel from process, reducing personnel safety risk and promoting local capability development within Trinidad and Tobago.

Drilling: Muds and Cuttings Disposal

Table 6.3: Drilling Mud and Cutting Disposal		
Options	**Potential HSE Impacts**	**Ranking**
Transport to shore	Emissions. HSE risks associated with transportation. Onshore disposal is an issue	H
Treat & discharge overboard	Aligned with bp Environmental Expectations if data demonstrates that there are no long term sustained changes to area's baseline	M
Annulus cuttings re-injection	No discharge into the marine environment	L
Dedicated Cuttings Injection well	No discharge into the marine environment	L
Slurry line (to another platform for re-injection)	No discharge into the marine environment	L

The option chosen is treat and discharge overboard within stipulated limits. Currently existing operations discharge muds and cuttings at 6% retention of oil on cuttings (ROC). The Cannonball Field Development project will be discharging muds and cuttings as an interim solution as bpTT continues to monitor on a longer term the impact of muds and cuttings on the marine environment. This approach is in compliance with national standards as well as bpTT's internal strategy.

Power Generation

Table 6.4: Power Generation		
Options	**Potential HSE Impacts**	**Ranking**
Umbilical: Power from Cassia B via sub sea cable	Zero emissions to atmosphere (emissions increases on Cassia B Hub) Smallest footprint	L
Natural Gas Generator set	High emissions from exhaust	M
Diesel Generator set	High emissions from exhaust	H
Solar Power with Gas Generator set	High emissions from the engine exhaust Extremely large footprint due to the solar power cells	M
Micro-turbine Power Generator	Second smallest footprint Lower emissions than gas and diesel engines	L

The option chosen for power generation is a dual micro-turbine unit each rated at 60Kw as the prime source with a third unit as a back up. The microturbines produce lower emissions than existing generators being used on other facilities and it requires low maintenance (refer to the electrical power study in Appendix G)

Blowdown

Table 6.5: Blowdown		
Options	**Potential HSE Impacts**	**Ranking**
Cold Vent	Methane to atmosphere although relatively low volumes (Global warming potential of 21)	M
Ignitable Vent (flare)	Carbon Dioxide to atmosphere (lower Global warming potential)	L

The option chosen for blowdown is a cold vent. It is important to note that this facility will only be venting to atmosphere on three occasions:

- Mobilization and demobilization of the Jack up drilling rig
- Unplanned maintenance
- Emergency blowdown, which only occurs if a fire, is detected.

Continuous venting has been eliminated on this facility.

These options are also evaluated against criteria other than HSE impacts, one important criteria being the development of local capability in Trinidad and Tobago. The flare boom required for flaring would increase the weight of the structure hence reducing the possibility of the facility being fabricated and assembled in Trinidad and Tobago.

Sewage Treatment:

Table 6.6: Sewage Treatment		
Options	**Potential HSE Impacts**	**Ranking**
Marine Macerator	Untreated effluent discharged into the marine environment however volumes are very low (Frequency of use is a maximum of two to three persons per visit approximately 45 gallons per year)	M
Sewage Treatment Unit	Treated Effluent discharged into the sea	L

The option chosen for sewage treatment is the use of an electric toilet with a marine macerator for grinding up solids to approximately 1/8 of an inch. As discussed previously, other criteria are used to evaluate the option such as:

- Safety
- Alignment with the Normally Unmanned Installation concept
- Costs

The use of a marine macerator will reduce the maintenance frequency and allow the visitation frequency of once a quarter to be a possibility. Other existing facilities within bp (NUI Concept) have similar practices, for example: platforms in the southern North Sea, UK. They are also located greater than 12km offshore.

6.3. No Action Alternative

The evaluation of the "No Action Alternative " is intended to determine the environmental state that would exist if the project were not implemented. The Cannonball Field Development Project overall has a moderate impact on the environment both offshore and onshore. If this project did not materialize, the environmental impact would not exist however it is important to note that the areas under development are not greenfield areas but brownfield areas and have already been impacted to some extent.

Cannonball is a relatively small project with a substantial economic impact to the local communities of Mayaro and Guayaguayare as well as the nation on a whole. Implementation of this project would have negative socio-economic impacts for Trinidad and Tobago.

6.4. Summary

The Cannonball Field Development Project had several options ranging from subsurface to specifics for the basis of design. Initially Cannonball was based on the previous project development concept of a small normally unmanned platform. The development concept was always fixed platforms with some latitude around the size and number.

As the project progressed through its different phases many more strategies with options were identified such as:

- Export: Number of platforms
- Normally Unmanned Installation: Visitation Frequency
- Muds and Cuttings Disposal
- Power Generation
- Blowdown
- Sewage Treatment

Options identified for each of these strategies were evaluated against several criteria, HSE being one of the criteria. This analysis was purely comparative but from this evaluation the project was able to screen out those options that were not feasible. The final options chosen are as a follows:

1. **Export: Number of platforms**
   One small fixed platform with a 5km long 26" diameter pipeline to the Cassia B Central Processing Hub

2. **Normally Unmanned Installation: Visitation Frequency**
   Visitation frequency of once per quarter to reduce the interaction personnel will have with the facility hence reducing the overall Health and Safety risk.

3. **Muds and Cuttings Disposal**
   Treat to 6% ROC and discharge muds and cuttings overboard into the marine environment. This strategy is aligned with the bpTT's aspiration of understanding whether there is a long term impact associated with the disposal of muds and cuttings as well as the National standards stipulated by the Ministry of Energy and Energy Industries.

4. **Power Generation**
   Microturbines have been chosen as the preferred mode of generating power mainly because there are low emissions and low maintenance, which is aligned to the strategy of visitation once per quarter.

5. **Blowdown**
   A cold vent has been placed on this facility as a safety feature in the event there is a fire. It is important to note that there is no continuous purge on this facility. The emissions volumes are low as mentioned in Section 3: Project Description.

6. **Sewage Treatment**
   An electric toilet with a marine macerator has been chosen as the preferred means of sewage treatment. This equipment complies with MARPOL regulations for marine vessels. Overall the impact is low as personnel will only be visiting this facility once per quarter and there will be maximum of 10 persons per visit. See section 5 for a detailed discussion on impacts from sewage discharge.

7. SIGNIFICANT ENVIRONMENTAL IMPACTS

This section identifies and evaluates the environmental impacts resulting from the activities of the Cannonball Field Development Project as described in Section 3 - Project Description. This is done through a systematic analysis of the effect of the project on the physical, biological and cultural resources in both the offshore Cannonball WPP area and the onshore Beachfield Gas Receiving Facility area. bpTT has an active Environmental Management System, certified to ISO 14001, with methodologies that have been developed for identification of aspects and impacts and determination of significance or risk.

7.1. Environmental Assessment Methodology

This EIA uses a structured methodology for the identification and quantification (where necessary) of the potential environmental impacts of the Cannonball Field Development Project. The entire Cannonball project was broken down into the following phases:

1. Transportation of the Cannonball Wellhead Protector Platform (WPP) offshore
2. Installation of the WPP offshore
3. Drilling the Cannonball Wells using a Jack-up Rig
4. Installation of the 5km 26" Pipeline between Cannonball and Cassia "B"
5. Operation of the Cannonball WPP and 26" pipeline offshore
6. Construction and modification activities at the Beachfield Gas Receiving Facility in Guayaguayare.
7. Operation of the modified Beachfield Facility

The above phases were further broken down into the key activities, e.g. the drilling of the Cannonball Wells; the activities are anchoring of drilling rig, drilling the wells. For each key activity the environmental aspect can be identified (e.g. discharge of drilling fluids and cuttings). The potential impacts of these aspects were then identified and quantified by applying the following criteria:

- Probability of Occurrence (low, medium, high, continuous)

- Potential Severity of Impact (critical, high, medium, low)

The above criteria are defined and ranked as follows:

Table 7.1: Probability of Occurrence Ranking		
Probability of Occurrence	**Description**	**Ranking**
Continuous	Occurrence is continuous	1
High	Once or more per quarter	2
Medium	Once per year	3
Low	Less than once per year	4

Table 7.2: Potential Severity of Impact Ranking		
Severity of Impact	**Description**	**Ranking**
Critical	Regional/global environmental impacts, severe impacts to sensitive habitat, or impacts to endangered species	1
High	Local offsite environmental impacts/complaints, degradation of sensitive habitat or vegetative community, mortality of individual endangered animal, mortality of a large number of individuals from a key animal species	2
Medium	Local onsite environmental impacts/complaints, temporary degradation to sensitive habitat/vegetative community or mortality of several individuals of key animal species.	3
Low	Low potential of environmental impact or complaints	4

The decision on assigning the severity level (critical, high, medium, low) and probability of occurrence will take into account existing bpTT operational controls.

7.1.1. Environmental Risk Analysis

Risk factors for each aspect/impact are calculated by averaging the numeric value for potential severity and probability of occurrence. For example: if an impact was determined to have continuous occurrence (ranking 1) and a medium severity (ranking 3), the average of the Risk Factor would equal 2 (See Table 7.3).

Table 7.3: Ranking of the Environmental Risk Factor					
		Probability of Occurrence			
		Low	**Medium**	**High**	**Continuous**
Potential Severity	**Critical**	2.5	2	1.5	1
	High	3	2.5	2	1.5
	Medium	3.5	3	2.5	2
	Low	4	3.5	3	2.5

Aspects with a Risk Factor of 2 or less (lower number = higher risk factor) are defined as significant (i.e. those aspects with a risk factor of 1, 1.5 and 2). Additionally, aspects with a Risk Factor of 2.5 resulting from a severity level that is Critical are defined as significant even when the probability of occurrence is Low.

7.1.2. Environmental Aspect Matrix

All the above criteria are summarized in an environmental aspect register or matrix to communicate the assessment results. The significant environmental impacts (as identified as those with a risk factor of 2 and below) will be highlighted. The environmental matrix for all aspects of the Cannonball Field Development Project is provided in Appendix G.

7.1.3. Mitigation and Management of Environmental Impacts

While all environmental aspects of the project are presented in Appendix G, the impacts assigned a significant ranking are discussed in this section. Furthermore, these impacts that are deemed significant by the environmental assessment methodology outlined above have been assigned specific mitigation management procedures that will be discussed in **Section 8 – Mitigation Management Plan.**

7.2. Discussion of Impacts

The impacted areas for the proposed Cannonball Field Development Project can be split into the offshore component, which includes the transportation, installation, drilling and operation of the Cannonball Wellhead Protector Platform, and the onshore component, which includes the construction activities around the Beachfield Gas Receiving Facility, the modifications to the facility and the operation of the modified facility itself. The following sections discuss the potential impacts of the Cannonball Project in detail.

7.2.1. Impacts of transportation of Cannonball WPP offshore

The Cannonball Well Protector Platform is expected to be fabricated at the La Brea Industrial Company (LABIDCO) Fabrication Yard located in La Brea on the western coast of Trinidad. Figure 7.1 below shows the location of the yard and the proposed transportation route to the offshore Cannonball location. The route is approximately 210km long and will take approximately 2 days to transport the platform. The platform will be transported on barges towed by tugboats.

The following impacts have been identified as a result of the transportation of the Cannonball Well Protector Platform offshore:

7.2.2. Water Quality

There will be sanitation and domestic waste discharges from the towing vessels during the transportation. These will include "black" water discharges composed of human body wastes from toilets and urinals and "grey" water discharges originating from showers, sinks, laundries and galleys. The discharge of these substances is controlled by both the MARPOL Convention and bpTT contractor HSE requirements. bpTT will have a representative aboard the towing vessels to ensure that there will be no discharge of these wastes within 20km of the shoreline. Outside this limit, all sanitation wastes will be treated using chemical and anaerobic digestion before discharge. Domestic wastes such as food wastes will be ground up into small pieces (less than 25mm diameter) before being discharged. The discharge of these wastes have the potential to increase nutrient levels offshore but will be localized and diluted due to the high current and wave action offshore. Therefore, minimal impacts on water quality and plankton are anticipated.

Figure 7.1: Probable Transportation Route of the Cannonball Platform Offshore

There will be no discharge of solid wastes such as plastics, metals, paper and wood that are generated during the towing operations. These discharges are prohibited by both the MARPOL Convention and bpTT HSE Contractor requirements. All solid wastes will be collected and shipped to shore for processing and disposal. This environmental impact is not anticipated to be significant.

Any spills of a fuel and chemical nature can impact on the water quality in the offshore marine environment. There will also be indirect impacts on plankton, seabirds, fishes, and air quality through the release of Volatile Organic Compounds (VOC). The impact of the fuel spills is not anticipated to be significant. A list of mitigation measures to minimize this impact has been developed and is included in the Mitigation Management Plan that will govern this Cannonball Field Development Project. This plan is presented in **Section 8: Mitigation Management Plan.**

7.2.3. Air Quality

The towing vessels will emit air pollutants that may negatively affect air quality mainly from the internal combustion sources such as diesel engines and generators. The pollutants include Nitrous Oxides (NO_x), Carbon Monoxide (CO), Carbon Dioxide (CO_2), Sulphur Dioxide (SO_2) and particulate matter (mainly Carbon). The quantity of emissions depends greatly on the state and maintenance of the diesel engines in question. The impact on the air quality is anticipated to be temporary and localized. A list of mitigation measures to minimise this impact has been developed and is included in the Mitigation Management Plan that will govern this Cannonball Field Development Project. This plan is presented in **Section 8: Mitigation Management Plan.**

7.2.4. Fishing Activities

The transportation of the platform will have potential impacts on fishermen's equipment and activities. During the fisheries survey conducted for the Baseline Description of the Environment (Section 4), it was identified that the fishermen were concerned that there maybe destruction to their fishing equipment caused by bpTT vessels operating within the fishing grounds. They also identified that the presence of the vessels in the area during the "crop season", which occurs between November – April, will interfere with their fishing activities.

It is expected that the transport of the platform will occur in May of 2005 and therefore will miss the "crop season. This impact is considered to be temporary but significant. A list of mitigation measures to minimise this impact has been developed and is included in the Mitigation Management Plan that will govern this Cannonball Field Development Project. This plan is presented in **Section 8: Mitigation Management Plan.**

7.2.5. Marine Traffic

There is potential for the transportation of the platform to impact negatively on the marine traffic along the transportation route. This is due to the slow movements of the towing vessels and its inability to respond rapidly to vessels along its route. This environmental impact is not anticipated to be significant. A list of mitigation measures to minimise this impact has been developed and is included in the Mitigation Management Plan that will govern this Cannonball Field Development Project. This plan is presented in **Section 8: Mitigation Management Plan.**

7.2.6. Summary of Impacts

The following table outlines the impact assessment for the transportation of the Cannonball Wellhead Protector Platform offshore.

Table 7.4: Impact Assessment of Transportation of Cannonball WPP offshore

Impacting Aspect	Nature	Duration	Probability of Occurrence	Severity	Significance Ranking
Discharge of sanitation and domestic Wastes	Direct/Indirect	Temporary	4	4	4
Disposal of garbage and debris	Direct/Indirect	Temporary	4	4	4
Spills to Sea	Direct/Indirect	Temporary	3	3	3
Combustion Emissions	Direct	Temporary	4	4	4
Interruption of Fishing Activities	Direct/Indirect	Temporary	3	2	2.5
Interruption to Marine Traffic	Direct	Temporary	4	3	3.5

7.3. Installation of Cannonball Wellhead Protector Platform Offshore

The installation of the Cannonball Well Protection Platform will be conducted using a large lifting crane barge anchored at the offshore Cannonball site. The barge will be anchored using a 12-anchor spread with an approximate radius of 2,195m.

The following impacts have been identified as a result of the installation of the Cannonball Wellhead Protector Platform offshore:

7.3.1. Impact to Benthic Communities

The benthic communities are sessile organisms that live in the upper seafloor sediments and play an important part in the overall food chain that exists offshore. The baseline surveys conducted indicated that the offshore Cannonball area is characterised by soft clay/mud with a low biodiversity typical of East Coast conditions. There were no coral or hard substrate areas within the offshore study area.

The installation of the Cannonball WPP will crush and bury the benthic organisms due to the impact of the anchors, pile driving and direct placement of the platform structure on the seabed.

It is expected that there will be 12 anchors used during the installation with weights of up to 50,000 lbs or more. The anchors will be positioned in a spread formation with a radius of approximately 550m based on estimated 1: 7 ratio of anchor spread to water depth (U.S. Minerals Management Service, 2001). The loss on benthic communities will be localized to the specific areas covered by the anchors. Since the placement of the anchors will be temporary, lasting for the duration of the installation (1 month or less), it is expected that the loss of the benthic communities will be minimal and temporary given that previous studies have indicated that the benthic communities regenerate in the area once the impacting activity is removed (Gobin, J., 2003). This impact to the benthic community is seen as minimal given its temporary nature and the fact that the community will regenerate.

Installation of the Cannonball wellhead protector platform will, however, result in permanent loss of the benthic communities at the site of the platform legs and well hole sites. Given that the legs are approximately 1.2m in diameter, it is estimated that the total area to be disturbed is approximately $23m^2$. The loss will be long-term however the disturbed area is small and there is no coral or hard substrate, it is expected that this impact is minimal.

bpTT is committed to ensuring that the impact to the benthic communities is kept to a minimum. Therefore the baseline survey, described in **Section 3**, included a macrofaunal and meiofaunal survey of the benthic communities at the installation site , as well as the surrounding areas. bpTT also collected underwater video footage at these sites to record the seafloor conditions before the installation and operation of the Cannonball WPP. This will be used to compare with the benthic and photographic surveys that will be conducted post installation to determine the changes caused by the platform installation activities. **Section 9: Monitoring Plan** outlines the proposed bpTT Cannonball Monitoring Plan.

7.3.2. Impact on seabed sediments

The anchoring of the installation barges and the actual installation of the Cannonball WPP will cause temporary plumes of sediment to be entrained in the water column. The prevailing currents will transport this sediment to the northwest. The sediment will then deposit over the seafloor and smother benthic communities northwest of the installation area. The amount of sediment entrained, however, will be small given the footprint of the anchors and well legs. The smothered benthic communities will regenerate in 7-8 months particularly given the fact that they are on soft clay/mud type substrate and not hard or coral substrate which exists north of the study area (Gobin, J., 2003). This impact, therefore, is expected to be minimal and temporary.

7.3.3. Impact on Water Quality from discharges from installation vessels

The crane barges used for the installation are expected to have a crew of up to 75 - 100 persons. There will be sanitation and domestic waste discharges from the installation vessels which will include “black” water discharges composed of human body wastes from toilets and urinals and “grey” water discharges originating from showers, sinks, laundries and galleys. The discharge of these substances is controlled by both the MARPOL Convention and bpTT contractor HSE requirements. All sanitation wastes will be treated using chemical and anaerobic digestion before discharge. Domestic wastes such as food wastes will be ground up into small pieces (less than 25mm diameter) before being discharged. The discharge of these wastes have the potential to increase nutrient levels offshore but will be localized and diluted due to the high current and wave action offshore. Therefore, minimal impacts on water quality and plankton are anticipated. The impact will also be temporary.

There will be no discharge of solid wastes such as plastics, metals, paper and wood that are generated during the installation operations. These discharges are prohibited by both the MARPOL Convention and bpTT HSE Management System. All solid wastes will be collected and shipped to shore for processing and disposal.

7.3.4. Impacts of Installation of Platform on Marine Traffic

The presence of the crane barges and support vessels during the installation process will adversely impact on marine traffic in the area due to the immobility of the barges and its anchor spread. For safety reasons there should be no vessel activity within the anchor spread therefore there will be a safety zone around the crane barges during the installation process of approximately 1km. The installation will take place at the Cannonball site 60km southeast of Trinidad and therefore will be outside of normal shipping routes. This is impact is anticipated to be minimal due to its temporary nature, the location of the impact and the mitigation measures taken by bpTT.

7.3.5. Impact of the Installation on Fishing Activities

The main interaction with marine traffic will be fishermen conducting line fishing and gillnetting. These fishing techniques employ fishing equipment, which is deployed in the water and allowed to drift in the current. The presence of the installation barges will interfere with the movements of the nets and lines and would require the fishermen to closely monitor their equipment. The baseline survey of the local fishermen using the East Coast indicates that this is a cumulative impact of bpTT's presence on the East Coast. They indicate that their fishing times are being reduced since they have to pick up their equipment sooner than they would like to due to the increasing presence of platforms and rigs off the East Coast. The cumulative impact is significant and this will be discussed in **Section 7.8** below.

7.3.6. Air Quality

The installation vessels will emit air pollutants that may negatively affect local air quality mainly from internal combustion sources such as diesel engines and generators. These are similar air emissions that were discussed in Section 7.2.3 above with regard to the transportation vessels.

The pollutants include Nitrous Oxides (NO_x), Carbon Monoxide (CO), Carbon Dioxide (CO_2), Sulphur Dioxide (SO_2) and particulate matter (mainly Carbon). The amount of emissions depends greatly on the state and maintenance of the diesel engines in question. The impact on the air quality is anticipated to be minimal due to the temporary and localised nature of the emissions.

7.3.7. Impacts of the Installation of the platform on marine mammals and turtle populations

Potential effects on marine mammals are mainly related to the noise produced by the platform activities. Previous studies conducted in UK waters identify marine vessels and drilling rigs as potential sources of noise disturbance to the local marine environment (Richardson et. al. 1995). Acoustic disturbance is generated from numerous sources including the rotation of propellers, the use of positioning thrusters and from vessel engines. Stone (1998) suggests that boat traffic is the most prevalent form of acoustic disturbance in UK waters and research has offered inconclusive results with evidence of habituation as well as avoidance. These marine vessels are in an area of existing boat traffic and open ocean where it is likely the cetaceans will have become habituated to the regular vessel operations (Lawson et al. 2001). Therefore the effects of installation operations are not expected to have a significant effect on cetaceans. bpTT also commissioned a literature review of the marine and turtle populations off the East Coast of Trinidad . The results are presented in Section 4.3.18.

7.3.8. Summary of Impacts of the installation of the platform

The following table outlines the impact assessment for the installation of the Cannonball Well Protector Platform offshore.

Table 7.5: Impact Assessment of Installation of Cannonball WPP offshore

Impacting Aspect	Nature	Duration	Probability of Occurrence	Severity	Significance Ranking
Discharge of Sanitation and Domestic Wastes	Direct/Indirect	Temporary	4	4	4
Disposal of Solid Wastes	Direct/Indirect	Temporary	4	4	4
Combustion Emissions	Direct	Temporary	4	4	4
Fishing Activities – Loss of Equipment	Direct	Temporary	3	2	2.5
Fishing Activities – Loss of Fishing Time -Cannonball	Indirect	Long-Term	3	2	2.5
Benthic Communities- Anchoring of installation barge	Direct	Temporary	3	4	3.5
Benthic Communities – Installation of Platform	Direct	Long Term	1	4	2.5
Marine Traffic	Direct	Temporary	4	3	3.5
Marine Mammals	Indirect	Temporary	4	3	3.5
Marine Turtles	Indirect	Temporary	4	3	3.5

7.4. Drilling of Cannonball Wells

After the installation of the Cannonball Wellhead Protector Platform (WPP), two (2) Cannonball Wells will be drilled using a Jack-up drilling rig cantilevered over the WPP. The setup is described in Section 3.4.9.

The drilling operation is expected to last approximately 184 days from May – November 2005. The following impacts have been identified for the drilling program.

7.4.1. Impact on Water Quality

Sanitation and Domestic Wastewater Discharges

The drilling rig will be operating for approximately 184 days on site and will have on board, on average, approximately 90 people. There will be sanitation and domestic waste discharges from the drilling rig similar to the installation vessels as discussed in **Section 7.3.3.** The discharge of these wastes have the potential to increase nutrient levels offshore but will be localized and diluted due to the moderate to high current speeds and wave action offshore. Therefore, minimal impacts on water quality and plankton are anticipated. The impact will also be temporary as they will last for the duration of the drilling exercise.

Solid Wastes and Garbage

There will be no discharge of solid wastes such as plastics, metals, paper and wood that are generated during the towing operations as these are prohibited by both the MARPOL Convention and bpTT HSE Contractor requirements. This impact is not anticipated to be significant.

Discharge of Drilling Mud

There will be a degradation of water quality during the discharge of the drilling muds from the drilling rig. The discharge of drilling muds is detailed in **Section 3.4.9.1.** In order to determine the impacts of the drilling mud and cuttings discharge on the environment, numerical modelling of the discharge over the entire drilling program was conducted. The model used was the MIKE21 Particle Assessment (PA) module, which was developed by the Danish Hydraulic Institute (DHI) in Denmark. The description of the modelling is given in Appendix E. A summary of the results is given here.

As described in **Section 3.4.9.1 - Project Description**, the production rates and grain sizes of cuttings discharged in the five (5) drilling intervals are given in Tables 7.6 and 7.7 below.

Table 7.6: Production Rates of Drilling Mud and Cuttings.		
Drilling Interval	**Discharge of WBM kg/s (duration of discharge)**	**Production Rate of Drill Cuttings and Mud kg/s (duration of discharge)**
I	0.37 (30 minutes)	4.76 (1 day)
II	12.69 (30 minutes)	4.73 (3 days)
III (SOBM)	0	1.63 (8 days)
IV (SOBM)	0	1.05 (9 days)
V	30.99 (30 minutes)	1.53 (4.5 days)

Drill Cuttings are made up of 30% sands of mean diameter 0.1mm and 70% shales of mean length 10mm with densities in the range 1950 to 2300 kg/m^3. Drilling muds have a typical density of 4200 kg/m^3 (barite).

Table 7.7: Drill Cuttings Composition by Percentage Mass.		
Drilling Interval	**Sand %**	**Shale %**
I		
II	30	70
III	30	70
IV	30	70
V	106	0
Average shale cutting size 10mm x 5mm x 2.5mm Average sand grain size 0.075mm		

Figure 7.2 below shows the dispersion of the WBM after discharge at the end of Drilling Interval I. In total 196 barrels of WBM are discharged. The plume can extend for 2.3 km in a northwesterly direction with a very low concentration of approximately 1-2 mg/l. In the natural environment the background levels will be typically greater than this value.

From the baseline survey, discussed in Section 4, the offshore background Total Suspended Solids (TSS) values range from 2 mg/l at the surface to 8mg/l at the seabed. Locally, at the discharge point the suspended sediment concentrations can be as high as 3 mg/l. The persistence of the plume is a result of the fine barite fractions in the WBM. These discharges are relatively unimportant since they are temporary and last only a few hours at maximum. The suspended sediment distribution plots shown contain very small amounts of drill cuttings as these rapidly settle onto the seabed.

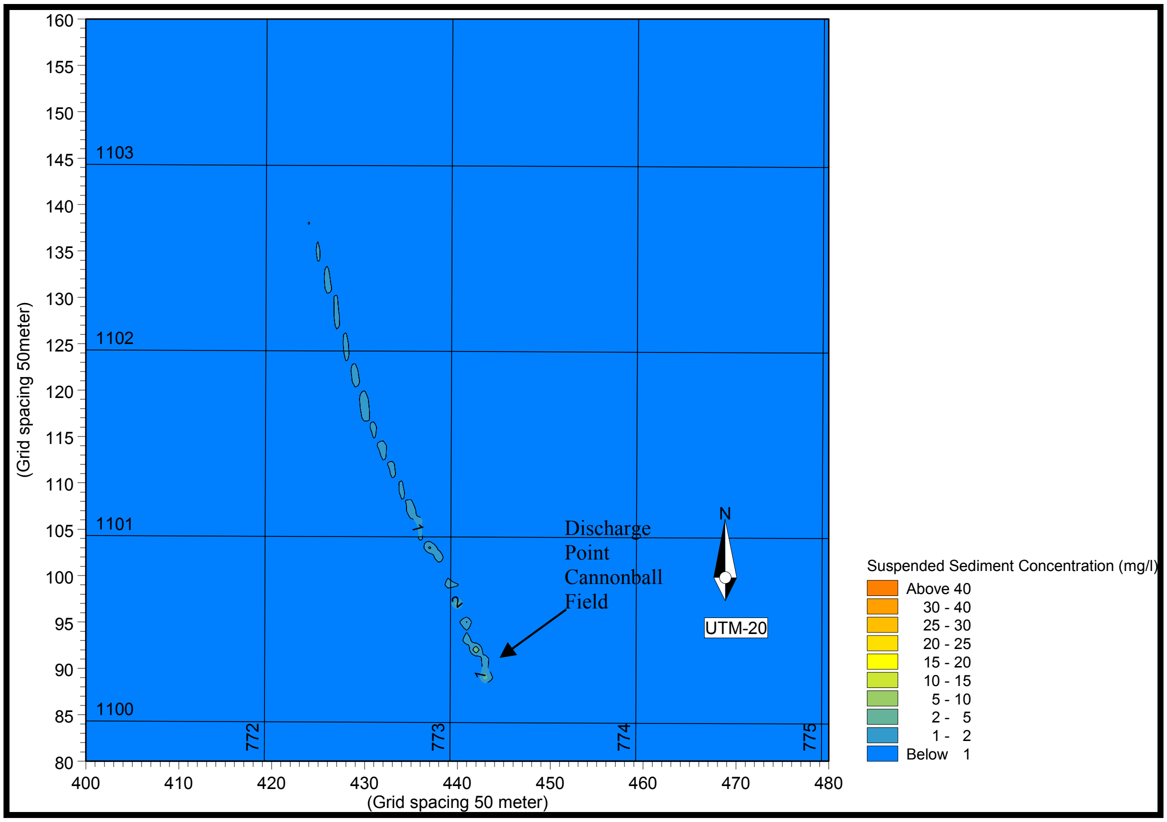

Figure 7.2: Suspended Sediment Distribution for Instantaneous Discharge of WBM at the end of Drilling Interval I.

The discharge of WBM after completion of Drilling Interval II is shown in Figure 7.3. At the end of this section 2032 barrels of WBM are discharged. The plume can extend for 2.6 km in a northwesterly direction with a very low concentration of approximately 1-2 mg/l. Locally; at the discharge point the suspended sediment concentrations can be as high as 12 mg/l. The persistence of the plume is a result of the fine barite fractions in the WBM. These discharges are relatively unimportant since they are temporary and last only a few hours at maximum. The suspended sediment distribution plots shown contain very small amounts of drill cuttings as these rapidly settle onto the seabed.

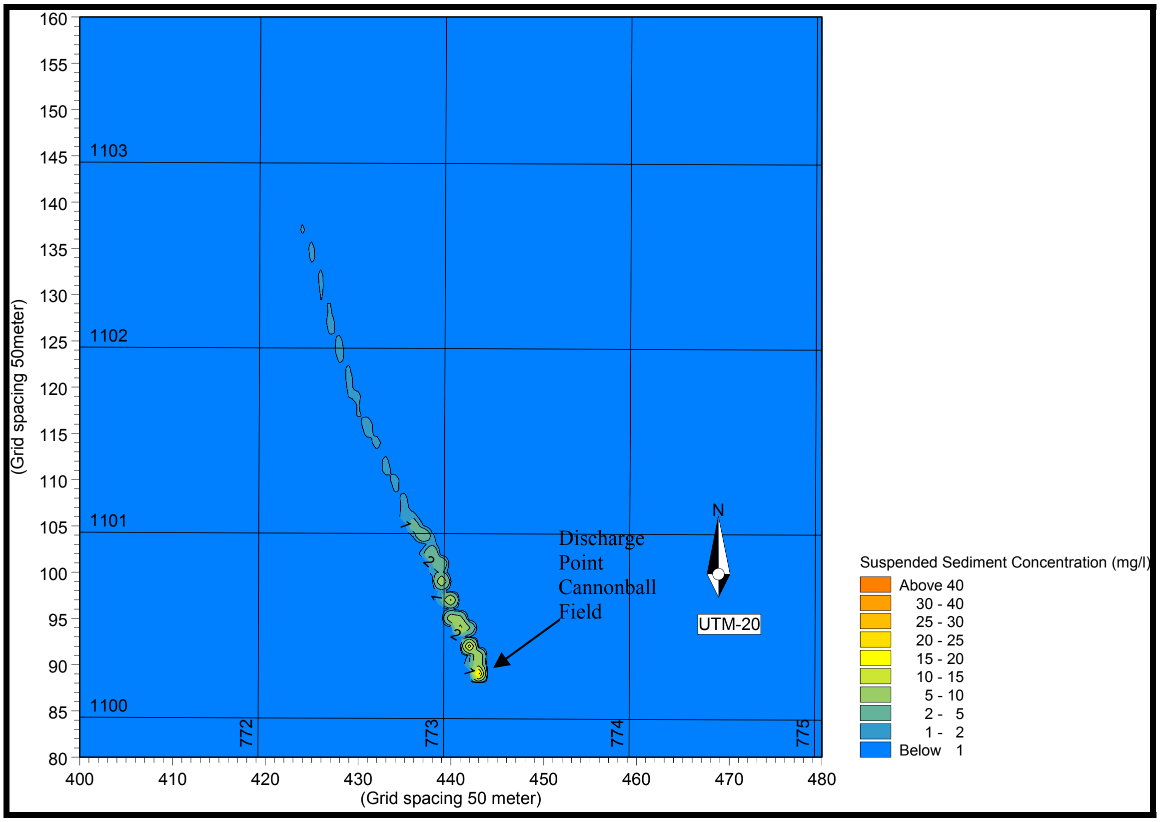

Figure 7.3: Suspended Sediment Distribution for Instantaneous Discharge of WBM at the end of Drilling Interval II.

At the end of the Drill Section V a total of 1889 barrels of WBM are discharged. The plume generated can extend for a distance of 1 km in a northwesterly direction with concentrations in the range 5 to 25 mg/l under the prescribed conditions (Figure 7.4). Locally, at the discharge point the suspended sediment concentrations can be as high as 38 mg/l. The persistence of the plume is a result of the fine barite fractions in the WBM. These discharges are relatively unimportant since they are temporary and last only a few hours at maximum. The suspended sediment distribution plots shown contain very small amounts of drill cuttings as these rapidly settle onto the seabed.

Summary of impacts of drilling mud discharges on water quality

The modelling shows that the Water Based Drilling muds can travel up to 2.6 km, to the northwest, from the drilling rig when discharged. However, the concentrations at this distance that are present in the modeled plume are generally less than the background TSS values obtained during the offshore field surveys. It is only around the discharge point and up to 1km away to the northwest that the plumes exceed the background levels (Figure 7.3 above). Therefore, the plumes will not be visible beyond this point. The plumes will also be temporary in nature and will reduce to the background levels in a matter of hours after the discharge has ceased.

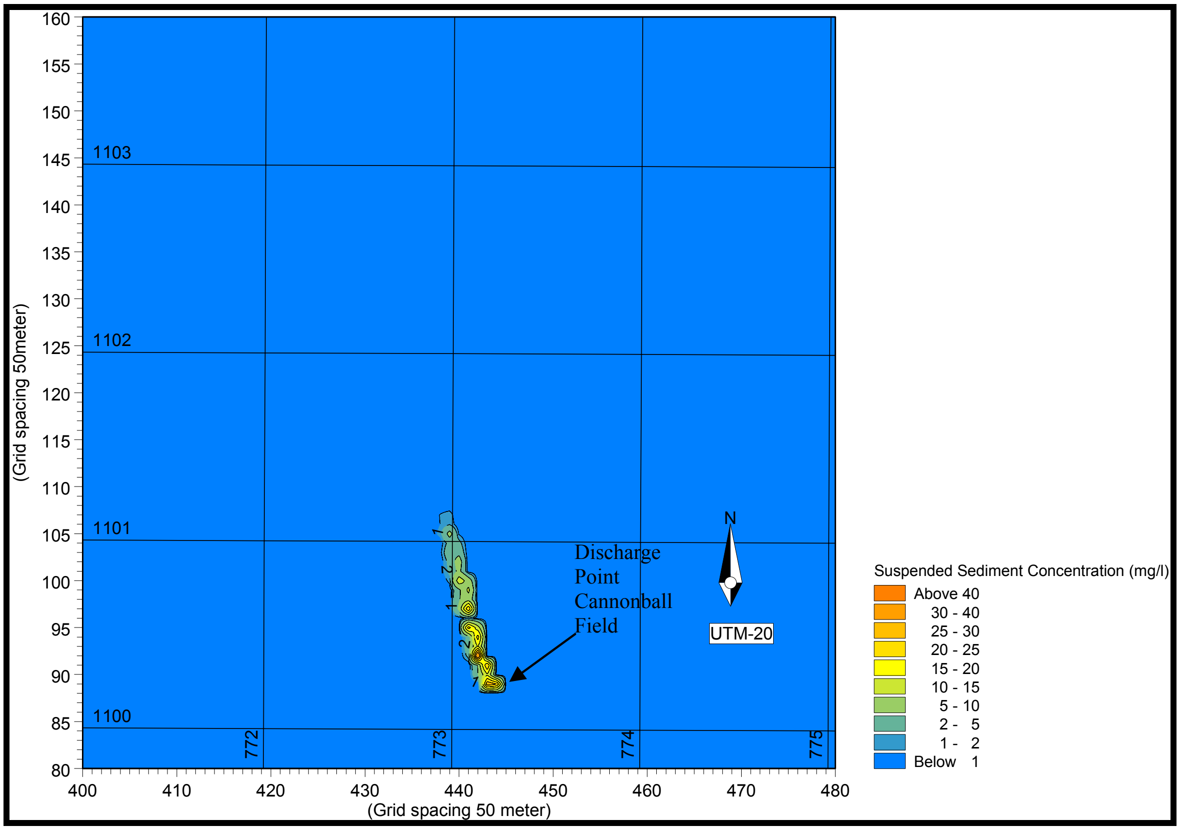

Figure 7.4: Suspended Sediment Distribution for Instantaneous Discharge of WBM at the end of Drilling Interval V.

7.4.2. Impact on Benthic Communities during drilling phase

Physical Impact of Drilling

The physical impact of drilling the well will destroy the benthic communities at the drilling site for each well location. There will be two (2) wells drilled from the Cannonball WPP. The area of this impact is not significant as it will only be the area immediately surrounding the drill hole locations.

When the drilling rig legs are placed into the mud, holes will be formed. Although the rig will be moved after drilling is complete, the holes will remain for several years. It can be assumed that the benthic communities around these drilling rig legs are permanently lost. However, the impact is not anticipated to be significant due to the relatively small areas being affected. There is also no hard substrate or corals in the vicinity of the drilling operations to be affected.

Drilling Mud and Cutting Discharge

The discharge of the drilling muds and cuttings will impact on the benthic communities that lie under the settled drill cuttings. Generally, the benthic communities will be smothered and stressed. Research has shown that the benthic communities can regenerate in a few months after the smothering has stopped (Gobin, J., 2003). However, to determine the impact to the benthic community it is important to examine the area that will be smothered by the drill cuttings and muds as they are being discharged.

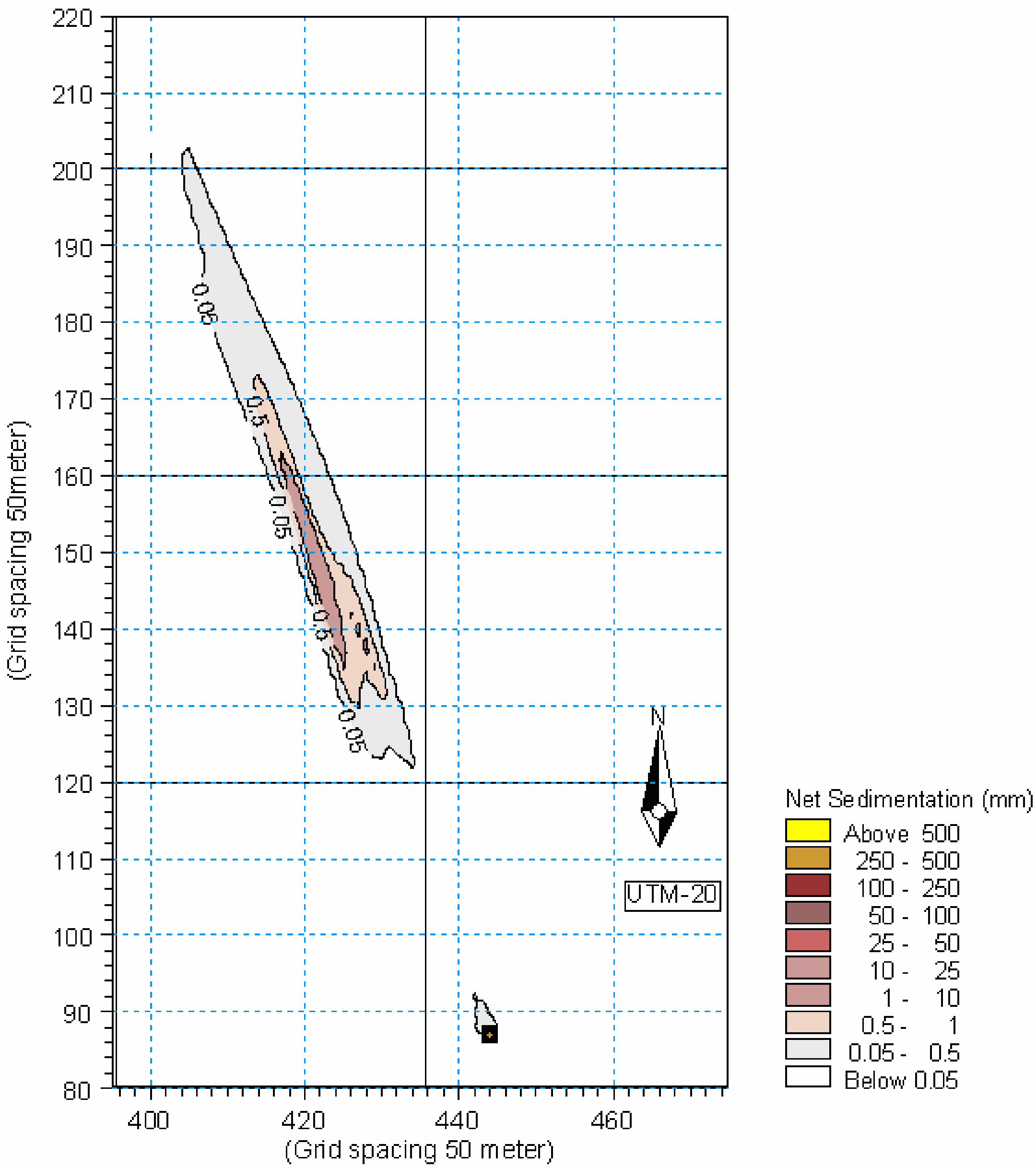

Figure 7.5: Sediment Accumulation at the Seabed after Completion of the Well.

Figure 7.5 above shows the deposition of drill cuttings and drill muds settling at the seabed. Almost all drill cuttings settle within a very small footprint immediately adjacent to the discharge point. The maximum deposition on the seabed varied between approximately 0.001m to 0.5m over an area of approximately 2500 m^2. The distribution shows a slight tendency to elongate the cuttings pile in the direction of the dominant current to the northwest. This is expected since research on the dispersion of drill cuttings suggests that the drill cuttings do not move large distances from the point of discharge except under strong current regimes. In the case of drill cuttings, the cuttings fall rapidly to the seafloor thereby increasing the mass of cuttings per unit area near the well site (Neff *et al.* 2000).

Based on the conditions at the well site and the modeled depth of drill cuttings of 0.5m there can be expected impacts to the benthic fauna within a 50m radius of the discharge point. At distances further than 50m from the discharge point the concentrations of drill cuttings and SOBM cuttings will be diminished and the thin veneer (less than a few millimeters) will rapidly biodegrade. Biological impacts to the benthic communities, from the effects of SOBM cuttings, may therefore be caused by toxicity of the drilling fluid constituents, effects of sediment anoxia due to biodegradation of the organic chemical in the SOBM cuttings, direct burial by drill cuttings and changes in the texture and physical/chemical properties of the sediments. Oxygen depletion by SOBM biodegradation in sediments contributes to adverse effects of SOBM cuttings on benthic communities. (Neff *et al.*, 2000).

Over time the percentage composition of SOBM in the seafloor sediments within the 50m radius will decrease due to bioturbation, sediment resuspension and transport. Neff *et al*. (2000) have estimated that SOBM concentrations in the drill cuttings decreases by 75% per year if Linear Alpha Olefin (LAO) type muds are used (such as Petrofree LE). This means that the region will be greatly reduced after one year. When SOBM concentrations exceed 1000mg/kg benthic fauna are more likely to be adversely affected by effects of organic enrichment such that species sensitive to low oxygen or high concentrations of sulphide and ammonia may be eliminated.

Shallow water benthic animals are able to migrate through several centimeters of sediment following burial (Maurer et al. 1986). The effect of the disposal of drill cuttings, SOBM cuttings and WBMs will therefore be limited to the immediate vicinity of the discharge area (within a 50m radius).

The impacts of the drill cuttings and mud discharge on the benthic community will be minimized as the communities can regenerate over time (up to a year) (Gobin, J., 2003).

7.4.3. Impacts on Fishing Activities

The impacts to the fishing activities in the area are a continuation of the impacts identified in the installation of the Cannonball WPP described in **Section 7.3.5**.

7.4.4. Impacts on Marine Mammals

As mentioned previously, potential effects on marine mammals are mainly related to the noise produced by drilling rigs and vessel operations. Drilling rigs are a stationary source of noise, the noise produced is likely to be restricted to a relatively small radius around the drilling rig and although there may be some short-term avoidance of the area, the

noise levels are not in the range that would cause any damage to these animals (Richardson et al. 1995). Effects are therefore not expected to be significant
(Lawson et al. 2001)

7.4.5. Impact on Air Quality

The drilling rig will emit air pollutants that may negatively affect air quality from internal combustion sources such as diesel engines and generators .

The internal combustion pollutants include Nitrous Oxides (NO_x), Carbon Monoxide (CO), Carbon Dioxide (CO_2), Sulphur Dioxide (SO_2) and particulate matter (mainly Carbon). The quantity of emissions depends greatly on the state and maintenance of the diesel engines and generators in question. This impact is temporary and localized hence it is not anticipated to be significant.

Volatile Organic Compounds (VOC) will be emitted from the shale shaker assemblies during the drilling program. The emissions are unavoidable. There are health implications to the workers in the vicinity of the shale shakers. The impact will warrant the use of protective gear to reduce the impact of VOCs on workers health.

The loss of well control will have a significant impact on air quality, water quality and worker safety should it occur. The loss of well control can occur when the formation pressure exceeds the mud pressure. Formation fluids (oil, gas or water) can now enter the borehole and travel upwards (Jahn, *et al.*, 1998). This is called a surface blowout and can cause severe impacts to worker's health as well as gaseous emissions of natural gas. The severity of this impact is high but the probability of occurrence is low however it is categorized as significant.

7.4.6. Impact on Marine Traffic

The impact to the marine traffic is a continuation of the impacts discussed for the installation of the Cannonball WPP. This was discussed in **Section 7.3.4**.

7.4.7. Summary of Impacts for Drilling

The following table outlines the impact assessment for the drilling of the Cannonball Wells offshore.

Table 7.8: Impact Assessment of Drilling of Cannonball's Wells					
Impacting Aspect	**Nature**	**Duration**	**Probability of Occurrence**	**Severity**	**Significance Ranking**
Disposal of Solid Wastes	Direct	Temporary	4	4	4
Discharge of Sanitation and Domestic Wastes	Direct	Temporary	4	4	4
Drilling fluid discharge	Direct	Temporary	2	3	2.5
Spills to Sea	Direct	Temporary	3	3	3
Combustion Emissions	Direct	Temporary	4	4	4
Loss of Well Control	Direct	Temporary	4	1	2.5
Benthic Communities- Physical Impact	Direct	Long Term	4	4	4
Benthic Communities – Smothering by drilling cuttings and muds	Indirect	Medium Term	2	3	2.5
Fishing Activities – Loss of Equipment	Direct	Temporary	3	2	2.5
Fishing Activities – Loss of Fishing Time	Indirect	Temporary	3	2	2.5
Marine Mammals	Indirect	Temporary	4	3	3.5
Marine Traffic	Direct	Temporary	3	3	3

7.5. Impacts of Installation of 26" Pipeline

The description of the installation of the 26" pipeline between the Cannonball WPP and the Cassia "B" hub was provided in **Section 3.5**.

Figure 7.6 below shows the pipeline route from Cannonball WPP to the Cassia "B" hub. The pipeline to be laid is approximately 5 km long and runs from Cannonball WPP southwest to Cassia "B". Pipeline installation is expected to begin April 2005 and will take approximately 21 days.

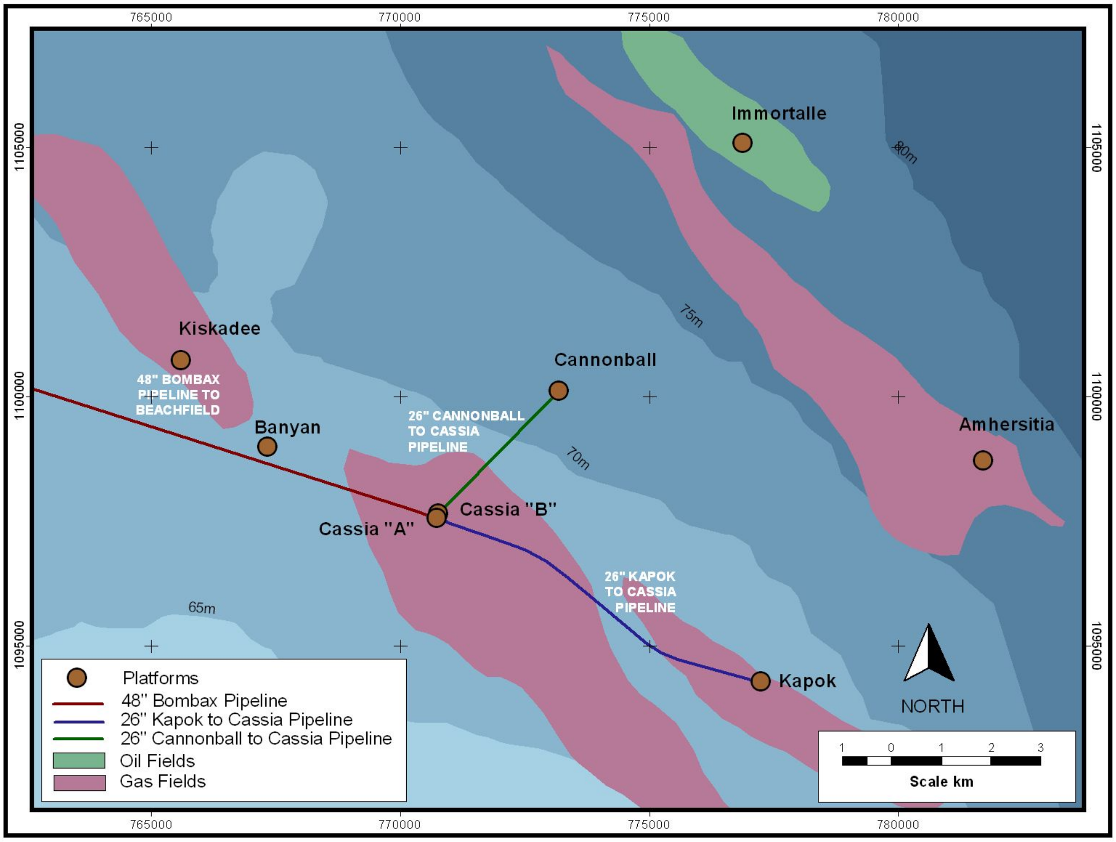

Figure 7.6: Pipeline Route from Cannonball Platform to Cassia "B"

Given the relatively shallow depths along the pipeline route and the seafloor conditions it is expected that the 26" pipeline between Cannonball and Cassia "B" will be laid directly onto the seafloor without burial from a lay barge using the S-Lay Method. The lay barge will have a 12 anchor mooring system, which is maneuvered to pull the barge forwards as the pipeline is laid. Pipe sections are welded and inspected before being lowered onto the seafloor.

The installation of the pipeline is projected to have the similar impacts on Fisheries, Air Quality, Marine Mammals and Turtles and Marine Traffic as in the transportation and installation of the Cannonball WPP offshore. Please refer to **Section 7.3** above for a discussion of these impacts.

7.5.1. Impacts to Benthic Communities

Installation of Pipeline on seabed

The physical impact and presence of the 26" pipeline on the seafloor will smother and crush the benthic community beneath the pipeline. This is unavoidable due to the weight and size of the pipeline. The area affected underneath the pipeline can be calculated as 5000m (length of pipeline) x 0.66m (width of pipeline) = 3,300 m^2 of offshore area affected. The benthic communities will most likely not be able to regenerate within this area. However, the severity of this impact is mitigated by the relatively small offshore area that will be affected, as well as the lack of other substrates other than the soft clay/mud found along the pipeline route. There are no corals or hard substrates found along the pipeline route.

Presence of the pipeline on seabed

A horizontal pipe lying on the seabed in a unidirectional current will cause scouring around the pipe due to changes in local flow field. Wherever the pipe causes an increase in transport capacity of the current there will be erosion and wherever the transportation capacity reduces there will be sedimentation (van Rijn, 1998). The flow field around the pipe on the seabed dictates the amount and extent of the scour/erosion that occurs in proximity to the pipeline.

Scour can occur around a horizontal pipe through three processes (van Rijn, 1998):

1. **Flow induced pressure differences**
   With a flow perpendicular to the pipeline there will be a difference in pressure between the upstream and downstream areas of the pipeline. This will cause erosion along the downstream areas of the pipeline due to mobilisation of sediment from groundwater flow.

2. **Vortices near the pipeline**
   Vortices will occur on both the upstream and downstream areas of the pipeline due to the interruption of the flow regime by the pipe. These vortices can cause erosion along the edges of the pipe (scouring), as well as increased sedimentation in the lee of the pipe.

3. **Imperfections in the seabed near the pipeline**
   Any imperfections along the seabed near the pipeline can cause a gap between the pipeline and the seafloor. There will be increased scouring at this point particularly if there is flow between the pipe and the seafloor.

According to van Rijn (1998) "the development of scour in a current is governed by the velocity below the pipeline, the downstream wake and the vortex shedding downstream of the pipeline".

Experimental results quoted from van Rijn (1998) show that the horizontal area of influence of the wake of the current on the seabed can extend to approximately 6 times the diameter of the pipeline. Therefore, we can expect various degrees of scouring taking place up to approximately 4m downstream of the 26" pipeline, in this case to the south of the pipeline. In reality, the affected area will be less since the flow along the seabed is not perpendicular to the 26" pipeline. It is estimated that the scouring will extend to 2m along the length of the pipeline.

There will also be scouring of sediment under the pipeline due to the current flow. van Rijn (1998) indicates that the extent of the scour can be calculated to be approximately 1 diameter in length. Therefore, for the 26" pipeline the maximum scour depth is approximately 26" below the pipe. Since the area under the pipe has already been impacted due to the smothering of benthic organisms by the pipeline itself, this impact is expected to be minor and unavoidable. The impact is limited to the immediate area under the pipeline.

The impact will be long-term as the scouring effect will always be present once the pipeline is there. Given the relatively small area affected, this impact is not seen to be significant.

Anchoring of the lay barge

It is expected that the lay barge will use a 12-anchor spread to move forward as the 26" pipeline is laid on the seabed. The anchors will crush and disturb benthic communities under the area of its impact. This impact is specific to the immediate area under the anchors. The resultant anchor scars may persist for several years but the benthic communities should regenerate within a year due to the type of benthic communities present. The benthic community was found to be of a low species diversity since the substrate along the pipeline route was soft clay/mud and homogeneous along the entire route. There were not hard bottom substrates found in the study area.

Summary of benthic impacts

There will be long-term loss of benthic creatures in an area of 3,300m^2 under the pipeline. Added to this would be a further 10,000m^2 lost due to the scouring effect of the pipeline. Although these impacts are long-term, they are not considered to be significant given the relatively small areas impacted. The significance of this impact is further mitigated by the homogeneous nature of the substrate: there is no coral or hard substrate found in the area. Therefore, the benthic communities lost are not specific to the area lost by the pipeline installation. The anchor impacts on the benthic community will be temporary since the community will regenerate once the anchors have been removed.

7.5.2. Impacts to Water Quality

After the installation of the 26" pipeline, the line will be pressure tested with treated water in a process called **"Hydrotesting"**. It is expected that this will occur in May 2005 after the installation of the 26" pipeline. In this process, seawater will be pressure filled into the 26" pipeline system to test for leaks. When the pipeline is filled with this water, it will be allowed to lie in the pipeline for approximately 1-2 days after which it will be discharged over the side of the Cassia "B" hub. In this situation no anti- corrosive agents or biocide will be used. The water will be ejected using a pig launched from the Cannonball WPP.

However, if the water remains in the pipeline for longer than 1-2 days then a biocide will be have to be added to reduce the corrosion of the inner portion of the pipeline. This biocide will then be discharged with the hydrotest water over the side of Cassia "B". The biocide will impact on water quality in its zone of influence. There will be indirect impacts to plankton, sea birds, fish and marine mammals.

The Material Safety Data Sheet (MSDS) of the probable biocide (XC102) to be used is presented in Appendix D. The biocide used will be approved by the Ministry of Energy and Energy Industries (MEEI) for use offshore.

The volume of water to be discharged during the hydrotesting is 1710 m^3 at a rate of $0.21 m^3/s$. The concentration of the biocide is 250mg/l. The 96hr LC_{50} for the biocide XC102 is 8.47 mg/l (bpTT, 2003). This is the concentration of the biocide that will cause 50 percent mortality in Metamysidopsis insularis (a local brine shrimp) in a 96-hour period. To determine the extent of the impact from the hydrotest discharge a modelling exercise was carried out. Details of the modelling are given in Appendix E.

Since there are no standards available with regard to biocide concentrations and toxicity during a hydrotest discharge, it was decided to model the distance from the discharge at which the hydrotest water attains the LC_{50} standard.

The LC_{50} of 8.47 mg/l for the biocide XC102 occurs at a distance of 1.1km downstream of the plume (northwest of the Cassia "B" hub). This is the worse case scenario assuming a homogenous water column and a buoyant plume. Under normal conditions the strong currents and vertical mixing will result in a higher dilution rate. Since the plume exists for a limited time (few hours) during the discharge the LC_{50} (96 hour) will not be encountered as a result the impact is considered significant and appropriate mitigation measures are outlined in **Section 8**.

7.5.3. Summary of Impacts of the installation of the 26" Pipeline

The following table outlines the impact assessment for the installation of the 26" Pipeline offshore.

Table 7.9: Impact Assessment of Installation of 26" Pipeline offshore					
Impacting Aspect	Nature	Duration	Probability of Occurrence	Severity	Significance Ranking
Disposal of Solid Wastes	Direct	Temporary	4	4	4
Discharge of Sanitation and Domestic Wastes	Direct	Temporary	4	4	4
Hydrotest Discharge	Direct	Temporary	3	2	2.5
Spills to Sea	Direct	Temporary	3	3	3
Combustion Emissions	Direct	Temporary	4	4	4
Physical Impact of anchors	Direct	Temporary	4	4	4
Smothering of benthic communities by Pipeline	Direct	Long Term	1	4	2.5
Benthic Communities – Scouring by Pipeline	Direct	Long Term	1	4	2.5
Fishing Activities – Loss of Equipment	Direct	Temporary	3	2	2.5
Marine Mammals	Indirect	Temporary	3	4	3.5
Marine Traffic	Direct	Temporary	3	3	3

7.6. Operation of Cannonball WPP Offshore

The operation of Cannonball WPP will have impacts to the environment from its various emissions and discharges as well as its physical presence. While some of the impacts, such as impacts to marine traffic, are a continuation of the impacts from the other activities offshore, such transportation of the platform and the drilling of the wells. They will be discussed in this section given the long-term aspects of these impacts.

7.6.1. Impact of Platform on Water Quality

Produced Water Discharge

Oil and gas reservoirs have a natural water layer (called formation water), which is denser than the overlying oil and gas. Oil reservoirs frequently contain large volumes of water, while gas reservoirs tend to produce only small quantities. Formation water is eventually produced along with the hydrocarbons and, as a gas field becomes depleted, the amount of produced water increases as the reservoir fills with injected seawater.

At the surface, produced water is separated from the hydrocarbons, treated to remove as much hydrocarbons as possible, and then either discharged into the sea or injected back into adjacent designated wells. In addition, some installations are able to inject produced water into other suitable geological formations.

Several studies have documented the fate and effects of produced water discharges on sediment contamination, benthic communities and bioaccumulation potential. The effects depend on the volume of the discharge, the chemical characterization of the discharge, and the physiography and hydrography of the receiving environment. Produced water derived contamination signals and/or effects on benthic organisms may be minimal near the discharge, but they may also be substantial and extend great distances from the discharge. Produced water derived contaminants may accumulate in the sediments adjacent to and downstream from the discharge point resulting in high concentrations of hydrocarbons to depths of 25 to 30 cm in vertical sediment cores. Hydrocarbon contamination resulting from these discharges may also persist through time both in surficial sediments and vertically into subsurface sediments. Therefore, the potential for significant environmental impact is possible if the produced water discharge is not managed in an environmentally sound manner.

Produced water from Cannonball will be pumped to Cassia B where the water will be treated and prepared for re-injection. A High Pressure Produced Water Treating, Pumping and Disposal facility is located on the Cassia B Platform. The facility includes five Hydrocyclones, one High Pressure Flash Drum, four Produced Water Injection Pumps and two Produced Water Filters. Please refer to Section 3.4.13 for a description of the produced water re-injection system used at Cassia “B”.

To determine the impacts of this discharge of the Produced Water should the re-injection system fail, numerical modelling was conducted on the resultant expected produced water discharge. The modelling is discussed in Appendix I. The results are discussed here. As the produced water from the Cannonball WPP is being mixed with the produced water from other gas platforms in the area, namely the Cassia, Immortelle, Flamboyant and Kapok Platforms, the impacts being modeled illustrate the cumulative impact of the produced water from all these installations on the East Coast rather than the specific impact of the Cannonball WPP' produced water discharge.

The discharge rate calculated is for a maximum outflow from all produced water treated at Cassia "B". This includes a discharge of produced water from Cassia, Immortelle, Flamboyant, Kapok and the Cannonball Field Developments, the resulting discharge will be a total of 1140 barrels/day when produced water at all wells reach their maximum. The discharge rate will therefore be at a maximum 0.0021 m^3/s. Specification of the discharge in terms of a pollutant concentration cannot be used in this case since the toxicity of the effluent should be a cumulative effect of the various toxic components. In these cases the toxicity of the effluent is best expressed as a percentage that can result in a mortality rate determined by testing in a laboratory using standard methods. This type of analysis, referred to as Acute Toxicity Testing, is conducted using the estuarine mysid shrimp, *Metamysidopsis insularis*. In order to model the toxic effects in the marine environment the discharge produced water is given a concentration of 100%. A flow rate of 0.0021 m^3/s during worse case conditions is specified in the analysis. The discharge will be near the sea surface. Field measurements conducted near Cassia B showed that the water column is stratified with a linear increase in density from the surface (1023.4 kg/m^3) to the seabed (1025 kg/m^3). Since the produced water has a higher temperature (29.4°C) than the ambient seawater and a salinity (22.8) that is much less than the marine environment the produced water will be buoyant under most conditions.

Table 7.10: Produced Water discharge parameters.

Flow Rate m^3/s	Oil Concentration mg/l	Salinity Ppt	Temperature °Celsius	Density kg/m^3
0.0021	29	22.8	29.4	1004

The model run shows that the discharge of the produced water into the marine environment will meet local standards for Total Petroleum Hydrocarbons (TPH) even when the discharge is at a maximum rate of 0.0021 m^3/s. This is due to the fact that the discharge is also well below the 80mg/l standard that is applicable for offshore marine discharges of TPH.

The dilution achieved at the edge of the Regulatory Mixing Zone (RMZ -100m) resulted in a reduction of the effluent concentration of 1.9%. Toxicity tests conducted for offshore gas installations in Louisiana, United States of America using *Americamysis bahia* (standard test organism used by the USEPA) gave estimates of 5% and 6% for the 96 hour LC50 (American Petroleum Institute Health and Environmental Sciences Department, 1996). The value of the effluent concentration for the Cannonball Field Development Project of 1.9% concentration at the edge of the Regulatory Mixing Zone (RMZ) is therefore lower than the known LC50 estimates for produced water from similar oil and gas facilities (5-6%). These results are consistent with modelling studies such as, Brandsma and Smith (1996). This impact is considered significant.

Sanitation Wastes and Sewage Discharges

The Cannonball Wellhead Protector Platform is an unmanned facility. There will be quarterly visits by a ten (10)-member group to conduct routine maintenance work on the platform. There will be a toilet facility on board comprised of a macerator which will grind the sewage before discharging, this may result in degradation of the water quality around the discharge point however, given the high surface currents and wave action, it is expected that the impact will be minimal and temporary due to the infrequency of the discharges. The discharge will, however, temporarily exceed the local standard for industrial discharges offshore of 400 faecal counts/100ml of discharge (TTBS "Specification for the Effluent from Industrial Processes discharged into the Environment", 1998).

7.6.2. Impact of possible Oil Spill

The potential for an oil spill from the platform is very low because the platform is a natural gas producer and is unmanned therefore there is a limited amount of movement of work and supply boats to and from bpTT Port at Galeota Point. However, there will be some movement of boats near the platform during the scheduled quarterly maintenance visits. Therefore, there is the possibility that a collision could occur between the vessel and the platform causing the vessel to sink. In order to determine the impact of the resultant oil spill, modelling exercise was conducted to predict the fate and transport of 1000 tonnes of diesel fuel, which represents a full load of a tank of a typical workboat.

The model used was the MIKE 21 Spill Analysis. The modelling exercise is discussed in Appendix I.

Oil spilled into the sea can persist for prolonged periods based on the transformation that occurs when it mixes with water and sediment. These persistence parameters are controlled primarily by dispersion, evaporation and water-oil emulsification. As previously stated emulsification data for oils are scarce and therefore emulsification data is estimated based on average values for similar oils. Evaporation and dispersion tends to remove oil from the oil slick while emulsification opposes these processes and causes persistence of the oil spill.

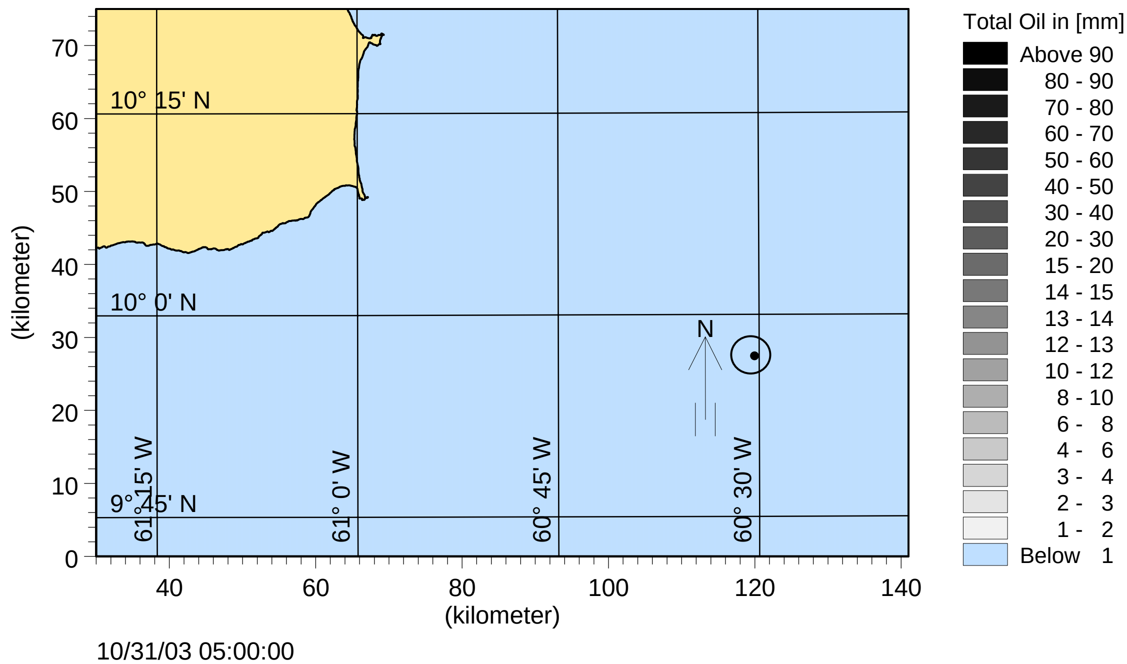

Figure 7.7 (a). 1 hour after spill.

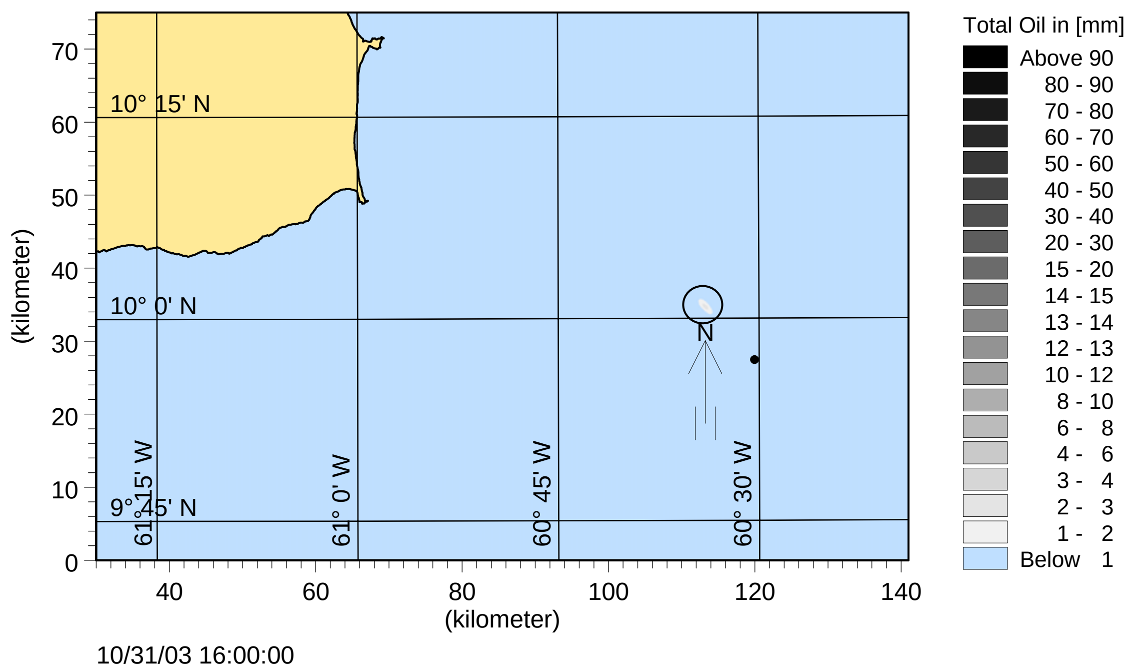

Figure 7.7b. 12 hours after spill.

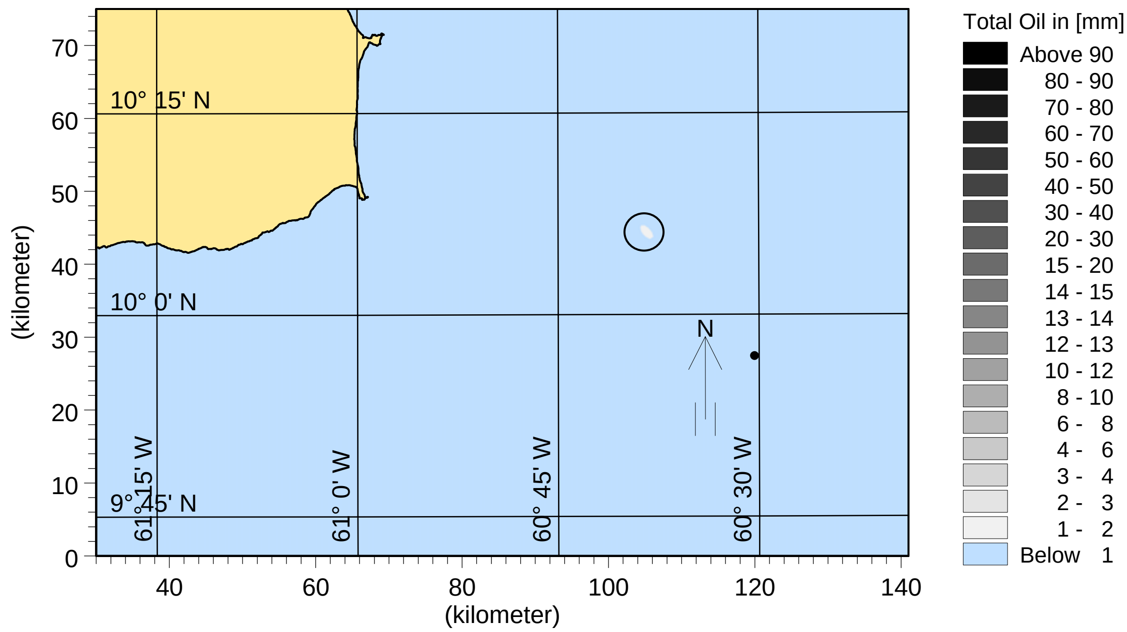

Figure 7.7 (c). 24 hours after spill.

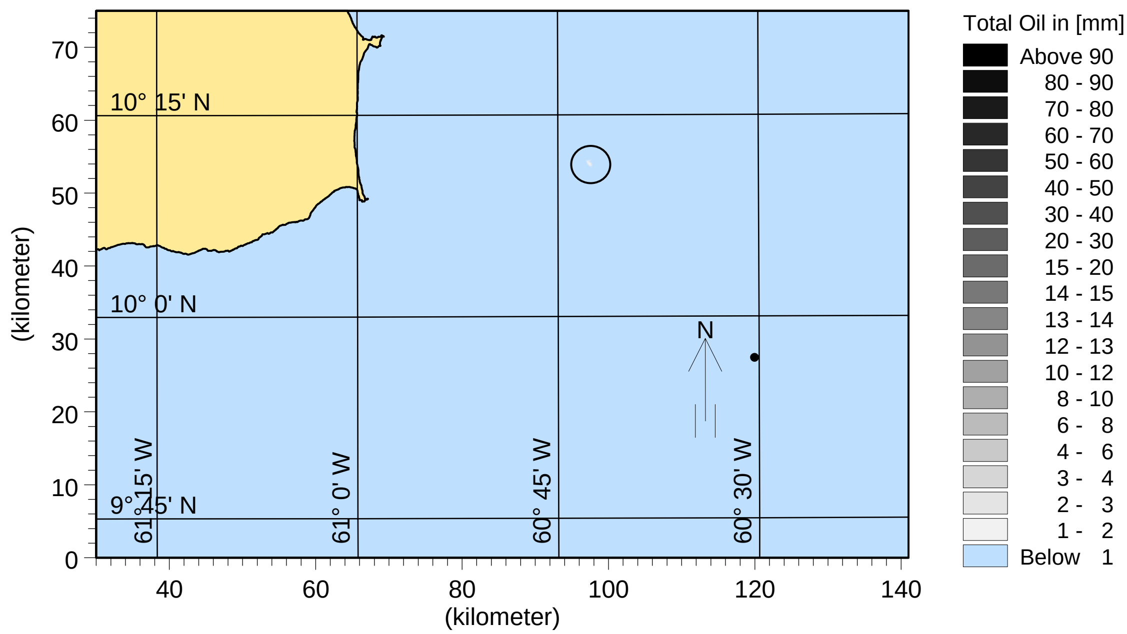

Figure 7.7 (d). 36 hours after spill.

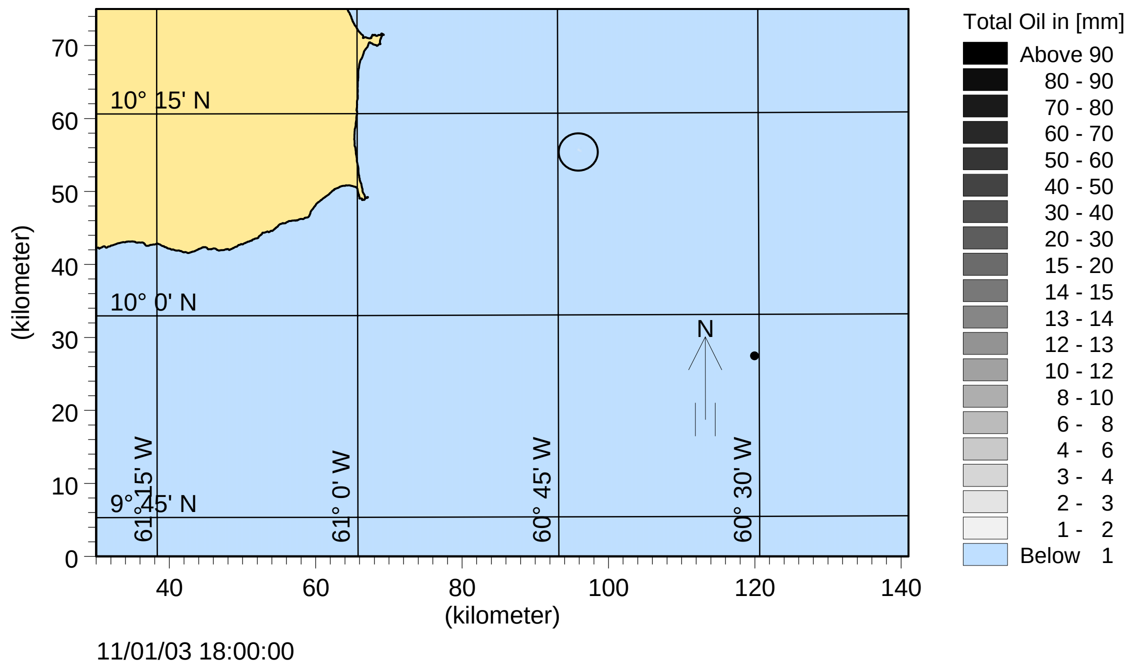

Figure 7.7 (e). 43 hours after spill.

Figures 7.7 (a-e) show the transport and spreading of the oil spill over the study area. The spill moves rapidly to the northwest and after 43 hours is less than 1mm thick. The spill will rapidly disperse as waves will lead to mixing and the dispersion of the spill into the water column. The spill covers a small area (less than 10 km^2) during the movement from the spill site and does not impact land, but is dispersed to very low levels as it travels towards the northwest.

bpTT has a comprehensive oil spill response plan that will be engaged should an oil spill occur. The plan is already in-place and it governs all of bpTT's oil spill response for their operations off the East Coast.

The anticipated impact of an oil spill resulting from a collision of the workboat and the Cannonball WPP is not anticipated to be significant. A list of mitigation measures to minimise this impact has been developed and is included in the Mitigation Management Plan that will govern this Cannonball Field Development Project. This plan is presented in **Section 8: Mitigation Management Plan**

7.6.3. Impact of Cannonball WPP platform on Air Quality

At the Cannonball Wellhead Protector Platform possible air emissions will include the following:

- Combustion gases from natural gas fuelled equipment such as the Microturbine for power generation.
- Hydrocarbon drips from minor spills

- Venting due to platform blowdown or through relief valves on emergency basis
- Minor fugitive emissions from general process related equipment.
- Combustion gases from the diesel fuel crane.

Table 7.11 below shows a summary of the expected CO_2 emissions from the Cannonball WPP, while Table 7.12 shows the emissions from the Cannonball WPP's Microturbine Generators:

Table 7.11: Summary of CO_2 Emissions from Cannonball Platform

Process	Vol Vented (SCF)	Vol Vented (MMSCF/yr)	Vol Vented (Tonnes/yr)	CO_2 Equivalent (Tonnes)	Notes
Routine	22,209	0.02	0.42	389.45	Assume pigging 4 times per year
Unplanned (downhole leaks)	23,683	0.02	0.45	9.51	Assuming downhole leaks will not occur more than once in 5 years based on previous experience
Planned Maintenance (non routine)	526,388	0.53	10.07	211.40	For example if an extra valve needs to be added onto the header (ie if another well is to be drilled). So far provisions have been made for the tie in of 3 wells on the headers.
Maintenance (Routine)	293,818	0.29	5.62	118.00	SCSSSV checks require blowdown of Flowline and Tubing 2 times per year. Xmas tree valves require flowline blowdown quarterly.
Planned platform Work (Rig)	306,848	0.31	5.87	123.23	The Platform needs to be blown down when the rig arrives and leaves. Apart from that it is envisioned that the platform should never have to blowdown (98% sure)
Emergency	153,424	0.15	2.93	61.62	

Table 7.12: Summary of Emissions from Cannonball's Microturbine Generators (Vendor supplied)

Gas Emitted	Vol. per kW-hr (gm/kW-hr)	Per year (Tonnes/yr)
NO_x	0.223	0.117
CO	0.603	0.317
HC	0.078	0.041
NO_x + HC	0.301	0.158
CO_2	724	380.534
O_2	7,060	3,710.736

The CO_2 equivalent emissions from the proposed Cannonball WPP are approximately 913 tonnes from the operation of the platform and 380.53 tonnes from the operation of the platform's Microturbine Generators. The figure for the platform emissions includes the discharge of Natural Gas by converting the Natural Gas amount to a CO_2 equivalent.

The emissions of NO_x and CO are generated from the microturbine generators (Table 7.12)

There are no local standards for CO_2 emissions. The USEPA has established the National Air Quality Standards (NAAQS) for emissions such as NO_x, CO and Volatile Organic Compounds (VOCs)) but does not include CO_2 in their standards. To determine the impact of the emissions from the Cannonball WPP on the nearest land, which is assumed to be Trinidad's Southeast Coast, the USEPA dispersion model, SCREEN 3, was used to estimate the concentrations of these pollutants reaching the coast. The modelling is outlined in Appendix E but the results are shown here. The model assumes worst-case meteorological conditions and was used to determine the concentration of the CO_2, NO_x and CO emissions on the nearest land 60km northwest from the Cannonball WPP site (Galeota Point, Trinidad).

Table 7.13: Modeled Results of the Air Emissions from Cannonball WPP

Parameter	Annual Emissions (tones)	Modelled Concentrations at 60km northwest (land) (ug/m^3)	Modelled Concentrations at 50km northwest (ug/m^3)	Modelled Concentrations at 40km northwest (ug/m^3)	USEPA NAASQ Standards (ug/m^3)
CO_2	1,293	Does not reach land	54.80	69.58	There is no standard
NO_x	0.117	Does not reach land	.0055	.007	100
CO	0.317	Does not reach land	.0148	.0188	10,000 (8hr average)

The modelled results show that the air emissions from the platform do not reach land even under the worst-case meteorological conditions, which were used in the modelling exercise (Appendix E). Therefore, it is unlikely to cause any degradation of the ambient air quality onshore or at any coastal regions.

7.6.4. Impact of Platform on Land Disposal Sites

There will be solid wastes generated by the operations on the Cannonball WPP once per quarter such as containers, chemical bottles etc. These volumes will be minimal hence the impact is considered to be minimal.

7.6.5. Impact of Platform on Fisheries

The existence of the platform will have an impact on the local fisheries as the platform acts as obstacle to the fishermen's equipment such as gillnets and Palangue lines that are free floating in the water. By itself this is not a significant impact since a single platform is not going to adversely affect the fishing activities off the east coast of Trinidad. However, this is a cumulative impact, since the Cannonball WPP is one of many installations being placed offshore by bpTT and other operators. This cumulative impact is discussed in the Section 7.8.

7.6.6. Impact of Platform on Marine Traffic

The presence of the Cannonball WPP will adversely impact on marine traffic in the area due to the immobility of the platform. There will also be a 500m Safety Zone around the platform. The impact to fishermen is discussed in Section 5.7.4 above. The Cannonball WPP is located 60km southeast of Galeota Point, Trinidad and is outside of the normal shipping lanes therefore the impact to marine traffic is anticipated to be minimal.

7.6.7. Summary of Impacts of the Operation of Cannonball WPP

The following table outlines the impact assessment for the operation of the Cannonball WPP offshore.

Table 7.14: Impact Assessment of Cannonball WPP Operations

Impacting Aspect	Nature	Duration	Probability of Occurrence	Severity	Significance Ranking
Disposal of Solid Wastes	Direct	Temporary	4	4	4
Discharge of Sanitation and Domestic Wastes	Direct	Temporary	3	2	2.5
Water Quality – Produced Water Discharge	Direct	Temporary	2	2	2
Spills to Sea	Direct	Temporary	4	2	3
Water Quality – Pipeline Rupture	Direct	Temporary	4	1	2.5
Air Quality – Fire and Gas Explosion	Direct	Temporary	4	1	2.5
Combustion Emissions	Direct	Long Term	1	4	2.5
Methane Emissions	Direct	Temporary	3	4	3.5
Fishing Activities – Loss of Equipment	Direct	Temporary	3	3	3
Fishing Activities – Loss of Fishing Time -Cannonball	Indirect	Long-Term	1	4	2.5
Fishing Activities- Loss of Fishing Time-Cumulative	Indirect	Long-Term	3	2	2.5
Marine Mammals	Indirect	Temporary	3	4	3.5
Marine Traffic	Direct	Temporary	3	3	3

7.7. Impacts due to modification of the Beachfield Gas Receiving Facility

Section 3.6 describes the modification of the Beachfield Gas Receiving Facility in Guayaguayare in the southeast corner of Trinidad. Figure 7.8 below shows the location of the Beachfield Gas Receiving Facility in relation to Guayaguayare Bay.

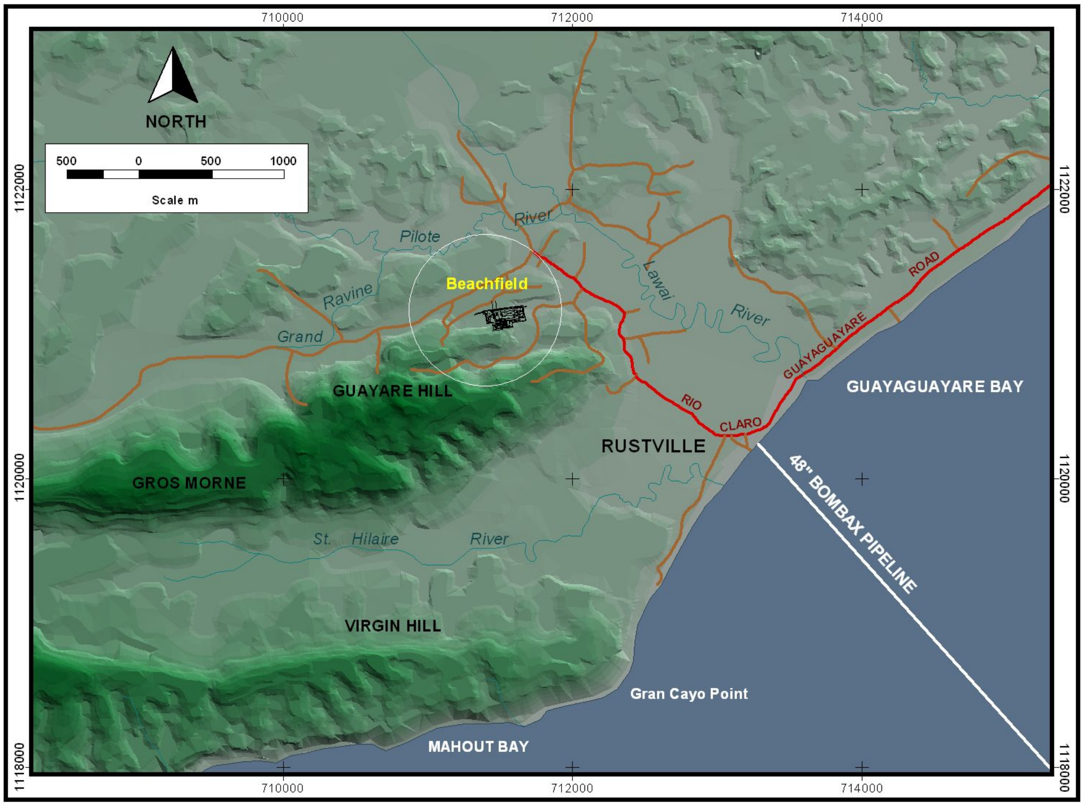

Figure 7.8: Location of the Beachfield Gas Receiving Facility, Guayaguayare.

The Cannonball Field Development Project requires modifications to be made to the Beachfield Gas Receiving facility in Guayaguayare to handle the increased gas and condensate volumes. This will include the following:

- Addition of a new Tuyere Separator/piping in parallel with existing
- Installation of a new Metering Skid including two (2) new Tuyere Separators
- 26" Temporary Bypass above ground from Pig Launcher to Pressure Control System
- 36" Tie-ins to Pig Launcher and 36" Tie-in to the Pressure Control System
- 48" Pipeline Tie-in to the 56" Cross Island Pipeline (CIP)

Please see Section 3.6 for complete details. The modification will require a 15 month construction programme proposed to start in May 2004. The construction will include clearing of an area south of the Beachfield Gas Receiving Facility to install the 575m, 48" Pipeline Tie-in to NGC's 56" Cross Island Pipeline (CIP) which will occur outside the compound. See Figure 7.9 below for an aerial photograph of the Beachfield Gas Receiving Facility showing the area to be cleared for the pipeline installation as well as the pipeline route (in red).

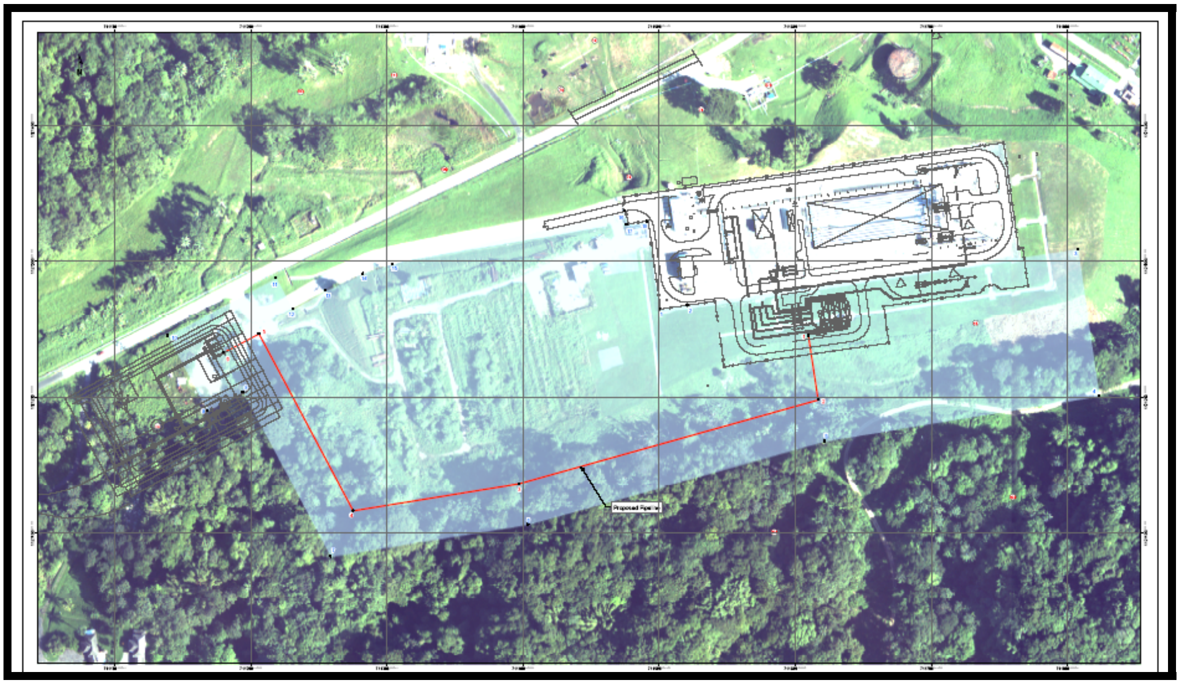

Figure 7.9: Beachfield Gas Receiving Facility showing are to be cleared and Pipeline Route

All other modifications will be conducted within the Beachfield Compound itself. The areas to be modified within the Beachfield Compound are shown in the schematic in Figure 7.10 below as the blue areas.

The possible impacting activities arising out of the modifications to the Beachfield Gas Receiving Facility are outlined as follows:

Construction Activities

- Clearance of vegetation and land for installation of 575m of 48” pipeline
- Discharge of Wastes both accidental and operational
- Discharge of Air Emissions from construction equipment
- Noise and Aesthetic Changes
- Hydrotesting of 575m 48” Pipeline
- Possible Spills (from fuels and chemicals)
- Movement of Construction Equipment to and from construction site
- Employment Opportunities

Operational Impacts

- Discharges of Air Emissions
- Accidental spills of fuels and wastes
- Leakage of Condensate Pipeline
- Rupture of the 575m 48" pipeline
- Solid Waste Disposal

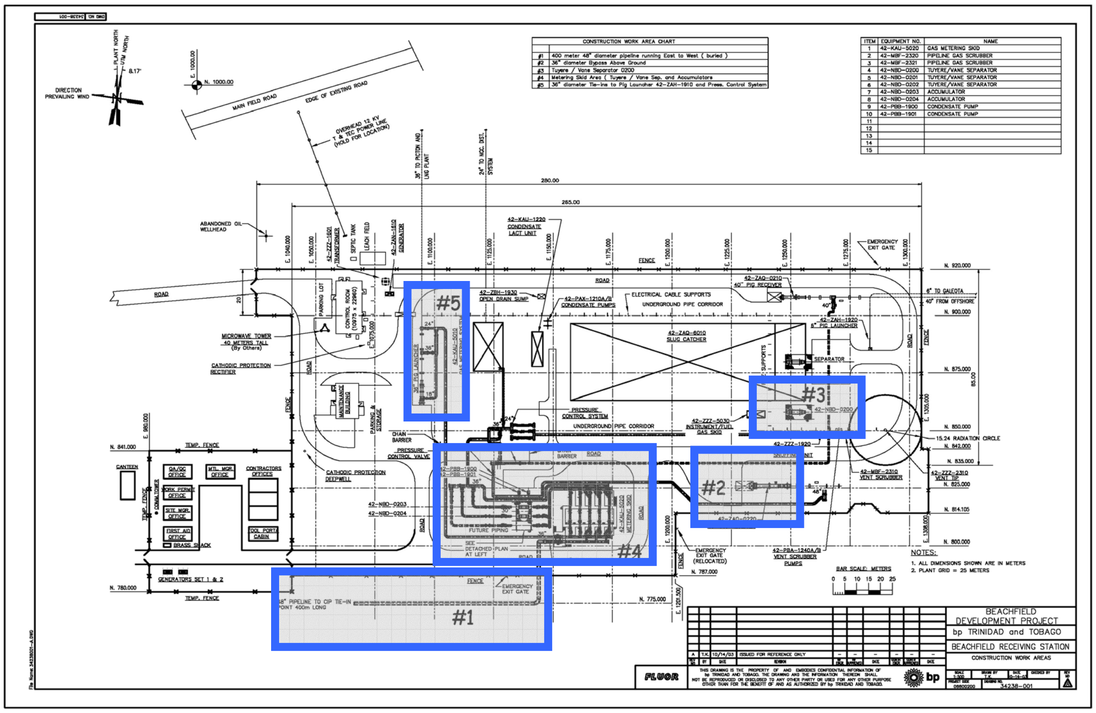

Figure 7.10: Proposed Modification Areas within the Beachfield Compound

7.7.1. Construction Impacts

7.7.1.1. Impact of the clearance of land outside of Beachfield Gas Receiving Facility

Figure 7.9 above shows the extent of the proposed land to be cleared for the 575m of 48" pipeline to tie into NGC's 56" Cross-Island Pipeline. The construction and pipeline laying areas will extent beyond the present Beachfield Facility boundary fence. The pipeline to be laid is 575m long and will be buried 1.2m (from the Top of Pipe). Its probable route is indicated in red on the figure. There will be a 12m wide permanent Right of Way (ROW) cleared along the pipeline route. The pipeline will be made of Carbon Steel and have a design pressure of 1050 psig. The pipeline will be supplied mainly by free excess pipe joints already located at the construction site however; there will be the need to transport in some sections of pipe.

The laying of the pipeline will require the clearance of some trees along the probable route. From Figure 7.9 above, the area to be cleared of trees is 575m (length of pipeline) x 12m (average width of tree clearance along the probable pipeline route). This is equivalent to 6,900m^2 of tree area to be cleared, assuming a tree density of 1 tree per 8m^2, this translates to approximately 863 trees to be cleared. Some trees/brush may be chipped and used as mulch for ROW restoration.

The Terrestrial Ecology survey discussed in Section 4 indicated that the forest, to the south of the Beachfield Gas Receiving Facility, is relatively impoverished, with a notable absence of most of the common canopy dominants which appears to be a result of the forest being high-graded (i.e. the selective extraction of commercial timber species) in the past (over 50 yrs ago). Species richness is extremely low at in this area.

The low species diversity of the area is due to the past timbering activities. Therefore, the impact of a loss of a possible 863 trees from this area caused by the Cannonball project would be minimal given the impoverished nature of the forests around the Beachfield Gas Receiving Facility.

However, the clearance of the trees must be examined in the context of the cumulative impact to the forests from the activities that have occurred over the past 50 years. Therefore the impact of the clearance of the trees is discussed in Section 7.8 Cumulative Impacts.

7.7.1.2. Impacts from Sediment runoff from Construction Site

Figure 7.9 above shows an aerial photograph of the Beachfield Gas Receiving Facility showing the area to be cleared to facilitate the installation of the 48” tie-in Pipeline (shown in red). The clearance of this land will expose the surface sediment to the elements. During the wet season, there will be sediment laden water runoff generated by rainfall, which will flow to the northwest (See Figure 7.11 below) and possibly enter the Lawai River, which runs to the south to the Rustville Wetlands and Guayaguayare Bay. The amount of runoff entering the Lawai River will not be significant given the distance and terrain to be traversed by the water . Any runoff entering the river will increase sedimentation levels in the river and lead to degradation of its water quality. The Lawai River is already sediment laden due to natural sediment runoff throughout its natural course. Section 4.4.5.1 describes the Lawai River and Rustville Wetlands, which it supplies.

The impact of this sediment runoff is not anticipated to be significant given the natural levels of sediment in the Lawai River as well the distance from the construction site. A list of mitigation measures to minimise this impact has been developed and is included in the Mitigation Management Plan that will govern this Cannonball Field Development Project. This plan is presented in **Section 8: Mitigation Management Plan.**

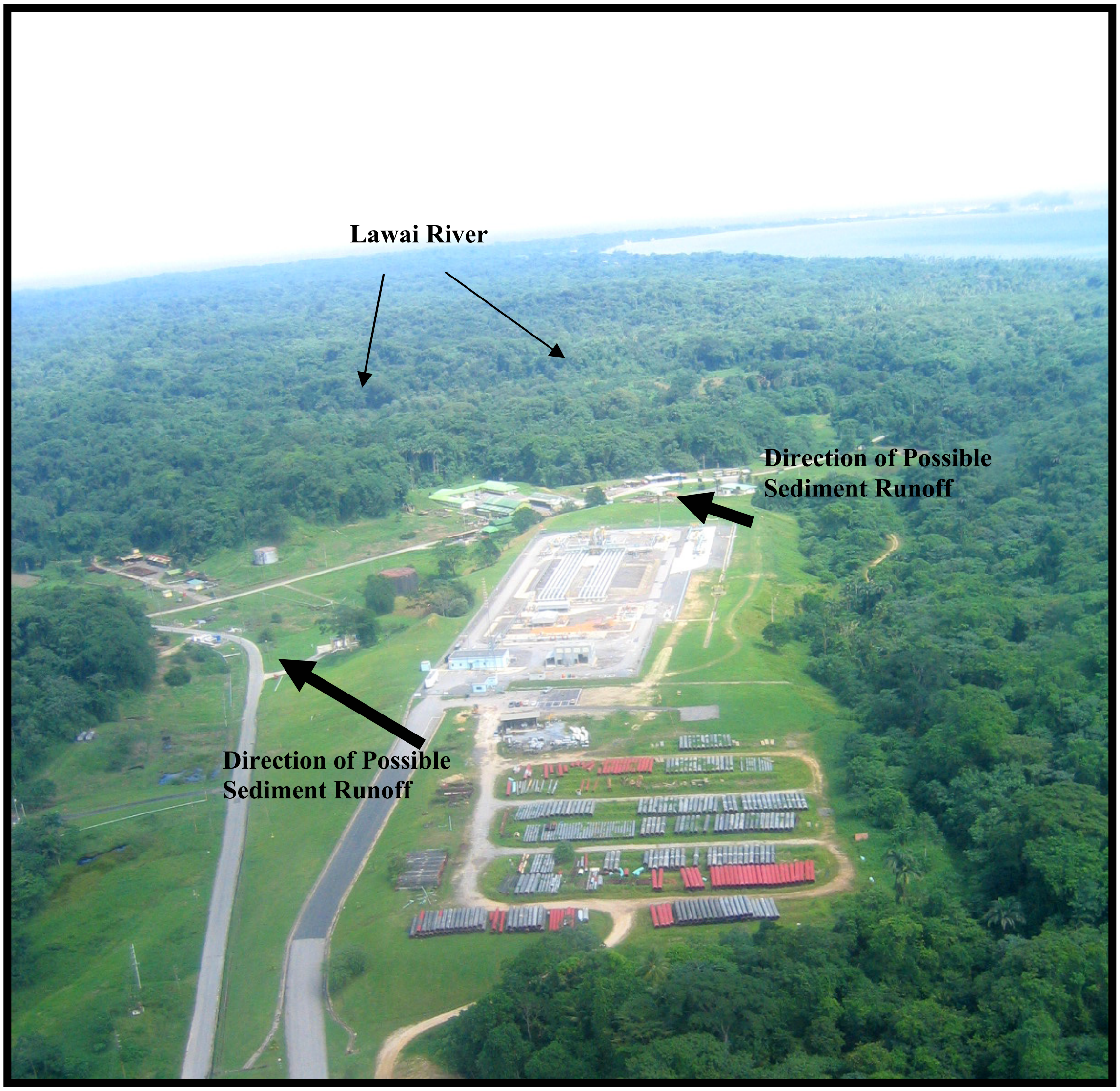

Figure 7.11: Direction of Possible Sediment Run-off from Construction Site

7.7.1.3. Impact of the Hydrotesting of 48" Pipeline

Section 3.6.2.1 describes the commissioning of the 48" Pipeline after its installation. The commissioning will require the pipeline to be pressure tested using water in the pipeline. This water is non-chlorinated freshwater with no added chemicals . After the hydrotest the water will be discharged via pipelines into the nearby Lawai River. Based on a diameter of 48" (1.22m) and a length of 575m, an approximate total of 672m^3 of hydrotest water will be discharged.

The impact of this discharge to the river is not anticipated to be significant due to fact that the discharge water will be fresh water with no added chemicals, the volume of discharge is small and the discharge will only occur once.

A list of mitigation measures to minimise this impact has been developed and is included in the Mitigation Management Plan that will govern this Cannonball Field Development Project. This plan is presented in **Section 8: Mitigation Management Plan.**

7.7.1.4. Impact of solid wastes generated from Construction Site

The construction activities at the Beachfield over 15 months will generate the following types of wastes:

- Sanitation Wastes
- Cooking Wastes
- Construction Solid Wastes such as scrap pipes, concrete
- Cleared Vegetation

bpTT has a Beachfield Construction HSE Plan, which manages the disposal for all wastes generated by the Beachfield Construction Activities. The entire plan is presented in Appendix C.

Table 7.15 below shows the estimated volumes of waste generated and the disposal options that bpTT will undertake to remove these wastes in an environmentally sound manner.

As such, it is anticipated that the waste generated by the construction activities will not have a significant impact on the environment.

7.7.1.5. Impact of possible spills from the Construction Site

There is also the possibility of accidental spills of chemicals and fuel wastes from the construction site such as paints, solvents and hydrocarbon spills. A significant potential impact exists for any accidental hydrocarbon release as it may enter the local water system, particularly the Lawai River to the east of the construction site. The input of these wastes into the river will severely degrade its water quality and impact on fish and other creatures living and depending on the river.

The Beachfield Construction HSE Plan, shown in Appendix C, has plans for the prevention and mitigation of any spills. This is summarised in Table 7.15 below. The impact of the spills is however, anticipated to be significant. A list of mitigation measures to minimize this impact has been developed and is included in the Mitigation Management Plan that will govern this Cannonball Field Development Project. This plan is presented in **Section 8: Mitigation Management Plan.**

Table 7.15: Estimated Waste Generated by the Beachfield Modifications		
Waste Type/Description	**Estimated Quantity Produced**	**Handling/Disposal Options**
Sanitary Wastes	42,060 gallons over 14 months	Portable toilets/port-a-cans to be provided at each construction site. Waste to be collected twice per week at a minimum and taken to an approved treatment facility for disposal.
Cooking Wastes	None	Cooking Wastes is nil as canteen on wheels will remove all associated wastes
Cleared Vegetation	130,000 ft^2	Waste to be spread or tilled over ROW when construction is completed.
Construction Solid Wastes: scrap pipes etc	42,060lbs	Store temporarily in lugger buckets. Haul to an approved landfill or recycling facility as appropriate.
Other inert Construction Wastes: concrete etc.	900 tonnes	Segregate debris according to category. Haul to an approved landfill or recycling facility as appropriate. Concrete trucks will wash out residual concrete at the approved disposal site (established for each delivery point) before returning to the batch plant. Concrete will not be washed out into a stream or water body.
Paints/Coatings/Solvents	500 gallons paint, 250 gallons of solvents	Use biodegradable cleaning agents in lieu of petroleum based solvents where practical. Fill used cans and buckets with sand or other inert material (ex. Bentonite) until no free liquid residue is present. Spread rags to allow air dry. Place lids on cans and buckets securely and insure that all hazardous material containers are labeled appropriately to describe contents. Provide a secure, fenced area for temporary storage of waste. Develop and implement a waste manifest for transfer of waste to an approved disposal site (i.e., Solid Waste Management Company Limited, SWMCOL). Use only approved waste transport companies to haul waste.
Hydrocarbon Spills/Waste Oil: oily waste including lubricating oil, hydraulic fluids, transmission fluids, grease, and used oil filters	Based upon equipment quantities but assume the following: 1. 10 each 42 gallon barrels of lubricating oils and grease	Develop and implement a spill prevention, control and countermeasures (SPCC) plan. Keep and maintain spill cleanup equipment at all construction sites where a reasonable potential for spills exists. Position hydrocarbon and fuel containers a reasonable distance away from water bodies. Provide secondary containment (berms or vaults) for fuel storage vessels/tanks and in locations where fuel transfer operations take place. Provide a secure, fenced area for temporary storage of waste. Develop and implement a waste manifest for transfer of waste material to an approved treatment facility or landfarm. Use only approved waste transport companies to haul waste.

7.7.1.6. Impact of Air Emissions from Construction Site

Construction Equipment

The construction activities will generate air emissions consistent with the operation of construction equipment such as cranes, trucks and standby generators. These emissions will include CO_2, NO_x, SO_x and CO and are typical of such construction activities, the quantity discharged is governed by the maintenance of the construction equipment. These will have a minimal impact on the localised Global Greenhouse Gas emissions as well the local air quality around the construction site.

7.7.1.7. Impacts to Noise and Aesthetics

There will increased noise produced by the construction and modification activities at the Beachfield Gas Receiving Facility. The Beachfield area is an existing industrial area and workers are required to wear hearing protection at all times. There are no houses or human receptors except for Beachfield personnel and Petrotrin employees who are in range of the increased construction noises.

There will be some impact of the noise on the local animal and bird populations living in the surrounding forests at Beachfield. However, these species would already be acclimatised to the noise levels of the Beachfield Operations and would not be significantly impacted. The construction activities will also be carried out only during the daytime hours to reduce the impact on the local wildlife populations.

A list of mitigation measures to minimise this impact has been developed and is included in the Mitigation Management Plan that will govern this Cannonball Field Development Project. This plan is presented in **Section 8: Mitigation Management Plan.**

7.7.1.8. Impacts to local road traffic caused by Construction Activities

The construction activities will require the movement of equipment to and from the Beachfield Gas Receiving Facility. The equipment will be moved from three points: Port of Spain, San Fernando and Galeota Point. This movement of heavy equipment is anticipated to start between February and May 2004. The local route for most of the equipment will be through the Mayaro and Guayaguayare road system, which is at present in a state of disrepair. The increased traffic from the construction activities will have the following impacts:

- Increased degradation of the local (Guayaguayare and Mayaro) road system
- Increased dust created by the movement of equipment
- Increased noise in local communities
- Increased congestion for local residents
- Increased chances of accidents

The Socio/Economic Survey described in Section 4 indicated that the increased road traffic was one of the major impacts identified by the local communities. It is expected that this impact will be significant.

The impact will be mitigated by the implementation of a Traffic Management Plan. This plan will be part of the Mitigation Management Plan the will govern the Cannonball Field Development Project and it is described in **Section 8: Mitigation Management Plan**.

7.7.1.9. Impact to local economy caused by Construction Activities

The construction activities at Beachfield are expected to have a direct impact on the economic conditions of the communities since it is expected to generate employment during the construction phase. It should be noted that the employment created would be on a temporary basis.

During the construction phase, Beachfield will create approximately 100 jobs (skilled and unskilled) over a 15-month period. bpTT has indicated that the contractor would require 25% to 33% of non-skilled to skilled labour as part of the Beachfield work force. Jobs will be created in Civil, Concrete, Structural Steel, Equipment/Mechanical, Piping, Electrical and Instrumentation.

This increase in the number of workers, in turn will tend to lead to increased business activity through the community such as increasing sales in the shops and parlours, restaurant, local transport and taxi services and housing accommodation. This impact is anticipated to be positive .

7.7.1.10. Impact of Beachfield Construction on Social Services

The activities of the project were assessed and found to have little or no impact on the social services in the study area during normal conditions. There may be increase demand for financial (banking) services on payday. This impact is not anticipated to be significant.

7.7.1.11. Impact of Beachfield Construction on Emergency Services

The construction activities at Beachfield will impact the local emergency services potential incidents are:

- Construction Accidents (normal to typical for construction projects of this size)
- Emergency accidents such as blowouts and pipeline rupture.

A review of the Health and Emergency Services has been conducted and is presented in Section 4- Description of the Environment.

Typical Accidents on Construction Site

It is anticipated that the local and bpTT emergency services as described above will not be adversely impacted by typical construction accidents that may occur on a construction project this size. bpTT has a Construction HSE Plan (Appendix C), which will require the construction contractor to provide the appropriate medical, evacuation and emergency plans in the event of a major accident. This impact is not anticipated to be significant.

Emergency accidents such as blowouts and pipeline rupture.

Emergencies such as blowouts and pipeline rupture will have a significant adverse impact on the local Health and Emergency services. These facilities do not have the capacity to handle extreme situations. The Social Survey conducted for this EIA indicates that this is an important concern for local residents, should a pipeline rupture occur, there will be significant impacts due to the potential ignition of the escaping gases. There will be impacts to the Beachfield Facilities' employees as well as local communities within the blast radius of the rupture. There will also be significant impacts to the local flora and fauna as well as to the air and water quality. There will be indirect significant impacts to local emergency and health services as well as the local communities through loss of jobs and livelihood.

7.7.1.12. Summary of Impacts of the Beachfield Construction Activities

The following table summarises the impacts of the Beach Gas Receiving Facility construction activities on the environment

Table 7.16: Impact Assessment of the Beachfield Construction Activities

Impacting Aspect	Nature	Duration	Probability of Occurrence	Severity	Significance Ranking
Garbage and Debris	Indirect	Temporary	1	3	2
Sanitation Wastes	Direct	Temporary	1	4	2.5
Sediment Run-off	Indirect	Temporary	2	4	3
Hydrotest Discharge	Direct	Temporary	3	3	3
Spills and Accidental Releases	Direct	Temporary	2	2	2
Air Quality – Engine and Generator emissions	Direct	Temporary	1	4	2.5
Noise	Direct	Temporary	1	4	2.5
Clearance of Vegetation	Direct	Long Term	4	2	3
Increased Traffic	Direct	Long Term	1	3	2

7.7.2. Impacts due to the Operation of the Beachfield Facility

The impact of the Beachfield Gas Receiving Facility will be in many respects similar to the impacts discussed above for the construction aspects particularly in terms of the emissions to the air, possible spill responses and the potential for a severe impact due to pipeline rupture or similar catastrophic accident.

7.7.2.1. Impact of Beachfield Operations on Air Emissions

Combustion Gas emissions: No_x, CO_2, CO and SO_x

There will be emissions from various pieces of equipment on the Beachfield Site such as:

- Standby Generators
- Various diesel trucks
- Water Blasting of Valve Stations (diesel run engines)

These all have diesel run engines, which will emit combustion gases such as NO_x, CO_2, CO and SO_x.

This equipment exists prior to the modifications however their operations are expected to increase due to the changes. These air emissions are typical of the operations of such equipment and the quantities discharged are governed by the level of maintenance of the equipment as well as the usage frequency of the equipment which is in this case is intermittent.

The Beachfield Operations are governed by a bpTT's Beachfield Environmental Management Plan, which ensures the regular maintenance of all equipment used in the Beachfield Facility. The impact of the emissions associated with the operating equipment at Beachfield is not anticipated to be significant due to the regular maintenance of the equipment and the intermittent and temporary nature of the emissions.

Natural Gas Emissions

Activities such as the preventative maintenance checks on valves, pig receiver depressurisation and the intermittent venting of the valve stations will cause the emissions of Natural Gas into the atmosphere. This will cause impacts to the local air quality and to the localised Global Green House Gas emissions. Given the intermittent and temporary nature of the natural gas emissions, the impact to the surrounding air quality is anticipated to be minimal.

Emergency release of Natural Gas

There will be discharges of natural gas from the following emergency events:

- Emergency Shutdown
- Emergency Blowdown
- Gas Pipeline Rupture
- Pipeline Explosion

These events will cause impacts to the local air quality and to the localised Global Green House Gas emissions. There are emergency control systems put into place to reduce the possible emissions of the natural gas should these events occur. It is not anticipated that this impact is significant.

7.7.2.2. Impact of spills and pipeline leaks

The leakage of the 6” condensate line has been identified as a possible significant impact on the surrounding water bodies. It is anticipated that should the Condensate Pipeline rupture approximately 3,000bbls of hydrocarbons will be spilled. The hydrocarbons can flow to the northeast out of the compound and enter the Lawai River running to the east of the facility (Figure 7.11 above). The impacts to the water quality and the wildlife in this river will be severe if this spill not mitigated particularly given the presence of the Rustville Wetlands, which receives water from the Lawai River. This impact is therefore significant and will be managed by the Mitigation Management Plan outlined in **Section 8: Mitigation Management Plan.**

7.7.2.3. Impact of Beachfield Operations on Noise Levels

The main contribution to an increase of noise levels at the Beachfield Gas Receiving Facility is the installation of the new metering skid. The Beachfield area is already an industrial area and workers are required to wear hearing protection at all times. There are no houses or human receptors except for Beachfield personnel and Petrotrin employees who are in range of the increased construction noises.

There will be some impact of the noise on the local animal and bird populations living in the surrounding forests at Beachfield. However, these species would already be acclimatised to the noise levels of the Beachfield Operations and would not be significantly impacted.

A list of mitigation measures to minimise this impact has been developed and is included in the Mitigation Management Plan that will govern this Cannonball Field Development Project. This plan is presented in **Section 8: Mitigation Management Plan.**

7.7.2.4. Impact of Beachfield Operation on Emergency Services

The impacts of the operation of the Beachfield Facility are anticipated to be similar to the impacts discussed during the construction phase (Section 5.7.1.11).

The incidents Beachfield which may impact the local emergency services are:

- Accidents (normal to typical operations for facilities of this type and size)
- Emergency accidents such as blowouts and pipeline rupture.

A review of the Health and Emergency Services has been conducted and is presented in Section 4- Description of the Environment.

Typical Accidents on the Beachfield Site during normal operations

It is anticipated that the local and bpTT emergency services as described above will not be adversely impacted by typical accidents that may occur on a facility such as the Beachfield Gas Receiving Facility . There is a Beachfield Emergency Response Plan that outlines the procedures to be taken during accidents to minimise worker health and safety. This impact is not anticipated to be significant.

Emergency accidents such as blowouts and pipeline rupture.

Emergencies such as blowouts and pipeline rupture will have a significant adverse impact on the local Health and Emergency services. These facilities do not have the capacity to handle extreme situations. The Social Survey conducted for this EIA indicates that this is an important concern for local residents should a pipeline rupture occur, there will be significant impacts due to the potential ignition of the escaping gases. There will be impacts to the Beachfield Facilities' employees as well as local communities within the blast radius of the rupture. There will also be significant impacts to the local flora and fauna as well as to the air and water quality. There will be indirect significant impacts to local emergency and health services as well as the local communities through loss of jobs and livelihood.

bpTT has conducted a Quantitative Risk Assessment (QRA) of the proposed Cannonball Field Development Project, which includes the Beachfield Operations. This is being submitted as a supporting document to this EIA.

The results of the QRA illustrate that the onsite risk and the societal risk for both onsite and offsite populations are within the BP Group Risk Acceptance Criteria but it lies in the zone where continuous improvement should be demonstrated. When compared to existing HSE risk criteria for other countries such as the United Kingdom, Holland and Hong Kong, the onsite risk and the societal risk are well within the maximum acceptable risk for workers and the public (DNV 2004: QRA for Beachfield Gas Receiving Station).

The potential accident scenarios modeled comprised of:

- Small leak
- Medium Leak
- Large Leak
- Catastrophic Failure - Rupture of pipes and ruptures of vessels

The results illustrated that the risk contour developed for the individual risk is $1x\ 10^{-4}$ per year contained within the plant boundary. The maximum individual risk inside the plant boundary was in the range of 1×10^{-3} per year but only in limited locations close to major equipment. Large leak scenarios in the Slug Catcher Section mostly contributed to this onsite risk. For the Control Room, the main risk contributor was the existing Metering

Skid 5010, the second largest risk contributor being the export line due to its close proximity to the control room.

The offsite individual risk for locations less than 300 m from the plant boundary is in the range 1 x 10^{-5} per year to 1 x 10^{-6} per year. The offsite individual risk for locations greater than 300 m from the plant boundary is less than 1 x 10^{-6}. The equipment that will give the highest contribution to the societal risk will be the pressure control system.

The result of this study shows that societal risk is below the intolerable risk line of BP's risk tolerance criteria. However, according to risk management principles practiced by BP, this means that continuous improvement should be demonstrated towards the goal of no accidents and no harm to people.

The QRA has outlined recommendations which are discussed in the Mitigation Management Plan the will govern the Cannonball Field Development Project. This is described in **Section 8: Mitigation Management Plan**.

7.7.2.5. Summary of Impacts of Beachfield Operation on the environment

Table 7.17: Impact Assessment of Beachfield Operations

Impacting Aspect	Nature	Duration	Probability of Occurrence	Severity	Significance Ranking
Garbage and Debris	Indirect	Long Term	1	4	2.5
Spills and Accidental Releases	Direct	Temporary	2	4	3
Air Quality – Engine and Generator emissions	Direct	Long Term	1	4	2.5
Methane Emissions	Direct	Long Term	4	3	3.5
Noise	Direct	Long Term	1	4	2.5
Pipeline Rupture	Direct	Temporary	4	1	2.5
Fire and Gas Explosion	Direct	Temporary	4	1	2.5

7.8. Cumulative Impacts

The following section discusses the cumulative impacts of the Cannonball Field Development Project

7.8.1. Impact of Cannonball WPP on Fishing Activities off the East Coast

The existence of the platform will have a cumulative impact on the fishing activity on the East Coast of Trinidad. The impact is cumulative since, by itself, the presence of the Cannonball WPP is not a significant obstacle to the fishermen's activities. However, the fishermen have identified, through the fisheries survey conducted for this EIA, that the Cannonball Wellhead Protector Platform is another addition to a growing number of obstacles that bpTT is placing offshore to the detriment of their livelihood.

Direct Interference with Fishing Activities

The main interference with marine traffic will be fishermen conducting line fishing and gillnetting. These fishing techniques employ fishing equipment, which is deployed in the water and allowed to drift in the current. The presence of the WPP will interfere with the movements of the nets and lines and would require the fishermen to closely monitor their equipment. The baseline survey of the local fishermen using the east coast indicates that this is a cumulative impact of bpTT's presence on the east coast. They indicate that their fishing times are being reduced since they have to pick up their equipment sooner than they would like to due to the increasing presence of installation of platforms and rigs off the east coast. The presence of the Cannonball Wellhead protector platform will add to a cumulative impact on the fishermen.

500m Safety Zone

Establishment of the 500m Safety zone is another associated cumulative impact imposed by bpTT around the Cannonball WPP. This safety zone has been established around all bpTT's platforms and rigs off the east coast and has been instituted for safety reasons. The fishing survey conducted for this EIA has found that the fishermen are upset about this zone given, as they report, that fishermen were allowed to fish near the platforms and rigs when the offshore installations were under The AMOCO Energy Company of Trinidad and Tobago. They also site the fact that in the Gulf of Paria, fishermen are allowed to tie off on the rig and fish. One of the arguments being used by the fishermen is that the platforms and rigs are acting as Fish Attracting Devices (FADs) because the commercial fish populations concentrate around the facility however bpTT unfairly bans the fishermen from catching the fishes in this area. This impact is not significant when evaluating the Cannonball WPP alone but becomes significant when taken in the context of the cumulative impact of all installations on the East Coast of Trinidad.

Support Boat interactions with the Fishermen.

The Cannonball WPP platform will not significantly increase the workboat traffic as it is an unmanned facility. There will be visits by a workboat every three (3) months to deliver a crew of ten (10) to conduct routine maintenance work. The movements of this workboat should not significantly impact on the fishermen's activities offshore; however as a cumulative impact there will be an increase in the interactions of the bpTT workboats and the fishermen who use the east coast as viable fishing grounds. The fishermen have communicated that there have been incidents where bpTT's support vessels do not respect the right-of-way of the fishermen when moving around the East Coast. The fishermen complain that they are less mobile than the workboats and find it difficult to retrieve their equipment and move out of the way from these workboats. This apparently happens mostly at night.

Summary of Impacts

bpTT recognizes this cumulative impact and have embarked on a consultation process with the fishermen at the five (5) affected fishing depots to address this issue. The fishing depots are Ortoire, Plaisance, Guayaguayare, La Retraite and Grand Chemin. The areas are shown in Section 4.6.3 along with a general description of the fishing activities off the east coast. Among the issues being discussed between bpTT and the fishermen is compensation for lost equipment, the reasons for the establishment of safety zones, possible installation of artificial reefs offshore to increase fish yields and training and awareness seminars of bpTT's workboat operators to discuss the interactions between the fishermen and the night time activities of the bpTT's workboats.

7.8.2. Impact of Beachfield Construction Activities on the surrounding forests

Although the impact of the loss of the trees is expected to be minimal in the context of the Cannonball project, the loss is also examined in the context of the cumulative impact to the area considering the amount of industrial and timbering activities that have occurred over the past 50 years in the Beachfield area. The two main impacting activities over the past 50 years would be the clearance of trees for industrial activities and the timbering of trees for its commercial value. These activities have had an impact over the past 50 years on the flora and fauna on the area.

Recognising that the loss of the trees might not be significant in the context of the Cannonball Project but significant in the overall cumulative impact of the loss of trees in the area, bpTT has decided to re-route the pipeline shown in Figure 7.9 to ensure that there will be no clearance of trees.

7.8.3. Cumulative Impact of Increased Gas Volumes at the Beachfield Gas Receiving Facility

Gas and condensate from Cannonball WPP will be transported to shore via the 48" Bombax pipeline onwards to the Beachfield Gas Receiving facility. The 48" Bombax pipeline design details are as follows:

- Design Capacity: 1.860bcfd
- Maximum Allowable Operating Pressure (MAOP): 1440 psig

The cumulative impact of this increased gas flow through this system is negligible, as the Cannonball platform and pipeline have been designed for a capacity of 1 billion standard cubic feet per day (scfd) at a maximum allowable operating pressure equal to or less than 1440 psig (Cannonball WPP normal operating pressure is 1300 psig). Cannonball will start production when the Kapok field and other existing bpTT gas fields have come off peak production therefore the volume of gas flowing through Cassia "B" will always be within the design parameters of 1.8 bcfd and MAOP of 1440 psig.

The Beachfield Gas Receiving Facility will be upgraded to 2.9 bcfd with an operating pressure between 900 and 1050 psig. The gas from the Cannonball WPP will flow through the proposed NGC 56 CIP, onwards to Atlantic LNG Train 4, which has been designed to accept the above-mentioned volumes and pressures.

Therefore, the cumulative impact of the increased gas volumes passing through the Beachfield Gas Receiving Facility is not anticipated to be significant.

7.8.4. Cumulative Impacts of the Cannonball Field Development Project on the Social Perceptions regarding bpTT

The Social and Economic survey conducted for this EIA identified that the communities of Guayaguayare and Mayaro generally seem to have a negative perception of bpTT and its operations in the area. These can be summarised as follows:

- There is a negative perception by some members of the community on the number of projects that bpTT has carried out in Guayaguayare and Mayaro: basically it was felt that the projects have produced limited benefits for the local communities over the years, as a result there is limited interest in the projects unless they address community needs and expectations.

- There is also an increasing sense of mistrust in the community about bpTT's intent with regard to their communications with the communities.

- The increasing number of projects in the area by bpTT and other oil and gas companies has brought with it a number of legal/administrative requirements, e.g. the public consultations requirement of the EIA process. While the communities welcome these discussions and the opportunity to be part of the decision making process, information from the preliminary consultation of this project suggests the communities are becoming frustrated by these consultations which in many instances seem to be *a talk shop* and not a *bon a fide* avenue to address their concerns.

The impacts described above are considered as cumulative since the Cannonball Project is adding to an existing negative perception from previous bpTT projects in the area. While these perceptions are not solely connected to the Cannonball Field Development Project, they should be addressed by bpTT.

This cumulative impact of this project on the social perceptions of bpTT in the Guayaguayare and Mayaro areas is anticipated as significant and will be managed by the Mitigation Management Plan outlined in **Section 8: Mitigation Management Plan.**

7.8.5. Summary of the Cumulative Impacts of the Cannonball Field Development Project

Table 7.18: Cumulative Impact Assessment of Cannonball Field Development Project

Impacting Aspect	Nature	Duration	Probability of Occurrence	Severity	Significance Ranking
Fishing Activities	Direct/Indirect	Long Term	1	4	2.5
Forests at Beachfield Gas Receiving Facility	Direct/Indirect	Long Term	1	4	2
Increased Gas Volumes at Beachfield Gas Receiving Facility	Direct	Long Term	1	4	2.5
Social Perceptions	Direct/Indirect	Long Term	1	3	2

8. MITIGATION MANGEMENT PLAN

In **Section 7: Significant Environmental Impacts**, the potential impacts of the Cannonball Field Development Project were discussed. In keeping with bpTT's commitment to develop the Cannonball Project to the highest environmental standards, several strategies have been adopted to mitigate these impacts whether they were evaluated as significant or not. These strategies will form part of an Environmental Management Plan (EMP) that will govern bpTT's activities in the Cannonball Field Development Project.

The Environmental Management Plan for the Cannonball Field Development Project will be based on the following bpTT standards and regulatory requirements;

1. **bpTT's Environmental Management System (EMS) which is certified to ISO 14001**
2. **bpTT's Waste Management Plan**
3. **bpTT's Emergency and Oil Spill Response Plan**
4. **bpTT's Contractor HSE Management Plan**
5. **bpTT HSE Requirements**
6. **Trinidad and Tobago Environmental Regulations as outlined in Section 2.**

In addition to the above, the Environmental Management Plan (EMP) for Cannonball will specifically include the following:

7. **The Mitigation Measures presented in this section**
8. **The Monitoring Plan presented in Section 9**

The Cannonball EMP will allow bpTT to manage the environmental performance of the Cannonball Field Development Project as well as to ensure that appropriate resources are dedicated to manage the environmental issues identified in this EIA.

The mitigation measures developed will ensure that the environmental impacts determined by this EIA are minimised or eliminated to as low as reasonably practicable. These measures will be included in the EMP for the Cannonball Field Development Project.

8.1. Offshore Impacts

8.1.1. Impacts to Marine Traffic

The installation, drilling and operation of the Cannonball WPP offshore will have a low environmental impact on the local marine traffic due to the following mitigation measures:

- The transportation of the platform from the La Brea area to the offshore site will be carried out in accordance with the rules and regulations governing the movement of large vessels in Trinidad and Tobago coastal and territorial waters, as set out by the Maritime Services Division of Trinidad and Tobago. These include:

- Notice to Mariners advertisement in the print media
- Flyers distributed at all relevant fishing depots
- One-to-one discussions with the fishermen at the relevant fishing depots
- Increased caution should transportation occur during the local fishermen's crop season: November – April
- Position of the Cannonball WPP will be submitted to the Maritime Services Division so it can be placed on the future navigation charts published locally and internationally by the Admiralty Chart and Publications (U.K. Hydrographer of the Navy)

- The platform will be situated outside the international shipping lanes.

- The Cannonball WPP, drilling rig and towing vessels will all be marked and lit in accordance with the Trinidad and Tobago maritime regulations as set out by the Maritime Services Division.

8.1.2. Air Quality Impacts

The air quality of the offshore Cannonball WPP area will be impacted by various activities such as: the transportation and installation of the WPP, drilling operations and the normal operation of the Cannonball WPP. The main emissions sources are generators, crane engines and the emission of natural gas from venting processes.

The impact of the Cannonball WPP on the ambient air quality has been evaluated using modelling techniques and the impact has been identified as low given the 60km distance from land. However, the following mitigation measures will be implemented to further reduce the air emissions:

- Venting on the platform will be minimised as practically possible

- Internal combustion engines (such as the Microturbine Generator) will be maintained in accordance to manufacturer's recommendations to reduce the emission of combustion gases such as SO_x, NO_x and CO.

- Drilling : The Jack up drilling rig chosen will have an active Environmental Management System to manage such environmental issues

8.1.3. Solid Wastes Discharge Impacts

The transportation barges, drilling rig and Cannonball Wellhead Protector Platform will all produce solid wastes such as garbage and metal scraps. These wastes can cause a moderate impact should they be discharged improperly such as over the side of the vessels. However, due to the implementation of bpTT's Waste Management Plan this impact is anticipated to be low. The mitigation measures are as follows:

- The storage and disposal of solid wastes generated by the offshore vessels and the platform will be managed according to the bpTT Waste Management Plan which does not allow the discharge of any solid waste material offshore. All solid wastes will be stored properly and transported to shore to the Galeota Point "ASCO" Base. there it will be treated and disposed at in an approved bpTT disposal site.

- A bpTT HSE representative will be on board at all times to ensure compliance with all local, international and bpTT HSE standards.

8.1.4. Sanitation and Domestic Waste Discharge Impacts

Discharges due to Transportation, Installation and Drilling Operations

The sanitation and domestic wastes discharges to the marine environment during the transportation, installation and drilling operations have been evaluated to be of low environmental risk. The potential risk to water quality will be mitigated by the following:

- The discharges will be managed by bpTT's Waste Management Plan

- The discharges will meet the Trinidad and Tobago Industrial Effluent Specification

- The discharges will be in accordance with international MARPOL standards

- A bpTT HSE representative will be on board at all times to ensure compliance with all local, international and bpTT HSE standards.

Discharges due to Cannonball Wellhead Protector Platform Offshore

There will be macerated sewage discharged by the Cannonball WPP offshore during its operation. The Cannonball WPP is an unmanned facility and will have a maintenance crew on board for 3 days (maximum of 10 persons) every three (3) months. It is estimated that there will be $0.16m^3$ of macerated sewage discharge every year from the Cannonball WPP with a Total Faecal Coliform Count of 1000 counts per 100ml. This exceeds the local effluent standards of 400 counts per 100ml. However, given the minor quantities discharged, the intermittent discharge pattern and the high current and wave energy conditions increasing dispersion, the environmental risk of this discharge is low. The following mitigation measures will be taken:

- A macerator will be used to grind the sewage to approximately 3 mm which allows for rapid dispersion when discharged into the marine environment.
- The macerator will be properly serviced and maintained to ensure its proper working condition during the short time it is required every three (3) months.

- Surface seawater samples will be collected at the platform to determine the actual faecal coliform levels, being discharged into the marine environment, at 50m and

100m down stream of the WPP. This will be carried out twice per year when personnel are on board the Cannonball WPP.

8.1.5. Potential Fuel Spills and Accidental Release Impacts

Potential fuel spills from marine vessels have been identified as a significant environmental risk as the spills can potentially impact water quality, fish, birds, marine turtles and marine mammals. There will also be indirect impacts to social and economic resources in area particularly with respect to fishing activities. The Cannonball WPP is a gas platform and hence, the worst case scenario for a fuel spill was a collision of a supply or workboat with the platform resulting in a spill of a full fuel tank from the vessel. Oil Spill modelling has been conducted (Section 7.6.1) and indicates that a full tank spill from a supply boat with a loss of 1,000 tonnes to the marine environment will cause a spill that will persist for approximately 2 days and be transported to the northwest. However, the spill does not impact the coast line due to the physical and chemical dispersive effects of the waves, currents and wind as well as the fact that the initial spill volume is relatively small.

A potential spill, whether it is a fuel spill from a vessel or an accidental liquid spill from the process on the Cannonball WPP, can, however have a significant impact to the marine environment and this will be mitigated through the following measures:

- All possible fuel spills are managed by bpTT's Oil Spill Contingency Plan which is currently in place.
- Oil Spill Response training for offshore Cannonball personnel
- Containment of potential spill areas by primary and secondary bunding.
- There will be leak detectors used in the chemical containment tank on the Cannonball WPP.

8.1.6. Drilling Fluids Discharge Impacts

The impacts of the discharge of the drilling mud is discussed in Section 7.4. The discharge of the drilling mud has the potential to directly impact the water quality of the surrounding marine environment and indirectly impact fish, birds, marine turtles and marine mammals. The impacts were evaluated to be of low environmental risk due to the low toxicity of Water Based Mud (WBM) being used in the drilling process and the diluting and dispersive effects of the high currents and wave forces in the area. Only the discharge of WBM will be allowed. There will be no discharge of Synthetic Oil Based Mud (SOBM) except that which is retained on the cuttings. This is discussed in the following section. The impact of the drilling mud to the marine environment is mitigated by the following measures:

- All drilling fluids and muds will be on the Ministry of Energy and Energy Industries (MEEI) approved list of chemical to be used offshore.

- Samples of the WBM discharge down current of the drilling rig will be collected twice during the 184 day drilling program. The seawater samples will be tested for Acute Toxicity (LC50 96Hr) using *Metamysidopsis insularis* as the test organism. The samples will be taken at 10 stations distributed downstream of the discharge to determine the spread and extent of the WBM discharge plume. This will be used to determine the zone of influence of the plume. The samples will also be tested for Total Suspended Solids (TSS).

- A Macrobenthic Survey will be conducted at the seven (7) offshore baseline stations to determine the impact of the discharge of the drilling muds on the marine benthic organisms. The Macrobenthic Survey will be conducted at the end of the drilling program and every six (months) after for a twelve period to compare the seabed communities before, during and after the drilling phase.

8.1.7. Drilling Cuttings Discharge Impacts

The impacts of the discharge of the drill cuttings were discussed in Section 7.4.1. The modelling of the drill cutting shows that the cuttings will deposit mostly in the area under the discharge point. Although the cuttings comprise of mostly rock, sand and shale fragments, there will be some retained Low Toxicity Synthetic Oil Based Mud on the cuttings. The amount of retained oil on cuttings (ROC) will be approximately 6% which is lower than that required by the MEEI. The potential impact of the discharge of the drill cuttings was found to be of an environmentally low risk since the main impact occurs 50m around the discharge point. The use of low toxicity Synthetic Oil Based Mud (SOBM) also reduces the environmental impact of the drill cuttings on the seafloor. The impact is further mitigated by the natural effects of bioturbation, sediment re-suspension and transport. The following mitigation measures will be adopted by bpTT to further mitigate the environmental impact of the drill cuttings discharge:

- Only a low toxicity Synthetic Oil Based Mud (SOBM) will be used in the drilling programme

- All drilling fluids and muds will be on the Ministry of Energy and Energy Industries (MEEI) approved list of chemical to be used offshore.

- The Retention of Oil on Cuttings (ROC) of the low toxicity Synthetic Oil Based Mud will be 6% which is lower than the 10% stipulated by the MEEI. At present bpTT is trying to continuously improve on this performance.

- Surface sediment samples will be collected at the discharge site for comparison with the pre-drilling survey conducted during the baseline survey. The samples will be analysed for its macro-benthic communities, meio-benthic communities and sediment quality. The results will be compared to the baseline survey data. The survey will be conducted at the end of the drilling program and every six (months) after for a twelve period to compare the seabed communities pre-, during and post drilling. Please see the Monitoring Programme outlined in Section 9 for details.

- An Underwater Video Survey of the seven (7) stations established by the baseline survey will be conducted after the completion of the drilling programme to determine the actual impact to the seabed surface. This survey will be repeated six (6) months and twelve (12) months after the completion of the drilling programme to determine if bioturbation and natural currents have mitigated the drill cutting discharge. Please see the Monitoring Programme outlined in Section 9 for details.

- A bathymetric survey will be done to determine the change in seabed levels caused by the discharge of the drill cuttings. The survey will be conducted along the area predicted by the modelling study and the results compared to the bathymetric data already collected for the area. The comparison will determine the actual spread of the drill cuttings on the seabed. The bathymetric survey will be repeated six months after the drilling has been completed to determine whether or not the levels of the drill cuttings on the floor has been reduced by natural forces such as sediment transport and bioturbation.

8.1.8. Impacts due to Offshore Pipeline Hydrotest Water Discharge

The discharge of the hydrotest water will have an impact offshore due to the possible presence of a biocide used to prevent corrosion in the pipeline. As described in **Section 3.0: Project Description** there are two possibilities with regard to the hydrotest water: (1) The hydrotest water will have no biocide present due to the short length of time in the pipeline which is assumed to be two (2) days or less and (2) The hydrotest water will remain in the pipeline for an extended period of time, which is assumed to be 2 months (approximately 60 days), in which case there will be a biocide added. Modelling conducted indicates that the zone of influence of the discharge is approximately 1039m northwest of the Cassia "B" hub. This was a worst case scenario with the biocide being at full strength. In reality, the biocide will have naturally degraded due to the extended length of time in the pipeline. The half-life decay of the probable biocide to be used is 59 days at a pH of 8 (which is the expected pH of the seawater to be used (taken from the baseline survey conducted for this EIA). Therefore, the biocide's concentration will be halved by the time it is discharged as part of the Hydrotest exercise.

The discharge of the Hydrotest Water will have a direct impact on the water quality within the zone of influence. There will also be indirect impacts to fishes, plankton, marine mammals and marine turtles. Due to the following mitigation measures, the impact is anticipated to be of low risk:

- To the extent possible, the use of biocide will be minimised. bpTT will not use the biocide if the pipeline can be hydrotested over two (2) days or less. If it has to be greater, the hydrotest water will be allowed to remain in the pipeline for at least 60 days so as to halve the concentration of the biocide through its natural degradation.

- The hydrotest water will be discharged at a depth of at least 7m below the surface of the sea to increase the mixing and dilution. This will decrease the extent of the discharge plume.

- A multi-port diffuser will be installed at the end of the discharge pipe for the hydrotest water. This will greatly reduce the extent of the hydrotest water plume through increased dilution and dispersion of the discharged water.

- Samples of the hydrotest water plume down current of the drilling rig will be collected during the hydrotest discharge. The seawater samples will be tested for Acute Toxicity (LC50 96Hr) using *Metamysidopsis insularis* as the test organism. The samples will be taken at 10 stations distributed downstream of the discharge to determine the spread and extent of the hydrotest discharge plume.

8.1.9. Impacts due to Offshore Produced Water Discharge

The discharge of the produced water will have an impact on the water quality in the area around the Cassia "B" Hub offshore. The produced water from the Cannonball WPP will be sent to the Cassia "B" Produced Water Re-Injection System (PWRI) where it will mix with the produced water coming from other platforms, namely: Cassia A, Immortelle, Flambuoyant and Kapok. The produced water will be injected into Well #8 at the Cassia A Platform. If re-injection occurs there will be environmental impacts to the offshore marine environment. However, in the case of the PWRI failing, then the produced water will be discharged overboard. The discharge will be treated to a concentration of 29ppm Total Petroleum Hydrocarbon (TPH). This is well below the 80ppm TPH levels stipulated by the EMA for offshore discharges. The PWRI system is expected to be on stream for 98% of the time (Jardine and Associates, 2001), so it is predicted that there will be discharge of the produced water 2% of the time. Modelling was done to determine this impact (See Section 7.6.1). It was determined that the produced water plume affects an area of approximately 100m downstream of the platform. The following mitigation measures will be adopted:

- The PWRI system on board the Cassia "B" Hub will be regularly maintained to reduce the potential downtime. The maintenance will be part of the Cannonball Environmental Management Plan (EMP).

- The produced water will be treated to reduce its TPH levels to 29ppm. This is lower than the 80ppm stipulated by the EMA for offshore discharges.

- Samples of the produced water plume down current of the Cassia B Hub will be collected during discharge events. The seawater samples will be tested for Acute Toxicity (LC50 96Hr) using *Metamysidopsis insularis* as the test organism. The samples will be taken at 5 stations distributed downstream of the discharge to determine the spread and extent of the produced water discharge plume. A sample will also be taken directly from the outlet of the produced water discharge on Cassia "B".

8.1.10. WPP and Drilling Rig installation and Removal Impacts on Benthic Communities

The Cannonball Field Development Project will physically impact on the benthic communities through the following activities:

- Installation of the drilling rig
- Drilling of the Cannonball Wells
- Installation of the Cannonball WPP
- Laying of the 26" Pipeline between Cannonball WPP and Cassia "B"
- Anchoring of crane barge during installation of the Cannonball WPP
- Anchoring of the lay barge during the 26" pipeline installation

During all these activities, there will be an impact to the benthic communities limited to the footprint of the legs of the drilling rig and the Cannonball WPP as well as the footprint of the anchor patterns used in the crane and pipeline laying barges. The impact is as a result of the physical smothering and crushing of the benthic communities by the above activities.

The impact of the installation of the Cannonball WPP and the 26" pipeline on the benthic communities is permanent and unavoidable. The impact of the anchoring of the drilling rig and installation barges are temporary and will last for the duration of the activities. The benthic communities in these areas are expected to re-generate. The following is a list of the mitigation measures taken to reduce this impact:

- A site survey was conducted throughout the area. The data collected, which included bathymetry, side scan sonar and sub-bottom profiling, was examined for potential areas of hard substrate and coral communities. There was none identified. This means that the impacts will be on soft clay-mud substrate which is homogeneous throughout the potentially impacted areas. For this reason the impact on the benthic communities will not be as severe as if the area had a hard substrate or coral communities. The baseline survey showed that the species diversity in the Cannonball Project area is low compared to areas north of the study site which had variations in substrate.

- A Macrobenthic Survey will be conducted at the seven (7) offshore baseline stations to determine the impact of the physical impact of the Cannonball Field Development Project. The Macrobenthic Survey will be conducted at the end of the installation and drilling programmes and then repeated every six (6) months for a 12 month period. Please see the Monitoring Programme outlined in Section 9 for details.

- An Underwater Video Survey of the seven (7) stations established by the baseline survey will be conducted after the completion of the installation and drilling programmes to determine the actual impact to the seabed surface. The Underwater Video Survey will be conducted at the end of the installation and drilling programmes and then repeated every six (6) months for a 12 month period. See the Monitoring Programme outlined in Section 9 for details.

8.1.11. Impacts from loss of well control

Loss of well control offshore has the potential to impact severely on workers health and safety as well as significantly impact on the marine and air environments through the release of natural gas and fluids. While the severity of this impact is high, the probability of occurrence is low. The following mitigation measures have been adopted:

- The drilling programme and the operation of the Cannonball WPP are conducted under "best practices" using the highest international industry standards.

- The jack up drilling rig has several well barriers to reduce the loss of well control:

  - Use of Blow out Preventer (BOP)
  - Ability to shear the drill pipe and shut in well
  - All well personnel on the drill floor are trained in several techniques for managing the potential for loss of well control.
  - The drilling rigs contracted by bpTT have modern well control equipment on board.

8.1.12. Impacts from offshore fire and gas explosion

The impact from an offshore fire or gas explosion will pose a severe environmental and safety risk to both offshore personnel and the marine and air environment. The severity of this impact is high; however the probability of its occurrence is low. The following mitigation measures were adopted:

- bpTT has conducted a Fire and Gas Dispersion study to determine the severity of the hazards resulting from explosions, fires and gas dispersion due to process events on the Cannonball WPP and to examine the adequacy of intended prevention, control, and mitigation measures. The results show that consequences of an explosion in the wellbay area are insignificant, and that the pool fire hazard is also considered insignificant. In order to minimize the consequence of a hydrocarbon leak from the wellheads or manifolds, fire and gas detection will be provided and will result in Total platform shut down (TPSD) (Fluor Daniel 2003; Fire and Gas Dispersion Study).

- bpTT has made the Cannonball Wellhead Protector Platform an unmanned facility. This reduces the potential impacts to worker safety and health.

- bpTT has designed the Cannonball WPP with no ignition sources capable of igniting gases (Flour Daniel, 2003: Ignition Risk Assessment)

8.1.13. Impacts on the Offshore Marine Mammals and Marine Turtles Populations

The offshore activities associated with the installation and operation of the Cannonball WPP, the drilling of the wells and the installation of the 26” pipeline will have a potential impact on marine mammals and turtles in the vicinity of the project activities. This is mainly due to the production of noise by the drilling and installation activities and the potential for collisions between the work and supply boats and the mammals and turtles. This impact has been evaluated as low due to the avoidance reflex of the mammals and turtles and the low population of these creatures in the project area. The following mitigation measures will further reduce the impact on these creatures:

- bpTT will train representatives of the work and supply boat crews to be observers who can identify species of marine mammals and turtles. The early sighting of these creatures will allow boats to avoid contact so as to reduce the possibility of collision.

- Personnel will also be trained on the drilling rig and the crane and lay barges to be on the lookout for marine mammals and turtles. Should a sighting occur, then an evaluation will be made as to the feasibility of ceasing the discharge of effluent until the creatures exit the area of influence.

- bpTT will set up a database to capture sighting data. The training of marine mammals and turtles will extend to other offshore facilities and drilling rigs to increase coverage of observational data.

8.2. Onshore Impacts – Beachfield Gas Receiving Facility Modifications

8.2.1. Impacts on Traffic

The construction activities at the Beachfield Gas Receiving Facility will have an impact on the traffic conditions in the Mayaro and Guayaguayare areas. This impact has been evaluated as significant due to its potential to affect a large segment of the local community. There will also be indirect impacts on the local economy from interruption of small business working hours.

The impact will be mitigated by the implementation of a Traffic Management Plan. This plan will be established after consultations with the local Guayaguayare and Mayaro communities. The details are as follows:

- bpTT will meet with key groups of the affected communities to establish the extent and implementation of a traffic management plan. The plan will incorporate the concerns of these community groups.

- The Traffic Management Plan will be drawn up and implemented before construction starts at the Beachfield Gas Receiving Facility.

- The Traffic management Plan will be communicated to the Guayaguayare and Mayaro communities through a program of community meetings and flyers distributed throughout the potentially affected areas.

- Some features of the Traffic Management Plan will include:

    - The transportation of the construction equipment will occur during local off-peak hours.

    - Police Outriders will be accompanying any large loads to ensure safe passage

    - All vehicle drivers will be trained in defensive driving techniques

    - bpTT will hire local community members to observe and report on the movement of the construction equipment.

    - Wherever possible, bpTT will use pipe joints which are already present on site to reduce the amount of pipeline being transported on the local roads.

8.2.2. Impacts from Solid Wastes and Garbage

The impact from the generation of solid wastes and garbage during the construction activities at the Beachfield Gas Receiving Facility is evaluated to be minimal. This impact is mitigated by the management of the wastes generated by the construction activities through bpTT's Waste Management Plan

8.2.3. Impacts from Sanitation Wastes

The impact of the sewage disposal from the Beachfield construction site is evaluated to be minimal. The construction site will use portable toilets and there is no anticipated increase in load to the existing Beachfield Sewage Treatment Plant.

8.2.4. Impacts from sediment runoff during the rainy season

There is a potential for sediment run-off to enter the Lawai River which is to the east of the construction site during the wet season which runs from June – December. The environmental risk from this impact is low due to the distance between the construction site and the Lawai River. The impact of the runoff will be mitigated by the implementation of silt screens and traps around the construction site during the wet season. This will trap the sediment as it leaves the compound and so prevent it from reaching the Lawai River or other water bodies nearby.

8.2.5. Impacts from Air Emissions

The Beachfield Gas Receiving Facility operation and construction activities will impact on the air quality in the immediate area around the facility. The emissions are combustible gases such as SO_x, NO_x and CO from the construction equipment and natural gas emissions from venting and pig launching processes. The impact has been identified as localised and minimal. However, a number of mitigation measures will be implemented:

- All internal combustion engines will be maintained in accordance to their manufacturer specifications.

- The maintenance programme for the equipment will be part of the Cannonball Environmental Management Plan (EMP).

- To the extent possible , venting of natural gas will be minimised

- There will be a survey of the flora and fauna of the surrounding forests at the Beachfield Gas Receiving Facility. This will take place mid-point during the construction programme (approximately seven months after construction starts). The survey will be repeated at the end of the construction programme and once again 6 months after the construction has been completed. All survey data will be compared to the baseline survey data collected in the Beachfield area to determine the extent of the impact to the surrounding forests. See the Monitoring Programme outlined in Section 9 for details.

8.2.6. Impacts from Spills and Accidental Releases

Fuel and chemicals spill from construction activities will have an impact on local water bodies, worker health and safety and local flora and fauna. This impact is mitigated by implementing the following:

- Provision of secondary containment (berms or vaults) to contain the flow of hydrocarbons from a leak or rupture.
- Develop and implement a spill prevention, control and countermeasures (SPCC) plan.
- Keep and maintain spill cleanup equipment at all construction sites where a reasonable potential for spills exists.
- Position hydrocarbon and fuel containers a reasonable distance away from water bodies.
- Provide a secure, fenced area for temporary storage of waste.
- Use only bpTT approved waste transport companies to haul wastes.

8.2.7. Impacts from the Hydrotesting Procedures

The discharge of the hydrotest water into the Lawai River can have an impact on its water quality. To reduce or eliminate this impact the following mitigation measures should be adopted:

- Use only freshwater with no additives
- No biocide to be used in the Hydrotesting procedure
- The discharge of the water from the hydrotest should be controlled so as to not cause a major disturbance to the flow rate of the river.
- A sample of the hydrotest water will be taken during its discharge. The sample will be tested for Acute Toxicity (LC50 96Hr) using *Metamysidopsis insularis* as the test organism. See **Section 9: Monitoring Plan** for details.

8.2.8. Impacts from the clearance of land for the Beachfield Facility modifications

The proposed clearance of vegetation and trees can impact on the local flora and fauna of the forests located to the south of the Beachfield Gas Receiving Facility as this is the proposed location of the clearance. It is estimated that approximately 863 trees will be removed. The impact is evaluated to be minimal due to the low species diversity of the surrounding forest. The area has been used for timbering in the past and this has caused degradation in the quality of the forests in the area. However, the socio-cultural survey conducted for this EIA has highlighted the loss of trees in the construction programme as an important impact in the view of local hunters and users of the forest. In light of this the following mitigation measures will be implemented:

- The pipeline route and its Right of Way (ROW) outside of the Beachfield Gas Receiving Facility has been changed to eliminate the clearance of any trees, therefore there will be no loss of trees due to this project.

- As in the mitigation for the possible air emissions, there will be a survey of the flora and fauna of the surrounding forests at the Beachfield Gas Receiving Facility. This would take place mid-point during the construction programme (approximately seven months after construction starts). The survey will be repeated at the end of the construction programme and once again 6 months after the construction has been completed. All survey data will be compared to the baseline survey data collected in the Beachfield area to determine the extent of the impact to the surrounding forests due to the pipeline installation and construction activities. See **Section 9: Monitoring Plan** for details.

8.2.9. Impacts from increased noise levels during construction activities and operation of the Beachfield Gas Receiving Facility

The construction activities are expected to increase the noise levels in the area around the Beachfield Gas Receiving Facility. There will also be an increase in the noise emanating from the facility after the completion of the modifications mainly due to the presence of the additional metering skids. The increase will impact of the fauna of the surrounding forests. The impact of the increased noise levels are anticipated to be minimal since the fauna has already acclimatised to the higher than normal noise levels from the present metering skid. The following mitigation measures will be implemented:

- Noise levels will be monitored during the construction phase of the project. Noise Level surveys will be conducted at four stations surrounding the Beachfield Gas Receiving Facility for a single day every month for the construction programme estimated to be 15 months. The noise level will also be measured before the construction activities start for a comparison level of noise. The monthly surveys will continue every three (3) months after construction is completed for a twelve (12) month period to determine the increase in noise levels during the operation of the modified Beachfield Facility. See **Section 9: Monitoring Plan** for details.

- As in the mitigation for the possible air emissions and the clearance of vegetation, there will be a survey of the fauna of the surrounding forests at the Beachfield Gas Receiving Facility. This would take place mid-point during the construction programme (approximately seven months after construction starts). The survey will be repeated at the end of the construction programme and once again 6 months after the construction has been completed. All survey data will be compared to the baseline survey data collected in the Beachfield area to determine the extent of the impact to the surrounding forests due to the noise from the construction activities. See **Section 9: Monitoring Plan** for details.

- Should the noise levels be seen to affect the fauna of the forest then bpTT will examine the feasibility of using noise reduction technology such as mufflers and sound barriers on their construction equipment and metering skids. However, the safety aspects of using this technology will be taken into account when deciding on the feasibility of implementing such measures.

8.2.10. Impact to the local economy

The impact of the construction activities at the Beachfield Gas Receiving Facility on the local economy is evaluated to be significantly positive due to job creation. It is estimated that at least 30 persons from the local communities will be employed for the 15 months of construction. The impact is temporary, however as there is no anticipated increase in the Beachfield Gas Receiving Facility employment levels after construction is completed. No mitigation measures are required since the impact is positive; however, bpTT will implement the following measure to increase the level of employment:

- bpTT will establish a temporary catering area on the construction site. There will be temporary booths constructed to allow local community members to provide catering services to the construction crews. This strategy will address the issues raised by women in the affected communities.

8.2.11. Impacts from possible pipeline rupture

Should a pipeline rupture occur, there will be significant impacts due to the potential ignition of the escaping gases. There will be impacts to the Beachfield Facilities' employees as well as local communities within the blast radius of the rupture. There will also be significant impacts to the local flora and fauna as well as to the air and water quality. There will be indirect significant impacts to local emergency and health services as well as the local communities through loss of jobs and livelihood.

bpTT has conducted a Quantitative Risk Assessment (QRA) of the proposed Cannonball Field Development Project which includes the Beachfield Modifications. The results illustrate that the onsite risk and the societal risk for both onsite and offsite populations are within the BP Group Risk Acceptance Criteria but it lies in the zone where continuous improvement should be demonstrated. When compared to existing HSE risk criteria for other countries such as the United Kingdom, Holland and Hong Kong, the onsite risk and the societal risk are well within the maximum acceptable risk for workers and the public (DNV 2004: QRA for Beachfield Gas Receiving Station).

The potential accident scenarios modeled comprised of:

- Small leak
- Medium Leak
- Large Leak
- Catastrophic Failure - Rupture of pipes and ruptures of vessels

The results illustrated that the risk contour developed for the individual risk is 1x 10^{-4} per year contained within the plant boundary. The maximum individual risk inside the plant boundary was in the range of 1 x 10^{-3} per year but only in limited locations close to major equipment. Large leak scenarios in the Slug Catcher Section mostly contributed to this onsite risk. For the Control Room, the main risk contributor was the existing Metering Skid 5010, the second largest risk contributor being the export line due to its close proximity to the control room.

The offsite individual risk for locations less than 300 m from the plant boundary is in the range 1 x 10^{-5} per year to 1 x 10^{-6} per year. The offsite individual risk for locations greater than 300 m from the plant boundary is less than 1 x 10^{-6}. The equipment that will give the highest contribution to the societal risk will be the pressure control system.

The result of this study shows that societal risk is below the intolerable risk line of BP's risk tolerance criteria. However, according to risk management principles practiced by BP, this means that continuous improvement should be demonstrated towards the goal of no accidents and no harm to people. To accomplish this goal, the following recommendations are made:

- Consider installing emergency isolation valves upstream of the metering skids.

- Upgrade the leak, fire and gas detection system for the Beachfield facility.

- Ensure all permanently manned areas on the facility are adequately protected against ingress of flammable gas.

- Minimize the potential for a full bore rupture event by:
  - managing onsite traffic
  - adequately maintaining the overpressure protection system
  - ensuring that equipment design matches requirement
  - managing the construction risk

- Develop integrated emergency response (ERP) plans for Beachfield that include BPTT, Petrotrin and other stakeholders (DNV 2004, QRA for the Beachfield Receiving Station).

- The ERP should be presented to the local communities and the relevant Health and Emergency Services so that all participants will know their role in the ERP.

- A geographic area of greatest risk should be identified around Beachfield and a database on the number of households with special characteristics (in particular households with disabilities) should be developed and mapped as part of the ERP. This will allow the Health and Emergency Service to plan any evacuation procedures to take into account persons unable to mobilise due to special circumstances. It is anticipated that the Geographical Information System (GIS) developed for this EIA can be used in this regard.

- bpTT should develop a procedure to communicate this plan to the local residents.

8.3. Cumulative Impacts

8.3.1. Impacts to Fishermen and Fishing Activities

There will be a moderate environmental impact to the local fishing communities because of the increase in number of bpTT's platforms offshore. This is a cumulative impact since the installation of the Cannonball WPP adds to the overall presence of bpTT off the east coast of Trinidad. The increased interactions between the fishermen and bpTT's workboats and the establishment of the 500m safety zone will reduce the time required for line and gillnet fishing in the specific Cannonball offshore area. The proposed mitigation measures are as follows:

- bpTT will be increase communication with the fishermen through one-to-one interactions at the relevant fishing depots.
- There will specific meetings held to address the issues around the 500m safety zone. The rationale for the safety zone will be discussed with the fishermen as they have identified that there is some confusion as to the purpose of the 500m safety zone.
- bpTT will embark on an education program for its supply boat captains and crew regarding the appropriate interactions with the fishermen particularly at night.
- bpTT will institute "night shift" look-outs on all vessels to reduce the possibility of collision between fishing boats and workboats particularly as the fishermen are reportedly immobile once their fishing equipment has been deployed overboard.
- Radar reflectors and lights will be purchased for the fishermen to help increase their visibility to bpTT's supply and work boats. The provision of this equipment is in progress.
- bpTT will carry out a Feasibility Study to evaluate the possibility of installing artificial reefs offshore which will act as Fish Attracting Devices (FAD) to increase fish catches offshore. Included in the Feasibility Study will be an evaluation of the use of decommissioned offshore structures as FADs.

8.3.2. Impacts of the Cannonball Project on public perceptions regarding bpTT

The Social and Economic survey conducted for this EIA identified that the communities of Guayaguayare and Mayaro generally seem to have a negative perception of bpTT and its operations in the area. These can be summarised as follows:

- There is a negative perception by some members of the community on the number of projects that bpTT has carried out in Guayaguayare and Mayaro: basically it was felt that the projects have produced limited benefits for the local communities over the years, as a result there is limited interest in the projects unless they address community needs and expectations.

- There is also an increasing sense of mistrust in the community about bpTT's intent with regard to their communications with the communities.

- The increasing number of projects in the area by bpTT and other oil and gas companies has brought with it a number of legal/administrative requirements, e.g. the public consultations requirement of the EIA process. While the communities welcome these discussions and the opportunity to be part of the decision making process, information from the preliminary consultation of this project suggests the communities are becoming frustrated by these consultations which in many instances seem to be *a talk shop* and not a *bon a fide* avenue to address their concerns.

The impacts described above is considered a cumulative one since the Cannonball Project is adding to an already existing negative perception from previous bpTT projects in the area. While these perceptions are not solely connected to the Cannonball Field Development Project, they should be addressed by bpTT.

The following is a list of proposed mitigation measures:

- To address the perceptions of members of the community bpTT must continue to have transparent, honest and open dialogue with the communities and community groups. The company needs to develop a plan to address relationship issues with the community.

- bpTT should advise the contractors to hire labour for the Cannonball Field Development project from the surrounding communities. The contractor can be encouraged to adopt this practice and also be provided with an up-to-date copy of the skills bank list from Mayaro Group Organisation for Un-employed Concerned Citizens (MGOUCC) and the Lions.

- Given the opportunities identified for the area by the Local Concept Development Plan especially for oil and gas and tourism, the company should develop a long term sustainable development plan for the company which clearly identifies the areas of intervention by the company, for instance projects which will directly impact on employment and the aesthetics of the community.

- Given the company's commitment to developing the area the company can:
    - Train persons from the community to assist in monitoring impacts from the Beachfield Gas Receiving Facility's modifications.
    - Identify areas where persons can be trained during the Cannonball Field Development Project.
    - Train and hire Guayaguayare and Mayaro fishermen to collect data on turtles and mammals as part of the monitoring for the Cannonball Field Development Project.

9. MONITORING PLAN

This section outlines the Monitoring Plan proposed by bpTT for the Cannonball Field Development Project. The purpose of the monitoring plan is as follows:

1. To monitor the industrial effluents being discharged by the Cannonball Field Development Project to determine compliance with the applicable environmental standards

2. To determine the extent of the actual impacts of the Cannonball Field Development EIA on the offshore and onshore environments

3. To assess the effectiveness of the proposed mitigation measures that have been proposed to minimise the environmental impact of the Cannonball Field Development Project.

4. To inform bpTT's Cannonball Environmental Management Plan.

5. To advise future Environmental Management Plans being developed for new development projects.

The following outlines the components of the Cannonball Field Development Monitoring Plan:

9.1. Offshore Activities

9.1.1. Sewage Disposal

There will be macerated sewage discharged by the Cannonball WPP offshore during its operation. The cannonball WPP is an unmanned facility and will have a maintenance crew on board for three days (maximum 10 persons) every 3 months. It is estimated that there will be $0.16m^3$ of macerated sewage discharged every year from the Cannonball WPP with a Total Faecal Coliform Count up to 1000 counts per 100 millilitres during each discharge. This exceeds the local effluent standard of 400 counts per 100 millilitres. The discharges are expected to be very low and intermittent. However, surface seawater samples will be collected at positions 50m and 100m from the Cannonball Platform to determine the actual faecal coliform levels being discharged into the marine environment. These surveys will be conducted twice per year when personnel are on board the Cannonball WPP.

9.1.2. Produced Water Discharge

It is expected that the Cannonball WPP will begin produced formation water in 2006. The produced water will, at this time, be sent to Cassia "B" for processing and re-injection into the Cassia "A" Well #8. The only time that Produced Water is expected to be discharged overboard at the Cassia "B" Platform is if the Re-Injection System fails. This is anticipated to be 2% of the time. The produced water will be treated to a Total Petroleum Hydrocarbon (TPH) concentration of 29ppm which is less than the Environmental Management Authority (EMA) offshore standard of 80ppm. During the times of produced water discharge, samples of the produced water plume down current of the Cassia B Hub will be collected. The samples will be taken at five (5) stations distributed downstream of the discharge to determine the spread and extent of the produced water discharge plume. A sample will also be taken directly from the outlet of the produced water discharge on Cassia "B". The samples will be tested for the following parameters:

- Acute Toxicity LC50 (96Hr) using *Metamysidopsis insularis* as the test organism
- Total Suspended Solids (TSS)
- Biological Oxygen Demand (BOD),
- pH
- Dissolved Oxygen (DO)
- Total Petroleum Hydrocarbon (TPH)

9.1.3. Hydrotest Water Discharge

Samples of the hydrotest water plume down current of the Cassia "B" Hub will be collected during the pipeline hydrotest discharge. The samples will be taken at five (5) stations distributed downstream of the discharge to determine the spread and extent of the hydrotest discharge plume. The samples will be tested for the following parameters:

- Acute Toxicity LC50 (96Hr) using *Metamysidopsis insularis* as the test organism
- Total Suspended Solids (TSS)
- Biological Oxygen Demand (BOD),
- pH
- Dissolved Oxygen (DO)

9.1.4. Drilling Mud and Cuttings Discharge

The discharge of the drill cuttings and mud during the Drilling Programme for the Cannonball Wells was described in Section 3.4.9. The modelling conducted for the EIA was presented in Section 7.4. The following parameters will be monitored during the drilling programme:

- The Water Based Mud (WBM) and the Synthetic Oil Based Mud to be used in the Cannonball WPP Drilling Programme will be tested for Acute Toxicity LC50 (96Hr) using *Metamysidopsis insularis* as the test organism.

- At least 5 Water Sampling stations will be established northwest of the drilling rig. Samples will be taken at surface, mid-depth and bottom to establish the drilling mud plume dimension and the following parameters will be tested:

- Acute Toxicity LC50 (96Hr) using *Metamysidopsis insularis* as the test organism
- Total Suspended Solids (TSS)

This survey will be repeated twice during the drilling programme.

- Surface sediment samples will be collected at the discharge site for comparison with the pre-drilling survey conducted during the baseline survey. The samples will be analysed for its macro-benthic communities, meio-benthic communities and sediment quality. The results will be compared to the baseline survey data. The survey will be conducted at the end of the drilling program and every six (months) after for a twelve period to compare the seabed communities pre-, during and post drilling. The methodology for the surveys is as outlined in the field surveys in **Section 3: Description of the Environment.**

- An Underwater Video Survey of the seven (7) stations established by the baseline survey will be conducted after the completion of the drilling programme to determine the actual impact to the seabed surface. This survey will be repeated six (6) months and twelve (12) months after the completion of the drilling programme to determine if bioturbation and natural currents have mitigated the drill cutting discharge.

- Changes in the bathymetry of the area will indicate the deposition of drill cuttings generated during the drilling process. The sediment modelling study has identified the areas at the well site which can be monitored to observe the spreading of drill cuttings over the area. By monitoring the bathymetry in the study area at regular intervals the extent and duration of these seabed changes can be identified. This survey should be conducted before the drilling activities start. The survey area should not be confined to the immediate area but extend to encompass the possible depositional areas as identified in the modelling study. The survey grid should be variable at a maximum of 200m intervals and a minimum of 5m intervals near the well site. All depths should be expressed relative to Chart Datum. The datum should be WGS-84 Datum. This survey should then be conducted again immediately after the completion of the drilling and then repeated every 12 months for a 2 year period. Comparison between the surveys should identify any changes in the deposition within the study area. It is important to ensure that the surveys are all conducted with the same positioning and datum parameters to ensure that proper comparisons can be made.

9.1.5. Offshore Baseline Environmental Monitoring Stations

In addition to the above monitoring of the offshore Cannonball Field Development Project activities, bpTT plans to monitor the environmental conditions at the seven (7) environmental monitoring stations described in Section 3: Description of Environment.

Figure 9.1 below shows the location of the seven (7) stations.

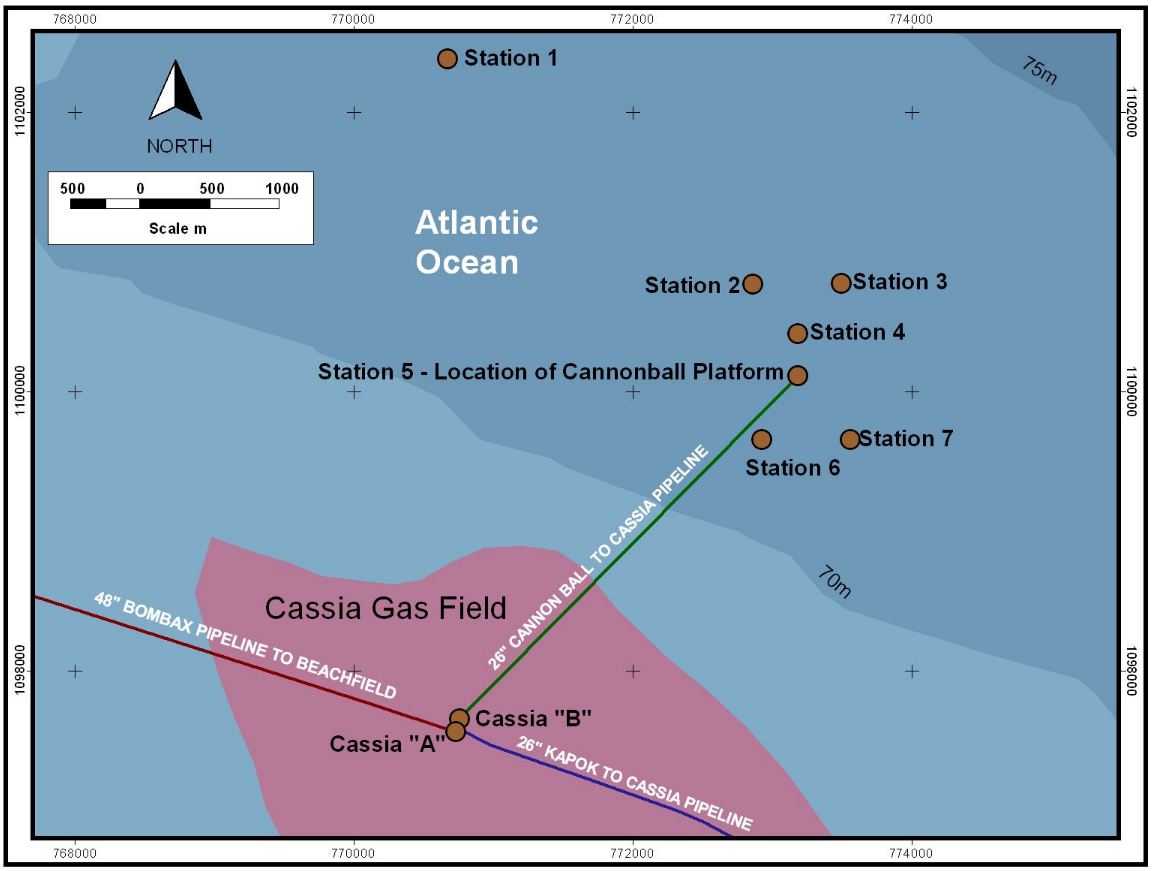

Figure 9.1: Offshore Baseline Environmental Monitoring Stations for Cannonball EIA

During the baseline survey the following surveys were conducted at these environmental monitoring stations:

- Water Quality Survey – surface, middle and bottom depths sampled
- Sediment Quality Survey – Surficial Sediments sampled
- Current Speed and Direction data for the offshore area
- Conductivity, Temperature and Density Data for the offshore area
- Macrobenthic Survey of the offshore area – Surficial Sediments sampled
- Meiobenthic Survey of the offshore area – Surficial Sediments sampled
- Video Survey of the offshore seabed

For the monitoring plan the above surveys will be repeated at the above stations six (6), twelve (12) and twenty four (24) months after the installation of the Cannonball WPP. The results of the survey will be compared to the baseline survey to determine the impacts of the installation, drilling and operation of the Cannonball WPP and its connecting pipeline to Cassia “B”.

The following is a summary of the field methodologies for the above environmental monitoring of the baseline stations:

Water Quality Survey

Water samples will be collected from the surface (2m below surface), mid-depth and bottom levels (1.5m above seabed) in the water column at each of the seven (7) stations using a 7 L Nisken Water Sampling Bottle. The samples will be stored in prepared sample jars (acid washed) and stored at 4°C until delivered to an approved analytical laboratory. The following water quality analyses will be done on the samples:

Total Petroleum Hydrocarbons (TPH), phenols, Total Organic Content, Heavy metals (nickel, cadmium, zinc, copper, lead, mercury, chromium) in addition to barium and vanadium, Total suspended solids, Nutrients (ammonia, sulphides, nitrates, nitrites).

Sediment Quality Survey

Surface Sediment samples will be taken at each of the seven (7) stations outlined above. The following sediment quality analysis will be done on each sample:

Total Petroleum Hydrocarbons (TPH), phenols, Total organic content, Heavy metals (nickel, cadmium, zinc, copper, lead, mercury, chromium) in addition to barium and vanadium (total and bio-available)

Macrofaunal Survey

Three (3) separate surficial sediment grabs will be taken for macrofaunal analysis at each of the stations. Each sample will be washed through a 0.5 mm^2 sieve and all organisms retained will be preserved in a 10% formalin buffered seawater solution. Additionally, the organisms will be stained using a proteinaceous dye (Rose Bengal) and securely stored in plastic containers for transport to the laboratory. In the laboratory, all samples will be gross sorted into two groups – marine worms (Phylum Annelida) and all other macrofauna. All organisms collected will be counted and identified as far as possible to the taxonomic level of species, using relevant taxonomic literature.

Meiofaunal Survey

Two (2) separate surface grabs will be taken for meiofaunal analysis at each station. For these samples the surface 1cm layer will be carefully extracted. The resultant sample (approximately 113cm^2 surface area) will be then stored in a Ziploc bag, stained with a proteinaceous dye (Rose Bengal) and preserved in a 10% formalin seawater buffered solution. The samples will later be analysed for its meiofaunal content.

9.1.6. Additional Meiofaunal Sample Stations

The Meiofaunal survey will also be conducted at three (3) stations up-current (to the southeast) from the Cannonball WPP. These samples will assist in determining the Meiofaunal community characteristics from areas that are not impacted by the installation of any offshore facilities. The Meiofaunal survey conducted as part of the baseline surveys for the Cannonball Project indicated that there were some changes in the species diversity in the offshore area over the past 50 years. It was not possible to determine the cause of the change: whether it was due to the oil and gas exploration and production activities over the years or whether the changes occurred from natural sources from the south (such as riverine inputs from South American rivers). One way of testing this would be to examine the Meiofaunal data from samples that would not have been impacted by the oil and gas activities but would still be affected by inputs from the south. This could be done by collecting and analysing samples to the southeast of the Cannonball WPP since the current flows (and hence the influence) are mainly from the south. Figure 9.2 below shows possible location of these Meiofaunal sample stations:

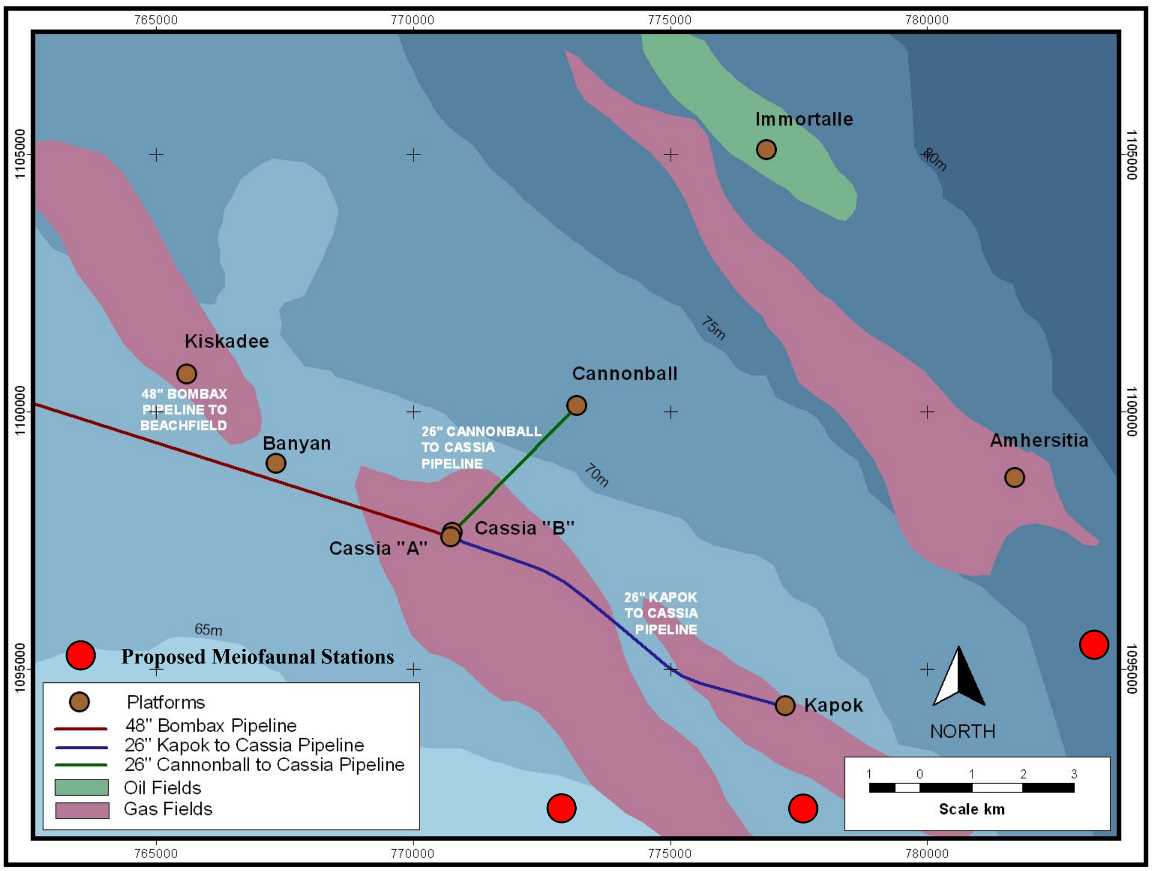

Figure 9.2 Possible Locations of the additional Meiofaunal Sample Stations

These samples will determine the Meiofaunal community characteristics from areas not impacted by oil and gas activities.

9.2. Onshore Monitoring Programme

The onshore modifications to the Beachfield Gas Receiving Facility will impact and disturb the surrounding environment mainly due to the construction activities around Beachfield for the 15-month period. Some of the impacting activities are:

- Traffic to and from the Construction Site
- Noise from the Construction Site
- Air Emissions from combustible sources such as diesel engines

bpTT has designed the onshore monitoring plan to identify both the magnitude of the impact caused by the above activities, as well as inform an appropriate mitigation plan that will reduce the impacts.

9.2.1. Noise

The construction activities will increase the noise levels around the Beachfield Gas Receiving Facility throughout the 15-month construction period. Although the impact of the increased noise was not seen as significant (See **Section 7: Significant Environmental Impacts**) to the surrounding forest areas because the forest fauna would have been acclimatised to existing noise levels from the Beachfield Gas Receiving Facility, bpTT will monitor the noise levels during the construction period.

Three noise monitoring stations will be established around the Beachfield Gas Receiving Facility (concentrating on the southern side) since this represents the forested area closest to the construction site as well as the proposed pipeline route. Figure 9.3 below shows the three proposed locations for the noise monitoring stations (red dots).

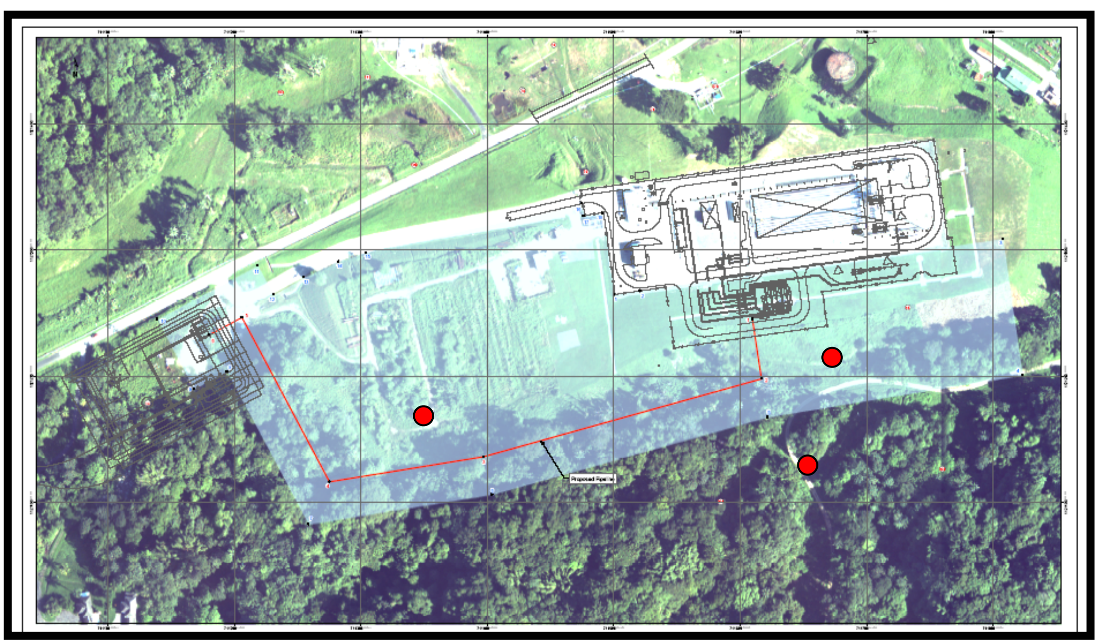

Figure 9.3: Proposed Locations for the Noise Monitors

Noise will be monitored at these three stations for a 12-hour period (daytime construction hours) during two (2) days, every month, for the 15-month construction period. The monthly noise monitoring will be carried out in the month prior to and after completion of the construction. This will assist in establishing the baseline noise levels as well as the existing noise levels at the modified Beachfield Gas Receiving Facility. The noise levels will then be monitored every six (6) months for the next twelve (12) month period to further establish the effect the modified Beachfield Gas Receiving Facility on the forested areas.

9.2.2. Traffic

The impact of traffic on the local Guayaguayare and Mayaro Communities is of great concern to bpTT. Hence bpTT will develop a Traffic Management Plan before embarking on the construction activities at the Beachfield Gas Receiving Facility. A discussion of the Traffic Management Plan is presented in **Section 8: Mitigation Management Plan**.

The plan will be developed in consultation with the community members for both Guayaguayare and Mayaro. As part of this plan bpTT plans to monitor the following during the construction phase:

- bpTT will establish traffic monitors during the construction mobilisation and demobilisation period. The monitors will be hired from the local communities. Part of their responsibility would be to record the amount of dust being generated by the transportation of construction equipment as well as the manner in which the drivers are conducting themselves on the road. The precise number of traffic monitors and the placement along the route will be determined after consultations with the local Guayaguayare and Mayaro communities.

9.2.3. Air Emissions

The construction activities associated with the Beachfield Gas Receiving Facility will release combustion emissions such as CO, SO_x and NO_x. These can impact negatively on the surrounding flora and fauna. bpTT will manage and mitigate this impact by ensuring that all construction equipment are maintained to their manufacturers' specifications. This will reduce the amount of air emissions. However, to determine the actual quantities of CO, SO_x and NO_x impacting the surrounding forests, bpTT will monitor the volumes of these gases by establishing air quality monitoring stations around the Beachfield Facility. The actual locations will be determined after consultation with the site engineers as to the areas of greatest construction equipment use. However, it is anticipated that three monitoring locations will be established particularly along the southern border of the Beachfield Facility (See Figure 9.3 above) as this is the closest forest to the construction areas. The air monitors will be placed at these three stations for a 12-hour period (daytime construction hours) during two (2) days every other month for the 15-month construction period. The monthly air quality monitoring will also be conducted in the month prior to and after completion of construction. This will establish the baseline data as well as the levels of air pollutants. The air quality levels will then be monitored every six (6) months for the next twelve (12) months to further establish the effect the modified Beachfield facility on the forested areas.

9.2.4. Wetlands

The only wetlands that may be affected by the construction activities at the Beachfield Gas Receiving Facility is the Rustville Weltands located to the south of the facility along the Guayaguayare Bay coastline. The Lawai River runs to the east of the Beachfield Gas Receiving Facility and may transport pollutants and sediment from the construction site particularly after rainfall. This impact is not anticipated to be significant due to the bpTT's Construction HSE Management Plan and Spill Management Plan that governs the construction site. There will also be sediment screens placed around the construction site to minimise the sediment runoff during rain.

However, bpTT will monitor the Rustville wetland every year at the five plots that were used to investigate the structural parameters of the system during the baseline survey. Please see **Section 4: Description of the Environment** for this discussion. Specifically the health of the system should be ascertained by recording any significant changes in the plots i.e. focus on any die-off of trees that may occur. If there is a significant die-off of trees, the cause of the die-off has to be ascertained and the necessary mitigation measures implemented. Additionally, measurements of the structural parameters of tree species, height and circumference at breast height (Cbh) should be repeated every two years within the plots, as suggested in CARICOMP (2001).

9.2.5. Avifaunal and Lepidoptera Surveys

To ensure that the surrounding forests at the Beachfield Gas Receiving Facility and along the coastline are not impacted during the construction period, the Avifaunal (Birds) and Lepidoptera (Butterflies) Surveys conducted for the baseline survey will be repeated during the construction period. This will be done every six (6) months during the 15 month construction period and thereafter every six (6) months for a year. The results of the surveys will be compared to the Avifaunal and Lepidoptera surveys conducted for the baseline description of the environment. The methodologies of these surveys are given in this section (Section 4: Description of the Environment).

10. INTERAGENCY AND PUBLIC/NGO INVOLVEMENT

As part of the consultation process for this EIA, bpTT has met with several stakeholders, community members and Non Governmental Organizations (NGOs). The following types of consultations were conducted for this EIA:

- Meetings with the Council of Presidents for the Environment (COPE)
- Relevant Community Based Organizations (CBOs)
- Meetings with the Government Agencies (refer to Appendix A)
- Stakeholder Interviews
- Guayaguayare and Mayaro Community Interviews
- Public Consultations

This section summarises the findings of these meetings.

10.1. NGO Meetings

Summary of COPE meeting: The objective of this meeting was to introduce the project to COPE and discuss bpTT's proposed approach to the Environmental Impact Assessment (EIA). bpTT and COPE were aligned as far as the team chosen to conduct the EIA and the use of the World Bank Guidelines.

Time: September 6th 2003 at 6:00 pm

Place: bpTT Albion Plaza, Port-of-Spain

The issues raised were:

- COPE indicated that they have had no consultation with NGC about the 56" line. In addition they expressed concern that the "56" line is a major environmental upset yet it is a fait accomplait".

- Comments were made about depleting resources.

- Data collection and sampling profiles should be carried out over a one-year period.

- Sustainable Development is one of bpTTs aspirations and more attention should be paid to the bpTTs partners, keeping them aligned with bpTTs aspirations.

- Cumulative impacts should be considered

- Social Impacts of the project on the community

10.2. Government Agency Meetings

All agencies outlined in the Terms of Reference issued by the EMA were invited to a meeting to discuss the Cannonball Field Development Project. The objective of this meeting was two fold:

- To discuss any issues associated with the Terms of Reference
- To present the project description and discuss associated issues

All present agreed that the terms of reference covered all relevant areas associated with the Cannonball Field Development.

Date and Time: November 6th at 9:00 am

Place: Crew's Inn, Chaguaramas

Agencies: Representative from the following agencies attended: -

- Institute of Marine Affairs
- NEMA
- Mayaro/Rio Claro Regional Corporation
- Fisheries Division
- Ministry of Labour
- Ministry of the Environment

Issues raised:

- Rationale for designing the Cannonball WPP as an unmanned facility
- Clearance of additional land for the modifications at the Beachfield Gas Receiving Facility
- Pipeline Specifications used in the design phase
- Contractor Management (specifically around the use of best practice HSE standards)
- Quantitative Risk Assessment
- The use of radioactive material
- Increased marine traffic
- Lifespan of the facility and the associated pipeline
- The use of existing roadways for the transportation of equipment
- The types of drilling muds being used during the drilling phase

10.3 Community Based Organizations

The following community based organizations were consulted on the Cannonball Field Development project:

- Mayaro/Guayaguayare Unemployment Organization for Concerned Citizens (MGOUCC)
- Habitat for Humanity,
- Guayaguayare Fishermen Co-operative,
- Guayaguayare Village Council,
- Ortoire Advisory Board
- Lions Club

Separate meetings were held with all of the above-mentioned groups to discuss the project description and any associated issues. Specific issues to each group were identified but overall the federal bpTT issues took precedence over the project's issues.

Date and Time:

- MGOUCC: October 9th 2003 at 6:00 pm
- Habitat for Humanity: October 20th 2003 at 6:00 pm
- Lions Club: October 22nd 2003 at 6:00 pm
- Guayaguayare Fishing Co-operative: October 27th 2003 at 11:00 am
- Guayaguayare Village Council: October 27th 2003 at 3:00 pm
- Ortoire Advisory Board: November 5th at 6:00 pm

Place: These meetings were held at various locations:

- Mayaro Resource Centre
- Seawall in Guayaguayare
- Lions Centre in Mayaro
- Guayaguayare Community Centre
- Ortoire Community Centre.

The issues raised were:

- Emergency Response Plan for the Beachfield Area
- bpTT past projects and the interaction with the community
- Gender issues (associated with women working on offshore facilities and on the construction sites)
- Provision of a Trade School
- Improve on the quality of the scholarships provided through bpTT's Scholarship program, ***Brighter Prospects***.
- Types of chemicals used
- Impact of the project on the marine environment

- Reforestation project for the area that maybe cleared at the Beachfield Gas Receiving Facility
- Seabed Disturbance
- Damage to fishing equipment
- Increased marine traffic
- Disturbance of fish breeding grounds

10.4 Guayaguayare and Mayaro Community Interviews

An extensive social and economic survey was conducted as part of this EIA. In order to determine the perceptions and attitude of the population in the immediate study area towards the project, a **Systematic Random Survey** was conducted with households in that area. This survey was conducted over an eight-day period from October 13-20, 2003 and included households from Guayaguayare, La Savanne, Grand Lagoon, Radix and Mayaro. A 25% sample was surveyed from the villages in the immediate study area. The head of the household or an adult from one in every five households was interviewed. The total number of houses visited was 640.

The results of this survey are presented in **Section 5: Social-Cultural Impact Assessment**

10.5. Public Consultation Meetings

This section of the document reports on the consultations and interviews, which were held by bpTT and the Consultants with the Guayaguayare and Mayaro communities. There were three (3) public consultations held:

Table 10.1: List of Public Consultations held for the Cannonball EIA

Consultation	Date	Where Held
First Public Consultation	30th October 2003	Guayaguayare Community Centre
Second Public Consultation	16th December 2003	Guayaguayare Community Centre
Third Public Consultation	13th January 2004	Guayaguayare Community Centre

Generally, the attendees were introduced to the Cannonball Field Development through a non-technical project description, after this the meeting was open to all for discussion of issues pertaining to the project.

In accordance with the requirements of the Environmental Management Act 2000 and in a move beyond compliance of the said Act, bpTT conducted a series of public consultations consistent with World Bank Guidelines specifically to ensure that most, if not all the issues likely to occur as a consequence of the project would be identified and mitigated. bpTT indicated that the EIA would have a strong social assessment component and there would be proper interaction with the stakeholders in a way that's meaningful and sustainable as the company wishes to build the capacity of groups to aid the EIA process.

There were some common issues raised at the meetings:

- The Emergency Response Plan
- Disruption of Seabed
- Chemical usage and discharge
- The effects of the project on Marine Life
- Reforestation
- Coastal Erosion
- Length and quality of employment
- Increase in marine traffic
- Disturbance of breathing ground for fish
- Loss of opportunities for employment owing to unmanned platform
- Additional Clearance of areas near Beachfield
- Type of Skills
- Contractor management
- Replication of HSE standards by contractors
- Quantitative Risk Assessment
- Lifespan of Pipeline
- Use of Radio Active materials
- Reinstatement of roads, bridges etc.
- Wages in the Industry (must be standardized)
- Cost of project and profits as opposed to community benefits from the project
- Making the EIA results available to the community in writing

The issues commonly raised by the stakeholders that were of particular concern are as follows:

- **Emergency Response Plan**. In both the individual group meetings and the public consultations, stakeholders identified the health and safety risks associated with the laying of gas pipelines, in particular the probability and consequence of a major accident leading to fire and/or explosions and the increased security risk at the Beachfield Gas Receiving Facility. The community also expressed that in the event of a major accident at Beachfield, the community is unaware of the evacuation procedures. In addition, the community identified the lack of adequate health facilities and the absence of a fire station in the event of a major accident.

- C**reation of employment**. This was another concern raised by the stakeholders particularly the community. They were concerned about the implications to employment creation from the design of an unmanned facility and requested additional information such as areas of employment to be created as well as the length and quality of the employment accessible to community members.

- **Upgrading Of Skills.** Stakeholders further raised the issue of upgrading the skills in the community to access work provided by the oil and gas industry. The community would like bpTT to provide a trade school to train community members in certain crafts so that they can be employed by the company or contractors on projects.

- **Environmental Concerns.**
  - the impact of clearing additional area at Beachfield,
  - impact on the marine life,
  - chemical and other discharges during drilling
  - erosion of the coastline.

The stakeholders were concerned about the likely impacts the project will have on the above-identified areas. Members of the community requested additional information on the drilling process and the use of drilling muds and the likely impact this will have on the marine environment.

The community repeatedly raised the issue of erosion of the coastline and its impact on their property and social activities (use of the beach).

A fisheries survey was conducted to determine the specific concerns of the fishermen in the Guayaguayare and Mayaro region as well as other affected fishing areas. The results and conclusions of this survey are summarised in **Section 4: Description of the Environment.** The fisheries survey report is also presented in **Appendix J**.

bpTT will continue to consult with the affected communities, relevant government agencies NGOs and CBOs to resolve the issues identified. This ensures that the approaches developed are acceptable to both the stakeholders and the company.

11 WEB-BASED GEOGRAPHICAL INFORMATION SYSTEM

11.1 Introduction

This section provides a description of the web-based Geographical Information System (GIS) developed for the Cannonball Field Development Project off the East Coast of Trinidad and on land at the Beachfield Gas Receiving Facility in Guayaguayare. The GIS provides a complete overview of project information pertinent to the study area.

Almost all computer users are familiar with Internet applications and the conventions of the HTML format. HTML has revolutionised the presentation of information via the Internet and has allowed a greater participation of the user in the presentation of the database. Generally, the interactive tools that are available in HTML have not been incorporated in traditional GIS presentations, whereas, maps and data that have been incorporated in HTML presentations have often not been spatially accurate or realistic. However, HTML offers a far more user-friendly medium than any other format.

The creation of a more user-friendly tool that can be used by GIS professionals, oil-spill planners, engineers, secretaries and the average layman requires a combination of both GIS and Web-based HTML disciplines. These maps have been created using the HTML format together with GIS generated maps to provide a visual representation of important aspects of the biological, physical, chemical and social-cultural data collected for the Cannonball Field Development EIA. This tool can be used by almost anyone with a basic familiarity in the use of a Personal Computer.

By linking the data (in the form of images, spreadsheets tables and text) to specific points on the map it is possible to directly relate the information to the location where it was collected, reducing ambiguity that might sometimes occur in text based documents. In addition, the visual format serves to make it more attractive and user-friendly to most viewers. This creates a more visual presentation (with images, graphics and colour) than a standard paper report.

11.2 Design and Implementation of Interactive Web Site

All environmental baseline data were incorporated in the form of a Web-based GIS interface. The interface has a thematic map of the study area which allows browsing by the users to access the environmental data. For example, clicking on the map at various locations will bring up all the environmental data for that area in various forms whether it is photographs, written descriptions, profile data, analysis or other forms of presentations. The application is readily accessible to varying levels of computer competency.

11.3 Software

The main goal of the project is to produce an application with which one can easily view thematic maps online. There is no need for advanced analytical functions, although the possibility to perform simple analyses could be incorporated into the functionality. Since the application is to be used by varying levels of users viewing the EIA, the final application has to cater for persons without any knowledge of GIS or advanced computing.

ESRI ArcView GIS 8.3 was used for the data manipulations using generic Internet software such as Windows Explorer for data presentation. The maps were generated using Geomedia Pro and exported to HTML web authoring software where the hyperlinks were added to link points to data.

11.4 Study Area

The study area used in this project is as defined in Figure 1:

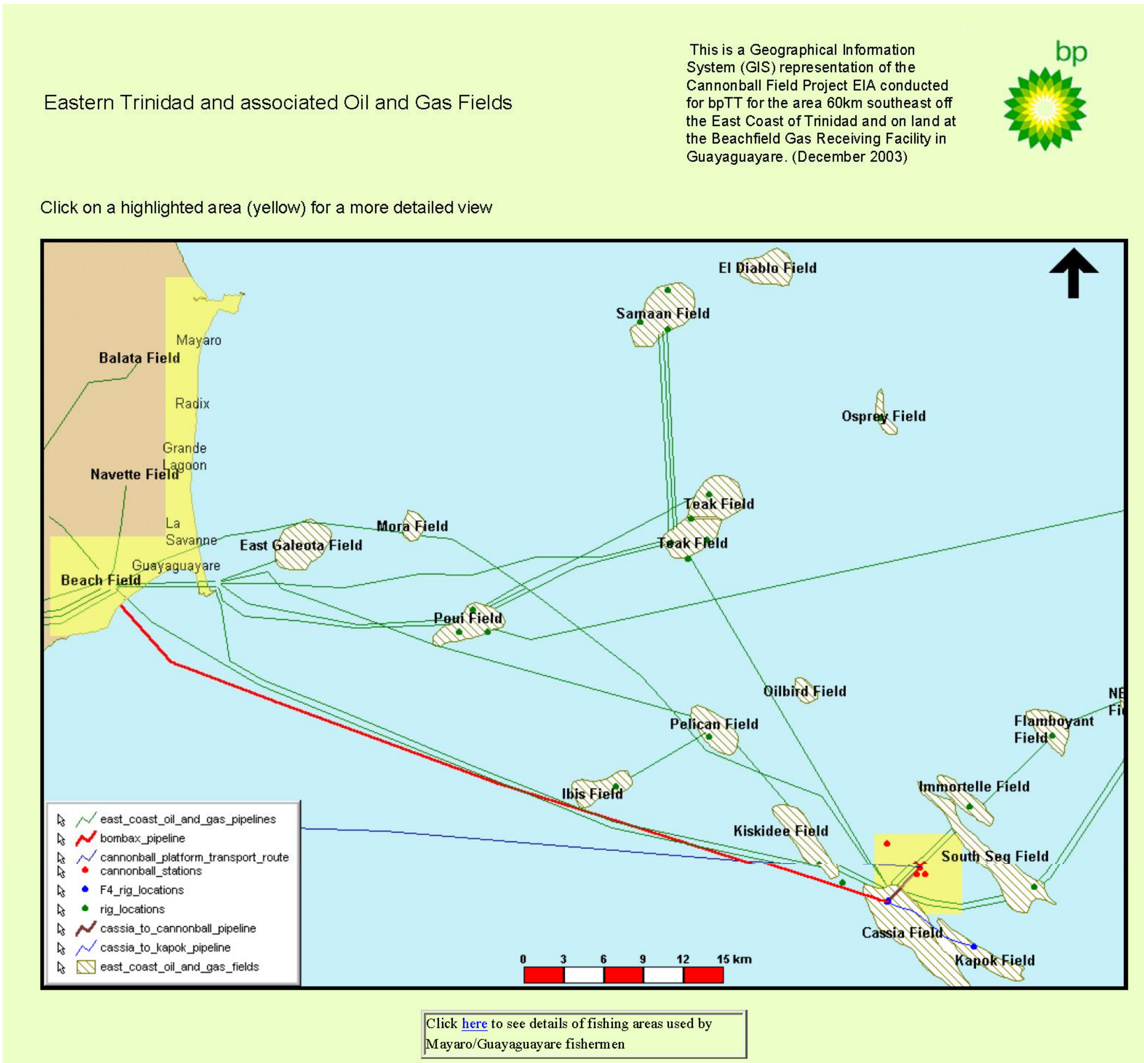

Figure 11.1. The Study Area Used in the Web-based GIS Preparation.

11.5 Data Presentation Formats

Three data types were utilised in this project.

- Spatial data layers were in the ESRI shapefile format (generated by the use of ArcView).
- Tabular data attached to spatial layers were imported in various Microsoft Software formats, including EXCEL and WORD files. These are used to display

information about the spatial data layers in the form of tables and short descriptions.
- Images used on the map are in the jpeg/bitmap picture format and were used to display pictures of Points of Interest.

The information is provided for a selected region along the East and South Coast from West of Guayaguayare Bay to Point Radix (Figure 11.2). The area covered extends approximately 10 km inland and further inland at places of interest to ensure all relevant roads and settlements are taken into consideration. Figure 11.2 shows an example of the application of the GIS method to the fishing methods within the study area.

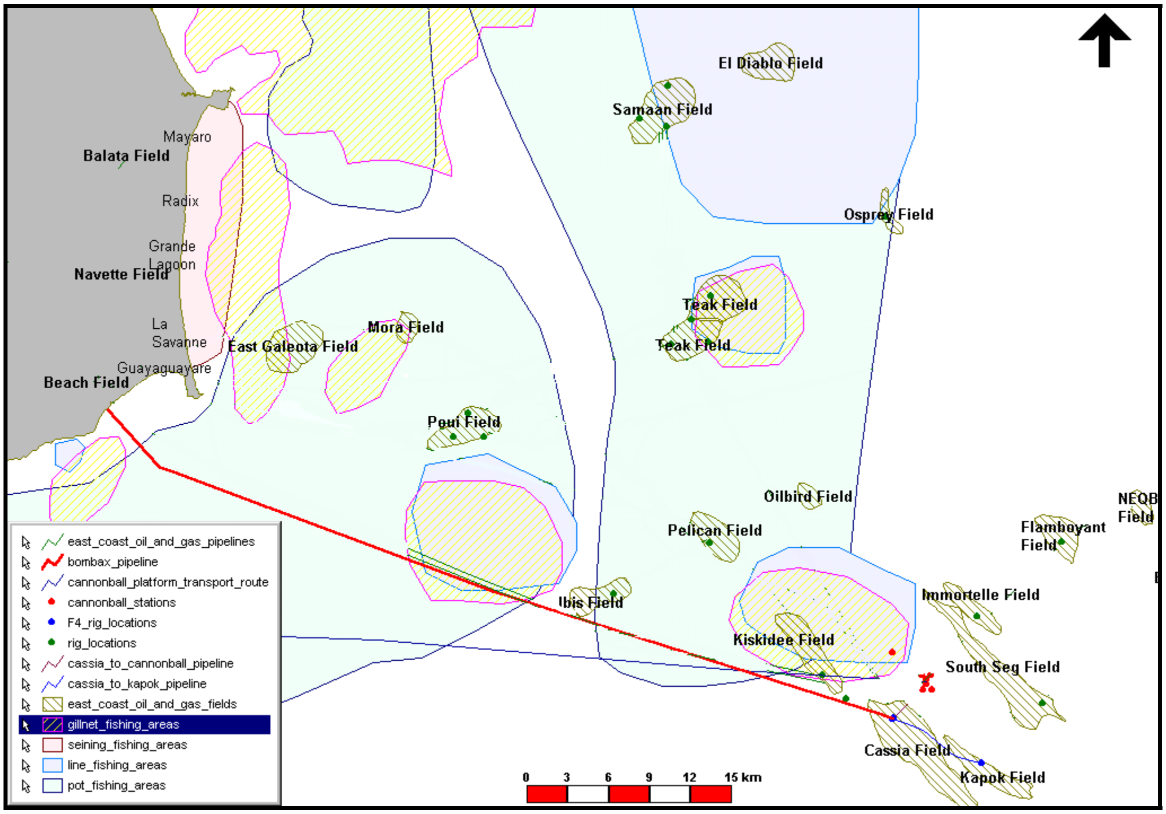

Figure 11.2. An example of one of the subsets showing the location of fishing areas.

In addition to these formats background information are provided for roads, buildings and other areas of interest in a variety of formats:

Landuse patterns - Provided as vector GIS data
Road Network - Provided as vector GIS data
Settlement locations - Provided as vector GIS data
Topographic maps - Scanned and vectorised from 1:75,000 scale maps
Emergency (fire stations, health centers and police stations) services – provided as point GIS data

Further information on the environmental aspects of the EIA has been included from field data collection exercises. These have been inputted as tabular data onto the map using ArcView software. Images were acquired during the fieldwork from aerial flights and ground reconnaissance using a digital camera. These pictures have also been incorporated in the GIS to provide further visual information within the study area.

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