CARIBBEAN GAS CHEMICAL LIMITED

ENVIRONMENTAL IMPACT ASSESSMENT FOR A PETROCHEMICALS COMPLEX TO BE SITED AT UNION INDUSTRIAL ESTATE, LA BREA, TRINIDAD AND TOBAGO.

Prepared by

RAPID ENVIRONMENTAL ASSESSMENTS (2003) LIMITED

In Association With

SENES CONSULTANTS LIMITED & COASTAL DYNAMICS LIMITED

MARCH 2014
EXECUTIVE SUMMARY

Overview

Caribbean Gas Chemical Limited (CGCL) is a joint venture enterprise owned by the consortium of Mitsubishi Gas Chemical Company Inc., Mitsubishi Corporation and the local conglomerate Neal & Massy Holdings Limited. CGCL is a locally registered and operated company formed to oversee the project development stage of the proposed Natural Gas to Petrochemicals Project at Union Industrial Estate, La Brea. The Project will begin with the installation and operation of Methanol and Dimethyl Ether (DME) plants.

The Project Development Agreement (PDA) for the establishment of the Project for the commercialization of Natural Gas based Petrochemicals was signed on April 8, 2013 by and among the Government of the Republic of Trinidad and Tobago (GORTT), the National Energy Corporation of Trinidad and Tobago Limited (National Energy), The National Gas Company of Trinidad and Tobago Limited (NGC), and the consortium. This Project in its entirety will be the anchor Project for the reindustrialization of the Ward of La Brea, an area on the south-western peninsula of Trinidad long associated with oil and gas exploration and production, asphalt mining and heavy industrial activity. The Methanol and DME plants are being designed by Mitsubishi Heavy Industries Limited (MHI) in conjunction with Mitsubishi Gas Chemical Company Inc., and are to be built by an Engineering, Procurement and Construction (EPC) Contractor and operated by CGCL.

The proposed Petrochemicals Complex is in the Project development stage and CGCL has applied to the Environmental Management Authority (EMA) for a Certificate of Environmental Clearance (CEC) [CEC3859/2013] for this Project. The EMA requires that the information submitted in the CEC application be supplemented with the results of an Environmental Impact Assessment (EIA) study and has provided Final Terms of Reference (TOR) against which the EIA was conducted.

Rapid Environmental Assessments (2003) Limited (REAL) was engaged by CGCL to conduct the EIA in accordance with the Terms of Reference issued by the EMA. This EIA is required to:

- Determine all probable impacts of the Project including its cumulative impacts with other Projects within the area of influence of this Project.

- Assess Alternatives to the Project.
- Assess the Risks and Hazards Associated with the Project.
- Develop a Management Plan to mitigate residual negative impacts.
- Develop a Monitoring Plan to be implemented over the life of the Project.
- Document all of the above in a comprehensive report.

This Executive Summary presents a simplified description of the proposed Project, describes its potential environmental and social impacts and lists all of the measures to be taken by CGCL to mitigate, monitor and manage all residual environmental and social impacts to ensure that the Project meets acceptable environmentally sound management principles and practices. Substantial details of the Project, an assessment of its impacts and all mitigation, monitoring and management systems and procedures to be employed over the entire life cycle of the Project are included in the Chapters that follow, inclusive of appendices.

Legislative, Regulatory and Compliance Framework

The proposed CGCL Petrochemicals Complex will be subject to a number of policies, laws and regulations that concentrate on health, safety and environmental management, both locally and internationally. The relevant policies, laws, rules and practices that are applicable to the Project include the following:

National Policies
- National Environment Policy,
- The National Wetlands Policy
- The National Policy on Biodiversity

Laws and Rules relating to Health, Safety and the Environment
- The Environmental Management Act,
  - Certificate of Environmental Clearance Rules,
  - Noise Pollution Control Rules,
  - Water Pollution Rules,
  - Draft Air Pollution Rules,
  - Draft Solid Waste Management Rules,
  - Draft Hazardous Waste Management Rules,
- Occupational Safety and Health Act,
• Conservation of Wildlife Act
• Regional Corporations Act
• Town and Country Planning Act
• Forest Act
• The Shipping Bill
• The Continental Shelf Act
• Oil Pollution of Territorial Waters Act

Management Principles and Practices
• Corporate Governance Policies and Practices of Project Sponsors,
• Health, Safety and Environment Policies,
• Corporate Social Responsibility Policy,
• International Standards Organization Management Systems
  o ISO 9000s – Quality Management
  o ISO 14000s – Environmental Management
• Safe To Work (STOW) Programme
• Point Lisas Energy Association – Community Awareness and Emergency Response (adapted for La Brea)
• Trinidad and Tobago Mutual Aid Scheme

Multilateral and International Agreements
• United Nations Framework Convention on Climate Change (UNFCC)
• Convention for the Control of the Transboundary Movement of Hazardous Wastes (BASEL Convention).

Table 1 summarizes the regulatory approvals necessary for the CGCL Petrochemicals Project to go forward from design to construction and operation.

**Table 1  Summary of Necessary Regulatory Approvals**

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<td>Safety and Health of Workers</td>
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Project Description

Caribbean Gas Chemical Limited (CGCL) is proposing to construct and operate Methanol, DME and ancillary process plants, including a desalination plant for process water generation, at the Union Industrial Estate (UIE), La Brea, Trinidad and Tobago. The proposed CGCL Petrochemicals Complex site will be located on approximately 50 hectares of land to be leased from the National Energy Corporation of Trinidad and Tobago (National Energy) at Main Site, UIE.

The proposed Petrochemicals Complex will initially use 100 million standard cubic feet per day (mmscf/d) of Natural Gas to produce 1,000,000 metric tonnes per year (MTPY) of Methanol of which 140,000 MTPY will be used to produce 100,000 MTPY of DME. The Methanol and DME products will be transported via pipeline to the Brighton Port then loaded onto ships. DME product will also be filled in trailers and or ISO tank containers at the loading station at the Plant site for local use.

The source of natural gas as the feedstock to the process will be from the National Gas Company of Trinidad and Tobago Limited (NGC). Natural gas will be supplied via the current pipeline to the site. Other utilities will be supplied from the national grid.

Peak employment during the construction is estimated to be about 2,500 people. During operations, 180 people are expected to be permanently employed by the Project with a similar number indirectly employed. The employees during operation will be process operators, engineers, maintenance staff, laboratory staff and administrative staff.

Site Description and Location

The proposed location for the Methanol and DME Plants is the northern region of Main Site of the UIE, La Brea, South-West Trinidad. The site is bounded on the North by Sobo Village and on the West by Square Deal Corner which are densely populated residential communities. The site is bordered to the East by lands associated with the Union Industrial Estate and on the south by the Vessigny River. Note that the site is separated from the two residential communities by a 100m wide buffer zone which is to be a green-zone managed jointly by National Energy and the respective tenants of the UIE.

Figure 1 provides a site location map of the entire UIE showing the location of the proposed CGCL plant site. The green shaded area encircling the entire UIE site is the
100m buffer zone. **Figure 2** shows the parcel of land allocated to the proposed CGCL Petrochemicals Complex and a plot plant for one of the proposed layouts of the plant. This layout is the preferred North-South orientation of the plant as opposed to an alternative East-West orientation which was also considered.

Further afield to the south-west of the proposed site lie the communities of Vessigny Village and Union Village; while lands belonging to the Stollmeyer Estate and Petrotrin are on the northern and eastern sides. Further afield to the south is the rest of the UIE and on which can be found the recently commissioned TGU 720 Mega Watt combined cycle power generation plant, the NGC’s natural gas distribution hub and some service industries.

The Brighton Harbour and Port, the La Brea Industrial Estate and the small town of La Brea lie further afield to the north-west of the proposed site. Note that the Brighton Port will support the export of Methanol and DME for the Project and this port is to be expanded and developed by National Energy.

**Methanol Process**

Methanol is a clear colourless liquid that has no odour in low concentrations. Methanol evaporates when exposed to air and dissolves completely when exposed to water. Methanol is produced from methane found in natural gas and is used in numerous applications including plastics, paints, glues and pharmaceuticals. There are currently seven (7) Methanol plants in Point Lisas Industrial Estate and in the past 30 years there have been no significant incidents associated with the operation of these plants and with the production of Methanol. The proposed CGCL Methanol plant will be the eighth Methanol plant to operate in Trinidad and Tobago. The Methanol plant will be divided into five (5) sections reflecting the different processes. These processes are shown in **Figure 3**.

- **Desulphurization:**
  Sulphur compounds that are naturally found in the natural gas will be reduced until they are at trace levels via the desulphurization process.
Figure 1: Showing the Site of the Proposed Petrochemicals Complex

– Not To Scale: for illustration only.

Proposed CGCL
Site Approx.
50ha

Union Industrial estate
Main Access Road

Southern Main Road

Vessigny River

100m Union Industrial Estate Buffer Zone

Union Industrial Estate

Figure 1: Showing the Site of the Proposed Petrochemicals Complex

– Not To Scale: for illustration only.
Figure 2: Plot Plan of the CGCL Plant on the Union Industrial Estate, La Brea

Not To Scale: For Illustration Only.
Figure 3: The Methanol Process
• **Reforming the natural gas feedstock with steam**
  The gas, after the desulphurization process, will be fed into the reforming section. The gas will be in contact with hot process condensate, which will yield to saturation with water vapour. This will be mixed with additional steam to result in an appropriate reformer feed gas and steam ratio.

• **Compression of the reformed gas**
  The reformed gas, after cooling, will be compressed via the Compressor.

• **Methanol synthesis of the reformed gas**
  This mixture will be preheated and the main reactions for Methanol synthesis will occur using a copper-based catalyst. The reacted gas will then be cooled, where the Methanol and water are condensed. This two-phase mixture will be separated which will yield crude Methanol. The crude Methanol will then be sent to the distillation section.

• **Distillation of the crude Methanol to remove the impurities**
  The crude Methanol includes small quantities of organic impurities such as dimethyl ether, methyl formate, various ketones, ethanol, higher alcohols, paraffinic hydrocarbons and other complexes. These will be separated in the distillation section.

The end-product is thus purified Methanol which will be stored onsite in purpose built tanks. The total capacity of the product Methanol tanks is 150,000 MT (50,000 MT per tank, total 3 tanks).

**Dimethyl Ether (DME) Process**

DME is a Methanol derivative that is a colourless gas at normal temperature and pressure with a slightly sweet odour. DME has similar physical properties to Liquefied Petroleum Gas (LPG); it is a flammable liquid, thermally stable, it has no tendency to peroxide formation and burns with a visible flame. DME is considered an environmentally ‘cleaner’ fuel with no ozone depleting emissions, minimal impact on water quality and no soot produced during combustion.

The DME plant will be the first of its kind in Trinidad and Tobago and in addition to export value, it is expected to provide a large market potential as LPG blend stock. DME is used as an alternative fuel for high thermal efficiency diesel engines with lower emissions of greenhouse gases per tonne of material used when compared to diesel
and fuel oils. DME is also widely used as a consumer product propellant (in aerosols) as an alternative to Chlorofluoro Hydrocarbons (CFCs) and petroleum distillates and with no toxicity or carcinogens associated with its use. DME can be used as a fuel for boilers, turbines in medium sized power plants and small scale power generation plants, for example the Cove Power Plant in Tobago.

The DME process is divided into the following three (3) sections reflecting the different processes.

- DME Synthesis Section
- DME Purification Section
- Methanol Recovery Section

These processes are shown in Figure 4.

![Figure 4: The DME Production Process](image)
The raw material, Methanol, is supplied to the DME Synthesis Section from the Methanol Process. The mixture of raw Methanol and recovered Methanol from the Methanol Recovery Section is vapourised and supplied to the DME synthesis reactor.

The reactor effluent, which is composed of DME, water and un-reacted Methanol, is cooled through heat exchangers and then supplied to the DME Purification Section. The reactor effluent is supplied to the DME distillation column, where the mixture is separated into product DME as a distillate and Methanol-water from the bottom.

Product DME is transferred to the DME storage tank through a pipeline. The total capacity of the DME storage tanks is 10,000 MT (5,000 MT per tank, total 2 tanks).

The Methanol-water mixture is supplied to the Methanol Recovery Section. The effluent from the bottom of the DME Distillation Column is supplied to the Methanol Recovery Column, where the mixture is separated into Methanol as a distillate and waste water. The distilled Methanol is recovered to DME Synthesis Section as a source of DME. The water is transferred to the waste water treatment unit.

**Figure 5** provides a block flow diagram of the entire Methanol/DME manufacturing processes.

**Desalination Plant**

CGCL proposes to establish a small reverse-osmosis desalination plant at the Union Industrial Estate. The proposed desalination plant fulfills the purpose of providing process and make up cooling water to the Methanol and DME plants. The Demineralization Unit will consist of an Activated Carbon Filter, a Cation Exchanger, an Anion Exchanger and Mixed Bed Polisher. It is in this unit that the process water will be produced. The desalination plant is being designed to process a maximum of 16,500/day of raw seawater resulting in a maximum of 6,000/day of desalinated water for process usage.

Desalinated Water (DSW) and the degasified RG Condensate from the Degasifiers in the DSW Storage Tank are transferred to the Demineralization Unit via a feed pump. The chemical feeding facilities for the demineralising system is also provided for regeneration and neutralization of the cation and anion exchangers.
Figure 5: Block Flow Diagram of the CGCL Methanol/DME Manufacture Processes.
Utility and Off-Site Facilities

During construction, water will be supplied by the Water and Sewerage Authority (WASA) from the national grid.

During the operational stage of the plant the major sources of water would be WASA and the in-house desalination plant. Potable water to the site would be supplied by WASA and it is estimated that 24/day would be utilized during routine plant operations.

Seawater taken from the Brighton Harbour would be used for cooling purposes. For cooling system use, a maximum of 12,000/day of sea water is piped to the plant site. The cooling system is comprised of a cycling non-contact watercooled system. Fresh water used to cool plant equipment will be circulated by a Cooling Water Circulation Pump. The warm cooling water returned from the plant is fed to a heat exchanger where the warm cooling water is cooled by the cycling sea water stream. The warm sea water from the heat exchanger is the fed to the Sea Water Cooling Tower where it cools and is then routed back out to sea via the combined single pipeline outfall line.

The air for the miscellaneous services such as hose connection and Instrument Air (IA) will be supplied by an Air Compressor that will be located on-site.

Chemicals used in the process will be stored in a designated chemical storage area. The storage containers will be made of polyethylene. The minimum amount of chemicals required for operation will stored on-site. Chemicals such as sulfuric acid and caustic soda will be transported to the site by vacuum tankers. A computerized inventory maintenance system will ensure that the chemicals are managed efficiently. The chemical storage area will be designed to ensure that all appropriate occupational health and safety, fire and environmental standards are met. Labeling for these chemicals will be in accordance the Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

Electrical power for the plant’s construction and operation will be supplied by the Trinidad And Tobago Electricity Commission (T&TEC). Backup power for the plant will be provided by an onsite diesel fired generator.

Pipelines will also be installed to facilitate the sea water intake and outfall. The seawater return line will transport brine water from the desalination plant and blow down water from the sea water cooling tower. It is proposed to have the outfall of the return
line from the desalination plant mix with the other treated process waste water and then leave the plant through a pipeline.

The pressure level of the steam is composed of high pressure (10.3MPaG), middle pressure (2.6MPaG) and low pressure (0.49MPaG). The high pressure steam is generated at the Waste Heat Boiler. The middle pressure steam is supplied by the extraction of turbine, Methanol reactor and auxiliary boiler. The low pressure is supplied by exhaust of back pressure turbine.

**Solid Waste Management System**

Solid waste will comprise of:

- Spent catalyst which will be disposed of at an off-island licensed disposal or regeneration facility.
- Assorted empty chemical containers and drums, plant debris, wood products and other innocuous material which will be disposed of at on-island waste management facilities by an authorized waste management company.
- General solid waste will comprise of domestic and office waste. Where appropriate, recycling programmes will be put in place to encourage responsible waste management practices. Local recyclers will collect these recyclables. The remaining waste will be collected by an approved local waste management company and taken to an authorized disposal facility, possibly the Guapo landfill run by the Point Fortin Borough Corporation.

**Waste Water Treatment System**

The major liquid effluent sources associated with routine plant operations are as follows:

- Sanitary waste water from each building
- Return sea water
- Brine and backwash water from the desalination plant
- Waste water from the demineralization system
- Blow down from the sea water cooling tower
- Waste Process water
- Waste water from the utilities
• Storm water

The process waste water from the Methanol and DME processes will be collected and adjusted to be in the pH range 6-9 in the Neutralization Basin. Once adjusted, the process waste water will then be sent to the Effluent Basin.

The oily/contaminated waste water from each process area and storage area will be collected in the relative pits (Process Area Oily Water Pit, No.1 Storage Area Oily Water Pit, No. 2 Storage Area Oily Water Pit). All oily/contaminated waste water will be sent to a Waste Water Pit where the oily matter will be removed and treated by incinerator.

A sewage treatment unit will be located on-site to treat domestic sewage waste and grey water (used water) waste. This system will have a biofilter and/or activated sludge with an aeration system to decompose the waste discharged into it. Treated effluent from this sewage treatment unit will be discharged to the Equalization Basin.

Stormwater will be collected in a designated rainwater pond. Once filled, this stormwater will be tested, treated if necessary and then released to the Vessigny River. Note that no releases to the Vessigny River shall occur during the dry season and any water in the pond will be used for site wetting and vegetation watering.

**Figure 6** presents the Block Flow Diagram of the Wastewater handling and disposal system.
6.1 WWT Configuration

Figure 6: Block Flow Diagram of the Wastewater System.
Description of Area of Influence of the Project

Definition of Environmental and Social Impact Receptor Zones

Given the spatial context of the proposed Project site, the study area for the EIA is determined by the extent of direct and indirect impacts on the physical, biological and social environments. It includes the proposed site, surrounding vegetation, roads, rivers/streams, coastal zone and the marine environment (i.e. Guapo Bay). The study area considers adjacent developments (and proposed developments that are planned within the range of influence of the Project site) as well as commercial and recreational activities in and around the UIE that may be affected by impacts during the construction and operational phases. These impacts include aspects such as noise, dust, air emissions, runoff and effluent releases. The study area also encompasses the potential range of effects from upset conditions and incidents such as spills, seepages/leakages or pipeline ruptures. Focus has been placed on surrounding communities which fall under the sphere of influence of these activities and impacts.

For this particular Project, the study area is defined by two components a “Wider Study Area” and an “Immediate Study Area”. The Immediate Study Area is defined as the area that may be directly impacted by the proposed Project activities and includes all of the air, land and sea within a five kilometer (5 km) radius of the proposed plant site that may be directly impacted by air emissions, noise, surface water runoff and wastewater discharges, vibration and hazards and risks. The Immediate Study Area includes the marine environment immediately adjacent to the proposed facility, the La Brea Industrial Estate, the town of La Brea and the communities of Brighton, Sobo Village, Vessigny Village, Union Village and Vance River.

The Wider Study Area is defined as that area that may be impacted by the direct, indirect and cumulative effects of activities associated with the operation of the Petrochemicals Complex at the UIE and encompasses the land, air, sea, social infrastructure and communities within a ten kilometer (10km) radius of the Project site. The Wider Study Area is administratively located within the municipality of Siparia (formerly in the County of St. Patrick) and the Ward of La Brea. It includes the following communities La Brea (proper), Rousillac, Sobo Village, Vance River, Gonzales, Cochrane, Union Village, Vessigny and Brighton. The Wider Study Area also includes the Gulf of Paria along the south west coast of Trinidad from Oropouche to Point Fortin.
Study Area Baseline Ecology

The vegetation observed on the proposed site consisted of species typically found in previously disturbed areas in the process of being re-colonised by vegetation. None of the plant species observed on the Project site were considered rare, endangered or of significant commercial value.

Communities of birds observed on the proposed development site consisted of opportunistic or aggressive species that are capable of exploiting habitats and food resources available in disturbed environments. None of the species observed were considered, rare or endangered.

The main site, now cleared of vegetation, offers very few suitable habitats for exploitation and limited food resources. It is unlikely that the Main Site in its present format can support a large population of terrestrial mammals, birds or reptiles. The Vessigny River and the coastal environment of the Vessigny Beach were classified as sensitive habitats for the purpose of this study. The lower part of the river supported a fair diversity of fish and also seems to act as a nursery for commercially important species of marine fish/shellfish. Brighton Harbour and adjacent marine areas are also used for artisanal fishing.

Study Area Baseline Climate and Air Quality.

In general, Trinidad lies south of the Atlantic Hurricane Track, but occasionally a tropical cyclone/hurricane may pass further south than usual. The wind speeds and wind direction influencing the study area will affect the dispersion of noise and air emissions. As such, data on prevailing wind speeds and direction have been included in an air dispersion model produced for the proposed Project.

There is a greater chance of flooding later in the rainy season when the ground has reached its capacity of water retention and ground water storage. However, major flood events throughout Trinidad and Tobago recorded by the Ministry of Works and Infrastructure, the Drainage Division of the Ministry of the Environment and Water Resources and the Water Resources Agency, do not identify Brighton or the UIE as flood prone districts.

Previous research indicates that relatively high concentrations of Volatile Organic Compounds are present in the ambient air within the area. This was associated with
natural emissions of hydrocarbon vapours from the Pitch Lake and/or traffic emissions along the Southern Main Road. Sources of other air emissions within the study area, and in particular particulate matter, which are likely to contribute to the air quality of the region, are:

Industries in the vicinity of the proposed facility (e.g. Trinidad Generation Unlimited). Vehicles passing along the roads that border the site (i.e. Southern Main Road). These roads have heavy traffic consisting of all types of vehicles since they provide access to the existing industrial estate and to the highway.

After air quality monitoring was conducted at various locations around the study area, it was concluded that the particulate matter levels, as well as the levels of other contaminants, were well below the limits established in the Draft Air Pollution Rules, 2013.

Study Area Baseline Noise Levels

Previous baseline studies within communities adjacent to the Project site showed that significant variations in noise levels occur between locations that were away from the influence of traffic on the Southern Main Road and other areas along this major roadway. In general, the background day-time and night-time sound pressure levels in community areas not influenced by traffic was less than 50dbA while areas affected by traffic showed a distinct difference between background noise levels from day to night. To assess baseline noise levels within the immediate study area, a noise monitoring exercise was carried out between June 25th and July 2nd, 2013, in accordance with the Noise Pollution Control and Abatement Rules 2001 of Trinidad and Tobago. Four (4) monitoring locations were surveyed over a continuous 72-hour period. The results of these surveys have been described in detail in the consultant’s summary report. The baseline sound levels obtained were comparable to those previously recorded in historical surveys (REAL 2005, 2010). The baseline values were generally less than the maximum limits for and during the day and night-time at all locations.

Noise levels in the areas adjacent to the plant site are expected to increase nominally during the construction and operation phases of the plant. The peak level of noise disturbance will be during the construction phase. All construction equipment will generate noise when in use.
In particular, the following equipment will generate high levels of noise during construction.

- Pile Rig/Driver: 90-100 dB(A) / unit at 30m from source (Peak period of Project months from 8 to 11)
- Diesel Generator: 80-90 dB(A) / unit at source (Peak period of Project months from 17 to 27)
- Compressor: 80-90dB(A) / unit at source (Peak period of Project months from 21 to 31)

The other construction equipment is expected to generate noise levels similar to the noise levels created by motor vehicles.

**Study Area Baseline Water Quality**

It is important to maintain the quality of water found within this area to ensure the preservation of the existing diversity observed, the ecological services provided by the fresh water and coastal habitats, and the quality of the bathing waters found within the nearshore environment of Vessigny Beach.

Water and sediment samples were collected from 3 locations along the Vessigny River during the month of June 2013. Data collected during the June 2013 surveys and historical records for the years 2010, 2005 and 2004 were used to assess the environmental quality of the Vessigny River.

The results suggest that the Vessigny River possesses chronic low levels of dissolved oxygen, high levels of biochemical oxygen demand and low pH levels. The river also experiences infrequent elevated levels of Nickel, Zinc, Lead and Copper. The elevated heavy metal concentrations observed within the water during the recent (June, 2013) survey may be an irregular event and associated with anthropogenic sources of contamination from the site or adjacent areas upstream of the site. This theory is supported by the fact that there was no evidence of high concentration of heavy metals within the sampled river sediment.

Brighton Bay was also surveyed during the months of June and July 2013. Based on the data collected, Brighton Bay appears to also be a disturbed natural coastal environment. The main environmental issues included periodic low levels of dissolved oxygen within the lower layers of the water column as well as high concentrations of
Total Suspended Solids, Copper and Hydrocarbons. The levels of these, in most cases, exceeded internationally suggested threshold levels for the protection of aquatic life.

The periodic low levels of dissolved oxygen was probably the result of poor mixing at the lower layers of the water profile as it was only seen at a few testing points. The high concentration of suspended solids present within the water is likely the result of increased rainfall during the rainy season coupled with silt run off from the land. Recent surveys also indicate that the water within the bay and the sediments at one point near the end of Berth 3, exhibit high levels of Copper. Previous studies of the area conducted in 2006, 2007 and 2010 by REAL recorded similar high levels of Copper. This may not be an issue of concern since copper is a naturally occurring metal in nature with a high potential for leaching out of terrestrial sediments. However, it is also a metal associated with corrosion coatings used on vessels and pipelines and other structures exposed to salt water. If the Copper noted in the marine sediments is due to leaching from anti-corrosion coatings then it will be important to ensure that these coatings are replaced with more “environmentally friendly” formulations in future maintenance activities by National Energy, LABIDCO and other tenants in the La Brea Industrial area.

High levels of hydrocarbon compounds were present within both the water and sediments of the bay and are most likely the result of documented natural seepages of petroleum in the area and from the presence of the Pitch Lake which influences the quality of all systems in the area. However, it should be noted that shipping and oil production activities take place within the wider study area and these can also contribute to the presence of hydrocarbons in the natural environment.

Study Area Seismicity

The district of La Brea continues to be affected by tectonic/seismic activities. The proposed Project site lies in a seismically active area due to the presence of the El Pillar and Los Bajos Faults. Coastal areas and areas close to the shore have had a few notable seismic events of magnitude less than 5.1 on the Richter scale. However, no incidents of note resulting in infrastructure or property damage have been recorded in recent times due to the seismic events.

On a local scale, the presence of the Pitch Lake which is a naturally occurring deposit of asphaltic petroleum, is of concern. The ground in the study area is known to shift frequently and significantly resulting in infrastructure and property damage. On the
proposed site for the Petrochemicals Complex were a number of these pitch outcroppings which would have hindered heavy construction on the site. National Energy advised that these outcropping of pitch and other unstable material on the site were excavated and removed when the UIE was being developed in 2005 and the site now has all regulatory approvals to support construction of the proposed Petrochemicals Complex on the UIE.

**Socio-economic Baseline of the Study Area.**

As part of the EIA, a Social Impact Assessment (SIA) was also conducted. The Study Area for this assessment is located within the municipality of Siparia (formerly the County of St. Patrick). It includes the Ward of La Brea and consists of La Brea, Point D’or, Union Village, Sobo Village, Vance River, Vessigny and Brighton.

The Direct Impact Zone includes Sobo Village, Vance River, Vessigny and Union Village. In order to determine the demographics and create a profile of the study area, a field survey was conducted in 2013. This information was used along with historical data to create a socioeconomic baseline of the area.

**Study Area Demographic Descriptors.**

The number of males and females almost equaled each other in the Siparia Region as well as in a number of the communities such as La Brea, Point D’or and Chinese Village. This was not the case with Sobo Village, Vessigny, Brighton, Vance River and Union Village, however the difference was minimal.

The residents of the communities in La Brea were predominantly of African descent, followed by East Indian descent and a considerable mixed population. According to 2011 National Census Data as well as field surveys conducted in the La Brea area, the majority of persons indicated secondary level education as the highest level of educational attainment, followed by primary level education and very few with graduate and post-graduate education.

The 2012 Human Development Atlas, published by the Ministry of Planning and sustainable Development, indicated that when compared to national figures,

“Point Fortin, Siparia and Princes Town had the highest percentage ranking in Secondary and Higher Education Attainment Rate which meant that the loss in human
development due to inequalities in Secondary and Higher Educational Attainment was greater.”

The 2010 Siparia Regional Corporation Spatial Development Plan notes that household and dwelling unit conditions in the Siparia region fall below the national standards for the country.

In the area, a larger portion of the population is employed in the service industry (55%). Statistics gathered from the Central Statistical Office show an average unemployment rate of 4.8% for Trinidad and Tobago (CSO, 2012). In 2005, the unemployment rate for the St. Patrick area stood at approximately 9% (Preliminary Labour Force Report 2005) Youths from the age group 15 – 19 and 20 – 24 were the ones who experienced the highest level of unemployment, both in St. Patrick and nationally.

**Public Facilities and Infrastructure**

Public facilities are mainly concentrated in the La Brea community. These include a Court House, Police Station, Post Office, Health Centre and Ministry of Works sub-office. The only health centre is at La Brea. There are a number of churches spread throughout the area. The Police Station has been in a state of disrepair for many years and a new building is under construction.

**Road Network**

The Southern Main Road is the only first class road in the area. It runs from San Fernando to the South, passing through Rousillac, Point D’Or, Vessigny and Union Village. The Southern Main Road, then continues to the Borough of Point Fortin and then further on to Cedros and Icacos. This road has two lanes, which facilitates two-way traffic. The construction of a four-lane highway from San Fernando to Point Fortin began in 2011. When completed the highway will provide a link to La Brea via a new road south of Vance River.

Second class roads connect Point D’or, La Brea and Brighton and network within each community. The road network within the community of Vance River is also second-class. A series of third class roads maintained by the oil companies in the area provide access to oil facilities and lines throughout the study area.

**Health Facilities**
The two nearest hospitals to the area are the San Fernando General Hospital and the Area Hospital in Point Fortin. Within the Siparia Regional Corporation there is one district health facility (Siparia), one area hospital (Point Fortin), one enhanced health care facility (Point Fortin), four health centres (Cedros, Erin, Fyzabad and La Brea) and four outreach centres (South Oropouche, Chatham, Granville and Icacos). The La Brea District Health Facility (capable of supporting a 24 Hour Accident and Emergency Unit) is the nearest health establishment. According to previous studies, the facility cannot cater to severe injuries which are transferred to the San Fernando General Hospital after triage and stabilization. This facility will need to be upgraded to meet the additional demands that will be placed on it from this and other Projects proposed for the area.

Fire Services

The Point Fortin Fire Station is the closest response facility to the study area. Eight fire officers man the Point Fortin Fire Station on a daily basis. The officers are equipped with one 1500 gallon fire tender and an ambulance. Due to the availability of the Petrotrin Water Treatment Plant in Techier Village, the Point Fortin Fire Services can access water whenever water from reliable sources such as the fire hydrants is unavailable. The estimated response time to get to La Brea from Point Fortin is twenty five minutes.

Water Supply

In 2005, 10.5% still depended on public stand pipe-borne water while 3.4% still rely on truck borne water and 0.6% on spring/river as their source of water supply. These figures are higher than the national figures. Of those households that have access to pipe-borne water, 36% of households in the study area receive a continuous supply of water, which is below the national level of 55%, with 20% of the households receiving water less than twice weekly. The Point Fortin desalination plant was commissioned in 2013 and this has increased the reliability and availability of water to the communities.

Environmental Aspect Analysis For The Project

A summary of all the potential impacts of the Project to people and the environment are summarized in the table below. It is important to recognize that many of these potential impacts are adequately mitigated through plant and process design. All residual impacts arising after mitigation through design are addressed by the implementation of
management systems, the implementation of best practice “housekeeping” during the routine operations of the plant, and by undertaking regular scheduled maintenance of plant and equipment.

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<th>Project Component</th>
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<td>Construction</td>
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<td>Operation</td>
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<td>o Energy consumption&lt;br&gt;o Natural gas usage&lt;br&gt;o Emissions to Atmosphere&lt;br&gt;o Discharges of process water&lt;br&gt;o Spills and leaks&lt;br&gt;o Use of water treatment chemicals&lt;br&gt;o Waste generation and</td>
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| Operation     | Wastewater Treatment | o Solids treatment and disposal  
o Outfall discharge                      |
| Operation     | General Operations     | o Storm water management  
o Security  
o Lighting  
o Use of labour  
o Transport (commuters, equipment, machinery)  
o Procurement of general plant/office supplies  
o Use of equipment and machinery  
o Equipment fuelling and maintenance  
o Fuel and chemical storage relating to support ancillary services (e.g. laboratory)  
o Use of lighting |
| Decommissioning |                  | o It is anticipated that a 'Decommissioning Management Plan' prepared at the end of the Project life will register the environmental aspects relating to this phase prior to commencement of works. |
Assessment and Mitigation of Impacts

**Site Preparation and Construction**

The CGCL Complex is a potential source of localized noise during the construction phase. All work is expected to be completed using conventional construction methods. Construction noise would be generated by activities such as general site grading, pile driving, foundation work and site servicing. The foundation installations for all buildings and equipment will take several months to complete and will require the use of various pieces of heavy equipment including bulldozers, front-end loaders, small trucks, backhoes, bobcats, dump trucks, compactors, cement trucks and cranes.

Other construction activities, such as the placement of the components of the CGCL Petrochemicals Complex, are expected to generate less noise. The movement of worker vehicles is not expected to have a significant effect on existing sound levels during the construction period.

During the construction phase, impacts to ambient air quality are expected to be realized through the site clearing, grading and preparation works. The primary contaminant will be particulate matter but some combustion gases derived from diesel and gasoline powered equipment, machinery and vehicles operating on the site will be expected.

Dust control measures such as site wetting, dust screens and silt traps (for trapping runoff during the rainy season) will be employed by CGCL and their contractors. Equipment, machinery and vehicles used by contractors on the site shall be well maintained to limit emission of combustion gases and CGCL will ensure this policy is adhered to under its contracts with various contractors.

The third significant impact to be realized during the construction phase will be impacts to road users along the Southern Main Road as trucks and other vehicles bring materials and other supplies to the site. Material movement will be via the dedicated industrial roadway from the Brighton Port to the site for materials imported through this port and the impact of this will be restricted to the intersection with the Southern Main Road and the industrial roads at the new roundabout. However, some increase in traffic from vehicles transporting materials, personnel and contractor vehicles is expected on the Southern Main Road itself as other modes of transportation are used to access the site and bring materials and supplies to it during the construction phase.
With construction expected to start in the third quarter of 2014 and lasting until the second quarter of 2016, these impacts will only be mitigated when the new highway network from San Fernando to Point Fortin is completed.

The CGCL Petrochemicals Complex will be constructed using standard Best Management Practices for construction projects and would include observance of the rules pertaining to construction. CGCL will also ensure that a proper system is established and functional to receive constant communication from the Project affected communities, to receive feedback from these communities and to receive and address specific complaints on a timely basis. This will be part of the company’s overall Community Engagement Programme of activities.

**Operational Phase**

The major residual environmental and social impacting activities during the operational phase of the Project will include:

- Noise from Process and Plant activities.
- Air Emissions from the Process.
- Effluent Disposal from the Process.
- Solid and Hazardous Waste Management.
- Potential Societal Risks from Process Operations and Material Transportation and Shipment.

Each of these and the proposed mitigation of impacts from each are discussed below.

**Noise**

There are over 160 potential noise sources at the proposed Complex. These sources of noise will be derived mainly from the operation of various pieces of plant equipment and machinery on the plant site and at the material handling facilities at the Brighton Port. The Complex will include the following key pieces of equipment:

- One (1) natural gas (NG) booster;
- One (1) NG booster turbine;
- Six (6) RG air cooler fans;
- Four (4) steam reformer burners;
- One (1) induced draft fan;
- One (1) DF lube oil (LO) pump;
- One (1) turbine;
- Two (2) syngas interstage air cooler fans;
- Six (6) syngas/NG booster turbine condenser fans;
- Eight (8) Methanol air cooler fans;
- Six (6) topping column No.1 condenser fans;
- Twenty-four (24) refining column No.1 condenser fans;
- One (1) distillation caustic tank agitator;
- Two (2) auxiliary boilers;
- Two (2) boiler PDF turbines; and
- Several other pumps, motors, turbines located throughout the Petrochemicals Complex.

The Environmental Management Authority (EMA) of Trinidad and Tobago has issued Noise Pollution Control Rules (EMA, 2001) (the Rules) under the Environmental Management Act (2000), which outline the current regulatory process for noise assessment in Trinidad and Tobago. Noise requirements differ by zone, which are identified in the Rules as:

Zone I – Industrial Areas;
Zone II – Environmentally Sensitive Areas; and
Zone III – The General Area.

The applicable zone for the proposed CGCL Petrochemicals Complex is Zone I (Industrial Areas), since the site is within an industrial estate and is bordered to the north, east and west by lands owned by industrial entities and/or the 100 m buffer zone between the proposed CGCL Petrochemicals Complex and surrounding areas. The applicable zone for the sensitive properties beyond the buffer zone around the UIE (e.g., residential, institutional, etc.) is Zone III (General Area).

Noise receptors are generally considered to be properties that are likely to be sensitive to elevated noise levels. The closest receptors to the proposed CGCL Petrochemicals Complex are the residences in Vessigny Village, Sobo Village and Union Village.

In order to predict the noise impact of the CGCL Petrochemicals Complex in terms of the Noise Pollution Control Rules, noise sources at the Petrochemicals Complex and
the nearby receptors were placed in an acoustic model and the propagation of sound from the noise sources to the receptors was predicted. The resulting sound level predictions at the receptors were then compared to the sound level limits outlined in the Rules.

The acoustical modeling was conducted using the Cadna-A computer software program (Data Kustik, 2009). The outdoor noise propagation model is based on ISO 9613, Part 1: Calculation of the absorption of sound by the atmosphere, 1993 and Part 2: General method of calculation (ISO, 1996). The noise from the CGCL site was modeled based on a maximum operating scenario. The following key considerations were incorporated in the modeling:

- a penalty of 5 dB was added to all transformer sources, which is a standard practice to account for the potential for annoyance due to the humming characteristic of these sources;
- an order of reflection of 3 was applied to all on-site noise sources meaning that the model would identify source-receptor paths with as many as 3 reflections (i.e., off of building walls, barriers);
- the site and surrounding area were assumed to be flat, as post-Project terrain contour data was not available (i.e., inclusive of site grading);
- global ground absorption was set to 1 (i.e., absorptive) as the off-site lands are primarily vegetated;
- local ground absorption was set to 0 (i.e., reflective) for the developed area of the CGCL (i.e., assumed to be paved); and
- receptors were modelled at a height of 1.5 above grade, in accordance with Section 4.3 of the Second Schedule in the Rules document, which outlines that the preferred measurement height is 1.2 m to 1.5 m.

The Acoustic Model calculated the receptor sound levels that are attributable solely to the operation of the CGCL Complex. As compliance with the sound level limits in the Rules is determined through measurement, the background sound level in the area measured during the conduct of field data collections in June and July 2013 were added to these predictions to arrive at the total sound pressure level at each receptor location. The model-predicted receptor sound pressure levels during maximum operations were shown to be in compliance with the applicable limits from the Trinidad and Tobago Noise Pollution Control Rules.


**Air Emissions**

There are a number of processes at the proposed Petrochemicals Complex that will result in air contaminant emissions. The Petrochemicals Complex will include the following key pieces of equipment from an air emissions standpoint:

- One (1) natural gas fired flare;
- One (1) natural gas fired incinerator;
- One (1) Purge/Vent gas reformer;
- One (1) diesel generator;
- Two (2) auxiliary boilers;
- One Methanol column;
- One LP Refining column;
- Three (3) Product Methanol tanks; and
- Two (2) Crude Methanol tanks.

The key air pollutants that will be emitted from the site are as follows:

- Particulate matter:
  - including Total Suspended Particulate Matter (TSP);
  - Particulate matter less than 10 microns (μ);
  - Particulate matter less than 2.5 microns (μ).
- Nitrogen Dioxide (NO);
- Sulphur Dioxide (SO);
- Carbon Monoxide (CO); and,
- Volatile Organic Compounds (VOC).
- Green House Gases

Emissions of these contaminants were included in the assessment and compared against the appropriate draft ambient standards and stack emission limits in the EMA’s *Draft Air Pollution Rules 2013* to be made under the *Environmental Management Act*.

The Draft Rules stipulate a schedule of substances at or in excess of defined maximum permissible levels prescribed are defined as air pollutants.
With respect to greenhouse gases, the Draft Rules acknowledge the potential of industries to affect global climate change and cause sea level rise. As such, the Draft Rules seek to implement commitments made by the government of Trinidad and Tobago who is a party to the *1992 United Nations Framework Convention on Climate Change* ratified in 1994 and the *Kyoto Protocol*. Accordingly, the Government has committed to conducting regular inventories of greenhouse gases and cooperating with relevant agencies to implement technologies to reduce, prevent or control man-made emissions of greenhouse gases.

In order to assess the potential air quality impacts of the proposed CGCL facility, it is important to study the atmospheric dispersion capability of the area. This capability to dilute contaminants is usually assessed using an air dispersion model that simulates the pollutant concentrations as they travel from their point of emission to their point of reception in the environment.

The model used in this study was the U.S. Environmental Protection Agency’s (U.S. EPA) CALPUFF modeling system, which is comprised of the CALMET meteorological model and the CALPUFF non-steady state, Lagrangian puff model. CALMET is a meteorological model that produces hourly, three dimensional gridded wind fields from available meteorological, terrain and land use data. CALPUFF is a non-steady state puff dispersion model that utilizes the CALMET wind fields and accounts for spatial changes in meteorology, variable surface conditions and plume interactions with terrain. CALPUFF can handle both simple and complex terrain as well as the complex meteorology near shorelines and coastal areas.

At a minimum, CALMET meteorological model requires only one surface station and one upper station to generate a meteorological dataset for air dispersion modeling. However, the Piarco Airport meteorological station is located more than 60 km NNE from the site at a more inland location, which would not be representative for the CGCL site. Therefore, more representative wind fields were generated using archived National Center for Environmental Predictions (NCEP) Global analysis wind fields. This data is available every 6 hours for a year based on all available surface and upper air observations.

Data from the NCEP on a 50 km x 50 km resolution for the year 2012 were used to initialize the meso-scale model WRF-NMM to produce hourly outputs to drive the CALMET diagnostic model. WRF-NMM modeling was used to cover a large area around the proposed CGCL facility with a horizontal resolution of approximately 3 km by 3 km. The output from the WRF-NMM model was used to generate hourly surface
meteorological data (wind speed, wind direction, temperature, cloud cover, etc.), in CD-144 format, at 17 evenly spaced locations throughout the CALMET modeling domain to create data as if there were 17 surface meteorological stations (pseudo stations). Hourly upper air profiles were also generated at the same 17 locations.

The Air Quality Assessment for the CGCL Petrochemicals Complex was completed to determine whether the construction and operation of the facility will result in potential negative effects to Air Quality due to emissions of VOCs, CO, , TSP, and . In addition, several scenarios were considered under Normal Operations, including average emissions, worst case 24-hour emissions, and start-up emissions.

The U.S. EPA CALMET/CALPUFF modeling system was used to simulate the pollutant concentrations as they travel from their point of emission to their point of reception in the environment, and determine the maximum concentrations at locations off-property, including nearby locations of more sensitive receptors such as schools and residences. The results of the assessment have shown that predicted incremental concentrations are below the limits prescribed by the EMA for all air pollutants and averaging periods included in this assessment. This is true for both the Construction and Operations phases.

Measured existing baseline concentrations of all contaminants are very low, and when added to the incremental concentrations, would not result in any exceedances of the corresponding EMA air quality standards. As such, there are no expected cumulative effects from the proposed facility.

It is therefore expected that there will be no residual impacts to Air Quality as a result of the construction and operation of the facility, and further mitigation measures other than those included in the design of the Petrochemicals Complex are not required.

**Effluent Discharge**

CGCL proposes to have a single marine outfall where the combined effluent streams from the cooling tower blow-down, cycling cooling water, desalination brine return and treated process wastewater can be discharged. The discharge of effluent will occur at the end of the outfall line and at a depth of 1 meter below the water surface in the nearshore area of the Brighton Harbour where water of depths of 12 m or more can be found.
In order to determine the residual impacts of this approach to effluent management, a plume dispersion modeling study was conducted. At the time of conduct of this plume dispersion modeling study, National Energy had only provided a conceptual master plan design for the upgraded and expanded Port of Brighton. Thus, this modeling study took into consideration three port layout options being considered by National Energy: Option 1B (allowing for effluent discharge in 12.2 m water depth); and Option 1C and Option 2B (both allowing for effluent discharge in 16.4 m water depth).

A comparison of the predicted combined waste water stream contaminant concentrations against the Water Pollution Rules 2001 (as amended) Second Schedule found that only chloride was non-compliant (above the No Increase Above Ambient, \{NIAA\} limit). The plume dispersion modeling study thus focused on the brine component of the discharge using the Cornell Mixing Zone Model (CORMIX) to predict the fate and transport of the effluent from the various port options.

The CORMIX model was configured to investigate if the Water Pollution Rules standard of “No Increase Above Ambient” of chloride ions (Cl⁻) could be achieved within a Regulatory Mixing Zone (RMZ) of 100 m. A RMZ allows for dilution of an effluent within a small area to prevent environmental impacts farther afield where end of pipe compliance cannot be achieved.

Initial outfall end of pipe designs as outlined by CGCL failed to achieve compliance in CORMIX 1 (single port diffuser) simulations. Sensitivity tests were then conducted using CORMIX 2 (multiport diffusers) where discharge depths, discharge angles and port diameters were altered to find better performing configurations. The results revealed that a near surface 100 m multiport diffuser situated 1 m below Lowest Astronomical Tide (LAT) with five (5) equally spaced 0.201 m diameter single risers, jetted vertically downward at -45° into the water column, significantly reduced excess Cl⁻ above ambient levels at the RMZ to 4.4 mg/L – 11.4 mg/L for dry season models and 174.2 mg/L – 330.3 mg/L for wet season models. This held true for discharges at the end of a petrochemical pier ending at water depths of 12.2 m (Port Layout Option 1B) and at water depths of 16.4 m (Port Layouts 1C and 2B).

The range of excess Cl⁻ above ambient near shore coastal water standards (as defined by the Water Pollution Rules) in the 100 m RMZ falls within natural environmental fluctuations of 19,028 ± 47.7 mg/L in the dry season and 17,285 ± 2463.1 mg/L in the wet season. When excess Cl⁻ is converted into salinity, a minimal increase of 0.04 ppt – 0.63 ppt is realized. Therefore, excess Cl⁻ at the RMZ and further away from the point of discharge in far field regions can be expected to have no significant impacts on the
physico-chemical conditions of the receiving environment and on marine organisms when discharged from either the 12 m or 16 m depth locations regardless of port option chosen.

**Operational Risks**

The structured Quantitative Risk Assessment (QRA) methodology used in this study followed the guidelines recommended by the Center for Chemical Process Safety (CCPS 1989) of the American Institute of Chemical Engineers (AIChE). The basic steps followed in the QRA process were as follows:

- Hazard identification and development of accident scenarios:
- Risk assessment of the identified scenarios:
- Probability analysis
- Consequence analysis
- Risk estimation
- Risk management

The sources of hazards identified for each process section and the locations were used to determine potential accident scenarios. Overall, 137 accident scenarios, including the variations of the main scenarios, were postulated and analyzed. The assessment paid close attention to the preventive and mitigative measures considered during the planning and designed phases of the Project. Special attention was been paid to the provisions for the secondary containment for the storage and handling of the hazardous chemicals. The site location and orientation were also considered through the analysis of various options for the plant and for the port operations.

The assessment of probabilities was based on the frequencies of the initiating events and the conditional probabilities of the chain events. The assessment of the consequences of the accident scenarios were based on the following end-effects:

- Toxicological effects;
- Burns due to exposure to heat;
- Injuries due to exposure to blast overpressure.

A risk matrix was used to estimate the level of the risk for accident scenarios based on their calculated probabilities and severity of the consequences. The estimated risk levels were grouped in three categories:
- Acceptable risk
- As Low As Reasonably Practicable (ALARP)
- Unacceptable Risk

The ALARP risk level is an acceptable risk level given that all practical preventive and mitigative measures are considered.

The results of the risk assessment were presented based on both individual and societal risk levels. Contour plots of the isopleths of the individual risk and the F-N plots of the calculated societal risk were presented. Based on the individual risk, the following accident scenarios were identified as ALARP:

- Traffic accidents resulting in potential release of chemicals
- Release of natural gas from failure of pipe stream no 1
- Release of reformed gases from K1301 stream no 32
- Release of reformed gases from failure of pipe stream no 32
- Release of reformed gases from E1301 stream no 31
- Release of large amounts of reformed gases from valves and pipe components
- Release of DME vapour from TK1841 PSV
- Release of hydrochloric acid (35%) from Tk-1820
- Release of hydrochloric acid (35%) from offloading
- Release of Methanol to sea from ship loading
- Release of DME to sea from ship loading
- Release of DME from truck loading
- Release of Methanol reactor outlet from pipe stream no 35

From the societal risk standpoint, except for the release of reformed gases from K1301, the societal risk for all scenarios is negligible.

Transient and local impact on the marine environment from a leak or spill of product is potentially possibly. However, because of the short half life of both Methanol and DME, these effects are expected to be short-term and localized. The impact on the shoreline is not expected as these chemicals leave no residue upon evaporation and degradation in the marine environment.

Due to the presence of a number of ALARP scenarios, CGCL recognizes that the preventive maintenance programme to be developed and implemented will form a
critical component of its impact mitigation strategy. CGCL will put a rigorous audit system in place to monitor the implementation of the preventive maintenance, particularly for the ALARP scenarios. Similar to the other ALARP scenarios, CGCL will also develop and implement a preventive maintenance and a rigorous safety audit programs for the loading docks.

Human Health Risk Assessment

The Human Health Risk assessment goes further than the QRA and evaluates the potential health effects on people residing and/or working in the immediate area from the substances emitted to the air from the proposed CGCL Petrochemicals Complex. The assessment implicitly considers the cumulative effects of other facilities in the area through the consideration of background. Note that only the inhalation pathway was considered since this is the more continuous pathway of exposure regardless of climatic seasonal influences.

The methodology used in assessing human health risks followed guidelines outlined by various regulatory agencies including the United States Environmental Protection Agency, and Health Canada. Toxicity Reference Values were obtained from reputable regulatory agencies such as the World Health Organization (WHO) and were expressed in terms of concentration ratio values for exposures to gaseous air pollutants. The concentration ratio is defined as the ratio of the predicted gaseous air pollutant concentration to a concentration protective of human health. Concentration ratios below 1 are not considered significant as background is considered in this ratio.

The possibility of short-term (1-hour, 8-hour and 24-hour) and long-term (annual) adverse human health outcomes were assessed based on exposures that would occur from predicted air concentrations at the maximum concentration location off the site (from the buffer zone outwards), which was chosen to provide the worst-case scenario. Maximum concentrations in the nearby communities of Sobo Village, Vessigny Village and Union Village were also used. Cautious estimates (i.e., likely over-estimates) of exposure were used in the assessment to ensure that risks were not underestimated. The Chemicals of Concern (COC) identified were gaseous air pollutants (carbon monoxide (CO), nitrogen oxides (NOx) and sulphur dioxide (SO2)), volatile organic compounds, and fine particulate matter. For the purposes of this assessment, short term and long-term health effects related to gaseous air pollutants were evaluated by a comparison of
the predicted concentrations with established values that were derived based on effects on respiratory health. Air quality dispersion modeling was carried out for the plant and port. However, the activities at the port do not result in any significant COC emissions. As such, these activities were not included in the air dispersion modeling assessment.

**Short Term Health Effects**

The results for the plant site showed that short-term concentration ratios associated with emissions of CO, N, and SO from the proposed CGCL Petrochemicals Complex at the maximum off-site location as well as all receptor locations are below 1 indicating that no incremental measurable adverse health outcomes would be expected in sensitive individuals living or working in the La Brea study area due to emissions from the proposed Petrochemicals Complex. Background concentrations represent a large portion of the total concentrations of CO and NO. Incremental concentrations of SO are higher than background levels for both plant layouts; however, the concentration ratio is still well below 1.

Fine particulate matter (PM and PM) background concentrations on a 24-hour basis in the La Brea area are below regulatory limits set out by the WHO and United States Environmental Protection Agency (U.S. EPA). The predicted incremental fine particulate matter (PM and PM) concentrations associated with emissions from the proposed CGCL Petrochemicals Complex even with the consideration of background, are below the health-based criteria; therefore no health effects related to particulate matter are expected from stack emissions from the proposed Petrochemicals Complex.

Based on the above results it is unlikely that adverse short-term health effects will be experienced by fenceline or Project affected community residents from emissions from the proposed Petrochemicals Complex, regardless of plant layout or port design option.

**Long Term Effects**

The concentration ratios for the long term exposure (annual) to NO are similar for both plant layouts and are well below a value of 1 indicating that there will be no adverse health effects from long-term exposure to gaseous pollutants from the proposed CGCL Petrochemicals Complex. In addition, the WHO indicates that compliance with the 24-
hour health-based guideline for ensures low annual concentrations that will not be associated with health effects. Since the predicted 24-hour concentrations are below a value of 50µg/L, it is not expected that any long-term adverse health effects will be observed.

The predicted annual incremental and .5 concentrations from the proposed CGCL Petrochemicals Complex are very low and will not be discernible from the natural variability in existing air quality. In addition, the .5 concentrations are below the U.S. EPA health-based limit of 15µg/L.

The predicted incremental Volatile Organic Compounds (VOC) concentrations are insignificant compared to the measured background VOC concentrations and therefore will not be discernible from background. Therefore it is unlikely that there will be increased risks from emissions of VOCs from the CGCL Petrochemicals Complex.

Based on the above results it is unlikely that long-term adverse health effects will be experienced by fenceline or Project affected community residents from emissions from the proposed CGCL Petrochemicals Complex, regardless of site layout or port design option. Therefore from a risk assessment perspective, the layout of the plant does not result in any significant differences in risk.

An evaluation of the uncertainties in various measurements and methods used in the current human health risk assessment indicated that the risks have been over-estimated as a result of the assumptions made about exposure (which were generally cautious). The results of this uncertainty analysis support the overall conclusion that no measurable adverse health effects would occur in the community in the La Brea study area.

In summary, predicted concentrations of gaseous air pollutants, VOCs, and fine particulate matter from the proposed CGCL Petrochemicals Complex will add to existing air quality levels for both considered site layouts and all port design options. However, the risk assessment demonstrated that these changes in air quality levels will not result in adverse effects in humans in the La Brea area.

Monitoring Plans
CGCL has developed a monitoring plan to ensure all mitigation strategies for predicted environmental and social impacts are meeting expected outcomes and to make certain liquid effluent, noise and air emission releases from the CGCL facility are meeting with legislated standards.

The Monitoring plan will be rolled out in two phases.

The design of comprehensive monitoring measures for construction and operation activities is occurring at the same time as the detailed engineering design. This will be done as a post-CEC grant activity.

Implementation of the designed measures for the following:

- Pre construction phase
- Construction phase
- Operational phase
- Decommissioning phase

**Pre construction phase**

During this phase, a number of activities are planned focusing on preparing the site for construction. The only monitoring activity proposed during this phase will be for the visual inspection of the property to ensure that dust control measures employed are meeting expectations.

**Construction phase**

Much of the moderate impacts will occur over the period of construction. The following monitoring conditions will apply during this phase of the Project.

<table>
<thead>
<tr>
<th>Monitoring Program</th>
<th>Frequency</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot checks along transport routes</td>
<td>Once a month during construction</td>
<td>CGCL, Regional Corporation,</td>
</tr>
</tbody>
</table>
### Monitoring Program Summary

<table>
<thead>
<tr>
<th>Monitoring Program</th>
<th>Frequency</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spot Social Surveys:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Employment</td>
<td>Every six months during the Construction Phase.</td>
<td>CGCL \ Regional Corporation</td>
</tr>
<tr>
<td>• Social Services</td>
<td></td>
<td></td>
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<tr>
<td>• Complaints and Feedback</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dust Monitoring</td>
<td>Daily visual inspections during the construction phase.</td>
<td>CGCL</td>
</tr>
<tr>
<td>Noise Monitoring</td>
<td>Monthly fenceline sampling and testing during the construction phase.</td>
<td>CGCL</td>
</tr>
</tbody>
</table>

#### Operational phase

During the operational life of the Project, the CGCL Plant will be expected to comply with the various pieces of environmental legislation in Trinidad and Tobago. The objectives of this monitoring plan will include but not be limited to:
## Monitoring Program

<table>
<thead>
<tr>
<th>Monitoring Program</th>
<th>Frequency</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring of Flora and Fauna downstream of plants.</td>
<td>Once at the end of the construction phase to establish baseline and on an annual basis throughout the operational life of complex.</td>
<td>CGCL</td>
</tr>
<tr>
<td>Effluent Testing of</td>
<td></td>
<td></td>
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<tr>
<td>• Process Effluent</td>
<td>On a monthly basis.</td>
<td>CGCL</td>
</tr>
<tr>
<td>• Sewage Effluent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Brine and backwash water Effluent (Desalination Plant)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marine Water Quality Monitoring:</td>
<td></td>
<td>CGCL</td>
</tr>
<tr>
<td>• pH, Conductivity, Salinity, Temperature, Dissolved Oxygen</td>
<td>Once per month for the first six months of steady state operation of the plant, and on a quarterly basis thereafter.</td>
<td></td>
</tr>
<tr>
<td>• Total Suspended Solids</td>
<td></td>
<td></td>
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<tr>
<td>• Nutrients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Iron, Copper, Zinc, Nickel</td>
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</tbody>
</table>
### Monitoring Program

<table>
<thead>
<tr>
<th>Monitoring Program</th>
<th>Frequency</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Five day Biological Oxygen Demand</td>
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<tr>
<td>• Oil and Grease</td>
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<td></td>
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<tr>
<td>• Phosphates (Total and Reactive)</td>
<td></td>
<td></td>
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<tr>
<td>• Faecal coliforms</td>
<td></td>
<td></td>
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<tr>
<td>• Chlorides</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Marine Sediment Monitoring:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• US EPA priority Trace Metals (Copper, Zinc, Cadmium, Chromium, Iron, Mercury, Nickel and Lead )</td>
<td>Sampling will take place once per quarter for the first six months of operation of the plant and once per season on an annual basis thereafter.</td>
<td>CGCL</td>
</tr>
<tr>
<td>• Petroleum Hydrocarbons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Benthic flora and fauna</td>
<td></td>
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</tbody>
</table>

### Noise Monitoring:

<p>| Noise Monitoring:                              | Noise monitoring will take place on a quarterly basis at 4 receptor locations around the plant site. | CGCL            |</p>
<table>
<thead>
<tr>
<th>Monitoring Program</th>
<th>Frequency</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stack Gas Monitoring:</td>
<td>Monitoring will take place during the operational phase and will take place on an annual basis on the reformer, boilers and flue gas stacks.</td>
<td>CGCL</td>
</tr>
<tr>
<td>Oxides of Nitrogen (NOx)</td>
<td></td>
<td></td>
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<tr>
<td>Sulphur Dioxide (SOx)</td>
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<td></td>
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<tr>
<td>Carbon Monoxide</td>
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<td></td>
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<tr>
<td>Particulate Matter</td>
<td></td>
<td></td>
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<tr>
<td>Unburnt Hydrocarbons</td>
<td></td>
<td></td>
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<tr>
<td>VOCs</td>
<td></td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ambient Air Quality Monitoring of:</th>
<th>Ambient air quality monitoring will take place on a quarterly basis at 4 receptor locations around the plant site.</th>
<th>CGCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulates,</td>
<td></td>
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<tr>
<td>NOx</td>
<td></td>
<td></td>
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<tr>
<td>SOx</td>
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<td></td>
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<tr>
<td>and VOCs</td>
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