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ES EXECUTIVE SUMMARY

ES.1. Introduction

The RTIP at Jubail II Project (RTIP) is the development and installation of a petrochemical complex on a greenfield site in the Jubail II Industrial City, Kingdom of Saudi Arabia (KSA) within the jurisdiction of the Royal Commission for Jubail and Yanbu (RCJY). RTIP will be built, owned and operated by a joint venture (JV) between Saudi Aramco and The Dow Chemical Company.

The overall complex will process ethane and naphtha as primary feedstocks to produce chemical and polymer products including polyethylenes, propylene glycols, amines, polyols, and urethane chemicals. Products from RTIP will be sold to companies in the Middle East and Asia for conversion to consumer products such as plastic containers and toys, insulation, antifreeze, adhesives and sealants, and paints.

RTIP will incorporate into its design the necessary environmental measures to comply with applicable RCJY standards, international guidelines and standards developed/adopted by Equator Principles Financial Institutions (World Bank and IFC), industry standards and partner companies' requirements and standards. In cases where duplicate or multiple requirements exist, the more stringent will be considered after appropriate risk-benefit analyses. The Environmental Management Plan addresses proposed mitigation measures to be implemented over time in order to ensure that all aspects of the project are in compliance with international standards.

In accordance with the Environmental Protection Standards set by the PME in 2001 [PME, 2001]) and Saudi Aramco and Dow Corporate requirements, as well as the Equator Principles and the IFC's Performance Standards, a detailed Environmental Impact Assessment (EIA) was carried out.

The EIA for RTIP required the following activities:

- Determine the data and analysis requirements to complete an environmental assessment which will meet local requirements and international standards of good practice;
- Ascertain what data are available and what additional surveys would be required;
- Liaise with the regulatory agencies and in particular the RCJY;
- Identify major issues and in particular those which may have an impact on design at an early stage;
- Establish the pre-construction environmental baseline for the RTIP site;
- Assess potential impacts of RTIP during construction, commissioning, operation and decommissioning;
- Identify mitigation measures to reduce any impacts;
- Develop a plan to monitor the implementation of the proposed mitigation measures; and

- Prepare well documented and defensible final reports and present the key findings to the regulatory agencies and the lending institutions.

The EIA is divided into Sections covering the following subjects/aspects: policy, legal and administration framework; project description; baseline sections (air & meteorology; onshore physical environment; ecology; noise; waste management; socio-economic aspects; archaeological and cultural heritage) assessment of impacts and mitigation measures, including cumulative impacts (air & meteorology; onshore physical environment; ecology; noise; waste management; socio-economic aspects; archaeological and cultural heritage); Summary of Impacts; Mitigation Measures; Monitoring Plan; Analysis of Alternatives; Sustainable Development Assessment; Appendices include: a stakeholder engagement plan, an Environmental Management Plan (EMP), and other complementary information. The Environmental Emergency Response Plan (EERP) for the facility prepared in accordance with the RCER 2010 will be provided as a supplement.

ES.2. Policy, Legal & Administrative Framework

The RTIP Project is located in Jubail, in the Eastern Province of the KSA, and lies within the jurisdiction of the RCJY. Although the Presidency of Meteorology and Environment (PME) has the overall authority in the KSA for environmental matters, the RCJY has been delegated responsibility for environmental matters within the boundaries of the industrial cities of Jubail and Yanbu. The RCJY is responsible for environmental management and controlling pollution associated with the development and operation of both industrial cities.

The key environmental regulations and standards applicable to the RTIP at Jubail are:

- "Royal Commission Environmental Regulations (RCER) Volume I, 2010 – Regulations and Standards" that includes all regulations, standards, and guidelines which industries operating in any of the industrial cities shall comply with. The RCER-2010 Volume I supersedes the last version RCER 2004. The RCER 2010 has been adopted by RTIP at Jubail to comply with regulatory requirements;

- "Royal Commission Environmental Regulations (RCER) Volume II, 2010 – Environmental Permit Program" that covers procedures and forms for applying to obtain "Environmental Permit to Construct" (EPC) and "Environmental Permit to Operate" (EPO) permits. The RCER 2010 Volume II supersedes the RCER 2004 Volume II.

"PME Environmental Regulations and Its Rules of Implementation, 2001" that includes the Environmental Protection Standards (Doc. No. 1409-01) has been considered as a reference for this project;

It is likely that RTIP funding will be provided by multiple financial institutions comprising a combination of Saudi Arabian and International banks. The Lenders are yet to be selected by the Project, but it is probable that major international financial institutions would be involved and that they would have adopted the Equator Principles, a financial industry framework for addressing environmental and social risks associated with a proposed project. Even in the absence of involvement of Equator Principles Financial Institutions (EPFIs), the Equator Principles provide an internationally accepted set of guidelines for major developments.

Therefore, international guidelines and standards developed by EPFIs will be also considered by the project.

The KSA is subject to international protocols and agreements adopted by the Kingdom and to other national environmental guidelines and standards, such as those developed by the PME as well as local specific environmental protection criteria developed by the RCJY which apply to industries within the boundaries of the industrial cities of Yanbu and Jubail. Additionally, the operator of a facility shall utilize Best Available Techniques (BAT) for environmental control, and shall apply methods and procedures for compliance, monitoring and sampling in accordance with international accepted standards, such as the American Standard Test Methods, U.S. Environmental Protection Agency (EPA), or Standard Methods for the Analysis of Water or Wastewater (Latest Edition).

ES.3. Project Description

The complex will occupy an area of about 576 hectares (ha), on a greenfield site identified as part of the Jubail II Industrial City, at approximately 3 km to the west of the existing Jubail Industrial City (JIC) in Saudi Arabia. The land area comprising the RTIP site is designated as industrial. The project will also occupy a tank farm and loading and unloading facilities at the Jubail King Fahd Industrial Port (KFIP).

The RTIP project combines multiple petrochemical process units to produce a broad range of chemicals and polymers. In total the site has about thirty different process units. Also the Project will include the utilities and infrastructure facilities required to support the process units.

The primary feedstocks to the Project are ethane and naphtha. The overall complex is configured with a mixed feed steam cracker and an aromatics plant as the core process units producing ethylene, propylene, benzene, and toluene as the four major hydrocarbon intermediate product streams. In addition, a chlor-alkali facility will produce chlorine, caustic soda and some hydrogen, from the electrolysis of brine, for use by the downstream derivative units.

Chemical and polymer products from the complex include polyethylenes, propylene glycols, amines, polyols, and urethane chemicals. All of the products will be sold to companies in the Middle East and Asia where they are converted to consumer products such as plastic containers and toys, insulation, antifreeze, adhesives and sealants, and paints.

The project comprises the following components:

- Hydrocarbon and Chlorine Core Units;
- Chemicals and Plastics Derivative Units;
- Utilities, Infrastructure and Site Logistics; and
- Value Parks (outside the scope of this impact assessment).

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JIC has a total of 176 industries in operation and as many as 76 in construction or at the design stage as well as infrastructure support utilities such as the Saudi Electric Company (SEC) for electric power, Marafiq for water desalination and distribution, sea water cooling pumps and network and waste water treatment facilities for sewage and process water (RCJY, 2010). Other infrastructure support utilities or neighbouring industries in the area include the Berri gas Plant, Jubail airport, Jubail Commercial Port (JCP) and King Fahad Industrial Port (KFIP).

Power and Utilities needed for the project, such as industrial water and potable water will be imported into the RTIP complex. Industrial gases such as high priority hydrogen, carbon monoxide, oxygen, nitrogen, ammonia, and compressed air will be supplied by third party Industrial Gas Provider (IGP). The JV's scope includes the site steam generation, demineralised water generation, electrical distribution, cooling water systems, site fire water system, condensate return system and the distribution of site utilities.

Other facilities necessary to support RTIP and within the JV's scope include:

- Hydrocarbons Infrastructure: Offsite pipelines (connecting the main site with the Port Facilities at King Fahd Industrial Port and other third party facilities within JIC), main pipe racks and storage for feedstock, return streams and finished products;

- Environmental facilities for wastewater handling, thermal treatment, and solid waste handling for offsite disposal. Industrial and Sanitary wastewater from the RTIP facility will be sent to Marafiq's Industrial Wastewater Treatment Plant and Sanitary Wastewater Treatment Plant, respectively.

- Port Facilities: raw materials and products loading and unloading docks, and tank farm at the KFIP;

- Temporary Facilities and Early Works: camps, lay down areas, office areas, and other support requirements and Early Works activities needed to support the mobilization of EPC contractors to the site;

- Transportation: roads, parking areas; and

- The site logistics services: Finished Products Packaging Centre Facilities (receiving, storage and shipping facilities) will be provided by third party, but will be located within the RTIP site.

The overall project schedule includes approximately fifty months of Engineering, Procurement and Construction (EPC), with site preparation starting in July 2011. Commissioning and Start-up is due to start in end of 2013 and is expected to last approximately twenty months, and the plant is expected to be in full operation by September 2015. A life of twenty five years has been considered, and it has been estimated that decommissioning will require an equivalent time to that needed for construction of RTIP. The number of personnel associated with RTIP fluctuates depending upon the particular work stage. Workforce during the peak, in construction phase, will reach 55,000 personnel (about 20% will be Saudi Nationals). Approximately 3,600 (about 75% will be Saudi Nationals) persons have been estimated to be involved in the commissioning and operation phases.

ES.4. Baseline

A characterization of the environmental, socio-economic and cultural resources of the area of influence of RTIP has been performed based on literature research, consultation with relevant stakeholders, previous reports and field studies performed as part of the scope of the EIA. The main findings are summarized in the following sections.

ES.4.1. Air Quality & Meteorology

The assessment of air quality and meteorological conditions in the area of influence of RTIP has been undertaken on the basis of ambient air quality data supplied by the RCJY and on surface and upper air meteorology data for the King Fahd International Airport at Dammam (hereinafter Dammam Airport) station.

The RCJY collect meteorological and air quality data from a network of seven ambient air quality and meteorological stations located within JIC. Air Quality Monitoring Station number 6 (AQMS#6), located next to the proposed RTIP site, has been selected to provide data for this study.

The RTIP site is surrounded by the following:

- Jubail Export Refinery (SATORP) under construction to the north-east;
- Jubail II undeveloped areas to the west and south;
- Road 274 to the south-east; and
- BeeA'h industrial / chemical landfill facility to the east corner of the RTIP site.

Additionally, other sources of air pollutants in the area, located predominantly to the north-east, are the existing 176 industries at JIC as well as infrastructure support utilities north-east from the site, and the Berri Gas Plant.

Hourly ambient air monitoring data from AQMS# 6 for NO_x, CO, SO_2, O_3, Total Hydrocarbons, $PM_{2.5}$ and PM_{10}, from 1st January to 31st December 2009 were selected to establish the ambient air quality conditions in the area by comparison of different averaging data with the RCER ambient air quality standards:

- Nitrogen dioxide concentrations were within ambient air standards during the monitoring period;
- Sulphur dioxide concentrations were within the standards for all criteria and averaging time periods;
- Ozone concentrations for the 1-hour and 8-hour averaging periods exceeded the RCER standards, ozone is a secondary pollutant and is considered to be a regional issue;
- Carbon monoxide concentrations for the 1-hour and 8-hour averaging periods for AQMS#6, were well below RCER standards; and

- Ambient air concentrations of PM_{10} and $PM_{2.5}$ greatly exceeded RCER ambient air quality standards for all averaging time periods. For PM_{10}, it is difficult to distinguish between industrial and non-anthropogenic sources of particulate matter. In arid, desert climates very high PM_{10} concentrations can be caused by sand storms and periods of high wind speed; however, the issue of natural wind blown dust makes interpretation of this ambient data difficult.

ES.4.2. Onshore Physical Environment

Both the Main RTIP site and the Port site were subject to an intensive Geotechnical Investigation followed by a Phase I and Phase II Environmental Site Assessment undertaken by third parties in order to determine the baseline geological, hydrological and soil/water chemical conditions.

Drilling investigations showed that the geology underlying the main RTIP site consist of Aeolian sands at the surface, becoming more dense with depth down the investigation limit of 50 m below ground surface (bgs). Geology at the Port site consisted of mixed granular soils to the investigation limit of 50m.

Groundwater levels at the main RTIP site varied between 2 and 12m bgs in 2010, and between 3.6 and 3.8 mbgl at the Port site. Chemical analysis of groundwater samples at both sites for TPH and PAH were below detection limits while all metals were considered to be at background concentrations.

Soil chemistry analyses were undertaken at both sites at depths of 0.1 and 1.0m bgs for TPH, PAH and metals. Concentrations of TPH and PAH were below detection limit in all samples and the concentration of metals were all below the Dutch Intervention Values. Based on the laboratory analytical report from the Phase II Site Assessments, it is considered that the reported analytical soil concentrations represent the current local background concentrations within the sandy soil down to maximum 1m depth.

ES.4.3. Ecology

Terrestrial Ecology

The RTIP site is surrounded by JIC settlements with the industrial area lying adjacent to the north and northeast. To the south of the site there is an extensive settlement consisting of worker camps, farms and forestry plantations. The BeeA'h landfill site is situated next to the south-eastern corner of the project site.

An area of natural or semi-natural vegetation lies in the southwest corner and along the southern edge of the site, and continues to the west of the site as far as the Abu Hadriyah road. This vegetation consists mainly of a community of moderately saline tolerant shrubs belonging to the family Chenopodiaceae, mixed with a community dominated by perennial grasses (*Panicum turgidum* and possibly *Pennisetum divisum)*, and clumps of date palm trees. It is often currently presented in poor condition due to waste or over-grazing.

Such habitats are considered of low ecological value, as they are only likely to support common desert species of breeding, migratory and wintering birds together with resident mammals and reptiles. These habitats are widespread throughout the Arabian Gulf, and present outside the project site towards the south-western side, therefore the loss of this type of habitat is considered an impact of only local extent.

The project site is located in a low-lying area along the eastern coast, where saline soils covered with halophytic (salt-tolerant) shrubs are predominant, though sand sheet areas, areas of standing water or wet mud basins, and beach habitats are also present.

The project site is situated about 10 km south of the Sabkhat Al-Fasl Lagoons, listed as an Important Bird Area (IBA) by BirdLife International. These are a series of evaporation lagoons on sabkha, which are used for storing excess wastewater from Jubail Industrial City. The Jubail Marine Wildlife Sanctuary, established after the events of the 1991 Gulf War, is the first of a series of proposed marine protected areas along the western coast of the Arabian Gulf which will promote the conservation of endangered species and allow for the appropriate management of the renewable biological resources of the area.

The site is likely to be used by a variety of generally common and widespread desert bird species, present at low densities. These will almost certainly include Hoopoe Lark (*Alaemon alaudipes*) and Crested Lark (*Galerida cristata*). A number of resident species are likely to nest or roost in the date palms, all of which will also be found in urban areas and tree plantations in the surrounding area. The site may also provide some foraging potential for commoner migrant species such as Red-throated Pipit (*Anthus cervinus*), Yellow Wagtail (*Motacilla flava*), Isabelline Shrike (*Lanius isabellinus*), Short-toed Lark (*Calandrella brachydactyla*), Desert Wheatear (*Oenanthe deserti*) and Desert Warbler (*Sylvia nana)*.

No comparatively large animals like hares and rodents were identified during the site walkover. Although no domesticated or feral animals were seen during the course of the survey, signs of grazing (likely by goats) were identified. Common species such as feral dogs and Red Fox (*Vulpes vulpes)* could occur on the site. It is likely that the better vegetated parts of the site support populations of the more common and widespread small mammal species such as Cheesman's Gerbil (*Gerbillus cheesmani*) and Baluchistan Gerbil (*G. nanus*). Other species that might occur in this habitat include Cape Hare (*Lepus capensis*), Sundevall's Jird (*Meriones crassus*) and Lesser Jerboa (*Jaculus jaculus*), all widespread in well vegetated sandy areas throughout the Arabian Gulf. One or more species of hedgehog may also occur in this area. Reptile activity on the site appeared to be poor, with only one track identified in the field survey. The most likely species to occur in this habitat is the White-spotted Lizard (*A. schmidti)*, a common and widespread species in softer sandy areas.

Marine Environment

The main RTIP site is approximately 18 km from the shoreline. The project will also have a tank farm and loading and unloading facilities at the existing King Fahd Industrial Port (KFIP or Port).

The marine ecology baseline investigation (Section 6.4 of Ecology Baseline) is based upon a literature review focusing on two areas, Jubail and Ras Tanura, between which the KFIP is located. The marine ecology baseline section is also based on prior knowledge of the habitat, flora and fauna of the general region and of other similar areas of the Arabian Gulf region.

KFIP is located within an ecologically diverse area of the Arabian Gulf and whilst the direct impacts at the Port (such as storage tank leakage or spills during loading and unloading) are confined to a smaller area of the Arabian Gulf, these impacts can have regional repercussions. Ras Tanura is approximately 50 km south of RTIP, but information on Ras Tanura provides some regional context for this section. The potential for long shore current to carry a spill of fuel, raw materials, finished product or other cargo from the Port area southward towards Ras Tanura means that this stretch of Gulf waters and coastline between the two points is also considered a potential receptor.

The Jubail Marine Wildlife Sanctuary is located to the north of JIC. The area consists of two large coastal embayment systems (Dawhat ad-Dafi and Dawhat al-Musallamiya) and five offshore coral islands (Harqus, Karan, Kurain, Jana and Juraid) along the stretch of coastline between Abu Ali and Ras az-Zaur. The area covers an area of approximately 2,300 km^2 and more than 400 km of coastline. The intertidal zone is characterised by sandy beaches, rocky shores, salt-marshes and mangroves. Seagrass beds, coral beds and coral reefs form the major types of subtidal habitats. The Sanctuary contains specimens of all major habitat types of the western Gulf. It includes the northernmost mangrove stands, the largest and most diverse coral reefs, and the most important nesting sites in the Arabian Gulf for marine turtles and several species of seabirds (Alam 1996, Fleming 1996, Krupp & Khushaim 1996, Ziegler & Krupp 1996, Abuzinada & Krupp 1994).

The prevailing long shore current moves southward along the eastern coast of Saudi Arabia. Therefore the habitats of the Jubail Marine Wildlife Sanctuary are an unlikely receptor of any spill or other accidental release of RTIP raw materials or finished products. However, the habitats of the Jubail Marine Wildlife Sanctuary attract species that may move throughout the coastal waters stretching from Ras Tanura, through the KFIP area, to the Sanctuary.

ES.4.4. Noise

A noise baseline investigation has been conducted to characterize existing ambient noise levels in order to assess the potential impacts of noise levels related to the different phases of RTIP. In addition, the areas that could potentially be affected by noise from RTIP activities have been reviewed to identify potential noise-sensitive receptors. The characterization was performed comparing the measured noise levels with the applicable noise standards which are those from the RCER, Volume I and II. Additionally, the World Bank noise limits have been included as a reference (World Bank, 2007a.)

The measurement campaign comprised measurements of noise pressure levels, both continuous (72 hour duration) and short term (10 minutes duration) in several points inside the RTIP main site, at the boundaries and in the closest sensitive receptors. Access to the port was not provided, therefore, the noise baseline study has been focused on the main site of the complex and its surroundings.

The area in which the main site of the RTIP complex will be built is designated as industrial and is currently under development. When the noise measurement campaign was performed, an electric substation was under construction in the northern corner of the site. A contractor camp was also located in the site, close to the northeast boundary. These likely affected the measured noise levels.

The nearest sensitive receptors to the RTIP complex are the following inhabited areas:

- Mixed use area consisting of a construction camp, factory and agricultural farm located at approximately 1.5 km south of the RTIP site;
- Jubail prison, located at approximately 3.8 km east of the RTIP site;
- Jubail Old Town, at approximately 13 km north-east of the RTIP site; and
- Jubail Community Area, located at approximately 17 km north of the RTIP site.

The following conclusions have been extracted from the RTIP Noise Survey:

- Average ambient noise levels (L_{eq} [72h]) and average of the 10 minute L_{10} measured in the long term monitoring locations within RTIP complex and its boundaries are below the RCER and the World Bank noise criteria. The L_{eq} noise levels measured in the Farm adjacent to Mega Coat Factory comply with both RCER standards and World Bank Guidelines. The measurement location in the vicinity of Jubail Prison is above the night-time standard for the World Bank Guidelines. Night exceedances are associated to peaks of traffic that took place every day, between 5:00 and 7:00 am, inclusive.
- While periods of high wind speed were avoided as far as was practicable, wind speed was high during long term noise measurements in certain locations, being perceived as the main noise source during the measurements. Windscreens were used in all the measurements, and in some cases, the noise meter was located in an open box in order to protect it from strong wind and sand.

ES.4.5. Waste Management

Information on the waste management infrastructure available in and around the project has been gathered during the field investigations, together with a desk-based search for information in official web pages. The local hazardous waste disposal and sanitary landfill facilities located in Jubail were visited as part of the field investigation undertaken in November 2010. In addition, a number of regional waste and wastewater treatment and/or disposal facilities were previously visited as part of a field investigation undertaken by the Owner’s Environmental personnel in April 2008 (Dow, 2008).

JIC contains various installations able to treat and dispose of industrial and domestic, liquid and solid waste streams. The facility which will manage the RTIP’s non-hazardous wastewater will be the Marafiq Wastewater Treatment Facility, which is itself divided into two plants which are the Marafiq Sanitary Wastewater Treatment Plant (SWTP) and the Marafiq Industrial Wastewater Treatment Plant (IWTP). Both of these plants use Primary and Secondary Treatment Processes. With regards to solid waste streams, there are two facilities directly adjacent to the RTIP site, which are able to manage and dispose of both hazardous and non-hazardous wastes. The first of these is operated by the National Environmental Preservation Company (BeeA’h) and includes hazardous waste landfill with both Class I and II landfill cells, and a Thermal Treatment facility. The second facility is operated by the Environment Development Company (EDCO) and also includes both Class I and II landfill cells, although there is no Thermal Treatment facility at present. In addition to these two facilities there is also the RCJY sanitary landfill which is equipped to handle non-hazardous wastes only.

ES.4.6. Social

A socio-economic baseline survey was undertaken in order to identify and characterise the communities that may be impacted by RTIP.

The proposed RTIP site is to occupy an area of approximately 5.76 km2 or 576 ha of land in Jubail II, as well as a tank farm and loading and unloading facilities at the KFIP. It lies within the Jubail Governorate in the Eastern Province of Saudi Arabia.

Jubail's main economic activity is related to the oil and gas industry. The robust increase of the oil sector in the past sixty years has lead to a high rate of economic immigrants from other parts of Saudi Arabia and foreign workers from the United States, United Kingdom, Middle East, and Asia. As such, Jubail and other areas in this region are a settlement of multi-ethnic residents from different cultures and backgrounds. Residents are engaged in support activities including fishing, services, education, business, and semi-skilled work.

These settlements have grown as have the housing infrastructure and services that support workers in these developments. There are residential areas located to the north and northeast of the proposed RTIP complex, and Jubail Town to the south. These areas include industrial installations/infrastructures, Corniche installations (restaurants, parks, coastguard buildings, mosque and palace), agricultural and fishing sites in Tarut Bay and some religious, educational and residential features.

This social baseline has identified the services and infrastructure available, and cultural background, of the RTIP site. A field survey conducted in November 2010 found that most of the available administrative, public and civil services are adequate for the current needs of the residents of Jubail. Networks for water supply and drainage, power supply and telecommunications are available to the community.

ES.4.7. Archaeological & Cultural Aspects

An archaeology and cultural heritage baseline study was compiled in order to identify existing or potential archaeological resources and cultural heritage, at the RTIP site that may be impacted by the project and to locate and document all archaeological and cultural heritage resources that may exist in the study area.

In order to carry out the archaeological and cultural heritage study for the RTIP site (a total area of 5.76 km^2), a combination of both a desktop study (literature search) and limited physical site "walk-over" survey was undertaken by Dr. Ahmed Abuelgasim El-Hassan, an Archaeologist and lecturer at Hail University, and a cultural heritage specialist. The physical site survey was conducted for the project area, which also included a buffer area of 10 km around the RTIP site.

On the basis of the results of the RTIP literature search and physical site survey conducted as part of the EIA, and previous survey and fieldwork investigations made by the Deputy of Antiquities and Museums in JIC II and its vicinity, it is not likely that any archaeological and/or cultural resources are present in the project area. None of the sixteen sites of national and regional archaeological interest identified during the literature review are located within the RTIP project area.

ES.5. Impact Assessment

ES.5.1. Introduction

To enable the assessment of impacts, a set of criteria was developed for determining the potential impacts resulting from the construction, commissioning, operation and decommissioning of the RTIP.

The criteria provides definitions of magnitude and significance as they apply to potential impacts from the project on air, marine, biological and onshore physical environments, socio-economic, cultural and health aspects and from noise and wastes. Common criteria definitions were developed as well as impact assessment criteria for each study area, i.e., air quality and meteorology, marine environment, etc., where necessary. Impacts are assessed with respect to their frequency, likelihood, extent, duration and magnitude. Impacts were further defined as positive or negative and direct or indirect. The overall significance was then determined in relation to each study area / environment as high, medium or low.

These criteria are aligned with criteria integrated in other impact assessment methodologies established by European Directives (Directive 85/337/EEC as amended by 97/11/EC and 2003/35/EC on the assessment of the effects of certain public and private projects on the environment); and impact assessment guidelines developed by international organizations such as the Institute of Environmental Management and Assessment (IEMA) which promotes best practices standards in environmental management, auditing and assessment.

ES.5.2. Air Quality & Meteorology

The air quality impact assessment evaluates the impacts caused by RTIP during all project phases. Main project emissions are dust during the construction phase, and those from combustion sources and fugitives, during the operational life of the project.

In order to evaluate the impacts, ambient air concentrations have been predicted based on anticipated emissions from the RTIP complex by means of air dispersion modelling applying the AERMOD or AERSCREEN programmes developed by the U.S. EPA. Thus, project emissions from dust during construction, and from: NO_X, SO_2, CO, PM_{10}, $PM_{2.5}$ and organic compounds to assess their health effect, during operation have been modelled. Additionally spills scenarios have been evaluated.

The current baseline particulate matter (PM_{10} and $PM_{2.5}$) concentrations are above the RC ambient air quality standards, as indicated by the data analyzed from AQMS #6 in JIC. During the construction phase, dust emissions from set-up and other construction activities will result in predicted concentrations below the RCJY standards but the existing high baseline particulate matter concentrations when summed with these modelled concentrations results in a potentially high magnitude impact, which cannot be mitigated by the RTIP project. These impacts are also expected to be present during the decommissioning phase of the project.

Impacts from exhaust emission caused by vehicles and construction machinery have also resulted in a high significance impact close to the RTIP boundary.

The predicted modelled contribution to the ground level concentrations for PM_{10} and $PM_{2.5}$ from RTIP operations are also well below the RC ambient air quality standards, however when summed to the existing high baseline particulate matter concentrations, result in a potentially high magnitude impact, which cannot be mitigated by the RTIP project. For NOx the maximum modelled concentration is below the ambient air quality standards, and below 50% of the RCJY air quality standard when summed to the baseline. These emissions represent a 27% consumption of the available ambient air quality increment for NOx, leading to a low magnitude impact and low significance. Available air quality increment is defined as the difference between the baseline and the corresponding ambient air quality standard.

From the organic compounds assessed, benzene resulted in a medium magnitude impact. The benzene modelled concentrations are within the RCJY ambient air quality standard for benzene, but above the assessment criteria for medium magnitude impact of 50% of ambient air quality standards. A risk assessment based on inhalation has demonstrated that the risk of cancer on the nearby population is within internationally acceptable criteria. The other pollutants assessed: Formaldehyde, Toluene, Xylene, Ammonia, Chlorine, Aniline, Ethylene Oxide, Hydrogen Chloride and Phosgene have modelled concentrations below the applicable ambient air quality or occupational standard. Therefore the impact significance associated to those emissions is low.

Finally, several spill scenarios have been modelled to estimate the impact from the release of products into the atmosphere. The assessment has been focused on a Benzene spill from tank and piperack failures, because benzene has the greatest downwind impacts both for tank and piperack spills, representing the worst case spill scenario, resulting in medium significance impacts.

Although the RTIP facility design incorporates many BAT concepts, additional suggestions for appropriate mitigation measures as included in Section 21, Summary of Mitigation which would be expected to lower the significance after mitigation to low. An exception to this is dust emissions where the background concentrations of PM_{10} and $PM_{2.5}$ already exceed the RCJY ambient air quality standards.

ES.5.3. Onshore Physical Environment

A number of impacts, ranging in significance, were identified as potentially occurring across each phase of the project. Baseline geological, soil and hydrogeological conditions have been evaluated and considered in the assessment of potential impacts. Mitigation measures and monitoring activities are identified for the majority of environmental impacts.

During the construction, commissioning and operation phases of the project there is the potential for negative environmental impacts through the accidental release or spill of hazardous materials such as raw materials and feedstock. The design of the RTIP facilities and operations includes spill prevention and containment measures for all phases of the project to prevent, to a practical extent, releases of hazardous materials to the physical environmental and to limit the duration and size of any possible release. The evaluation of impact of releases of hazardous materials is based on the formulation and evaluation of possible release scenarios and their potential impact on human or ecological receptors. Identified release scenarios were modelled for contaminant transport in groundwater in the alluvial shallow aquifer. None of the modelled scenarios identified the potential for released contaminants to reach any human receptors, the marine environment or sensitive terrestrial ecological receptors.

During the construction phase of the project there is the potential for environmental impacts of low significance through the degradation of soil quality due to activities associated with construction and earth movement; alteration of drainage characteristics and modification to the hydrogeological recharge system; accidental release or spill of hazardous materials.

A number of activities could potentially generate low significance environmental impacts on the onshore physical environment during commissioning. These are primarily related to accidental releases and spills of hazardous materials, continued modification of drainage characteristics and soil quality and modification of the hydrogeological recharge system.

During the operation phase of the project there is the potential for environmental impacts of low to medium significance. Potential environmental impacts of low significance are associated with continued modification of drainage characteristics and soil quality and modification of the local hydrogeological recharge system. Potential environmental impacts of low to medium significance are associated with releases and spills of hazardous materials that occur due to a pipe failure or spill from transportation tanks and containers.

Potentially positive and negative environmental impacts of low significance are associated with decommissioning activities. Potential positive impacts are associated with restoration of the local drainage and recharge patterns after demolition of project facilities, site restoration and remediation of contaminated soil (discovered after the demolition of facilities). The only potentially negative environmental impact associated with decommissioning activities could be generated by degradation of shallow soil and groundwater quality due to decommissioning activities, traffic and management of inert construction debris.

ES.5.4. Ecology

Terrestrial Ecology

During construction, onsite terrestrial biological resources would be affected by habitat disturbance, dust, noise, presence of structures, vehicle traffic and worker activity. Lighting and habitat fragmentation due to road cutting and grading are likely to occur. Small mammals may also be directly harmed or killed by machinery during the preparation process. The main impact will however be the loss of habitat. The total habitat loss associated with construction is not expected to exceed 200 ha and such habitats are considered marginal and of low value habitat for birds, mammals and reptiles due to the sparse distribution of plant cover on the project site. It is noted however that this will have only a small net impact on the ecology of the JIC area, and that the main site is located 10 km south of the Sabkhat Al-Fasl Lagoons, thus avoiding any direct negative impact on this protected area.

Impacts of construction include removal of vegetation, potential displacement of associated fauna, migratory and resident birds and vegetated areas. The construction phase will have an impact of low significance on onsite terrestrial biological resources.

Some impact on vegetation and fauna adjacent to RTIP site, specifically on migratory or resident birds residing at the coastline area (17.5 km from the RTIP main site) is likely due to the effects of dust, vibration, lighting and noise from earth moving vehicles during the construction period. These impacts are considered to be of low significance.

Commissioning is likely to increase ambient lighting and noise levels inside and outside the fence line of RTIP. This would undoubtedly disturb local birds and fauna, but as the impact will be of short duration and sensitive receptors are lacking, the commissioning phase is classified as having a low significance impact.

During the operational phase of RTIP security lighting for the site will have a low significance impact upon nocturnal animals that are in the vicinity of the site. Air emissions from the RTIP may have a low significance impact on vegetation, mammals, birds and reptiles.

The impacts during decommissioning will be similar to those predicted during site construction in terms of disturbance to mammals (and other fauna), although to a lesser degree because most of the RTIP would be unlikely to support wildlife or native vegetation prior to decommissioning. Demolition of structures and removal from RTIP will generate noise, dust, traffic and worker activity.

Only offsite sensitive habitats are likely to be affected by accidental spills, fires or the release of potentially hazardous materials to the environment, should a release to the environment be significant and not managed.

Accidents and spills may occur on the numerous pipelines that lead to and from RTIP and this could impact small numbers of wildlife. Overall, however, the potential impact on vegetation and fauna is considered to be of low significance.

Marine Environment

The main impacts to the marine environment during the life of the project are related to potential accidental events during transport and at KFIP, such as: 1) direct fuel or chemical spill to sea during transportation by a third-party transporter and 2) fuel or chemical spills from vessel collision or breach at the Port Facilities.

A major release of raw materials, finished product or other loss of cargo resulting from a ship collision within the navigation channel could generate a significant impact to the marine environment. All accidental events during transport will be the responsibility of the third-party transport provider. However, the Owners should incorporate certain considerations into their transport procurement activities. Decisions regarding preferred transport providers should consider the condition of a transport provider’s fleet and equipment, and the appropriateness of their operating and emergency procedures to RTIP requirements.

The impacts to the marine environment from an accidental tank, jetty topside handling equipment or vessel collision release are expected to be of medium significance given that some of the chemicals to be stored and handled in large volumes at KFIP which would be considered toxic, not biodegradable and not soluble. RTIP will be responsible for loading and unloading trucks and ships, and therefore responsible for accidents and emergency response at KFIP. It must be taken into account that design measures to avoid spills have been considered so that there should be minimal spill volumes reaching marine waters: the Tank Farm is provided with secondary containment; truck loading/unloading and the Jetty areas are curbed and containment is provided by sump, so any spill in these areas will be contained; pipelines have Emergency Block Valves (EBVs); and the Marine Loading Arms (MLAs) are being provided with Powered Emergency-Release Coupler (PERC) systems.

Impacts to the marine environment including water quality can result in loss of marine life and potential longer term impacts to the coral and seagrass habitats along the coastal area north and south of KFIP. In addition, impacts to marine organisms that pass through the coastal waters from Ras Tanura through the KFIP area to the Jubail Marine Sanctuary are of particular concern. The region is diverse in its marine ecology and lacking in sediment contamination. As such the ecological value of the region is considered as moderately high.

Other impacts that could affect the marine environment are related to wastewater effluents from the concrete batch plant (construction phase), hydrotest water (commissioning phase), potentially contaminated stormwater (operations phase) that could be discharged to sea in the event of a failure of the wastewater control testing systems. Contaminated water entering the marine environment can damage or kill marine organism, including important species for the local fisheries industry. Though the impact is considered of medium magnitude, due to the fact that the impact is a consequence of an accidental event associated to abnormal operation which is considered unlikely to occur, the significance of these impacts has been assessed as low to medium.

The marine environment will be affected, to a small degree, by an increase of vessel movements, lighting and noise at KFIP and potential accidental release of construction materials, equipment or fuel. Should a release occur it will likely be a small volume of diesel or petrol and likely confined to the local area. Volumes and concentrations of contaminants would be small and cargo would likely be inert, therefore the potential impacts derived from vessel movements would be of low significance. Potential impacts associated with noise are also considered of low significance, given the known avoidance behaviour of species expected to visit or forage the area, such as dugongs and sea turtles. In addition, the EPC contractors will ensure that all construction equipment has appropriate noise suppression installed and are well maintained.

ES.5.5. Noise

Noise will be generated at the RTIP during construction, commissioning and normal and emergency operations of the project. Decommissioning of the plant would also result in generation of noise from the site into adjoining areas.

Potential noise impacts from activities during each of these phases have been assessed using the noise criteria set in Section 11 – Impact Assessment Criteria (Tables 11-6 and 11-7). Focusing on assessing the noise impacts on areas of interest, which include inhabited areas (Jubail Prison, Jubail Old Town and JIC Community area) and the mixed use area located at approximately 1.5 km SE of the RTIP Site, which comprises the Mega Coat Factory, agricultural activity and construction areas with associated contractor camps.

The assessment has been performed by comparing expected noise levels during all project phases with existing noise levels and the applicable noise standards both at the site boundaries and at sensitive receptors. The expected RTIP operating noise levels have been predicted using SoundPLAN® software.

After analyzing the expected noise levels it has been concluded that the most significant noise sources are:

- Heavy vehicles circulating close to residential areas (Jubail Residential area and Jubail Old Town). This impact is expected to be of special relevance during the construction phase, as heavy traffic density is expected to be more significant, though heavy vehicle movements will take place during the rest of the project phases. The impact has been considered as of medium significance and some measures to minimize disturbance to the population have been proposed: scheduled good quality maintenance of the vehicles, and minimization of heavy vehicle movement close to or through inhabited areas, during the night period.

- High Pressure Steam Blows and flaring during commissioning. High pressure steam blows associated with commissioning activities could produce high noise levels (high magnitude impact). These events will be of short duration and will not occur under normal operation and are usually confined to daylight hours and the impact significance has been assessed as of medium significance. Temporary portable vent silencers will be used to control noise from steam blows to manageable levels. Low pressure continuous steam blowing will be used where practical. This method maintains relatively low pressures and continuous flowing stream of steam to achieve steady state blowing conditions. There is no information on noise from flaring but it is expected to be lower than steam blows.

Construction activities are considered continuous for the purposes of this assessment, but are not expected to result in any significant noise increase that could affect the population.

Noise levels as a result of operation activities, though of longer duration, are not expected to cause any significant increase of existing noise levels, and are expected to comply with the applicable limits according to the World Bank and the RCER. The impact has been assessed as of low significance.

High pressure steam blows and flaring also might take place during abnormal operations. In that case, though noise levels expected are similar to those in commissioning, due to the fact that the activity would be infrequent, the impact significance has been assessed as low.

Noise levels during decommissioning are expected to be similar to those expected for the construction phase.

ES.5.6. Waste Management

Wastes will be generated during the construction, commissioning, operation and decommissioning of RTIP. The majority of hazardous wastes will be produced during the commissioning and operational phases of the project, although a significant portion will also be generated during the construction phase. Non-hazardous and inert wastes will be generated during all project phases.

Two units will be constructed within the RTIP for the onsite preliminary waste management of solid and liquid waste streams. Wastewater Unit (Unit 773) is composed of Equalization and Diversion (EQ/DQ) tanks and an Emergency Holding Pond, and will be constructed onsite for the handling of any wastewater generated within the facility that meets RCER Table 3B standards. The wastewater stream will be tested to ensure compliance with RCER Table 3B standards, after which it will be sent to the IWTP in the Marafiq facility. In addition to this, a Solid Waste Handling Unit (Unit 778) will also be constructed within RTIP where waste segregation and temporary storage will be carried out for non-hazardous solid waste and both hazardous solid and liquid waste. The waste will be collected from this Unit to be transported to the designated off-site waste facility where it will be managed and disposed of.

The impact of onsite storage and offsite disposal of non-hazardous liquid waste on human health and the environment is expected to be of low significance during all project phases. Non-hazardous liquid waste streams will mainly include sanitary wastewater, process wastewater, surface runoff flows, and hydrotest water, over the course of the four project phases. All sanitary wastewater (mainly made up of grey and black water) generated during the project will be sent to the Marafiq SWTP for treatment, whilst process and hydrotest water will be sent to the IWTP (although in the case of the latter it may be directly discharged into the Marafiq Seawater Cooling Return Header if in compliance with RCER Table 3C). Surface runoff will be sent to the RC Drainage Channel when the water quality is in compliance with the RCER Table 3C, and when not in compliance will be diverted to the RTIP Unit 773 EQ/DQ tank. Specific environmental and quality control methods at the plant are unknown at this stage and the quantities of sanitary (during construction) and industrial wastewater (during operations) expected to be generated are considerable, so a potential impact of medium magnitude has been identified for soil, marine environment and the local population.

Although onsite storage of non-hazardous solid wastes is expected to be of low significance during all project phases, offsite disposal of these wastes is expected to be of medium significance during the construction and decommissioning phases. Non-hazardous wastes will be segregated and stored at the EPC contractor's camp during the construction phase, and then in the RTIP Solid Waste Handling Unit (Unit 778) during the rest of the project phases. Throughout the project, solid waste storage areas will be enclosed within four walls, floor and roof. Off-site disposal will be carried out at the RC sanitary landfill during the construction phase and in either BeeA'h or EDCO's Class II landfills or equivalent licensed facilities during the remaining project phases. Controls in place for off-site disposal management reduce the overall likelihood of potential windblown and subsurface contamination off-site.

The impact of on-site disposal and off-site disposal of hazardous waste on human health and the environment is expected to be of low to medium significance in all project phases, particularly given the materials involved (hazardous, potential long term affect, low quantity).

Offsite disposal will be carried out at either BeeA'h or EDCO's Class I landfills during the all project phases. As per their website, there is no documentary evidence of environmental controls being in place at the EDCO facility but nevertheless the disposal management practices used by EDCO are stated to be in accordance with the standards of the RCJY, PME and USEPA. In the case of BeeA'h, their facilities hold an ISO 14001 certification and their services are provided in accordance with International Conventions. The significance of these impacts can be further lowered if appropriate mitigation measures are taken. These include developing a comprehensive waste management plan, or auditing the waste management facility prior to the start of each phase of the project.

Hazardous waste transportation is expected to be of low to medium significance during all project phases. The significance of this impact depends greatly on the facility selected for hazardous waste disposal. BeeA'h, for example, state that they aim to ensure compliance with all applicable local and international regulations; that their services are provided in accordance with the requirements of the appropriate transport authority; and that in providing hazardous waste transportation services they also assume total liability for all material accepted. In the case of EDCO however, at present it is unclear whether or not they offer waste collection and transportation as part of their services. Therefore, depending on the facility selected there may be uncertainties associated to the transport of hazardous wastes and which would increase the likelihood of potential contamination occurring, as well as potential future liabilities.

During all phases of the project there is the potential for accidental releases of liquid and solid hazardous wastes both in RTIP and during offsite transportation. The significance of the potential impact resulting from an accidental release is considered medium to high but can be reduced to low if the appropriate mitigation measures are taken and comprehensive and adequate Emergency & Incident Response and Contingency Plans are prepared and implemented.

ES.5.7. Social

The implementation of the RTIP project may result in social and health impacts at local, regional, and national levels.

The social baseline included in Section 9 was compiled in order to identify and characterise the receptors that may be impacted by RTIP, and to provide a general understanding of the social and cultural setting for the project. However, limitations in data availability do not permit the development of a thorough local baseline description. For this reason, CH2MHILL has adopted a conservative approach and where local information was not available the worst credible scenario has been considered.

The equator principles and international standards such as the World Bank and IFC Performance standards form the basis for the potential impact assessment.

An archaeological and cultural impact assessment is provided in Section 18 and occupational health is addressed using the operator's health and safety practices and EPC contractor's health and safety standards (see Appendix A EMP). Information regarding impacts related to dust, noise, cultural heritage, and waste management have been addressed and discussed in Section

12 Air Quality & Meteorology, Section 15 Noise Section 18 Archaeological and Cultural Heritage, and Section 16 Waste Management, respectively.

The construction phase of RTIP, estimated to be approximately forty months, will result in a number of social impacts. It is estimated that about 55,000 workers will be required during periods of peak construction activity. The expected increase in road traffic may cause disruption for residents of nearby community areas and local fishermen of medium significance. The increase in income, as a result of additional employment and demand for goods and services, will have a positive impact of medium significance, which will be followed by a decrease in income resulting from the demobilization of the majority of the workforce once construction is completed with a negative impact of medium significance. The importation of workers from other countries will result in medium negative impacts to their families and a low negative impact related to potential increase in demand and hence prices for local housing. The demand for infrastructure and services will result in an increase in impacts on availability which is considered of low significance. The increase in demands on housing will have an impact of high negative significance. The additional need for health provision and the potential spread of communicable diseases will have a negative impact of high significance.

During commissioning, most of the social impacts associated with construction activities are maintained throughout the commissioning phase, though their potential significance is reduced considering the decrease in staff numbers and therefore, in associated traffic levels, and demand for services and infrastructure, amongst others.

During the operation phases of RTIP, there are potential socio-economic impacts relating to RTIP employees. In comparison with the larger workforce of RTIP during construction activities, the workforce during operations is smaller but still significant, at approximately 3,600 (which represents 2.6% of the current total population of Jubail). The main impact is related to the net increase in road traffic (though lower than that expected during the construction phase) which is expected to have a medium negative significance. The increase in employment and related income (while relatively smaller than for construction, is over a longer term) is expected to have a positive impact of low to medium significance. The negative impact resulting from the increase in demand on services during the operation phase is expected to be of low to medium significance considering the existing infrastructure and services offered by the RCJY.

The decommissioning phase is expected to involve the same impacts as construction (increase in road traffic and increase in employment and related income). In addition, the demobilisation of the workforce will result in very low to medium impacts.

The occurrence of accidents and spills at any stage of the project could impact health and the economy of certain residents. Road Traffic Accidents (RTA), fires and explosions, accidental releases are other accidental issues posing health and safety hazards to the community during the project lifetime.

ES.5.8. Archaeological & Cultural Heritage

On the basis of our literature review and baseline assessment, there is a very low probability of finding exposed or buried cultural and archaeological resources within or in the vicinity of the project area.

The significance of impacts of the proposed RTIP site on the local archaeology and cultural heritage resources, if any, has been assessed as having low or medium significance and applicable mitigation measures are identified below to minimize impacts. Project activities and baseline conditions for archaeological and cultural resources have been considered for the assessment of potential impacts. The RTIP site, which will also encompass a tank farm and loading and unloading facilities at the KFIP, is largely disturbed and developed for industrial uses, and no archaeological or cultural resources were previously identified in the area.

Impacts to archaeological and cultural resources are very unlikely in the RTIP site area because no significant archaeological and/or cultural resources were identified as a result of a literature search, physical site survey, and a previous survey and fieldwork investigations made by the Deputy of Antiquities and Museums in JIC II and its vicinity.

The greatest impact on archaeological resources would occur during employment of expatriate workers during all project phases. Potential impacts to cultural heritage from the employment of expatriate workers and cross-cultural tensions with the local community, and disturbance to archaeological resources during expatriate worker´s tourist visits if archaeological sites are disturbed or if found artefacts are kept as souvenirs, have been assessed as being of medium significance.

These impacts would be reduced if appropriate mitigation measures are adopted. These mitigation measures include developing “archaeological chance find procedures” for any planned construction work that includes a trained observer to oversee the work, and providing briefing to supervisors before the start of construction activities. After the implementation of applicable mitigation measures, the residual impacts would be low / insignificant.

ES.6. Sustainable Development Assessment

A sustainable development assessment (SDA) for the RTIP complex has been performed through an analysis of how the sustainable development principles are integrated into both RTIP’s EIA and the project itself.

The assessment of the three elements (environment, social, and economic aspects) reflects not only the way in which sustainable development principles are integrated within this EIA but also that project activities can be performed in a bearable, equitable and viable manner.

In addition to the KSA’s national standards and guidelines, the RTIP design and management policy will incorporate the principles of sustainable development as laid down in Our Common Future (WCED, 1987).

The results of the EIA study have been the basis for the sustainability assessment of the project, though it has been complemented by an analysis of the deviation of this study with regards to sustainable development principles (intragenerational and intergenerational equity).

Based on the sustainability assessment of the EIA, one area where additional focus could be considered is with regards to sustainable development (largely due to cultural norms in the Kingdom) is related to Stakeholder Engagement (public information and participation). Although this has already been addressed through the representation of the Royal Commission, it may be favourable for the JV as a long term goal to undertake more direct communication with the Project stakeholders, as this could be particularly beneficial with regards to public perception towards the Project. Further areas identified include the limitations of the social impact assessment, and resulting limitations in the integrated assessment of environmental, social and economic factors and associated mitigation measures largely owing to the indirect nature of engagement with the local population. There were also some inherent limitations in the analysis of global impacts, GHG emissions and therefore climate change are discussed in Section 12, but no comprehensive analysis of global impacts or implications was carried out as this was beyond the scope of the EIA.

To assess the sustainability of RTIP, the confluence of the three elements of sustainable development throughout the project's lifecycle (design, construction and operation) were analyzed.

The sustainability concept has been addressed in RTIP from the early stage "the design phase", which has reduced the adverse impact of the project on the environment and community. Some examples of this are:

- Project location (industrial area remote from residential areas);
- Site location (proximity of existing infrastructure and common utilities);
- Feasibility studies involving environmental criteria (EIA, BAT analysis, air dispersion modelling, noise study, process hazards analysis); and
- Concept design (processing hydrocarbon products in the same country where it is extracted implies incomes from both upstream and downstream activities).

The project will create indirect and direct employment, benefits for the local economy through network suppliers, and the economic contribution that the Operator makes to the region. Despite the economic and social benefits that the project will bring to the country, there are negative impacts that were evaluated to understand the implications of achieving these benefits, especially concerning the environment, the community, and on potential global impacts for both present and future generations.

The results of the sustainability assessment of the RTIP project reveal insights into the overall impacts the project will have on local, national and international populations, and the duration of those impacts. One revealing finding is the lack of any impacts for which the effects are expected to exceed a decadal timeframe. It is however important to note in this case that climate change - a process with a duration which is thought to greatly exceed decades - no comprehensive analysis was undertaken of the potential impacts that could arise from the project's GHG emissions as this is generally outside the scope of an EIA. This is the same case as with impacts of an international extent, with the main impact identified being the use of foreign workers during the construction phase. Further to this, it was found that impacts on the physical environment (including air quality and the acoustic environment) were generally found to cover smaller extensions (local – provincial) and have durations ranging from years to decades. Impacts on the marine environment were found to range between a local and regional extent and to have a duration of from months to years. Finally, the impacts which were found to be most relevant to sustainability considerations were the impacts on society, as they covered the largest geographical area as well as lasting for decades.

The key areas where additional project focus is required identified by this assessment, in terms of sustainability, and the high priority ones for which measures are suggested which are:

- Community (direct public participation as a long term objective);
- Water consumption; and
- GHG and energy efficiency.

Recommended sustainability practices have been suggested for RTIP with the aim of making the most advantage of natural resources while minimizing potential impacts. These measures are provided as complementary measures for those suggested in Section 21 to enhance the sustainable performance of RTIP.

ES.7. Project Justification and Analysis of Alternatives

This section provides an overview of the analysis of the justification for the project and the feasible alternatives for the proposed preferred design.

The overall objective of RTIP is to meet the growing global demand for refined petrochemical products used for automotive, appliance and consumer products, and promote a shift from export-oriented petrochemical production to manufacturing of value-added specialty chemicals.

The alternatives considered include:

- *Alternate Project "Do nothing" option (no project)*: The option of not proceeding with the RTIP would merely mean that a similar project or projects would be constructed elsewhere to meet the market demands. This alternative is likely to have a negative impact on the Saudi economy, given that a significant percentage of the Kingdom's national economy is based on the development and export of oil and natural gas resources.; and future investments are focused on the expansion of the petrochemicals industry, and increase the predicted shortfall between global supply and demand;

- *Selection of Project Location:* Key factors that were taken into consideration during the site selection process were: availability and allocation of large quantities of feedstock, primarily ethane and naphtha; availability of existing infrastructure / common utilities; availability of existing port and harbour facilities; KSA policy and environmental protection; proximity to Dhahran-Jubail Highway and Abu Hadriyah Highway; proximity to JIC, which has existing infrastructure and services available for employees and their families; and site accessibility, availability of local construction workforce, and previous experience in the successful completion of other major industrial developments in JIC;

  RTIP will be located in Jubail II, which is an extension of JIC and one of the two industrial cities designated by the government for industrial development. The project location was selected over a Greenfield location because of its proximity to feedstock resources and infrastructure facilities of JIC and JIC II. The site location assigned for RTIP in JIC II will be used for similar projects if the RTIP is not materialized. Development at alternative locations, such as Greenfield sites outside the industrial city, would require substantial development of infrastructure to provide captive utility and logistics support to RTIP.

- *Process Selection:* The details of the process unit technologies and alternatives to these technologies are not discussed in detail due to confidential licensing agreements. Process control technologies were selected to use BAT to address potential impacts, and meet local and national regulatory requirements and international standards.

- *Wastewater pre-treatment and Waste Management alternatives*: An extensive analysis of various wastewater treatment and solid waste treatment alternatives was undertaken for this project. The alternatives analyses for wastewater included at-source reductions (within the proposed production units), design and construction of a centralized pre-treatment facility, and utilization of the existing Jubail Industrial City wastewater treatment infrastructure (Marafiq IWTP and SWTP). Similar to wastewater, the alternatives analyses for solid waste included at-source reductions (within the proposed production units), design and construction of dedicated centralized treatment facilities (internal kilns, etc.), and utilization of the existing Jubail Industrial City solid and hazardous waste treatment and disposal infrastructure (Bee'Ah and EDCO).

  After evaluation of the alternatives from an economic and sustainability perspective, it was decided that a combination of various at-source reduction and treatment assets, combined with the existing infrastructure was the appropriate alternative for this project. The use of existing infrastructure lowers the overall environmental footprint for the project, Industrial City and region.

ES.8. Cumulative Impacts Assessment

The cumulative impacts assessment has assessed the cumulative impacts that are likely to result from the Project on all affected environmental and socioeconomic conditions at the RTIP site including other existing, approved and/or planned projects in the region that could reasonably be expected to have a combined effect.

The assessment was focused on key primary issues such as air quality, terrestrial and marine biological resources, noise, wastes, socio-economic aspects and community health.

Planned future projects for the region are generally related to oil products processing facilities (including petrochemicals facilities), steel and metal industries, chemical processing facilities, and chlorine products. Cumulative impacts may occur when a project's schedule overlaps with RTIP's schedule.

As the construction schedule for several large projects in the Jubail Industrial City is unknown, there is a possibility of overlap with RTIP occurring. However, availability of financing, manpower and logistical constraints is likely to prevent simultaneous construction of multiple industries. The peak construction period for RTIP alone is expected to bring approximately 55,000 project employees to the Industrial City (predominantly within a construction camp or camps).

Cumulative impacts on air quality and noise may result from the vehicle construction traffic if several projects were under construction in parallel. These impacts are expected to be of low significance since they are localised and temporary in nature. It is anticipated that habitat loss as a result of the Project even in combination with other planned projects is going to be of relatively low significance due to the limited ecological biodiversity of the area. Regarding the marine environment, the increase in the number of tankers and other vessels that will service RTIP through the KFIP, as well as other future planned projects in Jubail Industrial City, will increase the potential for a major spill directly into the Arabian Gulf, as well as increase the risk of untreated or incompletely treated wastewater being discharged into the Gulf. The incremental waste that will be generated by the proposed project combined with other projects in Jubail Industrial City is considered negligible compared to the capacity and life expectancy of the various solid waste management facilities found in the area. The cumulative demand for wastewater management will have to be monitored carefully as Marafiq is the only provider of these services in the immediate surroundings. This is not however considered to prove problematic, as there are presently various expansion plans for the facility's two treatment plants being considered or in preparation. A significant cumulative impact is related to the demands on the current community health care infrastructure by the employees of RTIP and of the other future projects. Positive cumulative impacts identified are related to the overall increase in wealth and access to livelihood opportunities for the local community and the local employment and up-skilling/training by skilled non-Saudi workers.

During the operation phase of the proposed project, cumulative impacts on air quality are generally considered of low significance as all projects will be subject to RCJY permitting and emission requirements and RTIP is targeting to consume less than 25% of the increment available between the baseline and the applicable ambient air quality standards for criteria pollutants. However, as current baseline ambient air values for ozone exceed the RCJY ambient air quality standards, it would be prudent for the RCJY to consider undertaking a photochemical modelling study of the airshed to determine whether ozone formation may be an issue in relation to cumulative impacts.

Regarding cumulative noise impacts it is not expected that combined noise levels would pose a significant noise increase in the closest sensitive receptors and mixed used area. However, with regards to traffic the cumulative impact is expected to be similar to that described for construction, though during operation, part of the traffic for personnel transport will come/go from the JIC community area.

While this assessment has largely been qualitative in nature, identified cumulative impacts are considered to be either not significant, sufficiently mitigated by measures described in the EIA, or of a beneficial cumulative nature.

ES.9. Summary of Impacts

The assessment of all identified potential impacts was undertaken as discussed in the sections above for air quality and meteorology; onshore physical biological resources (terrestrial and marine); noise; waste management; socio-economic aspects, archaeological and cultural aspects. The impacts are summarised in a table [see Table 20-1 in Section 20 Summary of impacts] and include all the assessment results according to the criteria selected.

The table presents the impacts across each phase of the project, considering the frequency, likelihood, extent, duration and magnitude factors of the impact. The type (positive or negative) and potential significance of each impact are also included. Finally, the requirement for mitigation measure(s) is indicated, where appropriate or feasible, based on the impact assessment criteria defined for each environment.

ES.10.Summary of Mitigation

Where considered appropriate, mitigation measures have been identified that could minimise potential environmental impacts resulting from the construction, commissioning, operation and decommissioning of RTIP. The potential mitigation measures are summarised according to the impact in Table 21-1 in Section 21 Summary of Mitigation Measures. The significance of the impact is also indicated prior to and following implementation of the mitigation measure(s). Where possible the identified mitigation measures are presented as Good International Industry Practices (GIIP), according to World Bank Group Guidelines, 2007 and BAT to ensure that their adoption is technically and economically feasible.

ES.11.Monitoring Plan

A monitoring plan has been developed to monitor the implementation of the proposed mitigation measures during the life of the project. The monitoring plan will also enable the identification of actual environmental impacts. Point source or end-of-pipe emission monitoring should be undertaken by RTIP to ensure compliance with the relevant environmental standards (e.g., wastewater discharges, stack emissions, groundwater monitoring, etc.).

ES.12.Other Considerations

As part of this EIA, an EMP and a stakeholder engagement plan, are outlined and appended to this study.

ES.12.1. Stakeholder Engagement Plan

Identifying and classifying key stakeholders potentially affected by RTIP activities is an essential and initial element of consultation. To the extent possible, the RTIP project team will meet with key stakeholders at various stages of the project and solicit feedback on the key findings of this EIA study. The main stakeholder for this project is the RCJY. RCJY has been established by the government to manage industrial parks in Jubail, Yanbu and Ras Azzor to ensure that the sustainable development of these parks is maintained. RCJY is designated as the agency which represents both government and the residents of these parks. RCJY is engaged with both government and communities on the development of these parks.

Given the necessity to address and effectively plan for stakeholder consultation per World Bank/IFC standards and similarly accepted international standards (including the Equator Principles), RTIP has developed a stakeholder engagement plan that describes primary potential project stakeholders and methods to involve them. This plan, attached as Appendix F, considers the cultural context and the nature of JIC as an industrial park.

The stakeholder engagement plan has been prepared considering current practices in the country with regards to the consultation process. This means that the plan is focused only on the primary stakeholders of RTIP, which include local governmental agencies. The main objective of this plan is to inform stakeholders of activities involved in RTIP, and any potential affects from their activities.

ES.12.2. Environmental Management Plan (EMP)

The EMP addresses the environmental management of RTIP from an early stage. It will provide a detailed framework of specific management responses and references procedures required to manage the environmental impacts and issues identified during this EIA, to ensure compliance with recognised environmental management guidelines and other site management plans. An EMP to be used as a preliminary document to be updated as the project evolves has been prepared and attached as Appendix A.

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1 INTRODUCTION

1.1 Project Understanding & Overview

The RTIP Project is the development and installation of a petrochemical complex on a greenfield site, occupying an area of approximately 576 hectares (ha) within Jubail II of Jubail Industrial City, Kingdom of Saudi Arabia (KSA). RTIP will be built, owned and operated by a joint venture between Saudi Aramco and The Dow Chemical Company.

The overall complex will process ethane and naphtha as primary feedstocks to produce chemical and polymer products including polyethylenes, propylene glycols, amines, polyols, and urethane chemicals. Products from RTIP will be sold to companies in the Middle East and Asia where they are converted to consumer products such as plastic containers and toys, insulation, antifreeze, adhesives and sealants, and paints. In total, the Project comprises approximately thirty different process units more than half of which are based on technologies licensed from The Dow Chemical Co. and the remainder from various third-party providers.

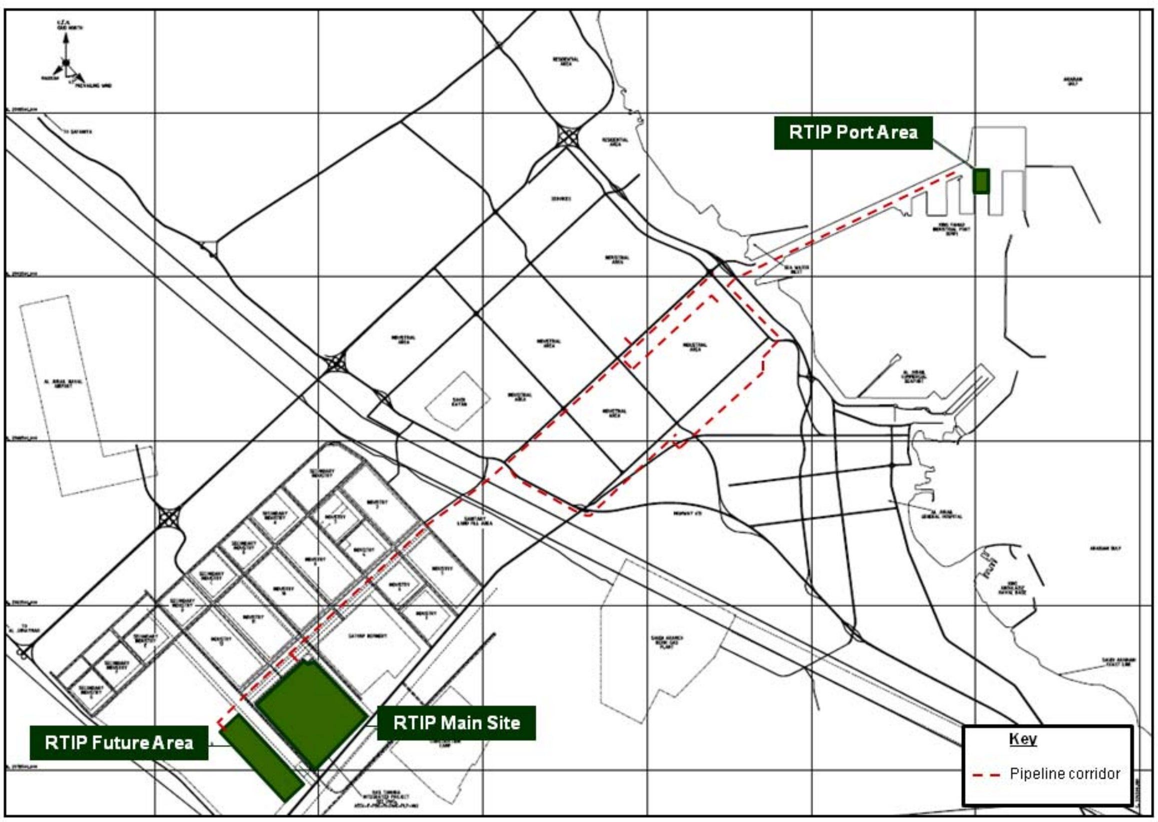
The RTIP project is located in the Eastern Province of KSA (see Figure 1-1), and is within the regulatory jurisdiction of the Royal Commission for Jubail and Yanbu (RCJY).

Figure 1-1 Map Showing Site Location within the Eastern Province, KSA
Source: CH2MHILL, 2011

RTIP consists of process units, utilities, infrastructure and site logistics, value parks (outside of the scope of this impact assessment), associated feedstock transfer and storage, as well as the offsite services necessary to support the safe and efficient operation of the petrochemical complex.

The Project comprises the construction and/or operations of the following installations (see Figure 1-2):

- Petrochemical complex in Jubail II Industrial City;
- Value Parks at the RTIP Future Area (out of the scope of the impact assessment);
- Third Party Packaging Centre, Third Party Hydrogen Peroxide and the Third Party Industrial Gases (IG) (Hydrogen and Carbon Monoxide (HYCO) Unit, and Ammonia Unit);
- Tank farm and loading and unloading facilities at the Jubail King Fahd Industrial Port (KFIP); and
- Pipelines between RTIP site and RTIP Port Facilities, and between RTIP site and other third parties facilities within JIC to transport feedstock, products and utilities.



Note: This is an schematic drawing based on KBR data provided (CH2MHILL, 2011)

Figure 1-2 Location of RTIP facilities at Jubail Industrial City
Source: Figure provided by KBR and modified by CH2M HILL, 2011.

The Project will use existing and/or planned facilities in Jubail for the following:

- import/export operation through Port Tank Farm and Jetty topsides;
- utilities including power, industrial water, potable water, sales gas/fuel gas, and fuel oil;
- feedstock, and industrial gases ;
- industrial and sanitary wastewater treatment, and storm water drainage system;
- discharge of effluents (following treatment as necessary) and other non-contaminated water via the Marafiq sea water return header; and
- hazardous and non-hazardous waste treatment and disposal.

An EIA is required for RTIP in order to demonstrate compliance with environmental control procedures in accordance with the Environmental Protection Standards set by the PME in 2001 (PME, 2001), insofar as the latter applies to the facility. The principal objective of the EIA is to identify and assess the environmental and social impacts that could occur as a result of the construction, commissioning, operation and abandonment/decommissioning of the RTIP complex. Impacts are considered for the relevant aspects of the natural (physical and biological) and social environments and also for the inter-relationships between them.

The National Procedure for EIA in KSA identifies the PME as the ultimate responsible authority for approval of the EIA procedures. It is however recognised that the RCJY has been delegated responsibility for environmental matters within the boundaries of the industrial cities of Jubail and Yanbu and as such is responsible for the approval of an EIA study when it is requested.

The EIA for RTIP required the following activities:

- Identify major issues and in particular those which may have an impact on design at an early stage;
- Ascertain what data is available and what additional surveys would be required;
- Establish the pre-construction environmental baseline for the RTIP site;
- Assess potential impacts of RTIP during construction, commissioning, operation and decommissioning;
- Identify mitigation measures to reduce any impacts and determine residual impacts;
- Develop a plan to monitor the implementation of the proposed mitigation measures; and
- Prepare well documented and defensible final reports and present the key findings to the regulatory agencies and the lending institutions.

In order to determine the potential impacts, a basic understanding of the proposed RTIP facility has been gained by reviewing a number of documents and information provided by KBR, including:

- KBR, 2010, “Project Description for Jubail Site”;
- KBR, Dec 2010 “Environmental Basis of Design”;

- KBR, 2011, "Geotechnical Investigation Services for RTIP Jubail II Main Site".

Other documentation and information was obtained specific to each key topic within this report. These are presented in Section 25 References.

Table 1-1 RTIP's Commitment to the Equator Principles

EQUATOR PRINCIPLES		RESPONSIBLE
Principle 1	*Review and Categorisation:* Categorisation of the project based on the magnitude of its potential impacts and risks in accordance with the environmental and social screening criteria of the International Finance Corporation (IFC)	Equator Principle Financial Institution (EPFI)
Principle 2	*Social and Environmental Assessment.* Identification of relevant social and environmental impacts and risks of the proposed project. The assessment should also propose mitigation and management measures relevant and appropriate to the nature and scale of the proposed project.	Dow and Saudi Aramco through the performance of an EIA. Principle covered under sections 12, 13, 14, 15, 16, 17, 18, 19, 20, 21 and 22 of this EIA report
Principle 3	*Applicable Environmental and Social Standards:* The assessment should consider the respective IFC Performance Standards and EHS Guidelines.	Dow and Saudi Aramco through the EIA. Principle addressed in this EIA report through the review of the regulatory framework applicable to this project and through the consideration of local, national and international standards and limits during the impact assessment process. Regulatory review was performed under section 2 and specific applicable international standards such as the EHS guidelines have been considered for each impact assessment section (see sections 12, 13, 14, 15, 16, 17, 18 and 19).
Principle 4	*Action Plan (AP) & Management System:* The AP should address relevant findings. The AP will describe and prioritise the actions needed to implement mitigation measures, corrective actions and monitoring measures necessary to manage the impacts and risks identified in the Assessment. Establish a Social and Environmental Management System.	Dow and Saudi Aramco. Appendix A of this EIA report outlines the Environmental Management Plan that will be further developed over the life of the project.
Principle 5	*Consultation and Disclosure:* Borrower has consulted with project affected communities in a structured and culturally appropriate manner.	Dow and Saudi Aramco through the implementation of a Stakeholder Engagement Plan. Appendix F of this EIA report outlines the Stakeholder Engagement Plan which involves disclosure and consultation of primary stakeholders of RTIP. The Plan has been prepared considering current cultural practices in KSA with regards to the consultation process. Public participation is not feasible at this stage, so compliance with international standards on this is set as a long term objective for the project. The plan is focused only on the primary stakeholders of RTIP, which include local governmental agencies. RCJY considers that it represents both government and residents of these parks.
Principle 6	*Grievance Mechanism:* The borrower will establish a grievance mechanism as part of the management system.	The General Environmental Regulations that govern the EIA process in the KSA do not require public consultation or stakeholder engagement for projects to be conducted in the country. Further, cultural norms in the Kingdom preclude the application of the normal model of stakeholder engagement with respect to public disclosure. Therefore, it is anticipated that international standards on public

Table 1-1 RTIP's Commitment to the Equator Principles

EQUATOR PRINCIPLES		RESPONSIBLE
		participation are not feasible at this stage and that compliance will be set as a long term objective for the project. Dow and Saudi Aramco will be responsible of this long term objective.
Principle 7	*Independent review:* An independent social or environmental expert not directly associated with the borrower will review the Assessment, AP and consultation process documentation in order to assist EPFI's due diligence, and assess Equator Principles compliance.	An external expert to assist the EPFI
Principle 8	*Covenants linked to compliance:* The borrower will covenant in financing documentation: to comply with host country regulations, the AP, periodic reports to the EPFI, to decommission facilities.	Dow and Saudi Aramco
Principle 9	*Monitoring:* EPFIs will require appointment of an independent environmental and/or social expert, or require that the borrower retain qualified and experienced external experts to verify its monitoring information which would be shared with EPFIs.	External expert
Principle 10	*EPFI Reporting:* Each EPFI adopting the Equator Principles commits to report publicly at least annually about its Equator Principles implementation processes and experience, taking into account appropriate confidentiality considerations.	EPFI
Source: The Equator Principles, July 2006. www.equator-principles.com/documents/Equator_Principles.pdf -		

Table 1-2 RTIP's Commitment with the IFC Performance Standards

IFC Performance Standard		Comment
Performance Standard 1	*Assessment and Management of Social and Environmental Risks and Impacts.* Requirements: (i) Policy; (ii) Identification of Risks and Impacts; (iii) Management Programs; (iv) Action Plans; (v) Organizational Capacity and Competency; (vi) Emergency Preparedness and Response; (vii) Monitoring and Review; (viii) External Communications; (ix) Stakeholder Analysis and Engagement Planning; (x) Dissemination of Information; (xi) Levels of Consultation; (xii) Consultation; (xiii) Informed Consultation Process; (xiv) Free, Prior and Informed Consent of indigenous peoples; (xv) Grievance Mechanism for Affected Communities; (xvi) Ongoing Reporting to Affected Communities; (xvii) Private Sector Responsibilities Under Government-Led Stakeholder Engagement.	Sections 12 to 18 include the identification and assessment of potential impacts on air quality, physical environment, biological resources (including marine environment), noise, waste management, social aspects (including health and safety aspects) and archaeology and cultural heritage. Section 19 includes the identification and assessment of potential cumulative impacts. The assessment process is based on current information, including an accurate project description (section 3), and appropriate social and environmental baseline data reported (sections 4 to 10). Mitigation measures and monitoring measures are also included in this EIA report and are summarized in sections 20 and 21. Appendix A outlines the Environmental Management Plan (including aspects such as organizational capacity, action plan, and staff training, among others) that be further developed over the life of the project. Appendix F outlines a Stakeholder Engagement Plan that involves disclosure and consultation of primary stakeholders of RTIP. Public participation is not feasible at this stage, due to cultural norms in KSA, and compliance with international standards on this is set as a long term objective for the project.
Performance Standard 2	Labor and Working Conditions	The social assessment process performed under Section 17 considered employment creation and income generation aspects and identifies and assesses potential impacts that the proposed project could pose on workers and community's health and measures to manage and monitor them are outlined in sections 21 and 22; and integrated in the Environmental Management Plan presented in Appendix A. The implementation of the actions necessary to meet the requirements of this Performance Standard is managed through the client's Social and Environmental Management System.
Performance Standard 3	Resource Efficiency and Pollution Prevention	A discussion on the energy efficiency of the RTIP facility is included in section 3. The project will utilize BAT for environmental control. A BAT Analysis will be included as part of the Permit Application Package according to RCER and a summary is provided in section 3.
Performance Standard 4	Community Health, Safety and Security	Section 17 identifies and assesses potential impacts that the proposed project could pose on workers and community's health and measures to manage and monitor them are outlined in sections 21 and 22; and they have been integrated in the Environmental Management Plan presented in Appendix A. Pursuant to RCER, an Environmental Emergency Response Plan will be later developed and implemented.

Table 1-2 RTIP's Commitment with the IFC Performance Standards

IFC Performance Standard		Comment
Performance Standard 5	Land Acquisition and Involuntary Resettlement	Not applicable to RTIP.
Performance Standard 6	Biodiversity Conservation and Sustainable Management of Living Natural Resources	Section 6 Ecology includes baseline conditions of the project area in regards to biological resources and Section 14 the identification and assessment of potential impacts that the proposed project could pose on existing habitats and ecosystems followed by recommendations to protect habitats and ecosystems.
Performance Standard 7	Indigenous Peoples	Not applicable to RTIP.
Performance Standard 8	Cultural Heritage	Section 10 includes baseline conditions of the project area in regards to archaeology and cultural heritage and Section 18 the identification and assessment of potential impacts that the proposed project could pose on existing archaeological and cultural heritage resources. Measures to avoid or minimize these potential impacts have been outlined through section 10 and summarized in section 21 with their corresponding monitoring measures in section 22.
Source: International Finance Corporation, IFC's Performance Standards on Social and Environmental Sustainability, Draft Version 2 (Review Phase III Versions), December 2010 (IFC, 2010).		

1.2 Report Structure

The structure of the EIA is as follows:

ES — **Executive Summary.** Provides an overview of the RTIP project phases, potential environmental and social impacts and proposed mitigation and monitoring strategies

Section 2 — **Policy, Legal and Administrative Framework. S**ummarises the key elements of national, local, and international law that apply to the proposed RTIP development. A summary of the relevant aspects of the legislation and regulations is provided and how these apply to the project.

Section 3 — **Project Description**. Provides an outline of the proposed works at the RTIP site including a process description, preliminary plans and the different phases of the project (construction, commissioning, operation and decommissioning) with their proposed schedules.

Baseline Sections

Section 4 — **Air Quality & Meteorology Baseline**. Presents a summary of the local climate and meteorology and an assessment of the existing ambient air quality conditions in the vicinity of RTIP. The established meteorological and air quality baseline conditions will be used to predict the impacts from air emissions (point and fugitive sources) during the various stages of development of the project and under upset and emergency conditions.

Section 5 — **Onshore Physical Environment Baseline**. Presents the findings of the baseline surveys, such as Phase I and II activities and geotechnical studies undertaken at the RTIP site to assist in the evaluation of potential impacts on the physical environment during construction, commissioning, operation, and decommissioning of the facility. The investigation addressed regional and local geological and hydrogeological conditions and characterised the soil and groundwater quality.

Section 6 — **Ecology Baseline**. Provides a baseline account of the terrestrial and marine ecology of the study area, including habitats and protected areas.

Section 7 — **Noise Baseline**. Presents the identification of existing noise sources and sensitive receptors that could be affected by the noise generated by the project; conclusions of the noise baseline survey and its evaluation in light of applicable criteria.

Section 8 — **Waste Management Baseline**. Presents the findings of the baseline investigation detailing the existing waste facilities and management practices in the Eastern Province to determine the waste disposal options for RTIP, covering both local and regional solid and liquid hazardous and non-hazardous waste treatment and/or disposal facilities.

Section 9 **Social Baseline**. This section includes a general description of the social, cultural and economic characteristics on a national and regional level including demography, economic activity, infrastructure, land use, available resources (markets, etc.), health, education and religion.

Section 10 **Archaeology and Cultural Heritage Baseline.** This section includes a general description of the archaeological and cultural characteristics on a national, regional and local level. It identifies the existing or potential archaeological resources and cultural heritage at the RTIP site that may be impacted by the project.

Impact Assessment Sections

Section 11 **Impact Assessment Criteria**. Provides the criteria for assessing the potential impacts resulting from the RTIP. Common criteria definitions are provided as well as impact assessment criteria for each study area, i.e., air quality and meteorology, onshore physical, biological resources and marine environment, noise, waste management, social and health aspects, and archaeological and cultural heritage.

Section 12 **Air Quality & Meteorology Impact Assessment**. Describes the methodology, impacts and associated mitigation measures proposed in relation to potential offsite impacts on ambient air quality during construction, commissioning, operation, upset and emergency conditions and decommissioning of RTIP.

Section 13 **Onshore Physical Environment Impact Assessment**. Presents an evaluation of the potential environmental impacts on the onshore physical environment resulting from construction, commissioning, operation and decommissioning activities that are part of the RTIP project. Includes a groundwater transport simulation in the event of a spill reaches the groundwater body.

Section 14 **Ecology Impact Assessment**. Presents the results and conclusions of the assessment of the terrestrial ecology of the site and the marine ecology nearshore in relation to the potential construction and operational impacts associated with the development of RTIP. The impact assessment for biological resources follows best practice guidelines published in the UK and broadly applicable to other countries.

Section 15 **Noise Impact Assessment**. Presents the assessment of the environmental impacts on receptors resulting from noise generated during the lifetime of RTIP in light of applicable criteria, existing noise levels in the area and modelling based predictions (provided by KBR).

Section 16 **Waste Management Impact Assessment**. Presents an evaluation of the potential environmental impacts resulting from wastes generation, storage and management activities during the lifetime of RTIP.

Section 17 **Social Impact Assessment**. Provides an assessment of potential impacts during construction, commissioning, operation and decommissioning phases that may result from the implementation of the RTIP project on existing social and health conditions.

Section 18 **Archaeology Impact Assessment.** Reviews the key archaeological and cultural heritage aspects associated with the RTIP Site and surrounding areas potentially impacted during the construction, commissioning, operational and decommissioning phases providing an assessment of the impacts identified.

Section 19 **Cumulative Impacts Assessment.** This section includes an assessment of the cumulative effects that are likely to result from RTIP on all affected environmental and socioeconomic conditions in the Study Area including other existing, approved and/or planned projects in the region that could reasonably be expected to have a combined effect.

Section 20 **Summary of Impacts**. Summarises in tabular form the impacts identified for each environment. The impacts are detailed for the construction, commissioning, operation and decommissioning phases of the project using the criteria set out in Section 11 and providing a magnitude and significance for each impact.

Section 21 **Summary of Mitigation Measures.** Summarises in tabular form the potential mitigation measures / options that have been identified in light of their applicability and cost effectiveness including any interactive impacts between issues.

Section 22 **Monitoring Plan**. Summarises in tabular form the development of a plan to monitor the implementation of the proposed mitigation measures / options during the life of the project.

Section 23 **Analysis of Alternatives.** This section compares feasible alternatives to the proposed preferred design of RTIP, including the no-build option.

Section 24 **Sustainable Development Assessment.** This section includes an analysis of how the sustainable development elements are integrated into both the RTIP EIA and the project itself. Project life cycle phases have been considered in each analysis where applicable.

Section 25 **References.** Provides a complete list of all the citations used in all the sections.

Section 26 **Glossary, Abbreviations & Acronyms.** This section comprises a glossary and a list of abbreviations and acronyms contained within the EIA Report.

Appendix A **Environmental Management Plan.** Translates the findings and recommendations of the EIA process into a succinct, clearly defined set of procedures and plans for implementation on the ground level. The EMP identifies those parties responsible for implementing the mitigation measures identified and integrates with existing documents including corporate and site specific management policies. The EMP includes an outline of environmental action plans, and Staffing and Training Recommendations.

Appendix B **Data for Vegetation Quadrats.** Presents the detailed results of the quadrat study conducted as part of the terrestrial ecology baseline survey.

Appendix C **Noise Monitoring Survey.** Summarises the results of the short and long term monitoring and includes the calibration certificates for each of the noise meters.

Appendix D **Onshore Physical.** Contains the following supporting documents to the onshore physical baseline section; pump test results and groundwater chemistry results.

Appendix E **Air Dispersion Modelling.** Describes the methodology and results of the air dispersion modelling undertaken for the project. Point and fugitive emission sources at RTIP have been modelled for five criteria pollutants and several organics and hazardous air pollutants to assess their health effects. Accidents and spills, including emergency flaring are also addressed.

Appendix F **Stakeholder Engagement Plan.** This document has the objective of identifying and classifying stakeholders potentially affected by RTIP activities. Once identified, methods for effective two-way stakeholder consultation are outlined to be developed and implemented before, during, and after the project, ensuring that mechanisms for feedback and response are incorporated into the communication cycle list.

2 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

2.1 Overview

The highest institutional authority for the environment within KSA is the Environmental Council. The Environmental Council is headed by the Presidency of Meteorology and Environment (PME) and composed of a number of ministries including the Ministry of Petroleum and Mineral Resources and governmental agencies. The Environmental Council responsibilities include:

- Suggests environmental strategies and policies for the KSA.
- Recommends environmental standards and directives.
- Coordinates environmental related issue with governmental agencies and private entities.
- Follows up the implementation of environmental policies with executing governmental agencies.

The RTIP Project is located in Jubail, in the municipality of the Eastern Province of the KSA, and lies within the jurisdiction of the RCJY. Although the PME has the overall authority in the KSA for environmental matters, the RCJY has been delegated responsibility for environmental matters within the boundaries of the industrial cities of Jubail and Yanbu by means of a Memorandum of Understanding issued by PME. The RCJY is responsible for environmental management and controlling pollution associated with the development and operation of both industrial cities.

The key environmental regulations and standards applicable to the RTIP at Jubail are:

- "Royal Commission Environmental Regulations (RCER) Volume I, 2010 – Regulations and Standards" that includes all regulations, standards, and guidelines which industries operating in any of the industrial cities shall comply with. The RCER-2010 Volume I supersedes the last version RCER 2004. The RCER 2010 has been adopted by RTIP at Jubail to comply with regulatory requirements;
- "Royal Commission Environmental Regulations (RCER) Volume II, 2010 – Environmental Permit Program" that covers procedures and forms for applying to obtain "Environmental Permit to Construct" (EPC) and "Environmental Permit to Operate" (EPO) permits. The RCER 2010 Volume II supersedes the RCER 2004 Volume II.

Besides this, the "General Environmental Regulations and Rules for Implementation" that include the Environmental Protection Standards (Doc. No. 1409-01) set by the PME in 2001 (PME, 2001) have been considered as a reference for this project.

As an additional control of pollution in KSA, the General Environmental Regulation (GER) places an obligation on lenders to consider compliance with applicable environmental

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standards as a condition precedent to the disbursement of funds under any loan (Al Tamimi & Company, 2009). It is likely that RTIP at Jubail funding will be provided by multiple financial institutions comprising a combination of Saudi Arabian and International banks. The Lenders are yet to be selected by the Project, but it is probable that major international financial institutions would be involved and that they would have adopted the Equator Principles, a financial industry framework for addressing environmental and social risks associated with a proposed project. Even in the absence of involvement of Equator Principles Financial Institutions (EPFIs), the Equator Principles provide an internationally accepted set of guidelines for major developments. Therefore, international guidelines and standards developed by EPFIs will be also considered by the project.

The KSA is subject to international protocols and agreements adopted by the Kingdom and to other national environmental guidelines and standards, such as those developed by the PME as well as local specific environmental protection criteria developed by the RCJY which apply to industries within the boundaries of the industrial cities of Yanbu and Jubail. Additionally, the operator of a facility shall utilize Best Available Techniques (BAT) for environmental control, and shall apply methods and procedures for compliance, monitoring and sampling in accordance with international accepted standards, such as the American Standard Test Methods, U.S. Environmental Protection Agency (EPA), or Standard Methods for the Analysis of Water or Wastewater (Latest Edition).

RTIP at Jubail will incorporate environmental design related elements in all facilities in accordance with applicable government (PME), international guidelines and standards developed/adopted by EPFIs, and partner companies' requirements and standards. In cases where duplicate or multiple requirements exist, the more stringent will be considered after appropriate risk-benefit analyses. It should be noted that the project will also incorporate the principles of sustainable development as laid down in the United Nations Brundtland Report.

The regulatory environmental framework and approval responsibilities relating to an EIA in KSA are explained in Section 2.2 National Policies.

The guidelines and standards relevant to the project are used as a basis for evaluating the project's impacts and are summarised in the subsequent sections (see Section 2.3 National Laws & Applicable International Standards, Section 2.4 International Conventions and Section 2.5 International Guidelines & Policies). As the guidelines and standards are presented as a summary, the most recent complete legislation should be consulted prior to implementation of any mitigation or monitoring actions.

2.2 Regulatory and Approval Responsibilities

2.2.1 Regulatory Responsibilities

The Environmental Council is the highest institutional authority for the environment within the KSA. The Environmental Council has the responsibility of establishing the Kingdom's position on environmental issues at national, regional and international levels, establishing a National Environmental Strategy, and coordinating and follow up of environmental activities within the Kingdom.

The PME is designated as the central government agency for the environment in the KSA, in addition to its functions in meteorology. The PME heads the Environmental Council. Other ministries work together with the PME, including the Ministries of: Agriculture and Water, Petroleum and Mineral Resources, Municipality and Rural Affairs, Industry and Electricity, Health, Foreign Affairs, Interior, and Finance and National Economy, as well as King Abdul Aziz City for Science and Technology (KACST), and the National Commission for Wildlife Conservation and Development (NCWCD).

In addition to this, the PME acts as the central environmental agency responsible for:

- Reviewing and evaluating the condition of the environment;
- Conducting environmental studies;
- Documenting and publishing environmental information;
- Preparing environment protection laws, standards and regulations (see section 2.3.1 National Standards-PME Environmental Protection Standards); and
- Promoting environmental awareness.

One of the most important duties of the PME is to ensure that entities such as ministries, departments or other government establishments observe the existing environmental regulations, standards and criteria. It shall also guarantee that they adopt the necessary procedures to co-ordinate and co-operate with each authority or licensing agency which is empowered to approve projects which may negatively impact on the environment (PME, 2001).

A key role of each authority or licensing agency is to ensure that any project which may negatively impact on the environment includes the preparation of an EIA at an early stage (project feasibility phase). The authority or licensing agency must then ensure that the project conducts and implements the EIA in accordance with the standards specified by the PME regulations (PME, 2001).

The RTIP Project is located in the industrial city of Jubail. Therefore, the Project EIA will be under the jurisdiction of the RCJY, the competent authority and regulatory body for environmental management and protection within Jubail Industrial City. It is thus responsible for controlling pollution associated with the development and operations of both industrial cities. The RCJY is the licensing authority for the RTIP project at Jubail.

2.2.2 EIA Requirements

An EIA is required for RTIP at Jubail in order to demonstrate compliance with environmental control procedures as outlined by RCER 2010 and in accordance with the Environmental Protection Standards set by the PME in 2001 (PME, 2001), insofar as the latter applies to the facility.

The National Procedure for EIA in the KSA identifies the PME as the ultimate authority responsible for the approval of the EIA procedures. The RCER 2004, available during the development of the EIA did not include the minimum content of an EIA. Therefore the PME, 2001 has been used for guidance on this issue. Appendix 2.4 of the PME 2001 lists the minimum content of an EIA.

As it is likely that funding for the RTIP will be provided by multiple financial institutions, the EIA will also follow additional requirements stated by EPFIs and the Organization for Economic Co-operation and Development (OECD) further described in Section 2.5 International Guidelines and Policies.

2.3 Relevant National, Local and International Standards

The main purpose of this section is to summarise the RCJY standards associated with the environmental and social resources potentially affected by the Project. This section also summarises other relevant international standards that have been considered in the assessment of environmental and social impacts associated with RTIP at Jubail activities.

The project will comply with the RCER 2010 regulations, as well as applicable PME and EH&S project requirements. The RTIP EH&S project requirements are based on the RCER-2010 regulations, as well as other international guidelines such as the International Finance Corporation (IFC)/World Bank. In addition, for parameters where there is no clear guidance from either the RCER 2010 regulations, or from the PME, regulations from other jurisdictions were consulted for possible incorporation into the EH&S project requirements. These other jurisdictions include the US EPA and the Texas Commission on Environmental Quality (TCEQ).

The RTIP will incorporate environmental design related elements in all facilities in accordance with the RCER 2010 international guidelines and standards developed/adopted by EPFIs, and partner companies' requirements and standards. In cases where duplicate or multiple requirements exist, the more stringent will be considered after appropriate risk-benefit analyses on a case-by-case basis.

2.3.1 National Standards-PME Environmental Protection Standards

The latest edition of the Environmental Protection Standards was issued in October 2001 as part of the "General Environmental Regulations and Rules for Implementation" document (PME, 2001). Its main purpose is to provide the appropriate basis for the evaluation and regulation of existing industrial and urban activities in the KSA and to help in the planning, design, implementation, and operation of facilities to be established in future.

The standards provide guidance for ambient air quality, air pollution sources, receiving water guidelines, direct water discharge and pre-treatment guidelines for discharge to central treatment facilities that shall be fulfilled during the location, design and operation of any new or major modification of a facility.

The "General Environmental Regulations and Rules for Implementation" as its name suggests is organized in two main parts: The General Environmental Regulations and Rules for Implementation. The General Environmental Regulations provides a general overview of the environmental framework in KSA. The Rules for Implementation defines how to execute the directives set out in the General Environmental Regulations, presented in the following six Appendices:

- Appendix 1 – Environmental Protection Standards (Document Nº 1409-01). This appendix summarizes the environmental limits applicable to RTIP in relation to Air Quality, Air Pollution Source Standards, Receiving Water Guidelines, Performance Standards for Direct Discharge and Pre-treatment Guidelines for Discharge to Central Treatment Facilities.

- Appendix 2 – Fundamentals and Standards for Environmental Impact Assessment of Industrial and Development Projects. This appendix provides a classification of the projects as well as the EIA requirements and EIA approval process (see Section 2.2.2)

- Appendix 3 – Guide To Environmental Accreditation Procedures. This appendix details the process for environmental accreditation in the KSA. It includes the types of accreditation certificates, and the accreditation requirements.

- Appendix 4 – Hazardous Waste Control Rules and Procedures (Document Nº 01-1423). This appendix establishes appropriate procedures for the control of processes in the production, transportation, storage, treatment and final disposal of hazardous waste in KSA.

- Appendix 5 – The National Contingency Plan for Combating Marine Pollution by Oil and Other Harmful Substances in Emergency Cases. This appendix includes a plan for the development of an immediate response and coordination system to protect the Saudi coast and marine environment. Both an area pollution control plan for the Kingdom's exclusive economic zones, on both the Arabian Gulf and the Red Sea, as well as local plans for the marine and coastal installations and facilities are highlighted for necessary implementation. Article III provides a list of the Agencies responsible for development of these plans. According to Article VIII, a National Committee for Combating Marine Environment Pollution shall be created to review pollution issues and recommend instructions.

- Appendix 6 –All Types of Violations and Penalties. This appendix summarizes the types of violation and fines associated with the development of environmental studies and consultations, hazardous waste disposal, water quality, air quality, operation of environmental technologies and other general violations.

2.3.2 Local Regulatory Standards

The RCJY is responsible for controlling pollution associated with the development and operations of Jubail and Yanbu industrial cities. In 2010, the Royal Commission issued the latest RCER, a document composed of two volumes; Volume I includes all regulations, standards, and guidelines which industries operating in any of the industrial cities shall comply with, and Volume II covers procedures and forms for applying to obtain EPC and EPO permits.

The RCER provides standards on air and water environments, hazardous materials management, waste management, dredging, and noise. Additionally, the operator of a facility shall utilize BAT for environmental control, and shall apply methods and procedures for compliance, monitoring and sampling in accordance with international accepted standards, such as the American Standard Test Methods, US EPA, or Standard Methods for the Analysis of Water or Wastewater (Latest Edition).

In case the RCER, or any amended version, lacks guidance for any source, discharge or environmental management practice, or there is a need to refer to other legislation, other recognised regulations may be used in the following order:

- Saudi National/PME Standards;
- IFC/World Bank Group; and
- Other internationally recognized and accepted regulatory bodies.

2.3.3 International Standards

The following International Standards which provide numerical standards have been reviewed and included in the next sub-sections. Other International Standards, such as the Equator Principles, the OECD and the World Bank/IFC guidelines have been included in Section 2.5 International Guidelines and Policies.

- World Bank Group: The IFC/ World Bank Group publication "Environmental, Health, and Safety (EHS) General Guidelines, 2007", consist of technical reference documents with general examples of Good International Industry Practice (GIIP); intended to be used together with relevant World Bank Industry Sector EHS Guidelines. They replace those documents previously published in Part III of the Pollution Prevention and Abatement Handbook of 1998. The EHS Guidelines provide performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs.

- World Bank: The World Bank publication "Environmental, Health and Safety Guidelines for Large Volume Petroleum-based Organic Chemicals Manufacturing, 2007" consist of technical reference documents with industry-specific examples of GIIP; intended to be used together with the World Bank General EHS Guidelines. The EHS Guidelines provide performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Large volume petroleum-based organic chemicals manufacturing facilities are referred hereinafter as LVOC manufacturing facilities.
- World Health Organization (WHO): "Air Quality Guidelines Global Update, 2005" which provide air quality guidelines for particulate matter (PM), ozone (O_3), nitrogen dioxide and sulphur dioxide (SO_2). This publication is a revision of the WHO Air Quality Guidelines for Europe (2000), taking into account new research from low-and middle-income countries, where air pollution levels are at their highest, and presented for worldwide use, applicable across all WHO regions.

Directorate-General for Environmental Protection (DGEP): "Circular on target values and intervention values for soil remediation, 2000" (Dutch National Standards) providing reference values for soil and groundwater contamination, indicating target values for sustainable environmental quality and intervention values at which contaminant concentrations become threatening. These standards have been issued by the Ministry of Housing, Spatial Planning and Environment of Netherlands and are recognized within Europe and Middle East as screening values for soil and groundwater for determining the need of remediation.

2.3.4 Air Quality

This section includes applicable local, national and international standards with respect to ambient air quality, source emissions, stationary source emissions and mobile source emissions. As a general rule, RCER-2010 states that the operator shall use BAT, to control emissions to the atmosphere. This will involve applying the most effective and advanced production processes, methods, technologies and operational practices to prevent or, at least, reduce emissions or discharges and other impacts to the environment. The emission or discharge standards included in RCER-2010 must be met through the application of BAT.

2.3.4.1 Ambient Air Quality

A compilation of local, national and international ambient air quality standards, limits and guidelines are presented as Table 2-1. The RCER-2010, Table 2Aand the PME Environmental Protection Standards (referred to as "PME" in the table) prescribe limit values for ambient air quality parameters and have been included in the following table.

Table 2-1 Ambient Air Quality Standards and Guidelines

Parameter	Agency	Type	Maximum Concentration (1) ($\mu g/m^3$)	Averaging Time
Ammonia (NH_3)	RCER-2010	AAQS	1,800	1 hour
Benzene	RCER-2010	AAQS	5	Annual
Carbon Monoxide (CO)	RCER-2010	AAQS	40 mg/m^3 10 mg/m^3	1 hour (2) 8 hour (2)
	PME	AAQS AQS	40 mg/m^3 10 mg/m^3	1 hour (2) 8 hours (2)
	WHO(7)	AQG(6)	100 mg/m^3 60 mg/m^3 30 mg/m^3 10 mg/m^3	15 minutes 30 minutes 1 hour 8 hours
Chlorine (Cl_2)	RCER-2010	AAQS	300	1 hour
Fluorides	RCER-2010	AAQS	1.0	Monthly
	PME	AAQS AQS	1.0	Monthly (8)
Hydrogen Sulphide (H_2S)	RCER-2010	AAQS	200 40	1 hour (3) 24 hour (3)
	PME	AAQS AQS	200 40	1 hour (3) 24 hours (3)
	WHO	AQG(6)	7 (4) 0.15 mg/m^3	30 minutes 24 hours

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Table 2-1 Ambient Air Quality Standards and Guidelines

Parameter	Agency	Type	Maximum Concentration (1) ($\mu g/m^3$)	Averaging Time
Particulate Matter (PM_{10}) (15) (5)	RCER-2010	AAQS	150 50	24 hour Annual
	IFC/ WB/ WHO	AQG	50 150 (Interim target-1) 100 (Interim target-2) 75 (Interim target-3) 20 70 (Interim target-1) 50 (Interim target-2) 30 (Interim target-3)	24 hours (10) Annual (10)
Particulate Matter ($PM_{2.5}$) (17) (5)	RCER-2010	AAQS	35 15	24 hour Annual
	IFC/ WB/ WHO	AQG	25 75 (Interim target-1) 50 (Interim target-2) 37.5 (Interim target-3) 10 35 (Interim target-1) 25 (Interim target-2) 15 (Interim target-3)	24 hours(10) Annual(10)
Lead (Pb)	RCER-2010	AAQS	1.5	3 month
	WHO	AQG(6)	0.5	Annual
Nitrogen oxides as NO_2	RCER-2010	AAQS	660 100	1 hour(2) Annual
	PME	AAQS AQS	660 100	1 hour(2) Annual (8)
	IFC/ WB/ WHO	AQG (6)	200 40	1 hour Annual
Non-Methane Hydrocarbon (NMHC) (14)	RCER-2010	AAQS	160	3 hour
Photochemical Oxidants as Ozone (O_3)	RCER-2010	AAQS	235 160	1 hour (2) 8 hour (12)
	PME	AQS	295	1 hour(2)
	IFC/ WB/ WHO	AQG	100 160 (Interim target-1)	8 hours daily maximum(10)
Sulphate	RCER-2010	AAQS	25	24 hour
Sulphur Dioxide (SO_2)	RCER-2010	AAQS	730 365	1 hour (2) 24 hour (3)

Table 2-1 Ambient Air Quality Standards and Guidelines

Parameter	Agency	Type	Maximum Concentration (1) (µg/m³)	Averaging Time
			80	Annual
	PME	AAQS AQS	730 365 80	1 hour (2) 24 hours (3) Annual (8)
	IFC/ WB/ WHO	AQG	500	10 minutes
			20 125 (Interim target-1) 50 (Interim target-2)	24 hours (10)

Notes:
1. *(1) Reference conditions are 25 C and 760 mm Hg. Concentrations are in µg/m³ unless otherwise stated.*
(2) Maximum concentration not to be exceeded more than twice per month (thirty days).
(3) Maximum concentration not to be exceeded more than once per year
(4) Recommended concentration to avoid odour nuisance, hence this value is less than the 24-hour guideline that incorporates a protection (safety) factor of 100
(5) The exceedance of the 24-hour or annual inhalable particulate standard as a result of abnormal natural background concentrations shall not be considered a violation of the standard.
(6) EAQG (European Air Quality Guideline) of the WHO
(7) Carbon monoxide was not included in the WHO Air Quality Guidelines 2005. As a result, the 2000 WHO guidelines per European Air Quality Guideline for CO remain in effect.
(8) Maximum concentration not to be exceeded, no exceptions allowed
(9) Not to be exceeded more than 3 times a calendar year
(10) IFC/WB provides interim targets in recognition of the need for a staged approach to achieving the recommended guidelines
(11) Inhalable particulates: < 10 microns equivalent aerodynamic diameter
(12) Maximum daily 8 hours
(13) Inhalable particulates: < 2.5 microns equivalent aerodynamic diameter
(14) There is no adopted standard for NMHC; this level is a goal to aid in the control of ambient ozone concentrations. Sampling period 0600 – 0900 hours

Abbreviations:
AQG: Air Quality Guideline
AQS: Air Quality Standard
AAQL: Ambient Air Quality Limit
AAQS: Ambient Air Quality Standard
EU: European Union
LTO: Long-Term Objective
PME :Presidency of Meteorology and Environment
TV: Target Value
USEPA: United States Environmental Protection Agency
WHO: World Health Organization

Sources:
Royal Commission Environmental Regulations (RCER) Volume I, 2010, Table 2A (RCER, 2010)
Environmental Protection Standards. Presidency of Meteorology and Environment. KSA, (PME, 2001)
IFC/World Bank Group publication "Environmental, Health, and Safety (EHS) General Guidelines, 2007
RTIP EH&S Basis of Design Jubail Site Revision 7 (KBR, 2010)
EU Directives: 2008/50/EC, 2004/107/EC
US EPA National Ambient Air Quality Standards (US EPA, 2010)
World Health Organization (WHO). Air Quality Guidelines Global Update, 2005
World Health Organization (WHO). Air Quality Guidelines for Europe, 2000

The RCER-2010, Table 2A-1also provides ambient air quality guideline values for additional compounds with health impact and odour annoyance based on World Health Organization (WHO) guidelines (see Table 2-2). Air dispersion modelling will also be conducted for these pollutants, if applicable to the project. All project facilities will design stack heights using the

USEPA Good Engineering Practice (GEP) guidelines, which sets the maximum stack height that can be used for air dispersion modelling purposes.

Table 2-2 Ambient Air Quality Guideline Values (1)
Additional compounds with Health Impact and Odour Annoyance

Pollutant	Averaging period	Maximum concentration (1) ($\mu g/m^3$)	Maximum concentration ppm
Cadmium (Health Impact)	Annual	0.005	-
Carbon disulphide (Odour Annoyance) Carbon disulphide (Health Impact)	30 minutes 24 hours	20 100	-
Formaldehyde (Health Impact)	30 minutes	100	-
Manganese (Health Impact)	Annual	0.15	-
Styrene (Odour Annoyance) Styrene (Health Impact)	30 minutes 1 week	7 260	-
Tetrachloroethylene (Odour Annoyance) Tetrachloroethylene (Health Impact)	30 minutes 24 hours	8,000 250	-
Toluene (Odour Annoyance) Toluene (Health Impact)	30 minutes 1 week	1,000 260	0.25
Vanadium (Health Impact)	24 hours	1	-
Vinyl chloride (2)	24 hours	26	0.01
Xylene (Health Impact)	24 hours	4,800	1.108

Notes:
(1) World Health Organization (WHO). Air Quality Guidelines for Europe, 2000
(2) USEPA value is provided as WHO Guidelines value is given in terms of unit risk of liver cancer in humans i.e. one person in million under 1 $\mu g/m^3$ concentration for life time exposure
Sources:
Royal Commission Environmental Regulations (RCER) Volume I, 2010 (RCER, 2010), Table 2A-1

According to RTIP EH&S project requirements, all the RTIP at Jubail facilities (including pre-treatment plants, wastewater treatment plants, waste management plants / systems) will employ best environmental practices and BAT to control the emissions of odours from their operating units. Moreover, all project facilities will install appropriate dust control devices during construction/site preparation phase to control dust emissions to less than Ambient Air Quality Standards for particulate matters established in the RCER-2010 and shown in Table 2-1.

In addition, as per IFC guidelines, the RTIP at Jubail will be designed so that as a general rule and as far as is practicable, emissions do not contribute a significant portion to the attainment of the ambient air quality standards to allow for additional, future sustainable development in the same airshed. As a general rule, a suggested IFC guideline, this project will consume no more than twenty five (25) percent of the available increment for each pollutant between the baseline and the ambient air quality standard. This is illustrated in the diagram below.

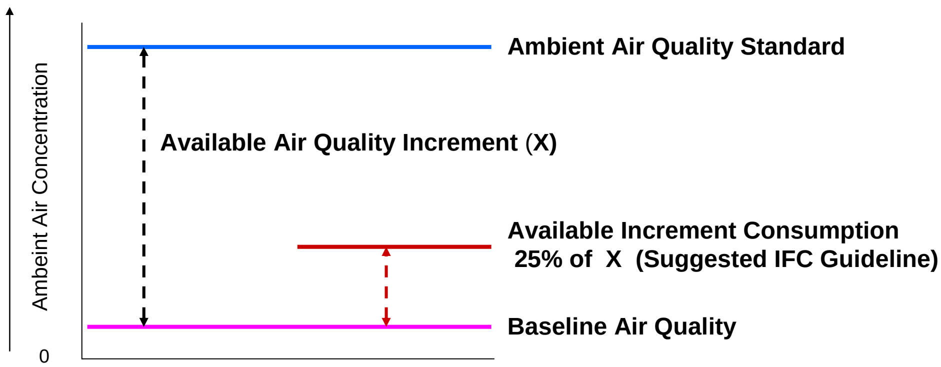

Figure 2-1 Available Air Quality Increment

2.3.4.2 Source Emissions

In addition to the ambient air quality standards, the RCJY has a number of specific standards that apply to individual facilities or point sources, as well as general standards that apply to any type of source and facility. Table 2-3 includes the general standards together with the standards for sources considered to be potentially applicable to RTIP at Jubail. Please refer to the RCER-2010 Table 2B (RCER, 2010) for the complete list of source emission standards.

Besides this, international guidelines and in particular IFC guidelines for air emissions levels have been included as compliance with IFC is likely to be of specific interest to international lenders. Therefore, the air emission levels from process emissions for LVOC manufacturing facilities from the WB (World Bank, 2007b) have been included in Table 2-3 below.

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Table 2-3 RCJY and IFC/ WB Source Emission Standards [1]

Industry	Source	Pollutant	Emission Standard [2]
General – All facilities [3]	All sources	Particulate	20% Opacity above background
		Asbestos	No emissions allowed.
	Stockpiles	Particulate	10% Opacity above background
	Cooling Towers	Particulate	< 0.0005% Drift Losses of Total Circulated Water
	Point sources	Visible Emissions	20% maximum opacity except for 6 minutes for any continuous 60 minutes period and except for water vapour
	Sources emitting > 100 g/h organic HAP [11] [4] [19] Constructed after September 1, 2005	VOC	20 mg/m^3 [5]
	Sources emitting > 2 kg/h or 5 t/y non-HAP VOC [4] [19] Constructed after September 1, 2005	VOC	80 mg/m^3 [5]
	For components in VOC service	Fugitive VOC	10,000 ppm
	For valves, connectors and flanges in organic HAP [11] [19] service	Fugitive organic HAP	500 ppm
	Acid gas flares	Visible emissions	No more than 20% opacity for 6 min. within any one hour period
	Process flares	Visible emissions	No more than 5 minutes of visible emission within any two hour period
	Flares: steam assisted [6]	VOC	Ht >= 11.2 MJ/scm Vmax < 122 m/s if Ht > 37.3 MJ/scm Log10 (Vmax) =< (Ht+28.8)/31.7 If Ht < 37.3 MJ/scm
	Flares: air assisted [6]	VOC	Ht >= 11.2 MJ/scm Vmax =< 8.706 + 0.7084 (Ht)

Table 2-3 RCJY and IFC/ WB Source Emission Standards [1]

Industry	Source	Pollutant	Emission Standard [2]
	Flares: non- assisted [6]	VOC	Ht >= 7.45 MJ/scm Vmax < 122 m/s if Ht > 37.3 MJ/scm Log10 (Vmax) =< (Ht+28.8)/31.7 If Ht < 37.3 MJ/scm
LVOC manufacturing facilities [20][21]	Process Emissions	Particulate Matter (PM)	20
		Nitrogen Oxides	300
		Hydrogen Chloride	10
		Sulphur Oxides	100
		Benzene	5
		1,2-Dichloroethane	5
		Vinyl Chloride (VCM)	5
		Acrylonitrile	0.5 (incineration) 2 (scrubbing)
		Ammonia	15
		VOCs	20
		Heavy Metals (total)	1.5
		Mercury and Compounds	0.2
		Formaldehyde	0.15
		Ethylene	150
		Ethylene Oxide	2
		Hydrogen Cyanide	2
		Hydrogen Sulphide	5
		Nitrobenzene	5
		Organic Sulphide and Mercaptans	2
		Phenols, Cresols and Xylols (as Phenol)	10
		Caprolactam	0.1
		Dioxins/Furans	0.1 NgTEQ/Nm^3
Abrasive Blasting	Sandblasting	Silica	< 5% silica in abrasive used in outdoor blasting

Table 2-3 RCJY and IFC/ WB Source Emission Standards (1)

Industry	Source	Pollutant	Emission Standard (2)
Boilers and Industrial Furnaces (BIF) Burning Hazardous Materials(17)	Stack gases	Organic Emissions	99.99% destruction removal efficiency
		CO	Not to exceed 100 ppmv on an hourly rolling average basis, corrected to 7% oxygen, dry gas basis
		NO_x	Same as for Combustion Facilities below, see NOx emissions standards (modified facilities constructed after September 1, 2005- Facilities not combusting chlorinated organics)
		SO_2	Same as for Combustion Facilities below, see SO_2 emissions standards (modified facilities constructed after September 1, 2005)
		Particulate	180 mg/dscm after correction to 7% oxygen stack gas concentration
		Chlorinated Organics	99.9999% Destruction removal efficiency
		Metals	Sb - 1500 g/h; Pb - 430 g/h; Ag - $1.5x10^4$ g./h; Ba - $2.5x10^5$ g/h; Hg - 1500 g/h; Tl - 1500 g/h; As -11 g/h; Cd - 28 g/h; Cr - 4.2 g/h; Be - 21 g/h
Chlorine Manufacturing	Exit gases	Chlorine gases (7)	30 mg/m^3
Combustion Facilities (Constructed or modified after September 1, 2005 facilities)	Fossil-fuel fired steam generating unit or furnaces with a heat input capacity more than 250 MBTU/h (73MW)	Particulates	43 ng/J (0.1 lb/MBTU)
		SO_2	340 ng/J (0.8 lb/MBTU)
		NOx	43 ng/J (0.1 lb/MBTU) gas fired 69 ng/J (0.16 lb/MBTU) oil fired
	Electric utility steam generating units operated on fossil fuel with more than 250 MBTU/h (73 MW) electrical output	Particulates	13 ng/J (0.03 lb/MBTU)
		SO_2	340 ng/J (0.8 lb/MBTU)
		NOx (10)	43 ng/J (0.1 lb/MBTU) gas fired 69 ng/J (0.16 lb/MBTU) oil fired
	Industrial/commercial/ institutional steam generating units or furnaces with a heat capacity more than 100 MBTU/h (29 MW)	Particulates	43 ng/J (0.1 lb/MBTU)
		SO_2	215 ng/J (0.5 lb/MBTU) When <30% heat input derived from oil 340 ng/J (0.8 lb/MBTU) When >30% heat input derived from oil
		NOx (9) (10)	43 ng/J (0.1 lb/MBTU) gas fired 69 ng/J (0.16 lb/MBTU) oil fired

Table 2-3 RCJY and IFC/ WB Source Emission Standards [(1)]

Industry	Source	Pollutant	Emission Standard [(2)]
	Small industrial/commercial/institutional steam generating units with a heat capacity 100 MBTU/h (29MW) or less but greater than or equal to 10 MBTU/h (2.9MW)	SO_2	215 ng/J (0.5 lb/MBTU)
	Stationery gas turbines with heat input > 100 MW	NOx [(9)]	9 ppmv @ 15% O_2 dry basis
		SO_2	0.015% by vol. @ 15% O_2 dry basis
		Sulphur contents of Turbine fuel	< 0.8% by sulphur by weight
	Stationery gas turbines with heat input > 10 MW and < 100 MW	NOx [(9)]	25 ppmv @ 15% O_2 dry basis
		SO_2	0.015% by vol. @ 15% O_2 dry basis
		Sulfur contents of Turbine fuel	< 0.8% by sulphur by weight
	Stationery gas turbines with heat input < 100 MW	NOx [(9)]	42 ppmv @ 15% O_2 dry basis
		SO_2	0.015% by vol. @ 15% O_2 dry basis
		Sulfur contents of Turbine fuel	< 0.8% by sulphur by weight
	Duct burner	NOx	86 ng/J (0.2 lb/MBTU) gas fired 130 ng/J (0.3 lb/MBTU) oil fired
Hazardous and Medical Waste Incineration (Constructed or modified after September 1, 2005 facilities) [(12)(18)]	Incinerator	Particulate	34 mg/dscm corrected to 7% oxygen
	Incinerator chamber	Visible emissions	10% opacity except for no more than 6 minutes in any hour
		Sulphur dioxide	50 mg/dscm
		CO	50 mg/dscm
		Chlorinated organics	>99.9999% destruction removal efficiency (DRE) for each chlorinated organic constituent
		Organics	>99.99% destruction removal efficiency (DRE) for each organic constituent
		Total Dioxins & Furans	0.1 ngTEQ/dscm
		PCB	1 mg/kg PCB feed for a maximum one hour average concentration or >99.9999% destruction removal efficiency (DRE)
		HCl	10 mg/dscm
		Hydrogen fluoride	1 mg/dscm
		TI + Cd	0.05 mg/dscm

Table 2-3 RCJY and IFC/ WB Source Emission Standards [1]

Industry	Source	Pollutant	Emission Standard [2]
		Sb + Pb + Co + As + Cr + Cu + Mn + Ni + V	0.5 mg/dscm
		Hg	0.05 mg/dscm
		Minimum post combustion Temperature and Minimum Residence Time	850C for 2 second OR 1100C for 2 seconds where incineration of >1% halogenated organic substances (expressed as chlorine) takes place
Hydrochloric Acid Plants	Hydrochloric acid plants Hydrochloric acid regenerating plants	HCl HCl Cl_2	0.25 kg/t of acid produced 25 ppmv 6 ppmv
Nitric Acid Plants	Exit gases	NOx Opacity	1.5 kg/t of acid produced (expressed as 100 percent nitric acid) 10%
Polymer Manufacturing (Polypropylene; Polyethylene; Polystyrene)	All facilities with process vents	TOC	Reduce emissions of TOC by 98% by wt. OR to a concentration of 20 ppmv on a dry basis corrected to 3% oxygen OR combust the emissions in a flare
Synthetic Organic Chemical Manufacturing Industry (SOCMI Processes):	1. Any air oxidation unit producing any of the chemicals listed in Table 2B (I)[14] of the RCER-2010 as a product or by -product 2. Any distillation operation producing any of the chemicals listed in Table 2B (II)[15] of the RCER-2010 as a product or by-product 3. Any reactor process[13] producing any of the chemicals listed in Table 2B (III)[16] of the RCER-2010 as a product or by-product	TOC	Reduce emissions of TOC by 98% by wt. OR to a concentration of 20 ppmv on a dry basis corrected to 3% oxygen OR combust the emissions in a flare

Notes:

(1) *The primary source of the standards is the United States Environmental Protection Agency (USEPA): Code of Federal Regulations (CFR) Title 40, Parts 60 - 63*
(2) *Compliance with the standards will be determined by comparison with hourly average data, unless otherwise specified, that are corrected to standard temperature and pressure, moisture and oxygen content as specified by USEPA Methods.*
(3) *General standards apply to all emissions sources unless individual facility standards are specified.*
(4) *Standard derived from Benchmark Release Levels quoted in the IPC Guidance Note S2 4.04 Inorganic Chemicals, Environment Agency, UK September 1999.*
(5) *Applies to facilities exempted by RC from conducting fugitive emission monitoring.*

Table 2-3 RCJY and IFC/ WB Source Emission Standards (1)

Industry	Source	Pollutant	Emission Standard (2)

(6) *The maximum exit velocity of a flare (V_{max}) is calculated by dividing the maximum volumetric flow rate at STP by the cross-sectional area of the flare tip. (Ht) is the Net Heating Value of the gas being combusted.*

(7) *Established from Federal Republic of Germany Environmental Law title Air Purity Regulations, Copyright 1978 by the Bureau of National Affairs*

(8) *The value of F for Stationary Gas Turbines NOx estimation shall be obtained using the following:*
Y = manufacturer rated heat rate at manufacturer's rated peak load (kJ/Wh) OR actual measured heat rate based on lower heating value of fuel as measured at actual peak load for the facility. The value of Y shall not exceed 14.4 kJ/Wh
F = NOx emission allowance for fuel bound nitrogen, defined below
N = fuel bound nitrogen

Fuel Bound Nitrogen (Percent by weight)	F (NOx by weight)
N =< 0.015	0
0.015 <= N<0.1	0.04 (N)
0.1<N=< 0.25	0.004 + 0.0067 (N - 0.1)
N>0.25	0.005

(9) *Based on Best Available Control Technology 1991, TNRCC, Texas*

(10) *For mixed fuel the standard is prorated according to the % heat input from derived from each fuel:*
NOx standard (ng/J) = (% heat input gas x NOx standard gas) + (% heat input oil x NOx standard oil) / (% heat input gas + % heat input oil)

(11) *Measured as individual organic Hazardous Air Pollutant(HAP) or as TOC*

(12) *Additional guidelines for hazardous waste incineration are retained in the documents entitled "Emission Guidelines for Hazardous Waste Incineration Facilities" by PME.*

(13) *Exemptions from the source standards for SOCMI reactor processes are as follows:*
a) Any reactor process that is designed and operated as a batch operation
b) A process unit with a total design capacity for all chemicals produced within that unit of less than 1,000 tonnes per year
c) If the vent stream from an affected facility is routed to a distillation unit subject to the SOCMI standards and has no other releases to the atmosphere except for a PRV the facility is exempt

(14) *Please refer to Table 2B (I) of the RCER-2010: Synthetic Organic Chemical Manufacturing Industries (SOCMI) Oxidation Processes Subject to Point Source Emission Standards*

(15) *Please refer to Table 2B (II) of the RCER-2010: Synthetic Organic Chemical Manufacturing Industries (SOCMI) Distillation Processes Subject to Point Source Emission Standards*

(16) *Please refer to Table 2B (III) of the RCER-2010: Synthetic Organic Chemical Manufacturing Industries (SOCMI) Reactor Processes Subject to Point Source Emission Standards*

(17) *These standards for BIF are not applicable to the Thermal Treatment Unit (see standards for Hazardous and Medical Waste Incineration).*

(18) *These standards are applicable to the Thermal Treatment Unit*

(19) *A table listing Hazardous Air Pollutants (HAP) is provided in Table 2C of the RCER-2010*

(20) *Dry, 273K (0°C), 101.3 kPa (1 atmosphere), 6% O2 for solid fuels; 3 % O2 for liquid and gaseous fuels.*

(21) *Standards from IFC/WB: Environmental, Health and Safety Guidelines for Large Volume Petroleum-based Organic Chemicals Manufacturing, 2007 (World Bank, 2007b)*

Abbreviations:
ppm : parts per million
TOC: Total Organic Compounds, less methane and ethane
VOC: Volatile Organic Compounds
Source:
Royal Commission Environmental Regulations 2010 Volume I (RCER, 2010) Environmental, Health and Safety Guidelines for Large Volume Petroleum-based Organic Chemicals Manufacturing, 2007 (World Bank, 2007b)
RTIP EH&S Basis of Design Jubail Site Rev 7 (KBR, 2010)

The point sources shall not emit air contaminants in excess of the following standards, but if these limits are exceeded during major upsets, emergencies, start-ups or shutdowns, it will be evaluated by RCJY on a case by case basis to determine the significance of the incident and also to assess whether such emission has violated the Source Emission Standards or not. The evaluation will be based on several factors such as: duration and frequency of emissions, quantities and characteristics of pollutants emitted, designs of equipments, preventive and maintenance plans and other relevant parameters (RCER, 2010.

The PME Rules for Implementation (PME, 2001) establishes source emission limits for combustion fossil fuel fired facilities and Petroleum and Petrochemical installations.

Additionally, it provides guidelines to minimize the emissions of Petroleum and Petrochemical facilities in its document Environmental Protection Standards (Appendix 1), for different process or units, specifically:

- Storage vessels for VOC with a capacity greater than 1000 barrels (5614 cubic feet) shall be equipped with vapour emission control systems.

- Fuel gas combustion processes shall utilize amine scrubbing or other appropriate gas cleaning process.

- Fugitive emissions of VOC from Petroleum and Petrochemical processes shall be limited through the utilization of good maintenance and inspection procedures as well as monitoring of potential VOC emission points.

The RCER-2010 is the applicable regulation for the project and they cover all the air emissions parameters relevant to the project.

Pursuant to the RCER-2010 continuous air emission monitoring is required for a number of point sources. Table 2-4 below includes the sources considered to be potentially applicable to RTIP at Jubail which need continuous air emission monitoring. Nevertheless, RTIP at Jubail will be responsible for all sources listed in Table 2D of the RCER-2010.

Table 2-4 Air Pollution Sources Subject to Continuous Emission Monitoring

Source (design bases)	PARAMETERS (1)
Gas Turbines > 50 MW heat input capacity	NO_x
Combustion Devices > 73 MW heat input capacity	Opacity (2), SO_2 (3), NO_x(4)
BIFs operating > 1000 hours per year	CO or Hydrocarbons
Hazardous waste incinerators RTIP Note – Thermal Treatment Unit is in this category	CO downstream of combustion zone Combustion temperature Waste feed rate, SO_2, HCl, PM and Oxygen
Nitric Acid Plants	NO_x

Table 2-4 Air Pollution Sources Subject to Continuous Emission Monitoring

Source (design bases)	PARAMETERS (1)

Notes:

(1) *Pertains to exhaust gases except where noted*

(2) *Combustion sources that burn natural gas or hydrogen only shall be exempt from the continuous emission monitoring requirements for fuel sulphur.*

(3) *Combustion sources that burn natural gas or hydrogen only shall be exempt from the continuous emission monitoring requirements for opacity and SO2.*

(4) *If the operator of the facility demonstrates during a performance test and subsequent point source monitoring tests that the emissions of NOx are consistently less than 70% of the applicable standard then the source is exempt from the requirement for continuous emission monitoring of NOx. Demonstration of consistent compliance will require one of the following number consecutive spot sampling tests:*

- *2 results < 50% standard*
- *3 results < 60% standard*
- *4 results < 70% standard*
- *30 days <70% standard using portable continuous emission monitor*

All spot sampling tests shall be separated by at least 3 months and completed within 2 years.

Source:
Royal Commission Environmental Regulations 2010 Volume I (RCER, 2010
RTIP EH&S Basis of Design Jubail Site (KBR, 2010)

2.3.4.3 Combustion of Hazardous Materials

At RTIP at Jubail liquid wastes containing hazardous materials will be burned in Thermal Treatment Units (TTU). Only hazardous materials approved by the RC and specified in the EPO (resulting for approvals in the EPC, submitted with the Permit Application Package [PAP]), may be burned in a TTU.

2.3.4.4 Fugitive Emissions

A list of Volatile Organic Compounds (VOCs) and Organic Hazardous Air Pollutants (OHAPs) shall be provided as part of the PAP. Table 2C of the RCER-2010provides a list of OHAPs. All affected components in VOC or organic OHAP service shall be individually identified by a specific number, service and location. An updated master list containing all of the affected components shall be kept on site at all times. During operations, all affected components in VOC service or in organic OHAP service shall be monitored, as determined by vapour pressure in Table 2E of the RCER-2010.

2.3.4.5 Storage of Volatile Organic Compounds

Stationary tanks, reservoirs, or any other container storing volatile VOCs shall be equipped with a control device, which will vary depending on the capacity of the tank as specified in Table 2F of the RCER-2010.

Vessels at gasoline service stations, vessels that are permanently mobile, vessels which maintain a pressure of at least 204.9 kPa and vessels with capacities less than 75 m^3, are exempt to the Storage of VOC requirements set by the RCER-2010.

Any operator of a facility installing or operating a fixed roof storage tank with an internal floating roof shall follow the criteria described in section 2.9.3 of RCER-2010 According to that same document, the operator of a facility with storage equipment equipped with external floating roofs shall undertake the measures listed in its section 2.9.4.

The operator shall notify the RCJY their schedule of seal inspection and all the results of the visual inspections of storage tank primary and secondary seals shall be documented and records shall be kept according to Recordkeeping Requirements of RCER-2010, Section 8.3. The following records shall be kept on site:

- chemical name of VOC stored;
- VOC storage tank capacity;
- details of periods when any required control device is not functional;
- true vapour pressure of the material stored.

2.3.4.6 Loading and Unloading of Volatile Organic Compounds

Vapours generated from loading or unloading VOCs or organic HAP compounds with a true vapour pressure greater than or equal to 1.5 psia, in quantities greater than 75 m^3 per day averaged over any consecutive 30 day period, shall be processed using a vapour control system (RCER, 2010).

The operations of the vapour control system for land and marine based VOC or OHAP loading and unloading shall be performed such that the conditions listed in Section 2.10 of the RCER-2010 are complied with.

2.3.4.7 Air Emissions Inventory

According to Article 2.11.1 of the RCER-2010 operators of facilities shall submit an air emissions inventory report as part of the application for the Environmental Permit for Operation renewal. The contents of the inventory report are provided in the said Article 2.11.1 of the RCER-2010. This includes an estimated inventory of six greenhouse gases as per Kyoto Protocol.

2.3.5 Water Quality

Water quality criteria have been developed to protect the long-term resources of the marine environment and water supply. These criteria have been established in order to minimise any adverse impact to soils, groundwater, water quality in the Arabian Gulf ecosystems and local fisheries.

Sanitary waste water will be collected in a dedicated above ground sanitary wastewater header and conveyed to the Jubail (Marafiq) Sanitary Wastewater Treatment Plant (SWTP). Process waste water will be sent in above ground pipelines to the RTIP at Jubail wastewater pre-treatment area, where pre-treatment, equalization, and pH adjustment will occur to comply with RCER-2010pre-treatment standards prior to conveyance to the Jubail (Marafiq) Industrial Wastewater Treatment Plant (IWTP).

Storm water from non-process areas of the RTIP at Jubail, may be discharged directly to the Royal Commission storm water drainage system, or collected and conveyed in surface ditches to the site's retention ponds. Water in the retention ponds, tested and found to be compliant with the discharge standards of RCER-2010Table 3C (see Table 2-8), may be discharged to the Royal Commission storm water drainage system. Potentially contaminated water shall not be sent to the site's retention pond(s) without proper characterization.

An impervious storm water management system will be provided to collect the first flush storm water from industrial process areas and hazardous material storage and handling areas. If the specifications in RCER-2010for storm water cannot be met, the water must be conveyed into the RTIP main wastewater header as well as the condensate considered contaminated. Further details on this matter can be found in Document No. A554-F-PRG-EV-GEN-PHL-002, Drainage Philosophy, as well as indications on what should be done in the case that wastewater fails to meet the pre-treatment conditions established in the RCER-2010.

This section provides the applicable local and international standards applicable to the RTIP at Jubail in terms of water quality discharge and storm water. Groundwater standards have been included in Section 2.3.6.

2.3.5.1 Coastal Water Quality Criteria

The coastal receiving water standards for the Arabian Gulf and the Harbour developed by RCJY are included in Table 2-5. The criteria have been established to avoid harm to public health, not impair visual or aesthetic appearance of the water, and avoid adverse impact on the Arabian Gulf and the Harbour waters. Additionally, the standards are developed to maintain marine life, protect fisheries, maintain the amenity value of the waters, are suitable for use as industrial cooling water and do not interfere with the use of seawater as a source for desalination water.

Table 2-5 Ambient Water Quality Criteria for Coastal Waters

Variable	Units	Limits		
		Maximum	Monthly Average (Arabian Gulf)	Monthly Average (Jubail Harbour)
Physical				
Floating Particles(1)	mg/l	1	0.5	0.5
Temperature(2)	°C	2.2	2	10(3)
Total Suspended Solids	mg/l	5	-	-
Turbidity	N.T.U.(4)	5	5	5
Chemical				
Aluminium	mg/l	0.05	-	-
Ammonia Free (as N)(5)	mg/l	1.2	0.1	0.1
Arsenic	mg/l	0.05	0.005	0.01
Barium	mg/l	1	-	-
Cadmium	mg/l	0.005	0.001	0.001
Chlorinated hydrocarbons	mg/l	0.01		
Chlorine Residual	mg/l	0.05	0.01	0.01
Chromium	mg/l	0.1	0.01	0.01

Table 2-5 Ambient Water Quality Criteria for Coastal Waters

Variable	Units	Limits		
		Maximum	Monthly Average (Arabian Gulf)	Monthly Average (Jubail Harbour)
Cobalt	mg/l	0.05	-	-
Copper	mg/l	0.015	0.015	0.015
Cyanide	mg/l	0.1	0.005	0.05
Fluoride	mg/l	1.5	-	-
Iron	mg/l	1	-	-
Lead	mg/l	0.01	0.01	0.01
Manganese	mg/l	0.05	-	-
Mercury	mg/l	0.0001	0.0001	0.0001
Nickel	mg/l	0.1	-	-
Nitrate as N	mg/l	1	0.1	0.1
Oil & Grease	mg/l	5	2	2
Oxygen - Dissolved	mg/l	5 (min)	5 (min)	5 (min)
pH	pH units	7.8 – 8.5 (6)	8 – 8.5 (6)	7.8 – 8.5 (6)
Phenols	mg/l	0.12	0.1	0.1
Phosphate- total	mg/l	0.025	0.02	0.02
Salinity above ambient	ppt (7)	1.4	-	-
Sulphide	mg/l	0.4	0.004	0.01
Total Kjeldahl Nitrogen (TKN)	mg/l	--	0.02	0.02
Total Organic Carbon (TOC)	mg/l	10	5	5
Zinc	mg/l	0.1	0.1	0.1
Bacteriological				
Faecal Coliform	MPN (8)/100 ml	--	2	2
Total Coliform	MPN/100 ml	--	70	70

Notes:
(1) Waters shall be free of all floating particles which may be attributed to wastewater or other discharges
(2) Temperature differential with respect to the water temperature at cooling water canal intake
(3) At the seawater cooling canal outfall
(4) N.T.U: Nephalometric Turbidity Unit
(5) Non-ionised concentration (pH and temperature dependant)
(6) Inclusive range
(7) Parts per thousand
(8) Most probable number
Source: Royal Commission Environmental Regulations 2010. Volume I - Regulations And Standards. Environmental Control Department

2.3.5.2 Water Quality Discharge Standards

The RCJY regulations state that the operator of a facility shall not discharge any water or effluents which contain contaminants to cause nuisance to public health, animal or aquatic life, vegetation or property.

Relevant standards and objectives primarily specified for water discharges are:

- Wastewater pre-treatment standards at the point of discharge to the Central Treatment Facilities (see Table 2-6 and Table 2-7 below); Water quality standards for direct discharge to the Seawater Cooling Return Canal, Variance Streams and Surface Drainage Ditches (see Table 2-8 below);

- Irrigation Water Quality Standards at the point of discharge to Irrigation System and Use Points (Table 3D of the RCER-2010. These standards are not applicable to RTIP, as the project will not reuse the water for irrigation;

- Ballast water (Table 3E of the RCER-2010. These standards are not applicable to RTIP.

Applicable standards relating to water discharge are described in the following subsection.

Wastewater Pre-Treatment Requirements

According to RCER-2010 the operator of a facility shall not discharge industrial wastewater to the Wastewater System if it exceeds the wastewater pre-treatment standards identified in RCER-2010, Tables 3B and 3B-1 at the point of discharge from their facility. If necessary, the operator of a facility shall install and operate a pre-treatment system at the facility to ensure that the wastewater meets the discharge standards. A wastewater pre-treatment area will be installed at RTIP at Jubail to ensure that the wastewater meet the pre-treatment standards established by the RCER-2010 which appear in Table 3B of the RCER-2010 and are included in Table 2-6 below.

Table 2-6 Wastewater Pre-Treatment Standards at the Point of Discharge to the Central Treatment Facilities of Jubail (1)

Parameter(2)	Units	Maximum Limits
Physical		
Temperature	°C	60(3)
Total Dissolved Solids	mg/l	2000
Total Suspended Solids	mg/l	2000
Chemical(4)		
Aluminium	mg/l	30
Ammonia, Total as N	mg/l	120
Arsenic	mg/l	1.25
Barium	mg/l	2
BOD	mg/l	-
Boron	mg/l	2.5
Cadmium	mg/l	0.5
Chloride	mg/l	1000
Chlorinated hydrocarbons	mg/l	0.5
Chromium - Total	mg/l	5
Chromium - Hexavalent	mg/l	0.25
Cobalt	mg/l	2
COD	mg/l	1800
Copper	mg/l	1.2
Cyanide	mg/l	3.5

Table 2-6 Wastewater Pre-Treatment Standards at the Point of Discharge to the Central Treatment Facilities of Jubail (1)

Parameter(2)	Units	Maximum Limits
Fluoride	mg/l	30
Iron	mg/l	25
Lead	mg/l	0.5
Manganese	mg/l	2
Mercury	mg/l	0.015
Nickel	mg/l	2.5
Oil & Grease	mg/l	120
pH(5)	mg/l	5 - 11
Phenols	mg/l	150
Phosphorous, Total P	mg/l	50
Silver	mg/l	0.25
Sodium	mg/l	1000
Sodium Absorption Ratio	SAR Units	20
Sulphate	mg/l	800
Sulphide	mg/l	6
TOC	mg/l	800
Zinc	mg/l	10

Notes:
(1) Facilities owned by the Operator of the Wastewater System including the Industrial Wastewater Treatment Plant (IWTP), the Sanitary Wastewater Treatment Plant (SWTP) and the associated wastewater sewers and pumping stations.
(2) For any parameters not identified, specific standards will be determine on a case-by-case basis
(3) The RCER-2010 pre-treatment standard for wastewater temperature is 60 degrees C.
(4) Metals standards represent total metals concentrations
(5) Inclusive range not to be exceeded
Source:
Table 3B of Royal Commission Environmental Regulations 2010 Volume I - Regulations And Standards. Environmental Control Department (RCER, 2010

In addition, the RCER-2010, Table 3B-1 provides wastewater pre-treatment values that trigger the consideration for BAT assessment. These values are included in Table 2-7.

Table 2-7 Wastewater Pre-Treatment Guideline Values at the Point of Discharge to the Central Treatment Facilities (1) (2)

Parameter	Pre-treatment Standards (µg/l) (unless otherwise specified)	
	Maximum for any One day	Maximum for Monthly Average
Total Volatile Organic Compounds (VOC) in mg/l	10	-
Benzene	134	57
Carbon Tetra Chloride	380	142
Chlorobenzene	380	142
Chloroethane	295	110
Chloroform	325	111

Table 2-7 Wastewater Pre-Treatment Guideline Values at the Point of Discharge to the Central Treatment Facilities (1) (2)

Parameter	Pre-treatment Standards (µg/l) (unless otherwise specified)	
	Maximum for any One day	Maximum for Monthly Average
1,1-Dichloroethane	59	22
1,2-Dichloroethane	574	180
1,2-Dichlorobenzene	794	196
1,3-Dichlorobenzene	380	142
1,4-Dichlorobenzene	380	142
1,1-Dichloroethylene	60	22
4,6-Dinitro-O-Cresol	277	78
1,2-Dichloropropane	794	196
1,3-Dichloropropylene	794	196
Ethylbenzene	380	142
Hexachlorobenzene	794	196
Hexachlorobutadiene	380	142
Hexachloroethane	794	196
Methyl Chloride	295	110
Methylene Chloride	170	36
Nitrobenzene	6,402	2,237
2-Nitrophenol	231	65
4-Nitrophenol	576	162
Tetrachloroethylene	164	52
Toluene	74	28
1,2,4-Trichlorobenzene	794	196
1,1,1-Trichloroethane	59	22
1,2-Trans-dichloroethylene	66	25
1,1,2-Trichloroethane	127	32
Trichloroethylene	69	26
Vinyl Chloride	172	97

Notes:
(1) Guideline values derived from Title 40 of the 40 Code of Federal Regulations (CFR) Part 414 Section 414.25.
(2) Trigger level for the facility to consider carrying out BAT assessment.
Source:
Table 3B-1 of Royal Commission Environmental Regulations 2010 Volume I - Regulations and Standards. Environmental Control Department (RCER, 2010)

Water Quality Standards for direct Discharge to the Seawater Cooling Return Canal, Variance Streams and Surface Drainage Ditches

Prior to discharge of any water to surface water drainage channels outside the battery limits of the facility, lagoons or evaporation ponds without an impermeable barrier, open ground or below the ground surface it is necessary to get an authorization from the RCJY. Moreover, water other than non-contact cooling water shall not be discharged to the seawater cooling discharge without the appropriate authorization.

According to RCER-2010 for the overall project discharging industrial wastewater to the Jubail IWTP, the project is required to provide an emergency holding pond lined with HDPE liner of minimum thickness of 1.5 mm with a storage capacity to retain three days (72 hours) of industrial wastewater production. Wastewater retained in the ponds shall be regularly discharged so that the ponds are normally kept empty to provide containment for emergencies and to minimize fugitive emissions.

For RTIP, water in the surface runoff retention basins (SRBs) in compliance with the discharge standards of Table 2-8 may be discharged to the Royal Commission storm water drainage system. Direct discharge streams (including variance streams) that meet with the aforementioned standards will be discharged to the Jubail Industrial City seawater cooling return.

Table 2-8 Water Quality Standards for Direct Discharge to the Seawater Cooling Return Canal, Variance Streams(1) and Surface Drainage Ditches(2)

Parameter(3)	Units	Jubail Industrial City	
		Maximum Allowable	Monthly Average
Physical			
Floating Particles	mg/m^2	NIL	NIL
Temperature (4)(10)	Δ ºC	10(5)	10(5)
Temperature (11)	Δ ºC	--	--
Total Suspended Solids	mg/l	40	25
Turbidity	N.T.U.	75(6)	50(7)
Chemical			
Aluminium	mg/l	25	15
Ammonia, Total as N	mg/l	3.0	1.0
Arsenic	mg/l	0.5	0.1
Barium	mg/l	2.0	1.0
BOD_5	mg/l	25	15
Cadmium	mg/l	0.05	0.01
COD	mg/l	150	75
Chlorinated hydrocarbons	mg/l	0.5	0.1
Chlorine Residual (7)	mg/l	0.3	0.2
Chromium (Total)	mg/l	0.5	0.1
Chromium (hexavalent)	mg/l	0.1	0.05
Cobalt	mg/l	2.0	0.1
Copper	mg/l	0.5	0.2
Cyanide	mg/l	0.1	0.05
Fluoride	mg/l	25	15
Iron	mg/l	10	5
Lead	mg/l	0.5	0.1
Manganese	mg/l	1.0	0.2
Mercury	mg/l	0.005	0.001
Vanadium	mg/l	--	--
Nickel	mg/l	0.5	0.2

Table 2-8 Water Quality Standards for Direct Discharge to the Seawater Cooling Return Canal, Variance Streams(1) and Surface Drainage Ditches(2)

Parameter(3)	Units	Jubail Industrial City	
		Maximum Allowable	Monthly Average
Nitrate as N	mg/l	10	1
Oil & Grease	mg/l	15	8
Oxygen - Dissolved	mg/l	2.0 (8)	5.0 (8)
pH	pH units	6 – 9 (9)	6 – 9 (9)
Phenols	mg/l	1	0.1
Phosphorous, total as P	mg/l	2	1
Sulfide	mg/l	0.1	0.05
TKN	mg/l	10	5
TOC	mg/l	75	--
Zinc	mg/l	5	2
Biological			
Total Coliform	MPN (7)/100 ml	2400	1000

Notes:
1) Permission to discharge variance streams subject to Section 3.5.5 of the RCER-2010 (RCER, 2010). Standards are applicable to variance stream discharges before dilution with the main non-contact cooling water flow.
2) Applicable to storm water discharges only, unless permission to discharge wastewater granted under Section 3.4.10a of the RCER-2010 (RCER, 2010.
3) For any parameters not identified, specific standards will be determined on a case-by-case basis
4) Temperature standard does not apply to variance stream discharges.
5) Differential temperature between seawater cooling intake and seawater cooling discharge.
6) Differential standard between seawater cooling intake and seawater cooling discharge for non-contact cooling water, absolute standard for all other discharges.
7) Chlorine residual is after 30 minutes contact and is total residual chlorine.
8) Dissolved oxygen requirement is a minimum concentration requirement
9) Allowable range
10) Difference between the discharge and the receiving water temperature.
11) Apply at the edge of the mixing zone following discharge.
Sources:
Table 3C of Royal Commission Environmental Regulations 2010 Volume I - Regulations And Standards. Environmental Control Department (RCER, 2010)

2.3.5.3 Storm Water Runoff Regulations

The storm water run-off from access roads, non-process areas and grassed and recreational areas shall be discharged to the RCJY water drainage system. Any facility shall set out an impervious (such as: HDPE liner of minimum thickness of 1.5 mm subject to the RC prior approval) storm water management system, independent from the industrial wastewaters system, to collect the first flush storm[1] water from industrial process and hazardous storage areas.

[1] The first flush is the first 30mm of rainfall from each storm event.

Once the first flush is collected, the additional rain falling may be diverted to the storm water drainage system. The retained first flush shall be discharged according to the following conditions:

- If contained in a dedicated storm water pond and fulfils the standards in Table 2-8 can be discharged in the RC storm water drainage system.
- If not contained in such pond or exceeds standards on Table 2-8, but complies with the ones in Table 2-5 shall be discharged as industrial wastewater.
- If do not comply with standards in Table 2-5, shall be pre-treated on-site or removed to waste disposal facilities.

All storm water from the non-process areas of the RTIP at Jubail are collected and conveyed in surface ditches to the site’s retention ponds. Storm water shall meet the discharge standards in Table 2-8 before being discharged to the Royal Commission Drainage Channel. If these specifications for storm water cannot be met, the water will be conveyed to the RTIP main wastewater header, and so will need to meet the pre-treatment standards set forth in Table 2-6.

2.3.6 Soil and Groundwater Regulations

The operator of a new facility handling more than 5000 kg of hazardous materials at any one time, shall install at least three permanent groundwater monitoring wells for obtaining representative samples prior to facility operation. The number of wells, design and installation of any groundwater monitoring wells shall be subject to review and approval by the RCJY as RC guidelines provided in RCER-2010Volume II.

If the installation has groundwater monitoring boreholes, the groundwater quality shall be monitored annually.

The RCER-2010does not directly address the protection of soils and subsurface resources. Potential regulatory standards that could be used as reference values include the Dutch Target and Intervention Values which are recognized within Europe and the Middle East as screening values for soil and groundwater for determining the need for remediation. However, the Dutch standards can be considered only as reference values, they are not compulsory threshold standards.

Target values indicate the contaminant concentration at which there is a sustainable soil and groundwater quality. These values indicate the level to be achieved in order to fully recover the functional properties for humans and plant and animal life. The target values also provide a benchmark for long term environmental quality based on an assumption of negligible risks to the ecosystem. Target values were derived from a Dutch project to set integrated environmental quality standards (INS); soil values were checked for practical feasibility as part of an ancillary project to evaluate the use of target values (HANS).

Intervention values indicate the contaminant concentration levels at which the functional properties for humans and plant and animal life are seriously impaired or threatened. These concentrations are representative of levels above which there is a serious case of contamination.

Groundwater concentrations have not been determined through a separate risk evaluation for contaminants, rather they have been derived from intervention values for soil.

Table 2-9 Dutch standards for soil and groundwater quality

Parameter	Soil (mg/kg dry matter)(1)		Groundwater (µg/L in solution)	
	Target Value	Intervention Value	Target Value	Intervention Value
Metals				
Antimony	3	15	-	20
Arsenic	29	55	10	60
Barium	160	625	50	625
Cadmium	0.8	12	0.4	6
Chromium	100	380	1	30
Cobalt	9	240	20	100
Copper	36	190	15	75
Mercury	0.3	10	0.05	0.3
Lead	85	530	15	75
Molybdenum	3	200	5	300
Nickel	35	210	15	75
Zinc	140	720	65	800
Inorganic Compounds				
Cyanides-free	1	20	5	1500
Cyanides-complex (pH<5) (2)	5	650	10	1500
Cyanides-complex (pH≥5)	5	50	10	1500
Thiocyanates (sum)	1	20	-	1500
Bromide (mg Br/l)	20	-	0.3 mg/L (3)	-
Chloride (mg Cl/l)	-	-	100 mg/L (3)	-
Fluoride (mg F/l)	500(4)	-	0.5 mg/L (3)	-
Aromatic Compounds				
Benzene	0.01	1	0.2	30
Ethyl benzene	0.03	50	4	150
Toluene	0.01	130	7	1000
Xylenes	0.1	25	0.2	70
Styrene (vinyl benzene)	0.3	100	6	300
Phenol	0.05	40	0.2	2000
Cresols (sum)	0.05	5	0.2	200
Catechol (o-dihydroxybenzene)	0.05	20	0.2	1250
Resorcinol (m-dihydroxybenzene)	0.05	10	0.2	600
Hydroquinone (p-dihydroxybenzene)	0.05	10	0.2	800
Polycyclic Aromatic Hydrocarbons (PAH)				
PAH (sum 10) (5,9)	1	40	-	
Naphthalene			0.01	70
Anthracene			0.0007*	5
Phenatrene			0.003*	5
Fluoranthene			0.003*	1
Benzo(a)anthracene			0.0001*	0.5

Table 2-9 Dutch standards for soil and groundwater quality

Parameter	Soil (mg/kg dry matter)(1)		Groundwater (µg/L in solution)	
	Target Value	Intervention Value	Target Value	Intervention Value
Chrysene			0.003*	0.2
Benzo(a)pyrene			0.0005*	0.05
benzo(ghi)perylene			0.0003*	0.05
benzo(k)fluoranthene			0.0004*	0.05
indeno(1,2,3-cd)pyrene			0.0004*	0.05
Chlorinated Hydrocarbons				
Vinyl chloride	0.01	0.1	0.01	5
Dichloromethane	0.4	10	0.01	1000
1,1-dichloroethane	0.02	15	7	900
1,2-dichloroethane	0.02	4	7	400
1,1-dichloroethene	0.1	0.3	0.01	10
1,2-dichloroethene (cis and trans)??	0.2	1	0.01	20
dichloropropane	0.002#	2	0.8	80
trichloromethane (chloroform)	0.02	10	6	400
1,1,1-trichloroethane	0.07	15	0.01	300
1,1,2-trichloroethane	0.4	10	0.01	130
Trichloroethene (Tri)	0.1	60	24	500
Tetrachloromethane (Tetra)	0.4	1	0.01	10
Tetrachloroethene (Per)	0.002	4	0.01	40
Chlorobenzenes (sum) (6,9)	0.03	30	-	-
Monochlorobenzene			7	180
Dichlorobenzenes			3	50
Trichlorobenzenes			0.01	10
Tetrachlorobenzenes			0.01	2.5
Pentachlorobenzene			0.003	1
Hexachlorobenzene			0.00009*	0.5
Chlorophenols (sum) (7,9)	0.01	10	-	-
Monochlorophenols (sum)			0.3	100
Dichlorophenols			0.2	30
Triclorophenols			0.03*	10
Tetracholorophenols			0.01*	10
Pentachlorophenol			0.04*	3
Chloronaphthalene	-	10	-	6
Monochloroaniline	0.005	50	-	30
Polychlorobiphenyls (sum 7) (8)	0.02	1	0.01*	0.01
EOX	0.3		-	

Notes :
** numeric value below the detection level/quantification level or measurement method is lacking*
 # These target values have not been tested in HANS. All the other values have been tested in HANS.
(1) *Values for soil/sediment have been expressed as the concentration in a standard soil (10% organic matter and 25% clay).*
(2) *Acidity: pH (0.01 M CaCl2). In order to determine whether pH is greater than or equal to 5, or less than 5, the 90 percentile of*

Table 2-9 Dutch standards for soil and groundwater quality

Parameter	Soil (mg/kg dry matter)(1)		Groundwater (µg/L in solution)	
	Target Value	Intervention Value	Target Value	Intervention Value

the measured values is taken.
(3) In areas subject to marine influence higher values occur naturally (salt and brackish water).
(4) Differentiation by clay content: (F) = 175 = 13L (L = % clay).
(5) PAH (sum of 10) here means the total of anthracene, benzo(a)anthracene, benzo(k) fluoroanthene, benzo(a)pyrene, chrysene, phenantrene, fluoroanthene, indeno(1,2,3-cd)pyrene, naphthalene and benzo(ghi)perylene.
(6) 'Chlorobenzenes (sum)' here means the total of all chlorobenzenes (mono-, di-, tri-, tetra-, penta- and hexachlorobenzene).
(7) 'Chlorophenols (sum)' here means the total of all chlorophenols (mono-, di-, tri-, tetra- and pentachlorophenol).
(8) In the case of the intervention value, 'polychlorobiphenyls (sum)' means the total of PCB 28, 52, 101, 118, 138, 153 and 180. For the target value it refers to the total excluding PCB 118.
(9) The values for the sum of polycyclic aromatic hydrocarbons, the sum of chlorophenols and the sum of chlorobenzenes in earth/sediment apply to the total concentration of the compounds belonging to the relevant category. If the contamination is due to only one compound of a category, the value used is the value for that compound. Where there are two or more compounds the value for the total of these compounds applies, etc. For earth/sediment, effects are directly additive (i.e. 1 mg of substance A has the same effect as 1 mg of substance B) and can be tested against an aggregate standard by summing the concentrations of the substances involved. In the case of groundwater, effects are indirectly additive and are expressed as a fraction of the individual intervention values (i.e. 0.5 of the intervention value of substance A has the same effect as 0.5 of the intervention value of substance B). This means that an addition formula must be used to determine whether an intervention value is exceeded. The intervention value for the sum of a group of substances is exceeded if:
{ ÓCi) / Ii > 1,
where: Ci = measured concentration of a substance in the group of substances in question Ii = intervention value for the group
Abbreviations:
mg/kg: milligrams per kilogram
µg/L: micrograms per litre
mg/L : milligrams per litre
Source:
Circular on target values and intervention values for soil remediation (DGEP, 2000)

2.3.7 Noise Limits

The RCER-2010only provides limits for Operational Noise. There are no specific criteria for equipment used outdoors referenced in noise limits provided by the World Bank standards. Therefore only operational noise limits provided by the RCER-2010 and World Bank guidelines are used as enforced thresholds and reference, respectively, for this project.

2.3.7.1 Operational Noise Limits

Noise criteria values are designed to protect the public and workers from physiological impairment that can result from excessive noise levels. The environmental noise standards that directly apply to the proposed plant are those from the RCJY Regulations. These standards are summarised in Table 2-10 in relation to noise from industrial plants at the property line.

Table 2-10 Maximum Allowable Noise Limits (dBA)

Zone	RCJY (1)	World Bank Guidelines(2)	
		Day(6)	Night(7)
Residential and Institutional(3)	50	55	45
Commercial(4)	65	70	70
Industrial(5)	75	70	70
Increase above background	--	+ 3	+ 3

Table 2-10 Maximum Allowable Noise Limits (dBA)

Zone	RCJY (1)	World Bank Guidelines(2)

Notes:
(1) Maximum Noise Measured at Property Line - Not to be exceeded >10% of Measured Time (dBA)
(2) Guidelines for petrochemical plants. Measurements are to be taken at noise receptors located outside the project property boundary. Maximum allowable log equivalent (hourly).
(3) A residential / institutional zone is an area where more than 50% of the properties are for accommodation. This includes schools, hospitals and mosques
(4) A commercial zone is an area where more than 50% of the properties are shops, offices, garages and trading premises
(5) An industrial zone is an area where more than 50% of the properties are for manufacturing facilities
(6)Day-time hours 07:00 to 22:00.
(7) Night-time hours 22:00 to 07:00.
(8) UK British Standard (BS:4142) difference between the background noise (dB LA90) and the noise from an industrial plant (dB LAeq)
(9) The impact would be of 'marginal significance'
(10) The impact would be such that 'complaints could be expected'
Sources:
Table 7 of the Royal Commission Environmental Regulations 2010 Volume I - Regulations And Standards. Environmental Control Department (RCER, 2010)
World Bank "Environmental, Health, and Safety General Guidelines, 2007" (WB, 2007a)

2.3.8 Hazardous Materials

A hazardous material is defined as any material in a quantity or concentration that, if improperly managed, may pose a hazard to public health or the environment. Hazardous materials may be solids, semi-solids, liquids or gases and include hazardous wastes. The use of PCBs in any facility is prohibited.

Data regarding the handling and storage of these hazardous materials shall be collected and submitted to the RCJY in the PAP.

The properties that characterize a hazardous waste are:

- Ignitable;
- Corrosive;
- Reactive;
- Toxic;
- Radioactive;
- Biohazard.

Environmental regulations of the RCJY relative to hazardous materials are divided into inventory; storage and handling; and transportation. Each one of these parts is described in the following subsections.

2.3.8.1 Hazardous Materials Inventory Regulations

Any facility utilizing or handling hazardous materials must retain the current Material Safety Data Sheets (MSDS). The Royal Commission considers hazardous materials to include raw materials / feed stocks, additives, fuels, solvents, lubricants, and any other chemicals or materials.

If the facility stores more than 50 kg of highly toxic materials and 5000 kg of other materials, it is necessary to develop and maintain a hazardous materials inventory summarizing the chemical and trade name of the hazardous materials, chemical composition, physical form, Temperature and true vapour pressure (kPa) for liquids and gases, storage quantities, associated hazard classification, and end use. This information must be reported annually to the RCJY.

2.3.8.2 Hazardous Materials Storage and Handling Regulations

The RCJY establishes that "Any hazardous material shall be managed in such a manner as to minimize to the fullest extent possible the potential for harm to human health or the environment". In that objective, a series of measures related to containers, storage areas, spill prevention, inspections, and monitoring must be followed. Those measures will be included in the EIA report.

Incompatible materials shall not be placed in common containment areas, the same containers or on the same vehicles. The list of materials that are presumed to be incompatible is provided in Table 4 of the RCER-2010

For the storing and handling of hazardous materials, the project shall maintain onsite adequate spill control equipment and chemicals to cope with realistic and probable emergencies associated with the hazardous materials. Secondary containment is necessary in areas of hazardous storage areas. In case of new facilities handling more than 5,000 kg of hazardous materials, the operator shall install, at least three permanent groundwater monitoring wells for obtaining representative samples prior to facility operation. Refer to Section 2.3.6 for further details.

Stockpiles of solid hazardous materials which may produce a hazardous leachate shall be stored, loaded and unloaded in impervious areas equipped with dikes, bunds, curbs or collection systems designed to retain leachate and precipitation.

Hazardous material storage areas shall be labelled including as a minimum the following:

- the type of material being stored within the area;
- identification of the hazard classification of the stored material in accordance with the U.S. National Fire Protection Association standard No. 704;
- the United Nations chemicals hazard classification.

For the handling of radioactive materials, the project shall obtain the necessary approvals from KSCST and a copy of the approval shall be submitted to the RC.

2.3.8.3 Hazardous Material Transportation Regulations

All the facilities shall ensure that:

- The transporters of hazardous materials shall be responsible for the safety of materials under transportation. This responsibility includes implementing emergency response contingency plans and any corrective action following accidental spill or release within Jubail Industrial City.

- The Operator of the facility needs to provide and maintain a hazard classification system in accordance with the UN chemical hazard classification system for the transport of dangerous goods. The RCJY has the right to obtain any information and data concerning details of transportation of hazardous materials.
- The transporter maintain proper containerization of the hazardous material, implement clear labelling of the hazardous material in Arabic and English and has the necessary documentation specified in RCER-2010, Section 4.4.3 which shall be kept in the vehicle during transportation.
- Drivers of transporting hazardous materials shall be trained in hazard awareness and emergency response procedures.

In case of an accident, the Royal Commission Industrial Security Department (ISD) and the Environmental Commission Department (ECD) should be notified immediately.

2.3.9 Waste Management

2.3.9.1 National Relevant Legislation

Environmental legislation relating to solid waste management is covered specifically by the RCJY Regulations. They describe the classification of wastes, the composition of the waste manifest, management and storage instructions for hazardous and non-hazardous wastes, record keeping, municipal and hazardous wastes disposal and transport requirements.

Moreover, the PME's regulations (PME, 2001) include within its Appendix 4, the Hazardous Waste Control Rules and Procedures (Document 01- 1423), which provides procedures to control the processes of production, transportation, storage, treatment and final disposal of hazardous wastes in the KSA.

2.3.9.2 Classification of Wastes

The classification and determination of the solid waste type and category will follow the RCER-2010. This regulation provides guidance to determine hazardous and non-hazardous waste classifications and their treatment/disposal method(s).

According to RCER-2010 waste can be classified into four categories, as is shown in Table 2-11. This constitutes a more detailed classification than that offered by the Basel Convention, which only classifies wastes into hazardous and non-hazardous wastes.

Table 2-11 Classification of Waste as defined by the RCJY

Waste Type	Definition
Hazardous Wastes	There are any solid, semi-solid, liquid, gaseous wastes or combination of such wastes, which may because of its quantity, concentration, physical or chemical characteristics, pose a hazard to human or environmental health and well being when improperly treated, stored, transported, disposed or otherwise managed. They shall also include: • All wastes with properties as defined in Section 4.1 of the RCER-2010 including commercial chemical products, off-specification products/chemicals, containers and spills residues. • Any waste if after application of the test TCLP(1) , they contain contaminant concentrations equal to or greater than those listed in Table 5-A of the RCER-2010. • Any wastes identified as hazardous by PME(2)
Non Hazardous Industrial Wastes	Any solid, liquid, semi-liquid or gaseous materials or wastes resulting from industrial, mining and agricultural operations and sludge from industrial, agricultural or mining, water supply treatment, wastewater treatment or air pollution control facilities, provided that they are not hazardous, municipal or inert wastes as otherwise defined in these regulations.
Municipal Wastes	They include garbage, refuse, food waste, office waste, waste vegetation and other decomposable material resulting from operation of residential, commercial, municipal, industrial or institutional establishments and from community activities.
Inert Wastes	Any wastes which are not biologically or chemically active in the natural environment, such as glass, concrete and brick materials, broken clay and manufactured rubber products.

Notes:
(1) *Extraction by Toxicity Characteristics Leachate Procedure (TCLP) as detailed in USEPA 40CFR Part 261 subpart D, section 261.35, dated 16 August 1991.*
(2) *Refer to "General Environmental Regulations and Rules for Implementation" of Presidency of Meteorology and Environment of Kingdom of Saudi Arabia; 15 October 2001 (PME, 2001).*
Source:
Royal Commission Environmental Regulations 2010 Volume I - Regulations And Standards. Environmental Control Department (RCER, 2010)

2.3.9.3 Toxicity Concentration Limits

The limits for solid waste leachate concentration are set by the RCJY in Table 5A of the RCER-2010 Wastes containing leachable contaminants exceeding the concentrations specified in the mentioned table are defined as hazardous.

2.3.9.4 Waste Treatments and Disposal

According to RCER-2010 industrial and hazardous wastes generated within the industrial city of Jubail shall be treated or disposed of in RCJY approved waste treatment and disposal facilities located inside the industrial city. Non-hazardous industrial and municipal wastes shall be disposed of in a Class II single lined landfill; whereas hazardous wastes need to be disposed of in a special Class I double lined landfill. In the specific case that the generated waste contains organic compounds above the levels specified in Section 5.4.4 of the RCER-2010 they will need to be disposed of by incineration.

Any facility or installation generating industrial, hazardous and municipal wastes will need to deliver to the RCJY a waste audit form, which will vary slightly depending on the type of waste.

It should be noted that there are requirements to be met on the frequency of collection and delivery of wastes, which are specified in Section 5.6.5 of the RCER-2010

2.3.9.5 Wastes Transportation Regulations

Waste Manifest Regulations

Before transportation of hazardous and non-hazardous industrial wastes either for recycle, reuse, treatment, storage or disposal, a waste manifest certifying that the wastes are properly classified, described, packaged, marked and labelled shall be completed and signed. The manifest needs to contain the following information:

- A unique, sequential number;
- Details of the generator, the transporter and the disposer;
- For non-hazardous waste, a description of the waste including compositional data;
- For hazardous waste, a detailed chemical and physical analysis, safety and hazardous material handling precautions, and hazard class materials;
- Proposed recycle, reuse, treatment or disposal method;
- The total quantity of waste being transported, and the number and type of containers being transported to the designated disposal facility.

It is also necessary to obtain the RCJY's approval for transporting waste to the designated waste management/disposal facility, and the transporter's signature on the manifest. No wastes shall be transported outside the boundary of Jubail Industrial City without Royal Commission prior approval.

The generator of the waste and disposal facility shall assume responsibility for the waste until it is disposed of permanently in an environmentally safe and sound manner.

Hazardous Waste Transportation

No wastes generated within Jubail Industrial City can be transported outside the boundary of the city for recycle, reuse, recovery or treatment without the RCJY approval and in compliance with PME regulations. Waste generators shall ensure that all wastes are placed in waste compatible, secured and clearly labelled containers that properly contain the waste to prevent any spill or leakage during transportation. Transporters need to be registered within the Royal Commission to transport hazardous and non-hazardous industrial wastes.

In the event that the waste disposal facility cannot accept the waste, the transporter shall return the waste to the generator within 48 hours and shall inform the RCJY immediately.

2.4 International Conventions

The KSA is party to several international conventions, including:

The *Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution, 1978* (hereafter the Convention), is the framework on which the majority of KSA's environmental control relating to the marine environment is based.

The *Regional Organisation for the Protection of the Marine Environment* (ROPME), which was established by the Convention in 1978, has established protocols for protecting the marine environment. Those relevant to the RTIP are:

- 1998, Protocol on the Control of Marine Transboundary Movements and Disposal of Hazardous Wastes and Other Wastes.

- 1978, Protocol Concerning Regional Co-operation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency.

On the regional and international levels, the KSA was a founder of ROPME, and the regional authority for *the Preservation of the Environment of the Red Sea and the Gulf of Aden* (PERSGA). It has also ratified the Vienna Convention and the Montreal Protocol for the protection of the ozone layer, and the Basel Convention on toxic substances. It also acceded to the UN framework convention on climate change as well as the convention to combat desertification. The KSA has participated in the activities of the IPCC [International Protocol on Climate Change] since its inception.

Saudi Arabia is also a contracting party to the World Heritage Convention and to the Action Plan for the Protection and Development of the Marine Environment and Coastal Areas.

Specific conventions and protocols potentially of relevance to this project are discussed in more detail in the following sections.

2.4.1 Basel Convention and Montreal Protocol

2.4.1.1 Control of Transboundary Movements of Hazardous Wastes

The Basel Convention of 1989 on the Control of Transboundary Movements of Hazardous Wastes and their Disposal is an international treaty designed to reduce the movements of hazardous waste between nations, and specifically to prevent transfer of hazardous waste from developed to less developed countries (LDCs). Saudi Arabia ratified this Convention in 1990 (Basel Convention, 1990).

The accord prevents signatories' states from accepting hazardous wastes from non-signatory countries and stipulates record keeping requirements, including a prior informed consent, before such wastes can be moved from one signatory country to another for transport, disposal or recycling.

Petrochemical operations will inevitably generate hazardous wastes which, if exported, would come within the remit of the Basel convention, Annex I identifies hazardous wastes such as: *"Waste oils / water, hydrocarbons/ water mixtures; and Residues arising from industrial waste disposal operations"* (Basel Convention, 1989). Article 2 includes definitions such as wastes, management, transboundary movement, disposal, approved site or facility, generator, disposer, illegal traffic etc.

2.4.1.2 Protection of the Ozone Layer

The 1985 Vienna Convention for the Protection of the Ozone Layer (UNEP, 1985) is a multilateral environmental agreement. It was agreed upon in Vienna in 1985 and entered into force in 1987. It acts as a framework for the international efforts to protect the ozone layer. However, it does not include legally binding reduction goals for the use of CFCs, the main chemical agents causing ozone depletion. These are laid out in the accompanying Montreal Protocol.

The 1987 Montreal Protocol on substances that deplete the ozone layer and its Amendments (UNEP, 1987) is an international treaty designed to protect the ozone layer by phasing out the production of a number of substances believed to be responsible for ozone depletion. It has undergone seven revisions, in 1990 (London), 1991 (Nairobi), 1992 (Copenhagen), 1993 (Bangkok), 1995 (Vienna), 1997 (Montreal), and 1999 (Beijing). Due to its widespread adoption and implementation it has been hailed as an example of exceptional international cooperation. Article 5 (UNEP, 2009) countries (including Saudi Arabia) committed themselves to joining the global effort to restore the depleted ozone layer.

Although the use of ODS is not expected in the RTIP, this protocol must be taken into account in the case that they become necessary, as the RCER establishes that: "the operator of a facility within the industrial cities shall phase out CFC's and halons or any other substances defined in the Montreal Protocol which are capable of depleting stratospheric ozone".

2.4.2 Results of Earth Summit

In 1992, a meeting of world leaders took place at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil. A set of agreements were signed at the Summit, including three binding agreements: **Agenda 21**, a programme run by the United Nations (UN) related to sustainable development; the **Convention on Climate Change**, which targets industrial and other emissions of greenhouse gases such as carbon dioxide and in turn led to the Kyoto Protocol; and the **Convention on Biological Diversity**.

2.4.2.1 Agenda 21 and UNCCD

The KSA adopted the plan of action and principles outlined in Agenda 21. In 1994, the KSA National Agenda 21, formulated by the MCE, was approved by Saudi Arabia's Council of Ministers. Commitment to these principles was re-affirmed at the World Summit on Sustainable Development (WSSD), held in Johannesburg, South Africa, in 2002.

The United Nations Convention to Combat Desertification (UNCCD) was the first legally binding agreement negotiated in direct response to Agenda 21. KSA became a Party to the Convention in 1997.

The Gulf countries area is particularly concerned about the issue of desertification and serious drought. Beyond environmental effects, desertification could affect economic growth and social development.

2.4.2.2 UNFCCC, United Nations Framework Convention on Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty produced at the UNCED, informally known as the Earth Summit (see Section 2.4.2). The treaty is aimed at reducing emissions of greenhouse gas in order to combat global warming. KSA became a Party to the Convention in 1994.

One of its first achievements was to establish a national greenhouse gas inventory, as a count of greenhouse gas (GHG) emissions and removals. The treaty originally set a voluntary "non-binding aim" to reduce atmospheric concentrations of greenhouse gases with the goal of "preventing dangerous anthropogenic interference with Earth's climate system." The treaty included provisions for updates (called "protocols") that would set mandatory emission limits. The principal update is the Kyoto Protocol, which has become much better known than the UNFCCC itself. It contains legally binding emissions targets for Annex I (developed) countries for the post-2000 period. Saudi Arabia became a signatory to the Kyoto Protocol in May 2005.

The agreement is currently being reviewed. Talks on commitments for the post-2012 period are on-going. In December 2009, Copenhagen held *The 2009 United Nations Climate Change Conference*, commonly known as the Copenhagen Summit. As a result, the Copenhagen Accord (UNFCCC, 2009b) was agreed in order to establish a framework for climate change mitigation beyond 2012 endorsing the continuation of the Kyoto Protocol. It should be noted that the accord was “taken note of” and not “adopted”. The Accord recognizes that the climate change is one of the greatest challenges of our time and that actions should be taken to keep the global temperature increases to below 2°C.

January 31, 2010 marked the deadline for parties to the Copenhagen Accord to submit their respective plans for reducing greenhouse gas emissions. The KSA has not yet responded whether it will or will not engage with the Copenhagen Accord (US CAN, 2010).

The Convention on Biological Diversity is the first global agreement on the conservation and sustainable use of biological diversity. More than 187 countries have ratified the agreement. The KSA became a Party to the Convention in 2001.

The Convention has three main goals:

- Conservation of biodiversity;
- Sustainable use of the components of biodiversity; and

- Sharing the benefits arising from the commercial and other utilization of genetic resources in a fair and equitable way.

It links traditional conservation efforts to the economic goal of using biological resources sustainably. Contrary to the UNFCCC, the Convention is legally binding; countries that join it are obliged to implement its provisions.

2.4.3 Arab or Islamic Perspective on Environment Legislation

Some declarations and statements have been made by the whole Arab or Islamic region. The Abu Dhabi Declaration on Environment and Energy (2003) and the Abu Dhabi Declaration on Arab Corporate Environmental Responsibility (2007) have been considered as the most relevant for the RTIP at Jubail project. The Abu Dhabi Declaration on Environment and Energy of 2003 applies directly to the Oil & Gas sector through the following statements:

- "Aware of the existing challenges and opportunities and the contribution of the energy sector in achieving sustainable development in the Arab world, and the importance of oil and gas as a strategic wealth, as well as of the potential offered by renewable energy resources in the Arab world which could be utilized";

- "Reaffirming the importance of using renewable energy resources and adopting environmentally sound technologies including the use of advanced and cleaner fossil fuel technologies, the sustainable use of conventional energy resources which would meet the increasing need of long range energy supplies to achieve sustainable development without obstructing opportunities for development at the regional level for oil-producing countries";

- "Reaffirming the commitment of the Arab oil-producing countries to make available energy resources to all countries, and stressing that their oil revenues still contribute to economic development and environmental protection in both industrial and developing countries worldwide, and further noting that they promote international co-operation by providing assistance in the form of loans and grants for development projects and alleviation of poverty in other countries";

- "Reaffirming the necessity of promoting financial and political support to achieve the required balance for development of renewable energies on one hand and conventional energy on the other hand, encouraging the adoption of cleaner fossil energy technologies to contribute in supporting sustainable development and avoiding any negative impact on the economies of the countries whose income depend on oil and gas".

In November 2007, Arab business leaders, environmentalist and United Nations experts, attended The Arab Corporate Environmental Responsibility Summit, which concluded with a declaration on corporate environmental responsibility and cleaner production. The declaration states that the Arab business leaders committed to reduce the use of energy and water in the production of their products by 20 per cent, by the year 2012 from base year 2002. They also committed to complying with national and international environmental regulations applicable to their operations and business. In addition, they agreed to conduct internal environmental reviews and periodically report on the results. In order to achieve the commitments of the declaration, they requested the United Nations Environment Programme (UNEP), the World

Business Council for Sustainable Development (WBCSD) and the Arab Forum for Environment and Development (AFED) to assist corporations operating in the Arab region by providing them with technical assistance, training and relevant information relating to best practices in achieving corporate environmental responsibility (Arab Environment Watch, 2007).

2.5 International Guidelines and Policies

This section references other international guidelines and policies relevant to the project, such as the Principles of sustainable development set out in the United Nations Brundtland Report, the World Bank/IFC guidelines and the Equator Principles, which form the basis for this EIA.

2.5.1 United Nations Brundtland Report

The Brundtland Report, also known as *"Our Common Future"* is the outcome of the World Commission on Environment and Development (WCED) in 1987. Published by an international group of politicians, civil servants and experts on the environment and development, the report provided a key statement on sustainable development, defining it as:

"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987).

The report highlighted three fundamental components to sustainable development: environmental protection, economic growth and social equity. The environment should be conserved and our resource base enhanced, by gradually changing the ways in which we develop and use technologies. Developing nations must be allowed to meet their basic needs of employment, food, energy, water and sanitation. If this is to be done in a sustainable manner, then there is a definite need for a sustainable level of population. Economic growth should be revived and developing nations should be allowed a growth of equal quality to the developed nations.

The RTIP at Jubail will incorporate the principles of sustainable development as laid down in the United Nations Brundtland Report, 1987, and as required by the RCER-2010

2.5.2 Equator Principles Signatories

The Equator Principles (Equator Principles, 2006) established in June 2003, updated in July 2006, acknowledge the role project financing plays in promoting responsible environmental stewardship and development in a socially responsible manner. The principles are a set of voluntary guidelines developed by leading banks that serve as a framework for financial institutions for the managing of social and environmental issues.

The EPFIs will only provide loans to projects that conform to Principles 1 to 9 as follows (in addition to the general annual reporting requirement of Principle 10):

- Principle 1: Review and Categorization (in accordance with IFC environmental and social screening criteria);
- Principle 2: Social and Environmental Assessment;

- Principle 3: Applicable Social and Environmental Standards;
- Principle 4: Action Plan and Management System;
- Principle 5: Consultation and Disclosure;
- Principle 6: Grievance Mechanism;
- Principle 7: Independent Review;
- Principle 8: Covenants;
- Principle 9: Independent Monitoring and Reporting;
- Principle 10: EPFI Reporting.

The adopting EPFIs view these Principles as a financial industry benchmark for developing individual, internal social and environmental policies, procedures and practices. As with all internal policies, these Principles do not create any rights in, or liability to, any person, public or private.

It is worth nothing that, the Equator Principles are under Strategic Review. It is expected that the Equator Principles update would be published later in 2011 following the conclusion of the IFC Performance Standards Review and Update process (see 2.5.3).

2.5.3 The World Bank and IFC

The World Bank and the IFC, its private sector lender organization, as recognised EPFIs, have adopted the "Operational Policies 4.01 Environmental Assessment" (IFC, 2007; published in 1998 [updated in March, 2007]) when considering whether or not a project is a suitable candidate for receiving financing, with regard to environmental aspects. These policies involve taking into consideration aspects regarding the natural environment, such as the obligations of the country under relevant environmental treaties and agreements.

The World Bank Group applies environmental and social standards and guidelines to all the projects it finances to minimize their impact on the environment and affected communities. The Performance Standards on Social and Environmental Sustainability (IFC, 2007) establishes eight defined standards that the client is to meet through the life of an IFC investment. Examples of these Performance Standards are: Social and Environmental Assessment and Management Systems, Labour and Working Conditions and Biodiversity Conservation and Sustainable Natural Resource Management.

IFC launched a review and update process of the Sustainability Framework, which includes the Policy and Performance Standards on Social and Environmental Sustainability, on September, 2009. The updated framework is expected to come into effect in 2011 (final version to be presented in May). Although the final version was not available at the time of writing this EIA, Draft Version 2 of the updated Performance Standards has been taken into consideration for this EIA (IFC 2010).

Additionally, the World Bank Group has developed within its general EHS guidelines the "Environmental, Health, and Safety (EHS) General Guidelines, 2007". The guidelines are designed to provide project developers, financiers, facility managers, and other decision makers with relevant industry background and technical information. They include information relevant to this project such as development and production activities; transportation activities including pipelines; other facilities including compressor stations and storage facilities; ancillary and support operators; and decommissioning. These guidelines are completed with the "Environmental, Health and Safety Guidelines for Large Volume Petroleum-based Organic Chemicals Manufacturing, 2007" for the production of the following products: lower olefins from virgin naphtha, natural gas, and gas oil, aromatics and oxygenated, nitrogenated and halogenated compounds, and establish emission and effluent guidelines for this sector.

2.5.4 Organization for Economic Co-operation and Development (OECD)

The forerunner of the OECD was the Organisation for European Economic Co-operation (OEEC). OECD took over from OEEC in 1961 after the Convention on the Organisation for Economic Co-operation was held in Paris in 14th December 1960. Since then, its mission has been (OECD, 2010) to achieve sustainable economic growth and employment by, amongst other means, contributing to the expansion of world trade in accordance with a non-discriminatory basis.

Becoming a member of OECD is not something that is automatically open to applicant countries. The member countries of the Organisation, meeting in its governing body (the Council), decide whether a country should be invited to join OECD and on what conditions. Although Saudi Arabia is not a member of the OECD, the RTIP at Jubail will use as far as is practicable, the recommendations and standards developed by the OECD committee, as reference guidelines, for keeping the project within international sustainable development standards.

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4 AIR QUALITY & METEOROLOGY BASELINE

4.1 Introduction

This section presents a summary of the local climate and meteorology and an assessment of the existing ambient air quality conditions in the vicinity of the RTIP at Jubail. The established meteorological and air quality baseline conditions are used to predict the impacts from air emissions (point and fugitive sources), that will be presented in section 12 Air Quality Impact Assessment. Impacts will be considered for the various stages of development of the project, including construction, commissioning, operations and decommissioning and under upset and selected emergency conditions.

4.2 Methodology

4.2.1 Overview

Meteorological and air quality data for this study have been provided by the Royal Commission for Jubail and Yanbu (RCJY). The RCJY collect meteorological and air quality data from a network of seven ambient air quality and meteorological stations located within Jubail Industrial City (JIC). Air Quality Monitoring Station number 6 (AQMS#6), located next to the future RTIP Site, has been selected to provide data for this study.

The meteorological data provided by RCJY for AQMS #6 at Jubail will be combined with surface data from Trinity Consultants for the King Fahd International Airport at Dammam (hereinafter Dammam Airport) station as the regional 'off-site' station to provide a meteorological data set for the dispersion modelling. Dammam Airport is located approximately 57 km south-east of the RTIP site. Thus data from Dammam Airport have also been analysed and presented in this baseline section as being representative of regional meteorology.

Figure 4-1 shows the position of the AQMS #6 with respect to the RTIP Complex.

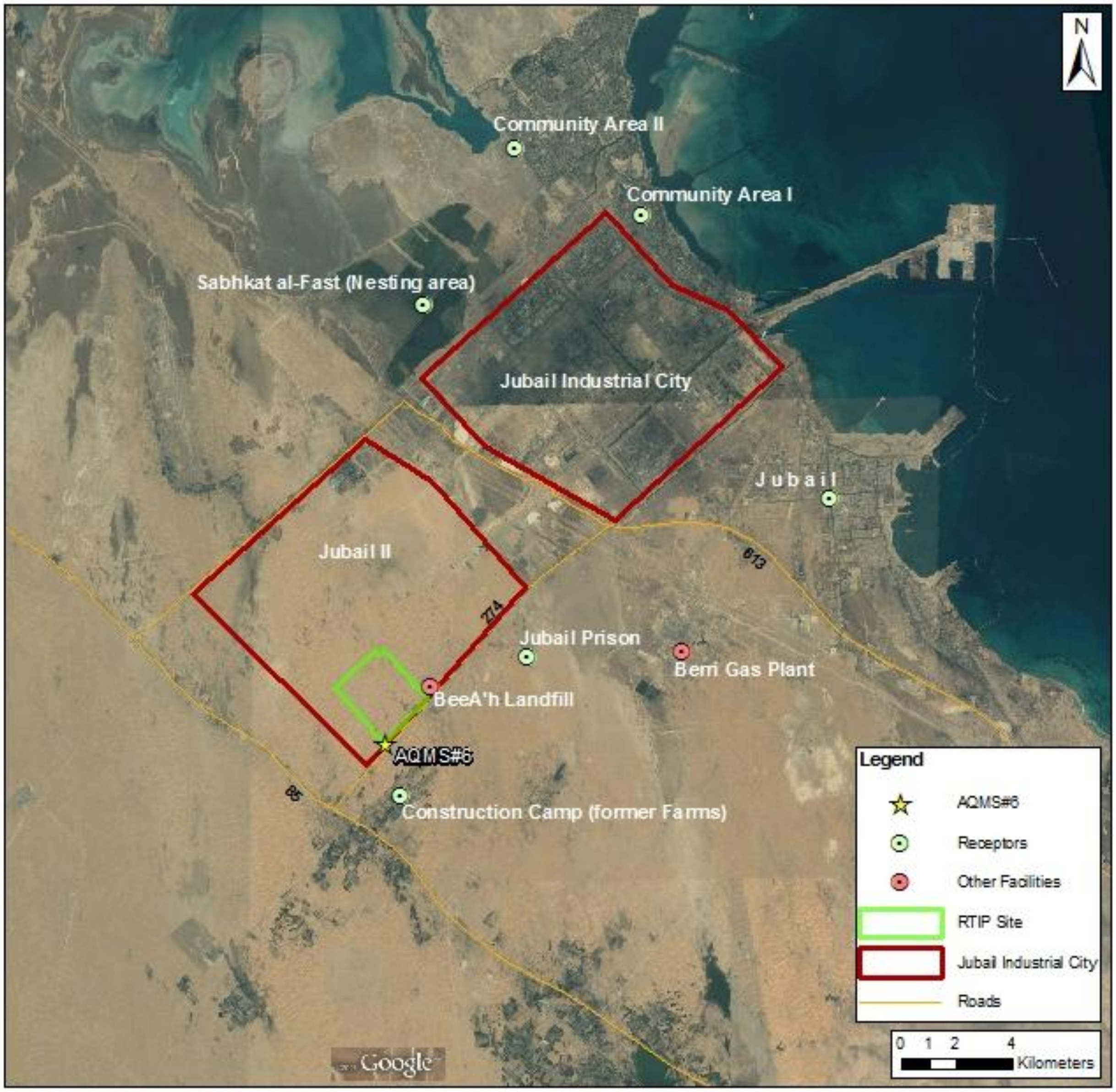

Figure 4-1 RCJY AQMS #6

Source: Google Earth 2006 image modified by CH2M HILL

Coordinates of the station in the Universal Transverse Mercator (UTM) system are displayed in Table 4-1.

Table 4-1 AQMS #6 Coordinates

X (m)	Y (m)
349,410	2,978,520
Source: *RCJY, 2010a*	

4.2.2 Meteorology Methodology

The concentration of a pollutant in the atmosphere is dependent on the amount of pollutant released, the physical characteristics of the emission source and the ability of the atmosphere to transport and disperse the pollutant. The main determinants of transport and dispersion are wind speed and direction, atmospheric stability or turbulence, ambient air temperature and the existence of inversion layers. Certain photo-chemically active pollutants such as Nitrogen Oxides (NOx) and Reactive Organic Gas (ROG) react under the presence of sunlight and can cause elevated levels of ground-level ozone, or smog. Warm temperatures accelerate the creation of ground-level ozone and can exacerbate conditions of poor air quality, particularly under stagnant conditions and conditions which limit vertical mixing.

Hourly meteorological data from RCJY AQMS #6 for the years 2005 to 2009 have been statistically summarized and are included in the sections below.

In order to supplement and assess the meteorological data captured by this station, meteorological data from Dammam Airport have been acquired from the U.S. National Oceanic and Atmospheric Administration (NOAA, 2009). Hourly measurements of surface air temperature, wind speed, wind direction and relative humidity were obtained over a five year period from the beginning of 2004 to the end of 2008. Monthly averages for the selected parameters have been calculated over the five year time period.

A comparison of the long-term Dammam Airport data to the AQMS #6 data (presented in the following sections) demonstrates that the meteorological conditions at Dammam are similar to those at the RTIP Complex and that the data are suitable and appropriate for the assessment of potential air quality impacts resulting from the construction and operation of the RTIP Complex.

4.2.3 Ambient Air Quality Methodology

The proposed RTIP Complex will be built in an undeveloped property, occupying an area of 576 hectares (ha) in Jubail Industrial City (JIC) II. JIC II is located 3km west from the Jubail Industrial City (JIC).

The RTIP site is surrounded by the following:

- Jubail Export Refinery (SARTOP) under construction to the north-east;
- Jubail II undeveloped areas to the west and south;
- Road 274 to the south-east;
- BeeA'h industrial / chemical landfill facility to the east corner of the RTIP Site.

Additionally, other sources of air pollutants in the area, located predominantly to the north-east, are the existing 176 industries at JIC as well as infrastructure support utilities north-east from the site, and the Berri Gas Plant.

The nearest residential areas to the RTIP complex are included in Table 4-2 below.

Table 4-2 Residential Areas

Residential Area	Distance *(km)
Construction camp	1.5 (South)
Jubail Prison	3.8 (East)
Jubail Old Town	13 (East North-East)
Jubail Community area I	17 (North-East)
Jubail Community area II	20 (North North-East)

Source:
CH2M HILL estimations based on satellite images
Note:
**Approximate distances.*

Hourly ambient air monitoring data from AQMS# 6 for NO_X, CO, SO_2, O_3, Total Hydrocarbons, $PM_{2.5}$ and PM_{10}, from 1st January to 31st December 2009 were selected to establish the ambient air quality conditions in the area.

It is understood that the station uses continuous analysers that meet international requirements, including USEPA specifications, but details of the equipment, their operation and calibration and auditing and quality control of the data were not available.

4.3 Baseline Conditions

4.3.1 Meteorology

Eastern Saudi Arabia has a subtropical desert climate because of its geographical situation in global patterns of atmospheric circulation. The climate in the Arabian Gulf is hot and dry. The air temperature averages 37 ºC in August and 12 ºC in January. The average rainfall is 50 mm per year and evaporation rates are high (MEPA, 1987).

4.3.1.1 Air Temperature & Humidity

The temperature records for Dammam Airport during the years 2004 to 2008 are displayed in Table 4-3 and show that the hottest months are June, July and August, and the coldest December, January and February.

Data from AQMS#6 for the year 2005 to 2009, as included in Table 4-3, show that the maximum temperatures were also recorded in June, July and August, and the coldest in December, January and February. Thus AQMS #6 has a diurnal and seasonal temperature range similar to that of Dammam, with temperatures slightly lower than those at Dammam.

Table 4-3 Mean Daily Extreme Temperatures at Dammam Airport and AQMS #6

Month	Dammam Airport		AQMS#6	
	Mean Daily Maximum (°C)	Mean Daily Minimum (°C)	Mean Daily Maximum (°C)	Mean Daily Minimum (°C)
January	20.0	10.0	19.1	9.2
February	22.9	11.8	23.3	12.4
March	29.4	15.2	28.9	15.7
April	33.8	20.0	33.3	21.0
May	40.1	25.2	40.6	24.5
June	43.1	28.0	43.4	27.5
July	44.2	29.7	44.4	29.1
August	44.0	29.0	45.1	30.2
September	41.0	25.4	41.5	26.8
October	36.7	21.5	37.3	22.6
November	28.9	16.7	28.4	17.2
December	21.7	10.4	22.1	11.5

Note:
Temperatures recorded at Dammam Airport station between 2004 and 2008
Temperature recorded at AQMS #6 between 2005 and 2009
Source:
NOAA, 2009
RCJY, 2010

Table 4-4 shows the mean relative humidity. The highest relative humidity during the years 2004 to 2008 at Dammam and AQMS #6 was recorded in January and February. The lowest relative humidity was recorded in June and July.

Relative humidity is slightly higher at AQMS #6, most likely due to the proximity of the AQMS #6, to the coast.

Table 4-4 Mean Relative Humidity at Dammam Airport and AQMS #6

Month	Dammam Airport		AQMS#6	
	Mean Daily Maximum (%)	Mean Daily Minimum (%)	Mean Daily Maximum (%)	Mean Daily Minimum (%)
January	79.1	34.6	89.8	40.4
February	76.2	29.6	90.0	31.6
March	63.6	16.8	79.7	18.7

Table 4-4 Mean Relative Humidity at Dammam Airport and AQMS #6

Month	Dammam Airport		AQMS#6	
	Mean Daily Maximum (%)	Mean Daily Minimum (%)	Mean Daily Maximum (%)	Mean Daily Minimum (%)
April	60.1	15.4	70.8	19.6
May	47.2	9.26	57.7	10.3
June	34.5	7.00	36.2	6.0
July	41.6	8.81	43.4	8.6
August	55.0	11.0	70.8	10.8
September	63.3	12.7	76.6	13.8
October	75.1	15.7	88.5	17.7
November	73.7	25.8	87.1	32.7
December	74.2	31.5	88.8	38.5

Note:
Relative humidity recorded at Dammam Airport station between 2004 and 2008
Relative humidity recorded at AQMS #6 between 2005 and 2009
Source:
NOAA, 2009
RCJY, 2010

4.3.1.2 Winds

Wind speed and direction are the most important variables for predicting potential air quality impacts from stationary emission sources. A comparison of wind data measured at Dammam Airport and AQMS #6 illustrates a strong correlation between the two data sets.

Wind speed data recorded at Dammam Airport station from 2004 to 2008 is shown in Table 4-5. The highest wind speeds at both locations were recorded in June while the lowest wind speeds were recorded in October. Wind speed is generally slightly higher at AQMS #6.

Table 4-5 Wind Speed Data at Dammam Airport and AQMS #6

Month	Dammam Airport		AQMS #6	
	Mean Daily Wind Speed (m/s)	Mean Daily Maximum (m/s)	Mean Daily Wind Speed (m/s)	Mean Daily Maximum (m/s)
January	4.47	7.61	4.85	7.57
February	4.69	7.89	5.24	8.49
March	4.52	8.19	4.96	8.55
April	4.46	8.49	4.72	8.48

Table 4-5 Wind Speed Data at Dammam Airport and AQMS #6

Month	Dammam Airport		AQMS #6	
	Mean Daily Wind Speed (m/s)	Mean Daily Maximum (m/s)	Mean Daily Wind Speed (m/s)	Mean Daily Maximum (m/s)
May	4.56	8.71	5.02	9.67
June	5.34	9.84	5.88	9.91
July	4.74	9.03	5.11	9.48
August	3.80	8.08	4.00	7.66
September	3.64	7.39	4.06	7.47
October	3.32	6.63	3.68	6.57
November	4.19	7.05	4.42	7.21
December	4.48	7.09	4.56	6.90

Note:
Wind speeds recorded at Dammam Airport station between 2004 and 2008
Wind speed recorded at AQMS #6 between 2005 and 2009
Source:
NOAA, 2009
RCJY, 2010

Finally, a comparison of the wind speed, direction and frequency of occurrence at Dammam Airport station from 2004 to 2008 and 2005 to 2009 at AQMS #6, is presented graphically as a wind rose in Figure 5-2. This wind rose indicates that the predominant wind directions at both stations are in both cases from the north with secondary peaks from the west north-west to the north-west.

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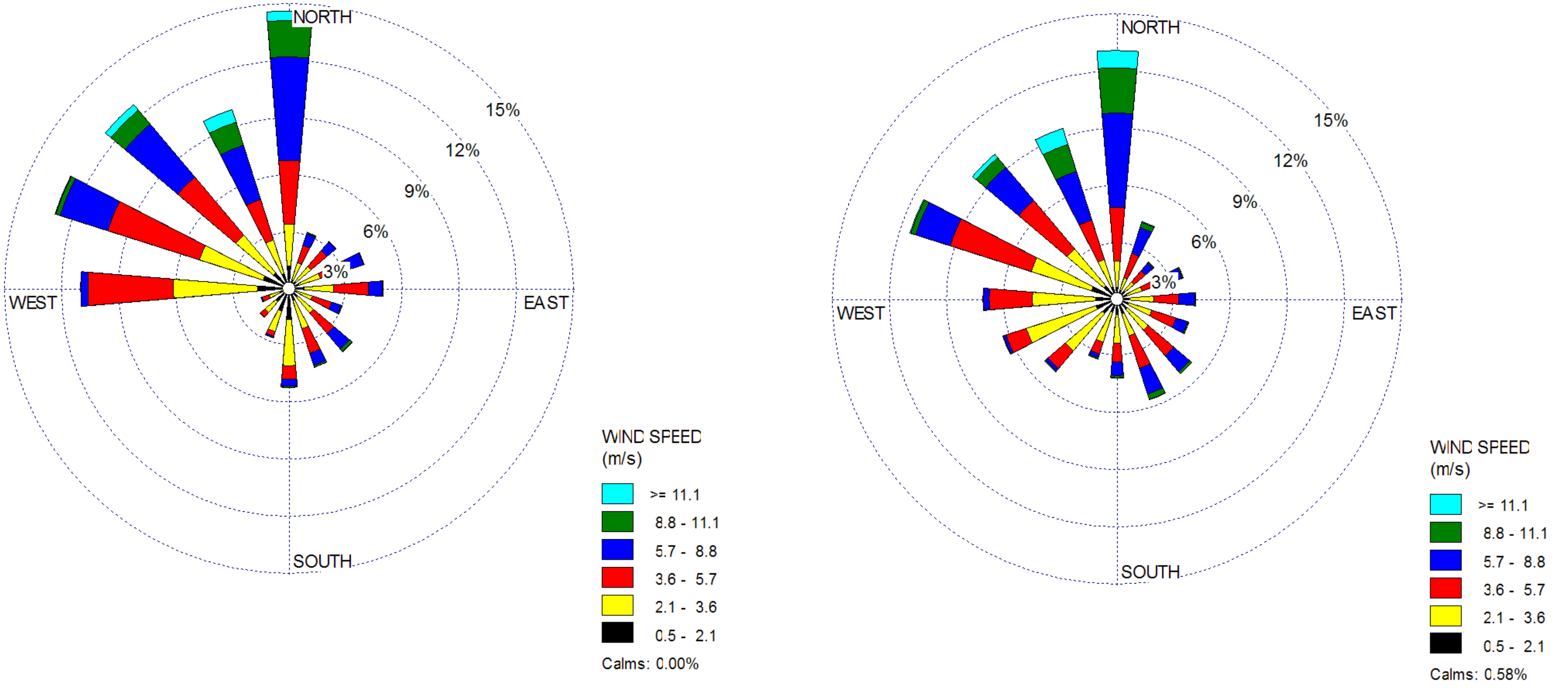

Figure 4-2 Combined Wind Roses 2004 to 2008 for Dammam Airport (left) and 2005 to 2009 for AQMS #6 (right) (Wind speed values in m/s)

4.3.1.3 Precipitation

Saudi Arabia is reported to be one of the driest countries in the world. However, the annual rainfall is not evenly distributed throughout the year and indeed Saudi Arabia is characterized as a country with erratic seasonal rainfall distribution; 97% of the annual precipitation can be recorded in one day, with implications for drainage requirements and runoff protection. No rainfall data are available for Dammam Airport during the period 2004 to 2008. From the data recorded at AQMS #6 during years 2005 to 2009, the months with the highest rainfall were December and January with mean values of 0.12 and 0.11mm, respectively.

4.3.2 Ambient Air Quality

Locally measured ambient air quality data are required to establish baseline conditions for the impact assessment, for both the construction and operational stages. Hourly data received from the RCJY are hourly arithmetic mean values for the following parameters:

- Particulate Matter (PM_{10} and $PM_{2.5}$);
- Nitric Oxide (NO), Nitrogen Oxides (NOx) and Nitrogen Dioxide (NO_2);
- Carbon Monoxide (CO);
- Ozone (O_3);
- Sulphur Dioxide (SO_2); and
- Total Hydrocarbons (THC).

One year of hourly data from 1st January to 31st December 2009, has been considered representative of the ambient air quality conditions at the RTIP complex area. The data recovery for each of the parameters during that period is as follows.

Table 4-6 Ambient Air Parameters at AQMS #6 (2009)

Parameter	Data Capture	
	Valid Hours	% Data Recovery (1)
Nitrogen Dioxide	6,176	70.5%
Sulphur Dioxide	7,813	89.2%
Ozone	7,895	90.1%
Carbon Monoxide	8,061	92.0%
$PM_{2.5}$ (2)	5,776	65.9%
PM_{10}	7,761	88.6%
THC	6,027	68.8%

Notes:
(1) Unless otherwise indicated, % data recovery based on 8760 total hours in the monitoring period
(2) Because of the low data capture for year 2009, PM2.5 data have calculated as an average of 2007 and 2009 data

Data recovery was assessed by comparing the number of hours of valid data provided with the total number of hours in that year. As none of the RCJY or Presidency of Meteorology and the Environment (PME) Standards stipulates data recovery criteria, the data completeness has been evaluated as per the US EPA Ambient Air Monitoring Guidelines for Prevention of Significant

Deterioration (PSD), which establishes a minimum of 80% of data recovery in air quality monitoring. Thus, data recovery for SO_2, Ozone, CO and PM_{10} was high during 2009, exceeding the 80% threshold while data recovery was below the threshold for NO_2, $PM_{2.5}$ and THC.

The hourly arithmetic mean values from monthly MS Excel files were extracted and incorporated into composite files and analysed using the statistical functions of MS Excel. The analysis was undertaken according to the averaging periods and statistical parameters specified in the regulatory section for ambient air quality. Rolling arithmetic means were used whenever possible. The use of rolling arithmetic means ensures a more complete analysis of the data. For example, if a peak concentration occurred at the end of a 24-hour period and the start of the next one, then discrete averaging would separate this event between two individual 24-hour periods. A rolling arithmetic mean will, however, ensure that the event is included in multiple 24-hourly arithmetic means according to the duration of the event.

4.3.2.1 Comparison of Statistical Data Analysis & Assessment Criteria

Section 2.3.4.1 of the Policy, Legal, and Administrative Framework, Section 2 presents a compilation of national and international ambient air quality standards, limits and guidelines for selected parameters (Table 2-1). These criteria are derived from the national and international legislation of the RCJY, PME and the International Finance Corporation/World Bank (IFC/WB) (World Bank, 2007a). The IFC/WB guidelines are generally more stringent than the other referenced standards and are regarded as a long-term objective. The monitored parameters are presented in Table 4-7 along with the criteria and averaging times for Royal Commission Environmental Regulations (RCER), PME, and IFC/WB standards. The IFC indicates that project emissions have to be compared with national legislated standards, or in their absence with WHO Ambient Air Quality Guidelines, or other international standards. Since national regulations exist, project emissions and background levels will just be compared with RCER standards. Therefore, grey cells indicate that the baseline exceeds the RCER ambient air quality standards for the corresponding parameter and averaging time period. The baseline levels for the different parameters have been calculated as defined according to the RCER Standards. Thus the SO_2, NO_2, CO, Ozone 1hr average concentrations and CO 8hr average concentrations were calculated by first selecting the 3rd highest values in each 30 day calendar period and then selecting the highest of the 12 preselected values. PM_{10}, $PM_{2.5}$ 24hr average and Ozone 8hr average were calculated as the highest of the respective values within the year of data. SO_2 24hr average was calculated as the 2nd highest of the 24hr average values within the 12 months of data. This approach to calculate background levels is an acceptable methodology practiced in US, as indicated in the Guideline on Air Quality Models (40 CFR 51, Appendix W).

The AQMS #6 monitoring results are compared with the standards and criteria, and are discussed in the context of the natural background concentrations for each parameter as documented in the literature. All gaseous parameters are reported in $\mu g/m^3$ for ease of comparison with standards; with the exception of carbon monoxide which is reported in mg/m^3. Conversion factors from ppb volumetric measurements (where applicable) are those cited by the World Health Organization (WHO, 2005).

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Table 4-7 Ambient Air Quality Baseline for 2009

Parameter	Ambient Air Concentration			
	AQMS #6	Ambient Air Quality Standard/Guideline		
		RCER	PME	IFC/WB
Nitrogen Dioxide [μg/m³]				
Maximum 1-Hour Average	222	---	---	200
1-Hour Average	212	660 (6)	660 (6)	---
Annual Average	28.1	100	100 (5)	40
Sulphur Dioxide [μg/m³]				
Maximum 10-Minutes Average	---	---	---	500
Maximum 1-Hour Average	151	---	---	---
1-Hour Average	44.3	730 (6)	730 (6)	---
Maximum 24-Hour Average	32.7	---	----	20 (2) 125 (Interim target-1) (3) 50 (Interim target-2 (3)
24-Hour Average	30.2	365 (7)	365 (7)	---
Annual Average	8.75	80	80 (5)	---
Ozone [μg/m³]				
Maximum 1-Hour Average	364	---	---	---
1-Hour Average	252	235 (6)	295 (6)	---
Maximum 8-Hour Average	221	160	---	160 (Interim target-1)(3)(4) 100 (2)(4)
Carbon Monoxide [mg/m³]				
Maximum 15-Minutes Average	---	---	---	100
Maximum 30-Minutes Average	---	---	---	60
Maximum 1-Hour Average	4.68	---	---	30
1-Hour Average	3.45	40 mg/m³ (6)	40 mg/m³ (6)	--
Maximum 8-Hour Average	3.25	---	---	10
8-Hour Average	1.14	10 mg/m³ (6)	10 mg/m³ (6)	--
$PM_{2.5}$ [μg/m³] (8)				
Maximum 24-hour Average	950	35	---	75 (Interim target-1) (3) 50 (Interim target-2) (3) 37.5 (Interim target-3) (3) 25 (2)
Annual Average	185	15	---	35 (Interim target-1) (3) 25 (Interim target-2) (3) 15 (Interim target-3) (3) 10 (2)

Table 4-7 Ambient Air Quality Baseline for 2009

Parameter	Ambient Air Concentration			
	AQMS #6	Ambient Air Quality Standard/Guideline		
		RCER	PME	IFC/WB
PM_{10} [µg/m³] (1)				
Maximum 24-Hour Average	4,077	150	340 (7)	150 (Interim target-1)(3) 100 (Interim target-2)(3) 75 (Interim target-3)(3) 50 (2)
Annual Average	305	50	80 (5)	70 (Interim target-1)(3) 50 (Interim target-2)(3) 30 (Interim target-3)(3) 20 (2)
THC				
Maximum 1-Hour Average (ppm)	45.4	---	---	---

Shaded cells indicate that the corresponding RCER standard has been exceeded
Notes:
(1) Suspended particulate matter below 10 microns in size.
(2) Guideline
(3) Interim targets are provided in recognition of the need of a staged approach to achieving the recommended guidelines.
(4) 8 hours daily maximum
(5) Maximum concentration not to be exceeded, no exceptions allowed
(6) Maximum concentration not to be exceeded more than twice per 30 days.
(7) Maximum concentration not to be exceeded more than once per year.
(8) Inhalable particulates: < 2.5 microns equivalent aerodynamic diameter
Sources:
Environmental Protection Standards. Presidency of Meteorology and Environment. KSA, (PME, 2001)
International Finance Corporation (IFC)/World Bank (WB), 2007. Environmental, Health, and Safety General Guidelines, April 2007. (World Bank, 2007a)
Royal Commission Environmental Regulations (RCER), Volume I, 2010 (RCER, 2010)

4.3.2.2 Nitrogen Dioxide

In relation to both RCER and PME criteria nitrogen dioxide concentrations were well within concentration limits during the monitoring period.

In the general urban environment the principal sources of oxides of nitrogen are traffic and to a lesser extent industry, shipping and households. In industrial cities it is expected that point source discharges from the industries contribute a higher proportion of the oxides of nitrogen present in the ambient air, with the exception of roadside locations. Combustion sources mainly emit NO which spontaneously oxidises to NO_2 when exposed to air. Nitrogen dioxide is generally found in the atmosphere in close association with other primary pollutants, including ultra fine particles. It is also a precursor of ozone and therefore co-exists in photochemically generated oxidant pollution. Nitrogen dioxide is itself toxic, and its concentrations are often strongly correlated with those of other toxic pollutants (WHO, 2005).

Maximum 30 minute and maximum 24-hour concentrations of nitrogen dioxide have been reported downwind of industrial and urban areas around the world at concentrations of up to 940 µg/m³ and 400 µg/m³, respectively. Urban levels have found to vary with time of day, season and meteorological factors. Typically, urban data is affected by traffic related peaks, which correspond to the rush-hour emissions of nitric oxide which are oxidised in the atmosphere to nitrogen dioxide (WHO, 2000).

4.3.2.3 Sulphur Dioxide

Sulphur dioxide concentrations were well within the RCER and PME and standards for all criteria and averaging time periods.

Data on concentrations of sulphur dioxide elsewhere in Europe are based either on national monitoring networks, which tend to be concentrated in urban areas, or on cooperative programmes for the study of long-range transport of pollutants. During the period 2000-2005, the highest sulphur dioxide concentrations were recorded in some of the megacities in developing countries, although some large urban areas have fairly low concentrations. Typical annual average concentrations of sulphur dioxide in urban areas in developing countries are 40–80 $\mu g/m^3$, those in North America and Europe are 10–30 $\mu g/m^3$, and in cities in the EU 6–35 $\mu g/m^3$ (WHO, 2005).

4.3.2.4 Ozone

Ozone is a secondary pollutant formed in the lower atmosphere by the action of sunlight (insolation) on nitrogen oxides and Volatile Organic Compounds (VOCs). Under strong summer insolation, it seems likely that coastal recirculations become "large natural photochemical reactors" where most of the oxides of nitrogen emissions and other ozone precursors are transformed into oxidants, acidic compounds, aerosols and ozone, potentially resulting in the exceedance of thresholds. Ozone is effectively generated at a regional scale from emissions from both industrial and urban areas, and a proportion of the observed ozone at any one location may result from advection within the recirculating air masses. This complicates data interpretation from the air monitoring stations and means that interpretation of pollution episodes need to be considered on a regional basis in addition to the impact of localised sources.

Ozone concentrations for the 1-hour averaging period exceeded the RCER but not the PME standards, whilst ozone concentrations for the 8-hour averaging period exceeded the RCER standard.

Generally, ozone concentrations are lower in urban centres than in the suburbs, mainly as a result of the scavenging of ozone by nitric oxide originating from traffic.

Diurnal variations in ozone vary according to location and the balance of the various ozone formation, transport and decomposition mechanisms. In the early morning, some time is required for the development of photochemical reactions. Ozone peaks typically occur in the afternoon. During the night ozone is scavenged by nitric oxide.

4.3.2.5 Carbon Monoxide

Carbon monoxide concentrations for the 1-hour and 8-hour averaging periods for AQMS#6, were well below the national (RCER and PME).

Natural background levels of carbon monoxide range between 0.06 and 0.14 mg/m^3. Concentrations in urban areas typically depend on weather and traffic density. They also vary greatly over time and with distance from source. The 8-hour mean concentrations are generally <20 mg/m^3. However, maximum 8-hour mean values of up to 60 mg/m^3 have been occasionally observed (WHO, 2000).

4.3.2.6 Particulate Matter ($PM_{2.5}$)

Ambient air concentrations of $PM_{2.5}$ greatly exceeded RCER and PME for respective criteria of the 24-hour and annual averaging periods. As with PM_{10}, it is difficult to distinguish between industrial and anthropogenic sources of $PM_{2.5}$ particulate matter. In arid, desert climates very high $PM_{2.5}$ concentrations can be caused by sand storms and periods of high wind speed.

$PM_{2.5}$ is an important indicator of risk to health from particulate pollution, and might also be a better indicator than PM_{10} for anthropogenic suspended particles in many areas. Natural sources of particulate matter can contribute significantly to $PM_{2.5}$ although less than they contribute to PM_{10}. The urban background concentrations of $PM_{2.5}$ in Europe are around 15–20 µg/m^3, and annual averages at traffic sites range between 20–30 µg/m^3 (WHO, 2005).

4.3.2.7 Particulate Matter (PM_{10})

Airborne particulate matter is a complex mixture of organic and inorganic constituents. The smaller particles represent the greatest risk since they are able to enter the lower respiratory tract. PM_{10} (particulate matter < 10 µm in size) is regarded by the USEPA as an indicator of health related particles. The natural background level as an annual arithmetic mean, in rural areas in Europe is generally between 50 and 150 µg/m^3 (measured gravimetrically). The annual arithmetic mean values are within the observed range for European population centres. In Asia the annual average concentrations are between 35 and 220 µg/m^3 (WHO, 2005).

Ambient air concentrations of PM_{10} greatly exceeded RCER and PME standards for all averaging time periods. For PM_{10}, it is difficult to distinguish between industrial and anthropogenic sources of particulate matter. In arid, desert climates very high PM_{10} concentrations can be caused by sand storms and periods of high wind speed; however, the issue of natural wind blown dust makes interpretation of this ambient data difficult.

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5 ONSHORE PHYSICAL ENVIRONMENT

5.1 Introduction

This section presents the findings of the onshore physical environment baseline survey undertaken at the RTIP Main Site and the RTIP Port Facility. The baseline information collected will be used to assist in the evaluation of the potential impacts on the onshore physical environment during the construction, commissioning, operation, and decommissioning of the facility. The onshore physical impacts assessment is included in Section 13 of this report.

The onshore physical environment survey comprised a study of regional and local geology and hydrogeology, and a baseline characterisation of the soil and groundwater quality. Conceptual groundwater transport modelling of the localised groundwater flow system will be carried out as part of the onshore physical impact assessment in Section 13.

5.2 Literature Review

An information and literature search was carried out to obtain relevant information for the onshore physical environment survey. A number of general publications, existing studies and reports were reviewed with particular reference to geology and hydrogeology. Studies undertaken at the site have been used as a key source of information relating to the current environmental conditions present at the RTIP Site. Remaining information and documentation was obtained from consultations and relevant websites.

Sources of information are quoted as applicable in the report and have been listed in Section 25, References.

5.3 Baseline Conditions

5.3.1 Introduction

Two geotechnical site investigations were carried out between July and October 2010 then between February and March 2011 and a Phase I Environmental Site Assessment (ESA) and a Phase II ESA have been undertaken in January and March 2011, respectively, at both the RTIP Main Site and the RTIP Port Facility. This allowed characterising the subsurface soil and groundwater, and preliminarily identifying any potential areas of environmental concern. Table 5-1 provides a summary of the field investigations carried out and an overview of the scope of work undertaken.

Table 5-1 Geotechnical and Environmental Investigations Carried out at the RTIP Site

Work Undertaken	Date	Description of field Work
Geotechnical Investigation (Kellogg Brown & Root Saudi Ltd, 2010)	July – October 2010	Geotechnical investigation to establish soil engineering properties for the main RTIP Site at Jubail II. Site work included the completion of 93 boreholes, testing of soil samples to establish geotechnical properties and analysis of groundwater samples.
Geotechnical Investigation (Kellogg Brown & Root Saudi Ltd, 2011)	Feb – March 2011	Geotechnical investigation to establish soil engineering properties for the RTIP Port Facility Site at King Fahd Industrial Port (KFIP).
Phase I Environmental Site Assessment (Arensco, 2011)	January 2011	Phase I Environmental Site Assessment comprising a site reconnaissance and desk top based environmental study.
Phase II Environmental Site Assessment Report – RTIP Main Site (Arensco, 2011)	March 2011	Phase II Environmental Site Assessment comprising of an intrusive soil and groundwater investigation.

The findings of the desktop and investigation work undertaken at the site are used here to develop the onshore physical baseline understanding. This will allow a comparison of the current baseline data to projected data relating to future operations and to evaluate any existing and potential environmental impacts that may result from the development of the RTIP Site.

5.3.2 Geology

5.3.2.1 Regional Geology

The geological formations of Saudi Arabia range in age from the Precambrian to the Present, forming part of a larger unit, known as the Arabian Plate, which includes the Arabian Peninsula. The principal geological events responsible for major landforms in the Arabian Peninsula include the separation of the Arabian and African plates as the Red Sea began to form around 20 million years ago (Miocene Epoch).

In general, Saudi Arabia is composed of four major geological units:

- Arabian Shield (the Shield);
- Arabian Platform (the Platform);
- Red Sea Rift Basin;
- Harrats.

The RTIP site is located within the Arabian Platform, which consists of Phanerozoic sedimentary rocks overlying the older Precambrian rocks that form the Shield. The Platform covers almost two thirds of the surface of Saudi Arabia, lying north and east of the Arabian Shield and extending eastward into the Arabian Gulf. The majority of the country oil reserves are present in the formations that comprise the Platform. The width of the platform varies between 100 km along the southern and western side of the Rub' al Khali basin, to 400 km across the Qatar peninsula (Vincent, 2008). Sediments of the Arabian Platform lie to the east of the Shield and rest on the buried Arabian Plate. The platform is largely a horizontal area with strata dipping very gently away from the edge of the Arabian Shield forming topography with gently sloping ridges of tilted sedimentary strata (Vincent, 2008). Quaternary deposits in the Arabian Peninsula comprise recent aeolian sands (often forming dunes) and deposits comprising marine sands and silts.

The Arabian Peninsula can be grouped into five broad geomorphologic categories, only one of which applies to the RTIP site (Coastal Plain and Lowland).

- Coastal Plain and Lowland comprises the coastal plains and low hills bordering the Red Sea, Gulf of Aden, and the Arabian Gulf;
- The Tertiary and Quaternary Harrat (lava field) are regions covered by Cenozoic flood basalt forming flat areas of incised terrain difficult to traverse;
- Sand Seas consist of large low lying areas of wind-blown sand, the most famous of which is the Ar Rub al Khali (the Empty Quarter) desert formation;
- Mountains exist around the margin of the Arabian Peninsula, including those that rise up to the lip of the Red Sea and Gulf of Aden escarpment at elevations of 2000-3600 m, mountains farther inland in Asir and Yemen, and mountains in Oman;
- Much of the Peninsula consists of vast regions of nearly flat Plateaus and Plains (pediments) covered by an irregular veneer of weathered rock, sand, and gravel, that are interrupted by hills and ridges remaining from incomplete erosion and levelling of the underlying bedrock by wind and water.

Figure **5-1** provides an overview of the main physiographic regions of the Arabian Peninsula.

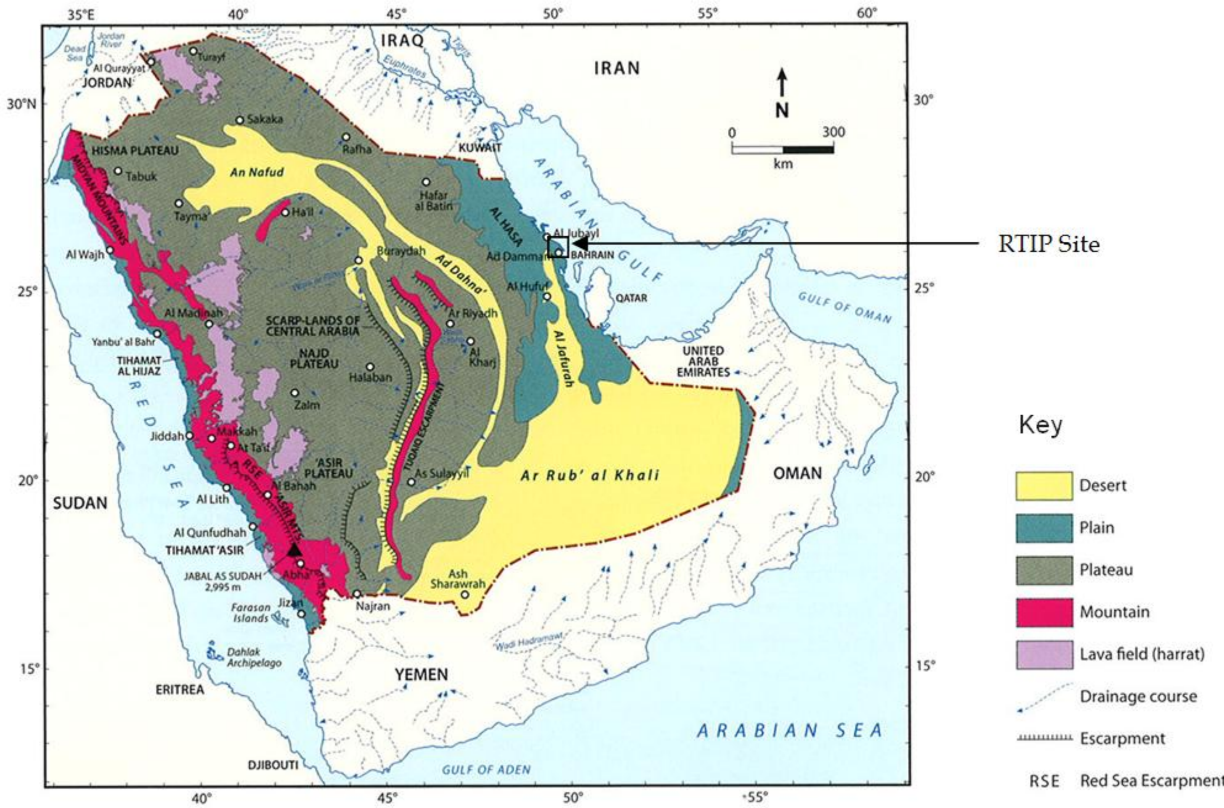

Figure 5-1 Main Physiographic Regions of Saudi Arabia

Source: Saudi Geological Society, 2009

5.3.2.2 Local Geology

The RTIP project site is located in the Jubail II Industrial City, south east of the city of Jubail and within the Arabian platform on the eastern coast of Saudi Arabia. The geology of this area consists of unconsolidated Quaternary sand and gravel blanket, with areas of sand dunes and outcrops of limestone and calcareous sandstones.

A geotechnical study of the RTIP site was undertaken by Osaimi Engineering Office (OEO), under contract to Kellogg Brown & Root Saudi Ltd., between August and September 2010. A total of 93 boreholes were drilled across the RTIP site (Figure 5-2) to a maximum depth of approximately 50 m below ground surface (mBGS). Based on the findings of this geotechnical study, the stratigraphy throughout the site consists of three lithological successions, as summarised in Table 5-2.

Table 5-2 Key Typical Geological Units Encountered Beneath the RTIP Main Project Site

Lithology	Extent of Unit (mBGS)
Loose Aeolian dune sands	From 0.0 to 0.5
Medium dense light brown sand	From 0.5 to 12.0 (variable throughout the site)
Dense to very dense light grey silty, sometimes clayey sand	12.0 – 50.0

Standard penetration tests (SPT) were undertaken by OEO to establish geotechnical engineering properties of the soil throughout the site. Soils were classified into two strength classifications:

1. Medium dense to very dense granular soils – consisting of poorly graded gravel with varying amounts of silt and clay or graded / poorly graded sands with varying amounts of sand and clay.

2. Dense to very dense fine grained soils – consisting of sandy silt, silty clay and lean clay.

Elevations on site ranged between approximately 13.0 to 23.0 m above sea level.

5.3.3 Groundwater

5.3.3.1 Regional

Situated in one of the most arid regions on earth, Saudi Arabia suffers from a severe lack of water. Due to continued population and industrial growth, water management is an important part of ensuring future sustainability. Demand for drinking water is largely met by desalinated water production. Irrigation water for agriculture has however largely been met through supply from extensive aquifer systems.

Groundwater resources in Saudi Arabia can be found in two main aquifer systems: shallow alluvial aquifers or deep sedimentary aquifers.

Shallow alluvial aquifers form in alluvial deposits along main *wadi* channels or flood plains of drainage basins. The shallow alluvial aquifers often form the only renewable water source. Coastal alluvial aquifers situated along the Gulf are often subject to salt water intrusion, owing largely to extensive groundwater abstraction for industrial and agricultural supplies which limits the potential for potable supply.

Deep groundwater resources can be found in eight large tectonic basins of sedimentary rocks. These groundwater resources form deep aquifers that store water and that are thousands of years old. The eight primary sedimentary aquifers are summarised in Table **5-3**.

Table 5-3 Primary Sedimentary Aquifers of Saudi Arabia

Aquifer	Geographical Location	Geological Time Scale (Oldest to Youngest)	Rock Formation
Wajid	West: East of Bishah and Jizan	Cambrian	Sandstone
Saq	North: Extending south from Tabuk to Riyadh	Cambrian	Sandstone
Tabuk	North: Outcropping at Tabuk and extending south to Buraydah	Silurian / Ordovician	Sandstone / shale
Minjur and Dhruma	East: Extending along the Gulf from Qaysumah to Dharan and inland to Sharawrah	Jurassic	Limestone and Sandstone
Wasiah-Biyadh	East: As above	Cretaceous	Sandstone
Umm Er Radhuma (UER)	East: As above	Paleocene	Limestone
Dammam	East: As above	Eocene	Limestone, marl and shale
Neogene	East: As above	Neogene	Carbonate
Source: Edgell, 1997			

Water suitable for domestic consumption is stored in the Saq, Tabuk, Wajid and Neogene Aquifers. The other primary aquifers require treatment prior to supply, as water tends to be saturated with calcium and magnesium, often with high levels of sulphate.

Jubail II is within the eastern province, with the Neogene, Dammam and UER aquifers being the principal aquifer units. Salinity in the UER formation is the highest in the eastern part of the aquifer system, ranging from 4,000 to 120,000 milligram (mg) NaCl/L (Al Bassam, 1997). The upper Dammam and Neogene formations contain fresh groundwater and have been heavily exploited for domestic, industrial and agricultural supply. Figure 5-3 provides a conceptual overview of the aquifer systems of the eastern province.

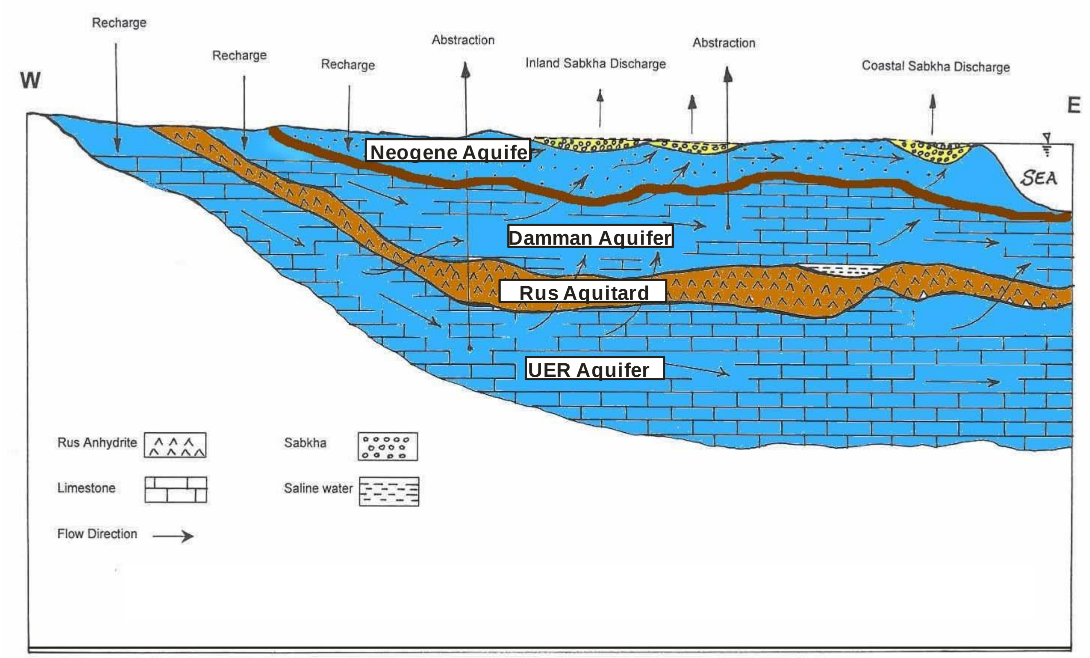

Figure 5-3 Conceptual Model of the Groundwater System, Eastern Province

Source: Saudi Water Association, 2006

Recharge

Saudi Arabia receives very little precipitation, except in the highland of Asir, where average annual rainfall is between 300 to 500 mm. Average rainfall within most areas of Saudi Arabia is 100 mm. Average annual rainfall in Jubail is less than 100 mm (Royal Commission for Jubail and Yanbu, 2010). When it does occur, rainfall is largely due to intense storms and lasts for short periods of time. Due to the aridity, soils have low organic matter, high percolation rate, high salinity and low water holding capacity (Alshamarry, 2007).

Recharge for all the deeper aquifers is estimated to be at a very limited 2.7 billion cubic metres per year (Uitto and Schneider, 1997). Recharge levels as a percentage of precipitation is low, often less than 20%.

5.3.3.2 Local

Shallow alluvial aquifers in the area of Jubail are typically between 2.0 and 5.0 mBGS, which is deeper than the shallow aquifers found closer to the coastline. Groundwater is generally of poor quality (moderately saline/brackish, high chloride content and containing sulphates). Local variations in groundwater quality are influenced by the proximity of the RTIP site to the Arabian Gulf and embayment.

It is recognised that the three main productive coastal aquifers in the province have been subjected to excessive water pumping to satisfy the growing demands of fast growing developments in all sectors, resulting in salt water intrusion close to the coastline and hence a rise in groundwater salinity, and decline in water levels.

Local Potentiometric Surface & Groundwater Flow

During the geotechnical study undertaken by OEO, the groundwater table at the time of drilling beneath the RTIP site was encountered at depths between 2.2 m to 12.5 mBGS. Piezometers were installed in 18 boreholes across the project site and monitored on a weekly basis throughout the period of the fieldwork (from July to October 2010). Groundwater fluctuation was observed to be between 0.20 to 0.50 mBGS, which is likely to be the common pattern across the entire project site.

Pumping tests were undertaken by OEO during October 2010 to provide localised characteristics of the groundwater bearing units beneath the RTIP site for the purpose of conceptual modelling of the shallow groundwater flow system. Interpretation of the pump test results provided the aquifer characteristics which are detailed in Section 13 of this EIA Report. Hydraulic tests were carried out in a series of new monitoring wells (MW1-MW6, as presented on Figure 5-2) and observation wells installed specifically for this purpose. The aquifer tests comprised of one aquifer constant rate pumping test and 6 piezometer slug tests (using bailers).

The aquifer pump test was undertaken by measuring groundwater drawdown and recovery in the pumped well (PW1) and groundwater drawdown and recovery in each of the observation wells (OW1-OW3). Pumping was undertaken using a small power pump for a total of 6 hours.

The piezometer bail tests were undertaken by hand bailing groundwater from each monitoring well. Groundwater levels were monitored with a transducer, and by manual measurements.

Initial groundwater elevation measurements taken at the start of the aquifer pump tests have been included in Figure 5-4 and have been contoured to show the potentiometric surface area, and the inferred groundwater flow direction is shown with arrows.

The results of the pumping tests undertaken are included as Appendix D-1.

Abstractions

No information regarding groundwater abstraction from wells could be sourced for the aquifer systems beneath the RTIP site. It is assumed that given the industrial nature of the surrounding areas, any groundwater abstraction local to the Site will be used as industrial process water and not abstraction for drinking; however this has not been confirmed because no official database is maintained and no anecdotal evidence was available to determine the presence or absence of abstraction wells in the area.

During the Phase I ESA, abstraction from 3 shallow ponds was observed (Arensco, 2011). Small surface pumps were being used to fill tankers, which are assumed to be supplying the nearby construction sites.

5.3.4 Surface Water

5.3.4.1 Regional

Due to the arid nature of Saudi Arabia, surface water features are scarce. There are very few permanent natural streams or rivers (Vincent, 2008). A man made river system called Ar Ha'ir was completed in 1976 and flows for around 60 km in length, replenished by treated water from the sewage system in Riyadh. Ar Ha'ir is located approximately 400km southwest of the study area, 25km south of Riyadh. Run-off occurs mainly in the form of intermittent flash floods with greater levels in the higher regions of Hijaz and Asir compared to the Gulf region. As much as 60% of Saudi Arabia's run off is channelled to the coast from the Asir escarpment (Vincent, 2008). Run-off is generally directed towards flood irrigation.

Springs provide an important surface water resource often present in *wadi* areas or limestone fractures. A study conducted by Bazuhair and Hussain (1990) identified five key types of spring as summarised in Table 5-4.

Table 5-4 Key Spring Systems Identified in Saudi Arabia

Spring Type	Formation
Alluvial	form in Quaternary wadi deposits
Sub-Basaltic	form in lava sheets
Fracture Springs	form in joints or faults in bedrock
Solution Opening Springs	form in limestone formations
Interstratified springs	form in thin aquicludes

Source:
Bazuhair and Hussain, 1990

Within the east of Saudi Arabia, many of the springs are no longer running due to excessive pumping of groundwater.

5.3.4.2 Local

Three small surface water ponds were observed within the boundary of the RTIP site during the Phase I ESA undertaken by Arensco. It appears these ponds are currently being used as water sources to fill tankers supplying the nearby substation construction site. It is assumed these ponds are man-made as a result of exposing the shallow groundwater table and are not naturally occurring.

5.3.5 Environmental Site Assessment (ESA)

Two phases of environmental site investigation were undertaken on both the main RTIP site and the RTIP Port Facility.

5.3.5.1 Main Site

The first phase was part of the OEO geotechnical investigation and was primarily a geotechnical investigation. It is herein referred to as the Preliminary Site Assessment (PSA). The preliminary assessment comprised a basic suite of soil and groundwater analyses to aid foundation design and provide preliminary environmental site data. The second phase of site assessment was the main Phase II ESA which comprised of a comprehensive soil and groundwater investigation across the site.

Preliminary Site Assessment Scope

The following section summarises the findings of this preliminary ESA for the RTIP Main site. The following scope of work was undertaken:

- Collection of shallow (<4.5 mBGS) soil samples from 12 boreholes;
- Collection of groundwater samples from the same 12 boreholes;
- Selected soil and water sample analysis at the laboratory analysis. Samples were selected from borehole numbers 7, 11, 24, 30, 41, 45, 49, 62, 65, 78, 83 and 90 which can be seen in Figure 5-2.

The chemical analysis of the soils was limited to pH, sulphate (SO_4), chloride (Cl) and carbonate (CO_3). Reportedly, there was no visible contamination identified during the site walkovers, the sampling and analysis plan was designed to provide an even spatial distribution of samples across the RTIP site. Soil samples were generally taken at 1.5, 3.0 and 4.5 mBGS for each of the boring locations. In total, 27 soil samples were collected and analysed for pH, SO_4, CO_3 and Cl.

Depth to groundwater ranges between 2.2m to 12.5m across the site. Twelve groundwater samples taken from the same 12 boreholes as the soil samples were analysed for the following parameters:

- Gasoline Range Organics (GRO) for the carbon banding C6 to C10);
- Diesel Range Organics (DRO) for the carbon banding C11 to C28);
- Polycyclic Aromatic Hydrocarbons (PAH);
- Metals (As, Ba, Cd, Cu, Cr, Pb, Hg, Ni, Ti, V & Zn);
- Cyanide (Free).

Phase II Site Assessment Scope

The objective of the Phase II ESA was to evaluate soil and groundwater quality over the RTIP Main site. The following tasks were completed as part of the Phase II ESA:

- Advancement of 36 test borings to a maximum depth of 8m to evaluate soil and groundwater contamination;
- Collection of two soil samples and one groundwater sample from each boring;
- Collection of 10 quality control (QC) samples;
- At the RTIP Post facility, the following tasks were undertaken:
  - Collection of a total of ten (10) soil samples from 5 boreholes;
  - Collection of three (3) seawater samples;
  - Collection of one (1) duplicate QC sample;

Both soil and groundwater samples were analysed for a comprehensive suite of parameters including PAH, Total Petroleum Hydrocarbons (TPH), Metals (As, Ba, Cd, Cr, Cu, Pb, Hg, Ni, Sn, V, Zn), pH and cyanide (free).

Criteria Used

In the absence of Kingdom of Saudi Arabia (KSA) regulatory standards for groundwater quality, the groundwater chemistry data collected as part of this baseline study have been compared to the Intervention Values published by the Netherlands Ministry of Housing, Spatial Planning and the Environment (2000) to evaluate the significance of the impacts detected. Although these Intervention Values have no statutory basis in KSA, they were selected because they allow a conservative overall assessment of the suitability of the land for unrestricted use.

Soil Quality – Chemical Analysis

During the Preliminary Site Assessment, only a limited range of soil analyses were undertaken as part of the geotechnical investigation. Table 5-5 provides a summary of the soil chemical analyses from this investigation.

Table 5-5 PSA Soil Chemistry Summary

Analyte	Range
pH	7.2 – 7.7
Sulphates	<0.002 – 0.012 (%)
Chlorides	0.002 – 0.023 (%)
Carbonates	<1.0 – 4.0 (%)

During the Phase II Site Assessment of the Main Site, a total of seventy six (76) soil samples, including four (4) duplicate QC samples were collected from thirty six (36) test locations from two different depths (10 cm and 100 cm). These samples were analyzed for various parameters, as described in the Phase II Scope section above. The analytical result of soil samples are provided in the Phase II Arensco Report. In summary, the following results were reported:

- pH ranged from 8.6 to 9.9. The samples were more alkaline than the PSA results;
- Non-metallic inorganic parameter such as cyanide (free) were below detection limits in all samples;
- Arsenic (As), cadmium (Cd), copper (Cu), lead (Pb), mercury (Hg), zinc (Zn) and tin (Sn) were below detection limits in all soil samples (Table 5-6);
- Barium (Ba), chromium (Cr) and nickel (Ni) and vanadium (V) were detected in many soil samples but were significantly below the Dutch Intervention screening criteria;
- None of the organic associated contaminants such as PAH and TPH fractions (C6 – C40) were below detection limits in all soil samples.

Based on the laboratory analytical report from the Phase II Site Assessment, (Arensco, 2011), it is considered that the reported analytical soil concentrations represent the current local background concentrations within the sandy soil down to maximum 1m depth.

Table 5-6 Phase II Site Assessment Soil Chemistry

Metals		Dutch Intervention Value	Concentration in Soils	
Name	Unit		Minimum	Maximum
Arsenic	mg/kg	55.000	<5	<5
Barium	mg/kg	625.000	<10	19
Cadmium	mg/kg	12.000	<1	<1
Chromium	mg/kg	380.000	4	8
Copper	mg/kg	190.000	<5	<5
Lead	mg/kg	530.000	<5	<5
Mercury	mg/kg	10.000	<0.1	<0.1
Nickel	mg/kg	210.000	3	11
Tin	mg/kg	900.000	<5	<5
Vanadium	mg/kg	250.000	<5	12
Zinc	mg/kg	720.000	<5	<5

Note: < value indicates value below lab method detection limit

Groundwater Quality – Chemical Analysis

This section provides an interpretation of the analytical results obtained for the groundwater samples collected during the PSA and the Phase II Site Assessment July 2010 to March 2011 to establish a baseline for the RTIP Site.

The results from the PSA groundwater sampling (Appendix D-2) indicated below detectable levels of TPH, PAH and major metals. Therefore, the detected compounds present in groundwater do not pose a risk on human health for future workers at the site. All analyses, with the exception of zinc, were below the Laboratory Method Detection Limit (LMDL) and all analyses were below the Dutch Intervention Values (DIV).

The Phase II Site assessment was more comprehensive and included a total of thirty eight (38) groundwater samples that were collected from thirty six (36) test locations and two field duplicate QC samples. These samples were analyzed for various parameters as described above. In summary, the following results were reported and are presented in Table 5-7:

- Groundwater pH varied from 7.2 to 8.2 and temperature ranged from 21.2°C to 29.1°C;
- All metal results were below the DIV with the exception of Chromium which was above the DIV (0.03 mg/L) in 20 out of 38 samples (52% of samples);
- PAH and TPH fractions (C6 – C40) were below detection limits in all groundwater samples.

Based on the results of the Phase II Site Assessment, it can be concluded that the baseline groundwater quality underlying the RTIP site is representative of background natural groundwater quality. The only parameter detected in groundwater above the DIV was chromium. As the chromium concentration was detected across the entire site above the DIV, it is considered to represent natural and/or background concentrations.

Table 5-7 Phase II Site Assessment Groundwater Chemistry Results

			Concentration in Groundwater (2010-2011)	
	Unit	**Dutch Intervention Values**	Minimum	Maximum
GEOTECHNICAL INVESTIGATION 2010				
pH	pH	n.a.	7.15	8.21
Temp	°C	n.a.	21.1	29.1
Sulphates (SO_4)	mg/L	n.a.	597	2837
Cl^{-1}	mg/L	n.a.	983	6945
Total dissolved solids	mg/L	n.a.	2612	16805
PHASE II INVESTIGATION 2011				
METALS-DISSOLVED				
Arsenic	mg/L	0.060	<0.001	0.012
Barium	mg/L	0.625	0.014	0.057
Cadmium	mg/L	0.006	<0.001	0.0012
Chromium	mg/L	0.030	<0.001	0.107
Copper	mg/L	0.075	<0.001	<0.001
Lead	mg/L	0.075	<0.001	0.049
Mercury	mg/L	0.000	<0.001	0.002
Nickel	mg/L	0.075	<0.001	0.007
Tin	mg/L	0.050	<0.001	<0.001
Vanadium	mg/L	0.070	<0.01	0.13
Zinc	mg/L	0.800	<0.005	0.184
INORGANIC COMPOUNDS				
Cyanide (free)	mg/L	1.5	<0.01	<0.01
POLYAROMATIC HYDROCARBONS (PAHs)				
Anthracene	µg/L	5	<1.0	<1.0
Benz(a)anthracene	µg/L	0.5	<1.0	<1.0
Benzo(a)pyrene	µg/L	0.05	<0.5	<0.5
Benzo(g,h,i)perylene	µg/L	0.05	<1.0	<1.0
Benzo(k)fluoranthene	µg/L	0.05	<1.0	<1.0
Chrysene	µg/L	0.2	<1.0	<1.0
Fluoranthene	µg/L	1	<1.0	<1.0
Indeno(1,2,3,cd)pyrene	µg/L	0.05	<1.0	<1.0
Naphthalene	µg/L	70	<1.0	<1.0
Phenanthrene	µg/L	5	<1.0	<1.0
Pyrene	µg/L	n.a.	<1.0	<1.0
TOTAL PETROLEUM HYDROCARBON (TPHs)				
C6 - C9 Fraction	µg/L	n.a.	<20	<20
C10 - C14 Fraction	µg/L	n.a.	<50	<50
C15 - C28 Fraction	µg/L	n.a.	<100	<100
C29 - C36 Fraction	µg/L	n.a.	<50	<50
C37 - C40 Fraction	µg/L	n.a.	<50	<50
Total C10 - C40 Fraction	µg/L	600	<50	<50

5.3.5.2 RTIP Port Facilities ESA

A Phase II ESA was undertaken at the RTIP Port Facility during March 2011 as part of the larger RTIP Environmental Impact Assessment. Investigation work carried out at the Port Facility included:

- Advancing 5 test borings to a depth of one meter below ground surface (bgs) to evaluate the site soil quality;
- Collection of two soil samples for chemical analysis from each test boring at depths of 10cm and 100cm bgs;
- Collection of three seawater samples adjacent to project property;
- Collection of one field duplicated soil sample as a part of quality assurance plan.

A figure showing the investigation locations is presented as Figure 5-5. A brief summary of the key analytical findings is presented below:

- Total organic carbon (TOC), total cyanide, sulphide, total chlorine and total phosphate were below the detection limit in all seawater samples.
- The range of fluoride, ammonia, nitrate, total Kjeldhal nitrogen and total suspended solids (TSS) were reported at 1.1 mg/L – 1.1 mg/L, 4.52 mg/L - 6.18 mg/L, below detection to 0.08 mg/L, below detection to 0.6 mg/L and 12 mg/L - 17 mg/L respectively.
- Arsenic (As), barium (Ba), chromium (Cr), lead (Pb), nickel (Ni), vanadium (V) and zinc (Zn) were reported below the detection limits in all seawater samples. The metals detected in seawater samples were in compliance with Ambient Water Quality Criteria for Coastal Waters, Royal Commission Environmental Regulations (RCER 2010).
- TPH for aliphatic and aromatic fractions, PAHs, phenol and total chlorinated hydrocarbons were below detection limits in all seawater samples.
- Arsenic (As), cadmium (Cd), copper (Cu) lead (Pb), mercury (Hg), tin (Sn) and Zinc (Zn) were reported below the detection limits in all soil samples
- Barium (Ba), chromium (Cr), Nickel (Ni) and vanadium (V) were detected in soil samples with an average of 12.1 mg/kg, 5.6 mg/kg, 7.2 mg/kg and 6.2 mg/kg respectively;
- PAH and TPH fractions (C6 – C40) were below the detection limits in all soil samples.

In conclusion, the analyses of both soil and seawater samples indicate baseline concentrations that are not considered representative of contamination at the RTIP Port Facility and the site can be considered to be representative of natural background quality.

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6 ECOLOGY BASELINE

6.1 Introduction

This section presents a baseline account of the terrestrial and marine ecology of the project study area, presented in separate sub sections, together with background information on climate, geology, soils, land use and habitats.

The terrestrial ecology baseline investigation is based upon data collected during a field survey undertaken in November 2010 and information from a literature review (desktop study). The marine ecology baseline investigation is based upon a literature review, focusing on two areas; Jubail and Ras Tanura, between which the King Fahd Industrial Port is located. Ras Tanura is approximately 50km south of RTIP and provides the regional context for this section. In addition, the potential for long shore current from the Port area to carry a spill of fuel or cargo southward to this area, means that Ras Tanura is also considered a potential receptor. Both sections are also based on prior knowledge of the habitats, flora and fauna of the general region and of other similar areas of the Arabian Gulf region.

Species and habitats present or likely to be present in the study area (‘ecological receptors’) are evaluated in terms of their local, regional or national importance in the Kingdom of Saudi Arabia or with respect to their status in the Arabian Gulf or globally.

6.2 Methodology

6.2.1 Literature Review

An extensive search was made of the available published literature on habitats, flora and fauna of the local and wider areas, particularly of similar coastal areas within the Arabian Gulf. This information was used to supplement the data obtained from the field surveys and to evaluate the results in the wider national, regional or global context. The reference sources provide important information on the identification, distribution, status and ecology of habitats and species evaluated for this assessment.

The literature includes various books, scientific journals, reports and other publications. Some additional information and documentation was obtained from web sites of conservation, natural history groups based in the Arabian Gulf and other bodies. A small amount of information was also available within other published consultancy reports pertaining to other developments in the local area.

An overview of the available information is given below. The full list of references and details of web sites of organisations and other groups is given in Section**Error! Reference source not found.** 25 References.

6.2.1.1 Vegetation and Flora

Key works on Arabian vegetation and plant communities are Zohary (1973) and a more recent overview by Ghazanfar & Fisher (1998). Detailed information on plant communities occurring in the eastern province of Saudi Arabia is to be found in Mandaville (1990).

The flora of Saudi Arabia has been documented by Migahid (1988), Chaudhary (1999) and Collenette (1985, 1999). A more recent project to describe the flora of the whole Arabian peninsula including Socotra has resulted in only two of a proposed five or six volumes being published (Miller & Cope 1996 and Cope 2008), the latter covering grasses and providing an important update to Chaudhary's work on the grasses of Saudi Arabia (1989). Mandaville (1990) remains the most authoritative reference on the flora of the Saudi Arabian Gulf region.

Ecological relationships of desert plants are well studied generally (e.g. Batanouny 2001) and there is also a body of traditional knowledge amongst the Bedouin concerning the cultural uses of plants (as medicines, cosmetics, etc.) as well as fodder for livestock. Much of this information has been researched and published by modern-day botanists (Boulos 1983, Mandaville 1990, Batanouny 2001).

There has especially been great interest in salt-tolerant species found in deserts and coastal habitats (e.g. Abbas & El-Oqlah 1992). Recent studies have been stimulated in part by the high development pressures that coastal areas in the Arabian Gulf are now experiencing (Barth & Böer 2002). The latter work includes a study of sabkha processes occurring in the Jubail area (Barth 2002).

6.2.1.2 Mammals

Harrison (1981) and Harrison & Bates (1991) provide the most comprehensive works on the status and distribution of mammals in the Arabian Peninsula; however, these books are now out of date for several species which are now better known. Recent popular guides on mammals covering the UAE (Jongbloed, 2001; Aspinall *et al.*, 2005) include most of the species that occur in eastern Saudi Arabia. The Abu Dhabi Environment Agency has published a status report on mammals and other fauna in the UAE (Drew *et al.* 2005) and some of this information is probably applicable to Saudi Arabia. An important source of scientific information on mammals and other wildlife in Saudi Arabia and other parts of the Arabian Peninsula is the *Fauna of Saudi Arabia* (25 volumes published to date), produced by the National Commission for Wildlife Conservation and Development (NCWCD).

6.2.1.3 Birds

Birds have been well studied over the Arabian Peninsula as a whole, with much research being carried out in Saudi Arabia by NCWCD on rare and protected species. The Atlas of Breeding Birds of Arabia (ABBA) project, supported by NCWCD, has been co-ordinating surveys and compiling data throughout the peninsula since 1984 and has recently produced a final atlas, which includes detailed species accounts (Jennings 2010). General sources of information on identification, distribution and status of species include Hollom *et al.* (1988), Porter *et al*. (1996) and the web site of the Ornithological Society of the Middle East (OSME). Details of 'Important Bird Areas' designated in Saudi Arabia by BirdLife International are given in Evans (1994).

6.2.1.4 Reptiles and Amphibians

Much of the relevant literature on amphibians and reptiles of the Arabian Peninsula has been published in the journal *Fauna of Saudi Arabia,* but generally these groups are poorly covered. Important identification keys include those for lizards (Arnold 1986) and snakes (Gasperetti 1988). Leviton *et al.* (1992) provide identification keys and a review of the status of species throughout the Middle East. An account of a survey for desert reptiles throughout Abu Dhabi Emirate (Baha el Din 1996) provides useful information on the status and habitat preferences of resident species in the Arabian Gulf region; this has been updated by Gardner (2005). Jongbloed (2000) gives a popular account of the distribution and ecology of reptiles and amphibians in the UAE.

6.2.1.5 Invertebrates

The only popular guide to insects in the Arabian Peninsula is by Walker and Pittaway (1987), which is long since out of print. Reviews of the invertebrates of the UAE (which share many species with Saudi Arabia) have been compiled by Tigar (1996) and Gillet & Gillet (2005). Detailed studies of species or groups in Saudi Arabia have appeared regularly in the *Fauna of Saudi Arabia* and for the UAE in *Tribulus* (the publication of the Emirates Natural History Group). A recent and still ongoing study of invertebrates in the UAE has been published as three volumes of species accounts to date (Van Harten 2008-2010).

6.2.2 Overview of the Project Site and Study Area

In order to undertake an ecological impact assessment it is important to first consider the potential impacts of the development project and their likely 'zone of influence'. This will be a major consideration in determining the areas to be included in the field surveys. Typically, the zone of influence will encompass the project site and include an area around it which may also be subject to direct or indirect impacts during construction, operation or other phases of the project. The zone of influence may also include areas some distance away from the project site, such as areas to be quarried for construction materials or areas affected by new infrastructure such as roads.

The project site is located approximately 15km southwest of the coastal town of Jubail and about 10km southeast of Jubail airport (Figure 6-1). The RTIP Site lies approximately 17.5km from the shoreline at its closest point. It measures 2.2km x 2.7km, with an area of

5.76 km^2 or 576 ha. A main road runs adjacent to the southern boundary of the site, serving as a connecting road between the Ad-Dammam- Jubail coastal road on the outskirts of Jubail (Route 613) and the Abu Hadriyah road (Route 85) further inland. There is no road infrastructure within the boundary of the site. The site is surrounded by Jubail Industrial City settlements with the industrial area lying adjacent to the north and northeast. To the south of the site there is an extensive settlement consisting of worker camps, farms and forestry plantations. The BeeA'h landfill site is situated next to the south-eastern corner of the project site.

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Figure 6-1 Location of RTIP Site

Source: Google Earth 2006 image modified by CH2M HILL

The project site is situated on a thin sand sheet overlying saline coastal substrates Geology, habitats and vegetation are described in more detail in Section 6.3. About 70% of the area has already been mechanically graded, leading to compaction of the surface and loss of almost all natural vegetation. The undisturbed areas with remaining vegetation lie in the southwest corner and along the southern edge. This habitat continues to the west of the site, as far as the Abu Hadriyah road.

The terrestrial ecology survey focused on the areas of natural or semi-natural vegetation, both within the site and adjacent to it. Areas with settlements, industrial areas and degraded desert were not included in the survey area as these are considered very unlikely to support habitats or species of significant ecological importance.

6.2.3 Baseline Survey

The field surveys took place during 3-5 November 2010 by Yahia El Dool, an Environmental Consultant with RGME. The purpose of the survey was to gather general information on land use, as well as habitats and species in the project site and other parts of the study area.

6.2.3.1 Survey Limitations

Security is strict within Jubail Industrial City and the surrounding areas and whilst a permit was obtained to access the site, this permit did not extend to the King Fahd Industrial Port area where the project plans to locate its tank farms and undertake loading and loading of product. This area however is designated for industrial use and surrounded by existing port facilities.

The survey was carried out during the autumn season. At this time perennial vegetation is not actively growing after the hot, dry summer and annual vegetation is not present. Perennial plants that are very dry and without fruit or flowers may be difficult to identify at this time of year, particularly perennial grasses and salt-shrubs. Some resident fauna (mammals, reptiles and some birds) may be present and partly active, but many breeding birds of desert habitats may be absent at this time Several nesting species occur mainly from early spring to early summer. A few species of desert birds migrate to the Arabian Gulf in the winter, and may have been present during the survey period. It was still possible to adequately record and assess the habitats and vegetation types and make reasonable assumptions concerning their likely associated fauna based on the literature review and experience with similar habitats. Published data can also be drawn on for describing the annual and seasonal variations in species likely to be present on the site.

6.2.3.2 Survey Methods

The field survey was carried out using four main methods:

1. Reconnaissance survey by vehicle

The project site and surrounding area were inspected from a four-wheel drive vehicle, driven on existing roads and tracks where possible. This was carried out to obtain general information on land use and settlements in the area, and to identify and map vegetated and non-vegetated areas of the project site and adjacent areas.

2. Walkover survey

Walked transects were carried out through the remaining areas of natural vegetation inside and adjacent to the project site. These were carried out in order to record species composition of the vegetation, dominant species, percentage cover, etc., and also to search for signs of fauna species including mammals, birds and reptiles. GPS devices were used to assist with mapping of vegetation and recording the locations of survey areas, quadrats (see below) and fauna.

3. Quadrat survey and photography

Quadrats measuring 10 x 10m were recorded in 15 locations over the site to gather more detailed data on the composition and structure of the vegetation. The method used provides both quantitative and qualitative data on the vegetation of an area and is relatively quick and easy to carry out. Quadrats were selected in areas considered representative of the wider stand of vegetation. The centre of each quadrat was marked by a bag or other object, and the 10 x 10m area was measured by pacing. For each quadrat the following attributes were recorded:

- Quadrat no., date, GPS location;
- Substrate and topography;
- Degree of soil compaction: (very soft, soft, firm, hard);
- Perennial cover to nearest 5% expressed as range (e.g. 5-10%, 10-15%);
- Average vegetation height as 10cm range (e.g. 0-10cm, 10-20cm, 20-30cm);
- Dominant species (the species with the highest cover);
- Co-dominant species, if present (the species with the second highest cover);
- Density (number of plants or clumps of each species).

For the wider area, notes on the following were recorded:

- General composition and pattern of the vegetation and presence of features such as wind-formed sandy mounds;
- Degree of human impact (e.g. presence of tracks, pipelines, fences, rubbish, bulldozed areas);

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- Signs of grazing by livestock or other herbivores.

At each quadrat location at least two photographs were taken using a digital camera, one to show the quadrat centre and another to show the wider stand of vegetation.

Please see Figure 6-2**Error! Reference source not found.** showing the location of quadrat sampling points and pitfall traps in the ungraded portion of the site.

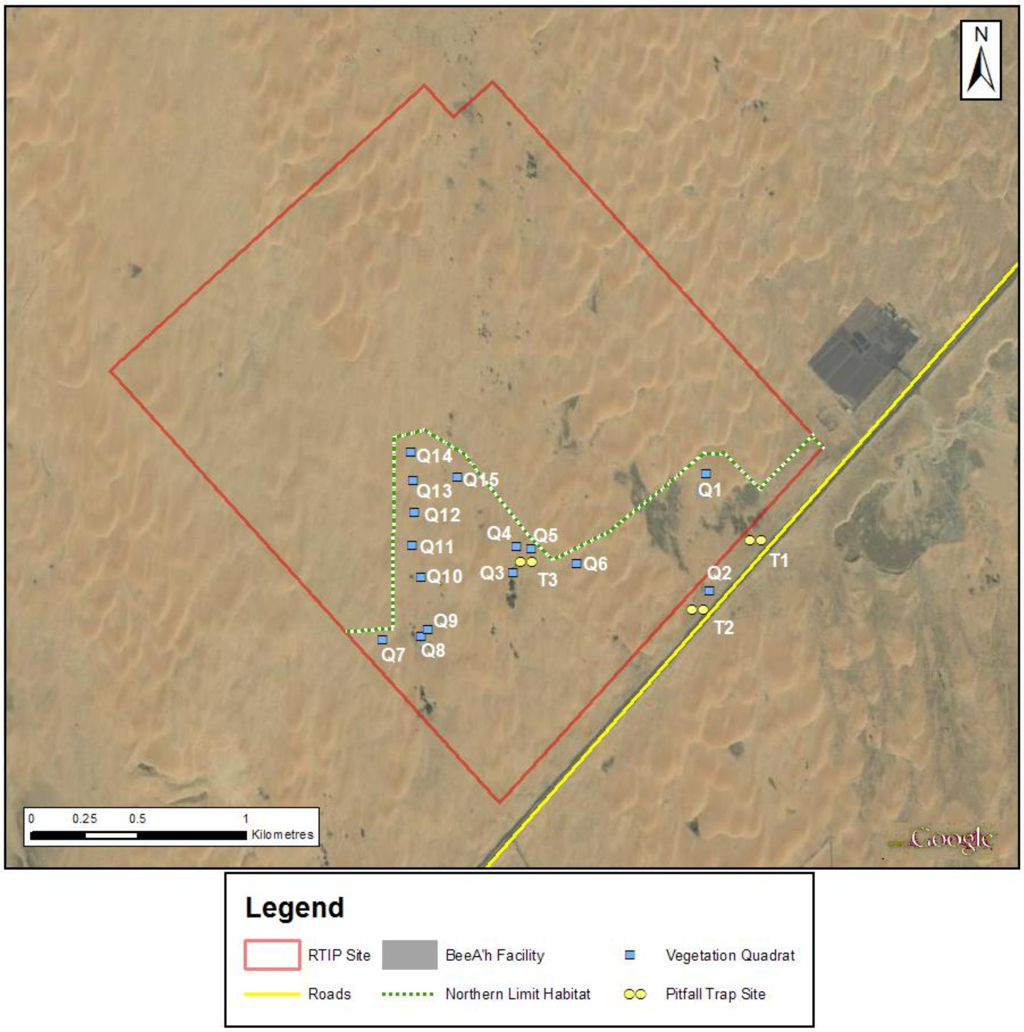

Figure 6-2 Location of Quadrats and Pitfall Traps in Ungraded Habitat
Source: Google Earth 2006 image modified by CH2M HILL

4. Pitfall trapping

Pitfall trapping was used as the main method of recording and assessing the presence/absence and diversity of smaller types of fauna present on the site, particularly for nocturnal reptiles and invertebrates which would not be recorded during general daytime surveys. Pitfall traps were set up in three localities within the site, selected in areas of densest vegetation where more fauna was likely to occur.

At each trap site two plastic buckets were sunk into the ground about 1.5m apart so that their rims were at ground level (Figure 6-3 and Figure 6-4). A plank of wood was laid across the top as a barrier to invertebrates trying to cross between the buckets, thereby directing them into one of the traps.

Traps were set up during late afternoon or early evening and were inspected and removed the following morning. GPS coordinates of each trap site were taken and any specimens caught were photographed.

Figure 6-3 Pitfall Trap Comprising Two Buckets Sunk at Ground Level Between Vegetation Mounds
Source: Eldool, 2010

Figure 6-4 Close-up of Pitfall Trap
Source: Eldool, 2010

6.3 Terrestrial Ecology

6.3.1 Geology, Soils, Climate and Habitats

Further information on these issues is provided in Sections 4 Air Quality and Meteorology Baseline and 5 Onshore Physical Environment.

6.3.1.1 Geology

Jubail lies on the eastern side of the Arabian Shelf or Platform, formed by sedimentary rocks (mostly limestone and sandstone). The area dips gently eastwards into a number of sedimentary basins. These range in age from Cambrian to the Pliocene. Unconsolidated quaternary aged sands and gravels blanket most of the eastern part of the Kingdom.

In the Jubail area the gradient towards the coast is very gradual and the coastline is characterised by extensive salt flats. Inland these give way to low, gently undulating sand sheets (Ministry of Agriculture and Water 1995).

6.3.1.2 Soils

Most soils in the Kingdom of Saudi Arabia are desert sandy soils. Generally, the soils of the project site area are sandy loams with occasional hard pan outcroppings. They are often saline with low organic content, low levels of nitrogen, phosphorus and potassium, and low exchangeable cations. A hard pan may form at some depth due to the hydrolytic decomposition of shallower minerals when sub surfaces moisture is present.

6.3.1.3 Climate

Eastern Saudi Arabia has a subtropical desert arid climate, largely due to its geographical situation in global patterns of atmospheric circulation. The climate in the Arabian Gulf is hot and dry. The air temperature averages 37°C in August and 12°C in January. The average rainfall is about 50mm per year and evaporation rates are high. These conditions mean that soil salinities are typically high, ranging between 38 and 41 parts per thousand along the Saudi Arabian coast (MEPA, 1987).

According to the data obtained in the nearest Meteorological Station to the project site (AQMS # 6). The mean daily maximum temperature in July and August reaches 44°C and falls in January to a minimum of 9.2°C. The relative humidity ranges between 36.2-6.0% in June and 89.8-40.4% in January; this rate decreases as one moves inland from the Arabian Gulf coast. Annual rainfall is not evenly distributed throughout the year. Saudi Arabia is characterized as a country with erratic seasonal rainfall distribution; 97% of the annual precipitation can be recorded in one day, with implications for drainage requirements and runoff protection.

The highest wind speed at AQMS # 6 was recorded in June, with a mean daily maximum of 9.91 (m/s), while the lowest wind speed was recorded in October at 6.57 (m/s). Wind effects in such an open, loose-soiled desert environment can often prove decisive to plant survival. Winds significantly increase the desiccating power of the already hot dry atmosphere and have a powerful effect in moulding topography, particularly in dune sands, where they directly affect the root stability of individual plants.

6.3.2 Site Setting

6.3.2.1 Habitats of the Project Site and Surrounding Area

Google Earth imagery shows the site and surrounding areas to lie within a large area of thin sand sheet overlying the coastal saline substrates. The sand is of Aeolian, not marine, origin, as shown by the orange colour. Some small areas of saline coastal sediments are visible as a darker grey colour in places and more extensive areas of saline flat and sabkha occur adjacent to the site and nearer to the coast. The sand has been shaped by the prevailing northerly wind into small dunes and also forms mounds around shrubs and grasses where these are present. This type of sand sheet habitat is very common along the Gulf coast.

Depending on the level of salinity, the coastal sediments may support dense or sparse vegetation composed of salt-tolerant shrubs, but salt-encrusted areas (true ‘sabkha’) cannot support any vegetation whatsoever as the amount of salt is too great. Salt-bush or saltmarsh vegetation also occurs in suitable intertidal sediments along the coast.

The field survey estimated that approximately 70% of the project site area has been altered through mechanical grading and has little or no natural vegetation. The remaining sand sheet habitat supports typically species poor communities, dominated by either small shrubs or perennial grasses (vegetation is described in more detail below). The covering of sand is enough to reduce the salinity, so that some halophobic species can grow side by side with moderately tolerant species. Clumps of date palms also grow in this habitat, probably as a result of previous plantings. The farms, settlements and industrial areas in the vicinity of the project site also support large numbers of planted trees and shrubs, including many in forestry plantations. Planted trees are also present on the Beeah Landfill, adjacent to the site. It is likely that winter and spring migrants may use these areas for nesting or foraging as well as being attracted to the native vegetation in the project area. The timing of the survey however was not able to confirm this.

6.3.2.2 Sites of Ecological Importance

The project site is situated about 10km south of the Sabkhat Al-Fasl Lagoons. These are a series of evaporation lagoons on sabkha, which are used for storing excess wastewater from Jubail Industrial City. The site is listed as an Important Bird Area (IBA) by BirdLife International (Evans 1994), because it attracts nationally or internationally important numbers of migrating and over-wintering waterfowl, especially Greater Flamingo *Phoenicopterus ruber*, various duck and wader species (see Section **Error! Reference source not found.**). Some species of waterfowl also breed on the site. It is now included within the boundary of the Jubail Marine Wildlife Sanctuary (see section 6.4.5 Marine Sites of Ecological Importance), which was established following the events of the 1991 Gulf War, through a joint environmental initiative between NCWCD in Riyadh and the European Commission in Brussels. The Jubail Marine Wildlife Sanctuary is the first of a series of proposed marine protected areas along the western coast of the Arabian Gulf which will promote the conservation of endangered species and allow for the appropriate management of the renewable biological resources of the area.

Tarut Bay lies about 60km southeast of the project site at Ras Tanura. This is also listed as an IBA for its important breeding and migrant populations of waterfowl (Evans 1994). It is a naturally-formed tidal inlet supporting extensive areas of sea-grass beds, intertidal salt marsh and mangroves. It is an important nursery for shrimp and fish and sustains several traditional fishing communities (Evans 1994). Its distance from the RTIP site means that it is unlikely that it would be directly affected by the project and is not considered any further in this chapter.

6.3.3 Vegetation

6.3.3.1 National Overview

The natural vegetation of Saudi Arabia is largely adapted to arid, desert conditions and predominantly consists of communities of dwarf shrubs and grasses, often growing at low density and cover. Over the Kingdom as a whole, the vegetation communities are moderately diverse, reflecting the wide differences in geology, landform and soil types.

Characteristic vegetation communities occur, for example, in areas of deep sand, shallow sand sheet, gravel plains, limestone escarpments and basalt rock fields that are found in various parts of the Kingdom. In the hottest and driest areas, such as the Rub’ Al-khali, vegetation may be absent from large areas, or very reduced in species diversity. Larger shrubs and trees, including *Acacia* spp. occur in some parts of the south-eastern desert areas, but such communities are better developed further south along the Gulf coast within the United Arab Emirates (Mandaville 1990, Jongbloed 2003).

Low-lying areas along the eastern coast have saline soils and are characterised by species-poor communities of halophytic shrubs. Depending on the level of salinity, vegetation cover in these areas may be very high, or completely absent. Annual plants occur in varying numbers throughout most of the vegetation types, except for those on saline soils. Generally, only a very small number of endemic plant species occur in these desert areas and most have large world ranges.

The mountainous Asir region in the south-west of the Kingdom (extending into Yemen) supports a range of deciduous and evergreen woodland and shrubland which support a high number of plant species, including many that are endemic or have restricted world ranges.

A vegetation map of the Kingdom is shown in Figure 6-5; this shows the varied vegetation communities and the predominance of sabkha vegetation along the Gulf coast.

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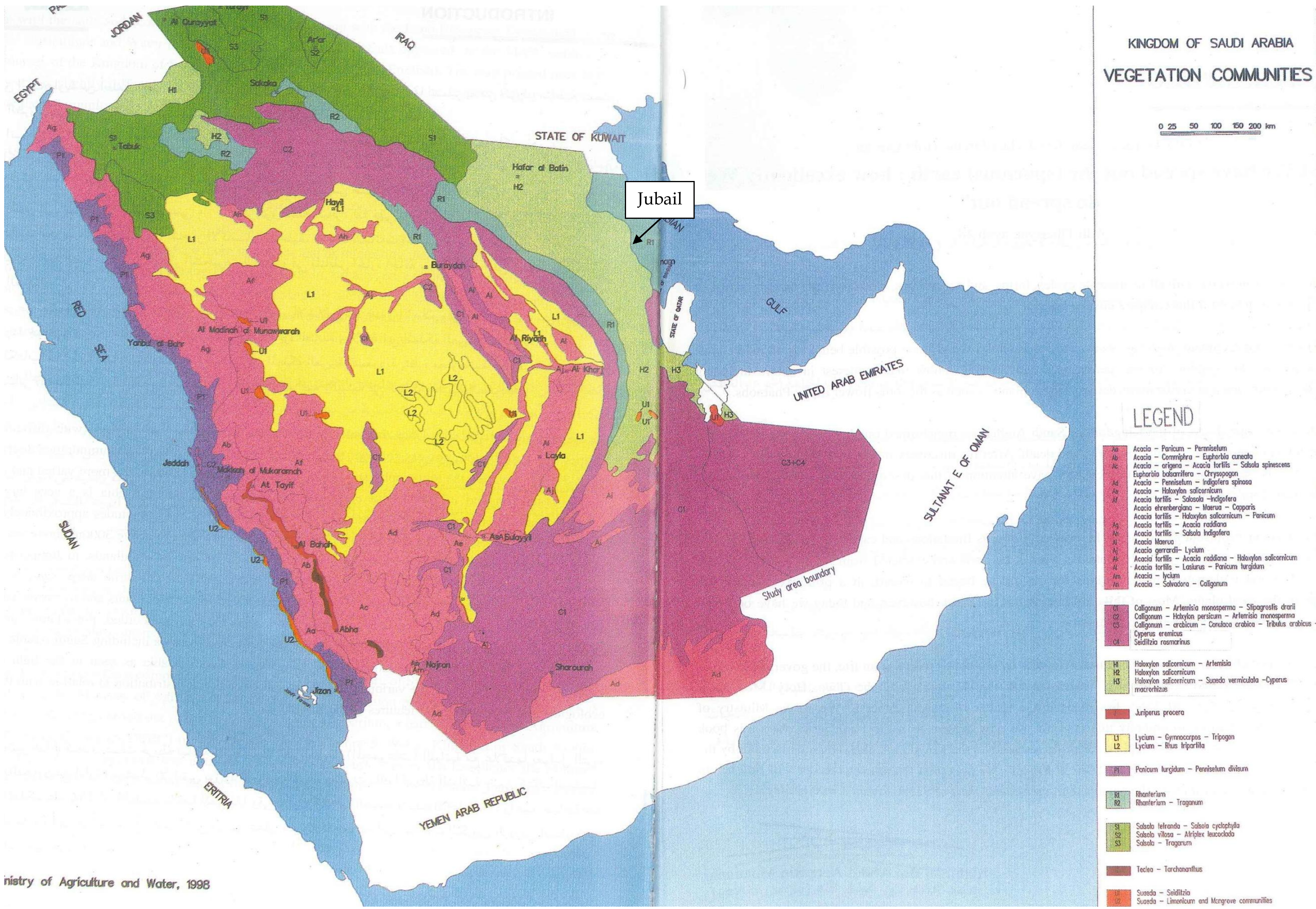

Figure 6-5 Vegetation Communities in the Kingdom of Saudi Arabia
Source: Ministry of Agriculture, Land Management Dept. 1998, Riyadh, Saudi Arabia.

6.3.3.2 Regional Overview

The project site is located in a low-lying area along the eastern coast, where saline soils covered with halophytic (salt-tolerant) shrubs are predominant, though sand sheet areas, areas of standing water or wet mud basins, and beach habitats are also present.

Barth (1999) studied vegetation communities in an area lying 20km southwest of Jubail, (probably in close proximity to the project site) and identified eight main plant communities, characterised by the following species:

1. *Calligonum comosum* (Family Polygonaceae - a large shrub).
2. *Panicum turgidum* (Family Poaceae - a perennial grass).
3. *Zygophyllum coccineum* (= *Z. qatarense*, Family Zygophyllaceae - a small shrub).
4. *Haloxylon salicornicum* (Family Chenopodiaceae - a small shrub).
5. *Rhanterium epapposum* (Family Asteraceae - a small shrub).
6. *Leptadenia pyrotechnica* (Family Asclepiadaceae - a large shrub).
7. *Phoenix dactylifera* (Family Arecacea - the Date Palm).
8. *Lycium shawii* (Family Solanaceae - a large, thorny shrub).

All of these are found in non-saline areas, except for the *Zygophyllum* and *Haloxylon salicornicum* communities which are moderately saline tolerant. Barth found that rangelands in these areas were deteriorating due to the open grazing system established in Saudi Arabia and lack of enforcement of the Rangeland and Forest Regulations in Saudi Arabia (revised in 2005).

6.3.3.3 Vegetation of the Project Site

From the walkover survey and data collected through quadrats, an approximate vegetation map for the project site was produced (Figure 6-6). The detailed results of the quadrat study are presented in Appendix B.

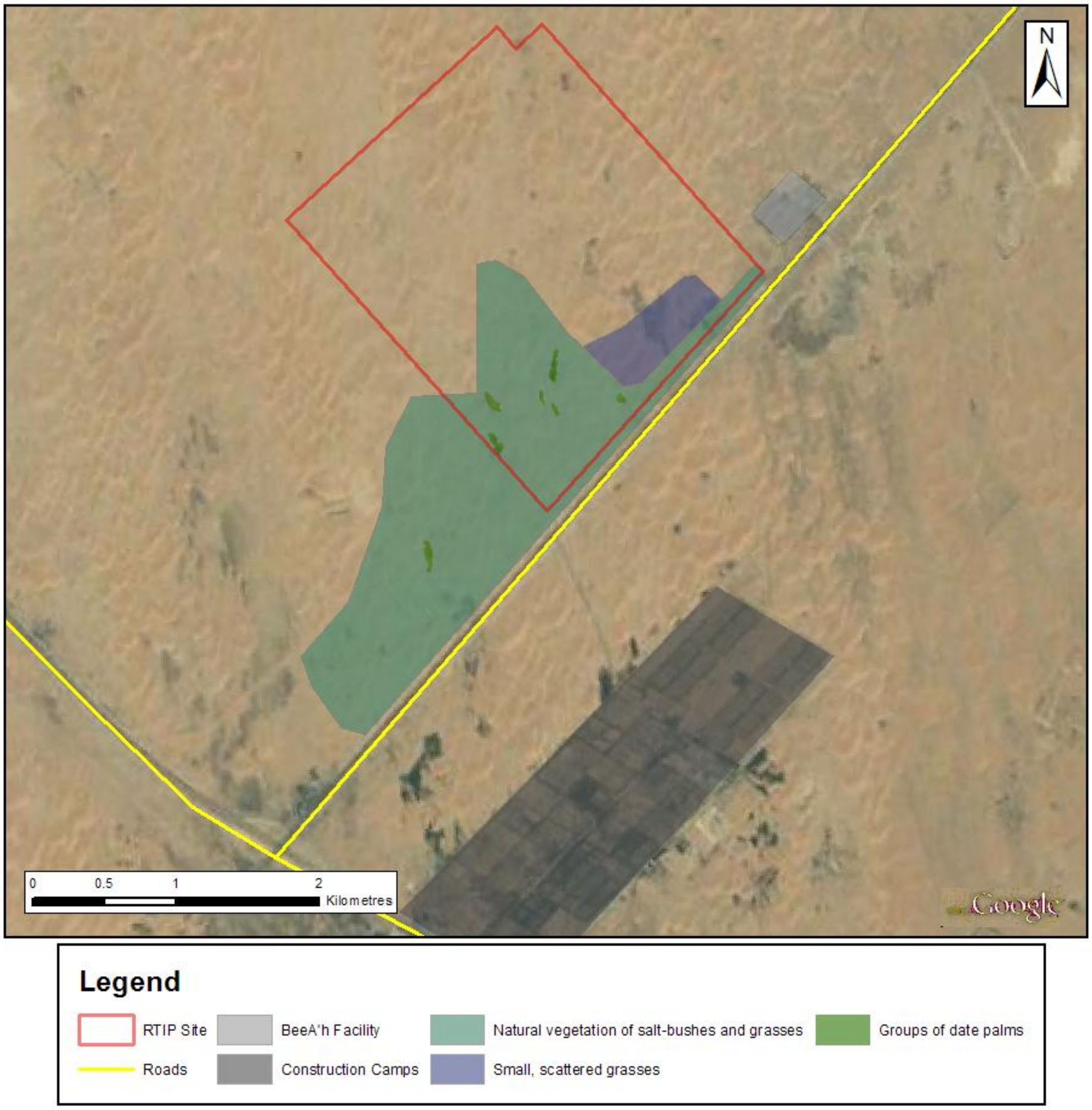

Figure 6-6 Sketch Map of the Vegetation of the Project Site
Source: Google Earth 2006 image modified by CH2M HILL

Two distinct vegetation types were identified on the site, the first being a community of moderately saline tolerant shrubs belonging to the family Chenopodiaceae (known as Chenopods or salt-bushes). These comprise *Salsola* sp. (known locally as 'khareet' and/or *Haloxylon salicornicum* 'rimth'). A well developed stand is shown in Figure 6-7. The second is a community dominated by the perennial grasses *Panicum turgidum* ('thamam') (and possibly also *Pennisetum divisum* ('theimoom'). Various *Salsola* species occur in coastal areas, but cannot be easily distinguished. *Salsola imbricata* is probably the commonest species in the vicinity of the site. It was found to be dominant in parts of the Ras Tanura area, during a similar survey in 2009 (unpublished ecological survey of the Ras Tanura site, 2009). The two grasses also have very similar growth patterns and cannot be easily distinguished when flowering stems are absent.

Figure 6-6 indicates that these two communities are mixed over most of the intact sand sheet areas within the site, as shown in Figure 6-8, but some areas of almost flat sand only support scattered small tussocks of grasses (Figure 6-10). Clumps of date palm trees occur throughout the area (Figure 6-8, Figure 6-9) and formerly extended across the site from the southwest to northeast corner (as shown by older Google Earth imagery). Outside the project site towards the southwestern side, the same vegetation pattern is repeated (Figure 6-9).

The introduced trees planted around the Beeah landfill near the southeastern corner of the site (Figure 6-11) are probably mixtures of *Prosopis* spp, *Tamarix* and *Ficus* spp. They look very green and healthy, possibly due to irrigation and the presence of buried waste which provides plentiful nutrients.

The vegetation of the coastal area near Jubail consists of poorly grown halophytic shrubs (Figure 6-12).

Figure 6-7 Well Developed Salt-bush Vegetation Outside the Southwest Corner of the RTIP Site
Source: Eldool, 2010

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Figure 6-8 Typical Vegetation within the Ungraded Portion of the RTIP Site; Date Palms, Small Shrubs and Grasses on an Undulating Sand Sheet

Source: Eldool, 2010

Figure 6-9 View Southwest; Continuation of Vegetation Shown in Figure 6-8

Source: Eldool, 2010

Figure 6-10 Scattered, Small Grass Tussocks in the South of the RTIP Site

Source: Eldool, 2010

Figure 6-11 Introduced Trees Planted as Shelterbelt around Al Bee'ah Landfill

Source: Eldool, 2010

Figure 6-12 View Near the Gulf Coast, Showing Degraded Halophytic Vegetation
Source: Eldool, 2010

6.3.4 Fauna

6.3.4.1 Mammals

No domesticated or feral livestock were seen during the course of the survey, however a number of the vegetation quadrats showed signs of grazing most likely by goats. It is likely that Red Fox *Vulpes vulpes* could occur on the site, a common and widespread scavenging species throughout Arabia. Feral dogs may also be present in the area.

It is likely that the better vegetated parts of the site support populations of the more common and widespread small mammal species. These might include both Cheesman's Gerbil (*Gerbillus cheesmani*), a species of sandy habitats and Baluchistan Gerbil (*G. nanus*), a species of rocky habitats, but also very common in coastal areas. Other species that might occur in this habitat include Cape Hare (*Lepus capensis*), Sundevall's Jird (*Meriones crassus*) and Lesser Jerboa (*Jaculus jaculus*), all of which are widespread and locally common in well vegetated sandy areas throughout the Arabian Gulf. One or more species of hedgehog may also occur in this area, the most likely being the Ethiopian Hedgehog (*Paraechinus aethiopicus*), the commonest of the desert species.

6.3.4.2 Birds

The Site is likely to be used by a variety of generally common and widespread desert species, present at low densities. These will almost certainly include Hoopoe Lark (*Alaemon alaudipes*) and Crested Lark (*Galerida cristata*) which are the most widespread and typical species of this habitat in the Gulf. A number of resident species are likely to nest or roost in the date palms, especially House Sparrow (*Passer domesticus*), Laughing Dove (*Streptopelia senegalensis*), Collared Dove (*S. decaocto*), White-cheeked Bulbul (*Pycnonotus* *leucogenys*) and Southern Grey Shrike (*Lanius meridionalis*). All these will also be found in urban areas and tree plantations in the surrounding area.

The site may also provide some foraging potential for commoner migrant species in spring and autumn, such as Red-throated Pipit (*Anthus cervinus*), Yellow Wagtail (*Motacilla flava*) and Isabelline Shrike (*Lanius isabellinus*). In winter the most frequent visitors are likely to be Short-toed Lark (*Calandrella brachydactyla*), Desert Wheatear (*Oenanthe deserti*) and Desert Warbler (*Sylvia nana)*.

Other resident species in the general area will also include various introduced and naturalised species of Asian origin such House Crow (*Corvus splendens)*, Common Myna (*Acridotheres tristis)* and Graceful Prinia (*Prinia gracilis)*.

6.3.4.3 Reptiles

Only one reptile track was noted during the site surveys (Figure 6-13Figure 6-13: Reptile Tracks Near Quadrat 8). This shows a heavy tail mark and was probably made by one of the *Acanthodactylus* lizards. The most likely species to occur in this habitat is the White-spotted Lizard (*A. schmidti)*, a common and widespread species in softer sandy areas.

Figure 6-13: Reptile Tracks Near Quadrat 8
Source: Eldool, 2010

The sand sheet habitat is also likely to support a number of other common species of reptiles, including the day-active Arabian Toad-headed Agama (*Phrynocephalus arabicus*) and one or more of the nocturnal gecko species, such as Arabian Sand Gecko *Stenodactylus arabicus*, Slevin's Big-headed Gecko *Stenodactylus slevini* and Baluch Rock Gecko *Bunopus tuberculatus*. The latter species occurs in a variety of different habitats and is also associated with disturbed sites, where there is discarded refuse. Another less common species that may also occur is the Yellow-spotted or Blue-headed Agama (*Trapelus flavimaculatus*), which prefers to hunt around larger shrubs. The habitat appears unsuitable for the Spiny-tailed Lizard (*Uromastyx microlepis*); this species is normally found in areas of gravelly substrate, where the large burrows can be excavated.

6.3.4.4 Invertebrates

The results of the pitfall trapping are shown in Table 6-1. Only two specimens of invertebrates were caught, a camel tick (Family Ixodidae) from trap 1 and a beetle from trap 3. This was probably a member of the Family Caribidae, but was not possible to identify. Ants were found in trap 2. During night surveys some mosquitoes were found.

The poor outcome of the survey is probably related to the relatively poor diversity of the vegetation, combined with the time of year (at the end of the summer period, when insect activity is very low).

Table 6-1 Location of Pitfall Traps in RTIP Site and Findings

Trap No.	Coordinates	Findings
1	0350606 E 2979763 N	One camel tick.
2	0350334 E 2979437 N	Ants.
3	0349536 E 2979662 N	One beetle, unidentified.

Figure 6-14: Pitfall Trap 1: Camel Tick
Source: Eldool, 2010

Figure 6-15: Pitfall Trap 2: An Unidentified Beetle

Source: Eldool, 2010

6.4 Marine Environment

The main RTIP Site is approximately 18km from the shoreline. The project will however have a tank farm and loading and unloading facilities at the existing Jubail Industrial Port, to be operated by the Port Authorities. The Jubail Industrial Port is located within an ecologically diverse area of the Arabian Gulf and whilst the direct impacts at the Port, such as spills at the jetty during loading and unloading are confined to a smaller area of the Arabian Gulf, these impacts can result in repercussions on the Gulf at large, particularly in terms of habitat shifts and the consequent species shifts. Cargo spills resulting from a vessel collision is likely to have a wider spreading impact. It is important to identify all aspects of the marine environment, on both a localized and regional scale to enable an assessment of the impacts of RTIP on the greater area of the Gulf to be quantified.

Information presented in this section has relied upon a desktop assessment and review of existing information on the area. A baseline study of local coastal conditions was undertaken at the Ras Tanura coast, approximately 50km south of Jubail, by King Fahd University Petroleum and Minerals in 2009 as part of a dredging EIA. The Dredging EIA (KFUPM, 2009) contains published data which is geographically closest to the RTIP Site. The document is extensive and the data well documented. The section of coastline south of Jubail to the former Ras Tanura project area is fairly uniform in depth, bottom type, temperature, salinity and current regimes and there are no major coastal disturbances in the area between the Port and Ras Tanura. It is therefore likely that conditions would be similar in Jubail due the prevailing longshore southerly currents in this reach of the western Gulf. Much of the documented analyses are therefore relevant to understanding the recent physical, chemical and biological conditions in the nearshore and offshore environment and has been used in this section to provide a regional characterisation of the marine baseline.

Local marine ecosystem features and resources, such as barrier islands, seagrass beds, hardbottom communities, fish populations, presence of marine mammals and reptiles may be influenced by the Port facilities as well as past and current port activities, and as such require some local survey. No sampling has been undertaken at the Jubail Port as part of this baseline study. Should information be made available by the Port authorities or Royal Commission this baseline section should be updated.

6.4.1 Circulation & Tidal Patterns

The marine environment of the Arabian Gulf along the Saudi Arabian shores is a unique ecosystem among the world's oceans. Primary determining factors are its restricted water exchange with the Arabian Sea, its high evaporation loss and low fresh water inflow, and its isolation (Hunter 1983).

Within the Arabian Gulf, tidal driven currents constitute a major part of circulation (KFUPM/RI, 2009). It is likely that, like other coastal areas of Saudi Arabia, the Jubail Port area is likely to exhibit signature tide-dominated currents semi-diurnal and mixed in nature.

For the KFUPM baseline, an Acoustic Doppler Current Profiler (ADCP) was deployed at a depth of 10m approximately 4.5km off the coast of Ras Tanura to evaluate circulation, wave and tidal patterns of the region. The ADCP was deployed for the period 20/07/2008 – 28/08/2008 and the program was designed to record at least one neap and spring tide.

The tidal current of the Arabian Gulf runs approximately parallel to the coastline in a northwest-southeast direction and the tidal pattern ranges from semi-diurnal to diurnal.

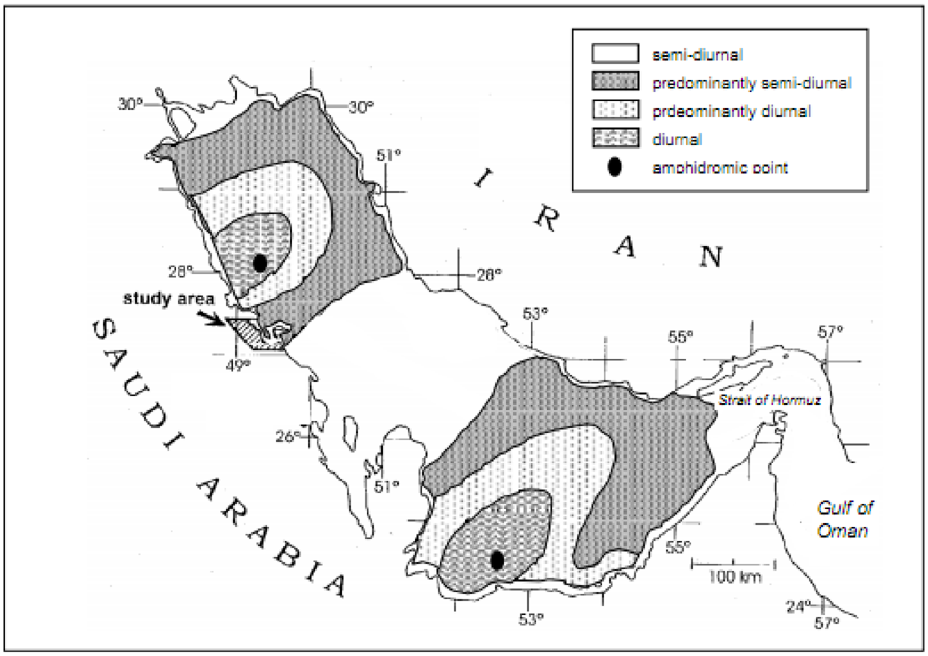

Figure 6-16: Tidal Patterns of the East Coast of Saudi Arabia

Source: The Jubail Marine Wildlife Sanctuary Research Database, 2010

6.4.2 Wave Climate

Weak wave characteristics were demonstrated in Ras Tanura with only occasional moderate waves. The average wave height observed during the study was 7.9 cm, a relatively small average when compared to other areas of the world (BOM, 2009). Additionally, the mean period distribution portrayed a weak wave environment with an average period during the study of 3.59 seconds. It has been previously reported that the offshore wave climate is stronger than that recorded during the ADCP sampling; however, sampling was only undertaken within the coastal environment, so this offshore characteristic was not detected.

6.4.3 Water Quality

Marine temperatures (Table 6-2) vary with season, depth and location within a water body. Chemical, physical and biological processes within a water body are all influenced by temperature, including growth and other responses in organisms. Higher temperatures decrease the solubility of gases and increase chemical reaction rates, leading to increased organic matter breakdown, oxygen consumption and plant growth rates (KFUPM/RI, 2009).

Table 6-2 Mean Temperatures, Electrical Conductivity and pH for the Gulf Water in Different Sites of the Eastern Coast of Saudi Arabia (April 2000)

Site	Temperature °C	Electrical conductivity S/m	pH
Al Khafji	27.8	41.4	8.3

Table 6-2 Mean Temperatures, Electrical Conductivity and pH for the Gulf Water in Different Sites of the Eastern Coast of Saudi Arabia (April 2000)

Site	Temperature °C	Electrical conductivity S/m	pH
Safiniya	28.0	42.0	8.3
Manifah	32.4	42.0	8.5
Jubail	32.9	42.0	8.5
Al Qatif	32.3	43.7	8.5
Al Dammam	32.3	44.0	8.7
Al Ogair	33.0	45.2	8.7
Salwa	33.9	45.7	8.8
Source: Al Fraidan, 2006			

Conductivity and salinity of the sea water (Table 6-2) provide measures of the total concentration of inorganic ions in water (Na^+, Cl^-, Ca^{++}, Mg^{++}, K^+, CO_2, and SO_4^{--}). When conductivity and salinity are elevated, it indicates that the natural chemical nature of the water is being altered due to the input of inorganic ions. Conductivity and salinity of water can provide an early warning of potential impacts to native biodiversity. Conductivity can significantly influence water chemistry and solubility of oxygen, metals and other compounds; most aquatic species can only adapt to a narrow range of conductivity/salinity.

pH is a measure of acidity that can be applied as an impact indicator within natural waters during severe contamination events. Pollutants such as industrial effluents and atmospheric deposition can significantly influence pH. The normal range of pH for most aquatic systems ranges between 6 and 8.5. pH affects water chemistry and the solubility of metals and gases. Many estuarine species are identified as being largely tolerant of a wide range of pH, but when exposed to low pH conditions over an extended period, some fish species may exhibit an excessive development of mucus lining of the gills, making air exchange difficult (KFUMP/RI CEW, 2001).

KFUPM/RI (2009) undertook sampling and analysis of water quality parameters of the coastal environment at Ras Tanura in order to establish existing water quality conditions previous to dredging activities and to provide a basis for understanding the variability in the water column in response to atmospheric conditions. Station patterns were prepared to cover the study site and proposed dredging area. In total, twenty-eight sampling stations were identified and sampling was undertaken at both the surface and bottom layers to account for any spatio-temporal variations.

Physical parameters assessed included temperature, salinity, pH, total dissolved solids (TDS) dissolved oxygen (DO), turbidity and photosynthetically active radiation (PAR). Surface samples were measured *in situ* during surface collection (at a depth of 1 m below the surface) and a YSI multiprobe environmental monitoring system (YSI multi parameter water quality Sonde, model 6600 V2) was utilized for bottom samples.

Samples were also collected from the surface and bottom for analysis of Total Suspended Solids (TSS), chlorophyll-a and nitrate at an offsite laboratory. A summary of results is presented in Table 6-3.

Table 6-3 Summary of Water Quality Parameters

	Temp	Salinity	pH	TDS	DO	Turbidity	PAR	Nitrate	TSS	Chl-a
Units	**°C**	**%**		**mg/L**	**mg/L**	**NTU**	**uM/s/m²**	**ppm**	**ppm**	**mg/m³**
Surface										
Minimum	33.14	4.16	7.97	40480	5.5	0	942	0.019	0.3	1.202
Maximum	34.45	4.29	8.07	41590	6.25	2.9	1998.3	0.426	2.7	2.179
Average	33.67	4.20	8.03	40860	5.76	0.75	1429.2	0.117	1.36	1.615
Bottom										
Minimum	33.09	4.16	7.99	40470	5.51	0	178.6	0.009	1.2	NA
Maximum	33.99	4.23	8.07	41100	6.02	2.6	600.5	0.474	2.4	NA
Average	33.32	4.19	8.04	40740	5.8	0.475	421	0.177	1.81	NA

Source: RTIP Dredging EIA (KFUPM/RI, 2009)

The water quality results when compared with the standards as seen in **Error! Reference source not found.** indicates that the coastal area in the Ras Tanura region is within objectives for a marine environment as set by PME.

The concentrations of total petroleum hydrocarbons (TPH) within surface and bottom waters of the 28 sampling stations were analysed using a gas chromatograph. In the surface waters, TPH concentrations averaged approximately 16.7 µg/L over the sampling areas with levels ranging from below the detection limit (BDL) (5 µg/L) to 25.2 µg/L. In bottom water, TPH concentrations averaged 14.4 µg/L and ranged from BDL to 15.2 µg/L. Analysis of Variance (ANOVA) indicated that there was little difference between surface and bottom TPH concentrations.

The guidelines proposed by the PME outline that the maximum permissible ambient water quality value for TPH is 0.5 mg/L (500 µg/L) and all TPH results were below this limit.

Heavy metal analysis was also performed on the coastal waters of Ras Tanura. Metals analysed included zinc (Zn), copper (Cu), iron (Fe), cobalt (Co), nickel (Ni) and Manganese (Mn). These metals were selected as they are considered biologically useful, however toxic in high concentrations (OHSA, 2008). Additionally, arsenic (As), lead (Pb), cadmium (Cd), chromium (Cr) and vanadium (Vn) were analysed as they are considered to be toxic to the biological environment having little biological use and are common by-products of industrial processes (OHSA, 2008).

The samples collected across the Ras Tanura coastal environment indicate that the overall water quality of the coastal environment was within limits as set by PME indicating that the water quality of the area was within an acceptable range.

6.4.4 Sediment Quality

Discharges to the ocean have the potential to contribute contaminants such as heavy metals, pesticides and nutrients to the marine sediments. These contaminants can have impacts on the marine flora and fauna living in and on the substrate (US EPA, 2008).

As discharges enter the marine environment through natural or anthropogenic processes, they have the potential to introduce chemicals and substances into the environment which can consequently partition into the particulate phase. Sediments provide a crucial habitat for benthic and epi-benthic organisms and the presence of certain substances within sediments can consequently enter these organisms and has the potential to travel up the food chain.

Marine sediments support a variety of life within the marine environment and the quality of sediments can be an indicator of the overall state of the marine environment. The presence of various constituents within sediments can provide an indication of the health of the food chain as oxygen present in the sediments provide the basis of the food chain. In some cases these compounds can bioaccumulate up the food chain and can have toxic repercussions.

6.4.4.1 Total Organic Carbon

The presence of organic carbon within the sediments of an environment is important due to carbon providing the primary food source for aquatic food webs.

The average concentration of TOC across the 81 sampling locations was 0.11±0.07% and ranged from 0.03% to 0.31% carbon. Nearshore areas were seen to have lower TOC concentrations then central and offshore areas analysed.

The results of the study provide an indication that current concentrations of TOC would not result in the degradation of the benthic environment and would continue to provide for benthic organisms and the marine food chain.

6.4.4.2 Total Petroleum Hydrocarbons (TPH), Polychlorinated Biphenyl (PCB), Polycyclic Aromatic Hydrocarbons (PAH) and Phenols

TPH

Massoud *et al.* (1996) proposed a guideline for the classification of pollution based on TPH concentrations (See Table 6-4).

Table 6-4 Guideline TPH Values for Pollution Levels in Bottom Sediment of the Arabian Gulf (Massoud *et al.* (1996))

TPH Concentration (mg/kg dry wt)	Classification based on Sediment TPH
10-15	Unpolluted areas (natural background levels)
15-50	Slightly polluted areas (upper permissible limit)
50-200	Moderately polluted areas

Table 6-4 Guideline TPH Values for Pollution Levels in Bottom Sediment of the Arabian Gulf (Massoud *et al.* (1996))

TPH Concentration (mg/kg dry wt)	Classification based on Sediment TPH
>200	Heavily polluted areas
Source: Massoud et al., 1996	

The average TPH concentration within the sediments of Ras Tanura was 0.39 mg/kg with concentrations ranging from 0.1 to 2.41 mg/kg. Core samples varied from 0.29 mg/kg to 3.5 mg/kg and averaged 1.32 mg/kg. Based on the Massoud *et al.* guideline all concentrations of TPH detected during the analysis of the area were considered unpolluted

PCB, PAHs and Phenols

PCB concentrations within the sediments were found to be less than 0.01 μg/g, lower then PME and National Oceanic and Atmospheric Administration (NOAA) guideline values for PCBs within sediments.

Concentrations of polycyclic aromatic hydrocarbons (PAH) at all 81 sampling locations were below the detection limit of <50 μg/kg indicating no recognition of PAH's within the sediments of Ras Tanura. It should be noted that a conclusion of no PAH presence cannot be made as there was potentially PAH's present at lower concentrations than the laboratory had the capability to detect.

Phenol concentrations in samples were all below the detection limit of 0.10 mg/kg indicating that no phenols were recognized in the sediment samples. It should be noted that a conclusion of no phenol presence cannot be made as there was potentially phenol presence at lower concentrations than the laboratory had the capability to detect.

Overall, the sediments of the Ras Tanura area showed limited presence of organic contaminants and the sediments of the area can therefore be considered un-contaminated with these contaminants as per local standards.

6.4.4.3 Heavy Metals

Sediments of Ras Tanura were collected at the 81 surface sampling sites with four sites selected for core sampling. All samples were analysed for levels of twelve heavy metals.

Most heavy metal concentrations detected within samples collected were within guideline limits as set by PME and other international bodies. The sediments of Ras Tanura can be considered to be relatively uncontaminated by heavy metals.

6.4.5 Marine Sites of Ecological Importance

In 1991, after the Gulf War Oil Spill a number of agencies in Saudi Arabia and a Task Force from the European Union proposed the establishment of a Marine Wildlife Sanctuary north of Jubail. The main involved organisations were:

- European Union (EU);
- Gulf Cooperation Council (GCC);
- Saudi Arabian National Commission for Wildlife Conservation and Development (NCWCD);
- King Fahd University of Petroleum and Minerals (KFUPM);
- Meteorology and Environmental Protection Administration of Saudi Arabia (MEPA); and
- Senckenberg Research Institute, Frankfurt.

The area was chosen as it contains representative examples of all the main habitat types found along the Western Arabian Gulf coast and includes highly productive bay areas important for local fisheries (The Jubail Marine Wildlife Sanctuary Research Database, 2010).

The Jubail Marine Wildlife Sanctuary is located to the north of the Industrial City of Jubail along the eastern coast of Saudi Arabia. The area consists of two large coastal embayment systems (Dawhat ad-Dafi and Dawhat al-Musallamiya) and five offshore coral islands (Harqus, Karan, Kurain, Jana and Juraid) along the stretch of coastline between Abu Ali and Ras az-Zaur. The area covers an area of approximately 2,300 km^2 and more than 400 kilometres of coastline. The terrestrial component consists of bedrock outcrops, sand sheets, dunes and sabkha. The intertidal zone is characterised by sandy beaches, rocky shores, salt-marshes and mangroves. Seagrass beds, coral beds and coral reefs form the major types of subtidal habitats. The Sanctuary contains specimens of all major habitat types of the western Gulf. It includes the northernmost mangrove stands, the largest and most diverse coral reefs, and the most important nesting sites in the Arabian Gulf for marine turtles and several species of seabirds (Alam 1996, Fleming 1996, Krupp & Khushaim 1996, Ziegler & Krupp 1996, Abuzinada & Krupp 1994). Figure 6-17 shows the extent of the extent of the Jubail Marine Wildlife Sanctuary and its location north of the Industrial City.

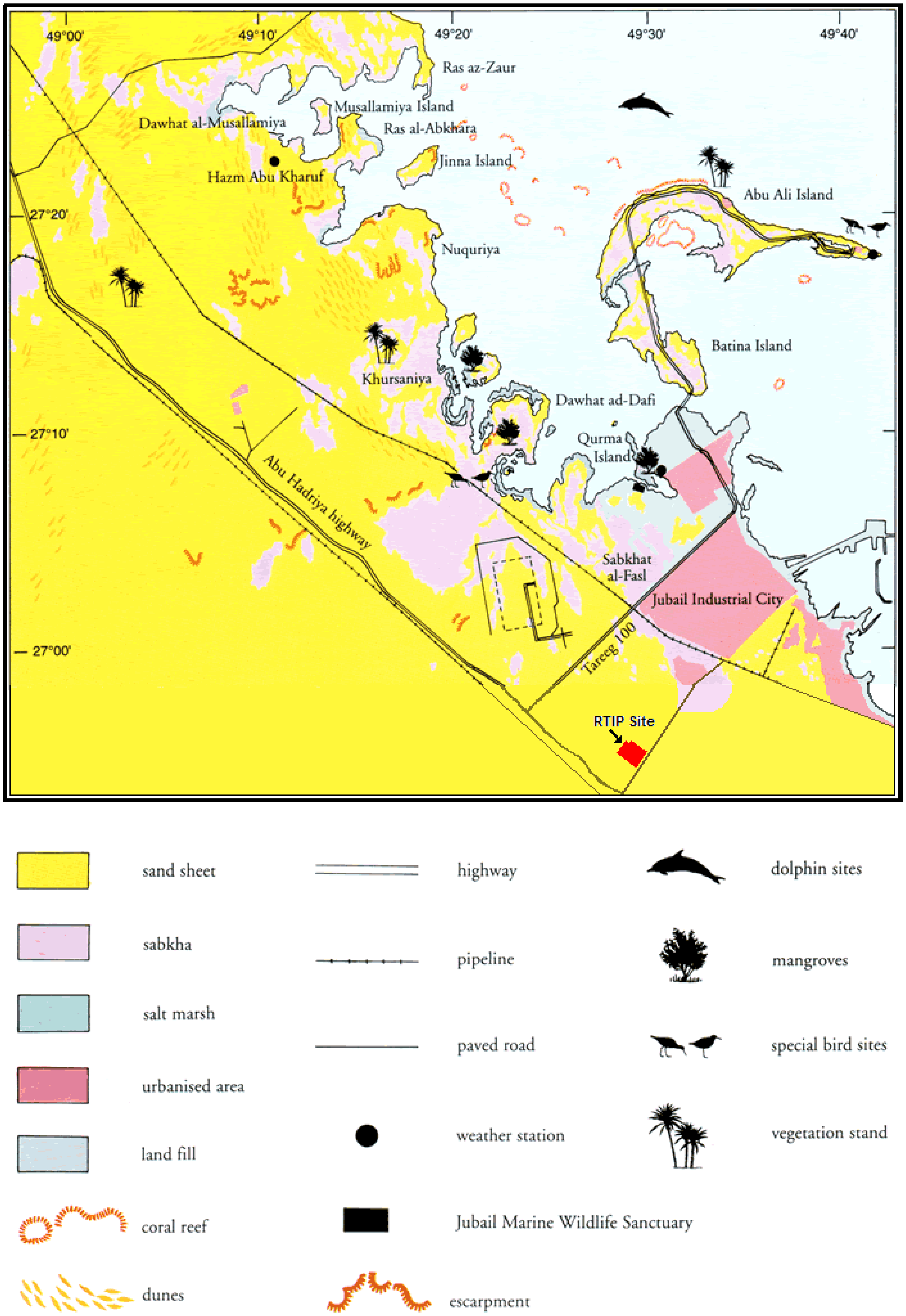

Figure 6-17 Jubail Marine Wildlife Sanctuary and the Project Site

Source: The Jubail Marine Wildlife Sanctuary Research Database, 2010

6.4.6 Marine Habitats

The following baseline condition assessment focuses on the biotic habitats of the region as they are more susceptible to the indirect impacts of anthropogenic activities.

6.4.6.1 Seagrass

Whilst it is not known if any seagrass communities exist in the Port area, this marine habitat has importance to many marine species as it serves as a nursery site, provides forage and cover for juvenile species and is used by listed endangered species such as the dugong (Dugong dugong) and most marine turtles. In the dredging EIA, seagrass communities off the Ras Tanura coastline were found to be predominantly comprised of needle or narrowlead seagrass (*Halodule uninervis)*. Some small communities of the tropical seagrass species, *Halophila stipulacea and paddle weed (H. ovalis)* have been observed mixing with communities of *Halodule uninervis* (KFUPM/RI, 2009). A noted decline in the seagrass population was seen from about 2km from the shoreline, or at depths of approximately 5m. Attenuation or penetration of light, combined with rocky and mud substrate offshore are likely the limiting factors in seagrass colonisation beyond this distance. The sandy areas within close proximity of the coastline and rocky areas overlain by sand are more suitable for seagrass colonisation. Seagrass meadow north of Jubail has been reported to support mixed seagrasses of the species noted above and a population of the green sea turtle (*Chelonia mydas*) (Marine Turtle News Letter, 1998). As green sea turtles are known to occur off Abu Ali and south of Safaniyah in Saudi Arabia as well as the UAE and Qatar, it is possible that green turtles may occur within the Port area. As seagrass colonizes low energy embayment type marine habitats, it likely existed in this area before the Port was developed. It is not known if any seagrass exists, but if it does it could provide the same habitat value that occurs in the Jubail Marine Reserve just to the north of the Port.

6.4.6.2 Coral

According to the KFUMP/RI (2009) report in the Ras Tanura area there is dense coverage of solitary coral communities, which are a distinctive feature of the area with no other marine waters of the Saudi Gulf coast comparing in density. The coral communities support a highly diverse biotic community of fishes and macro-invertebrates. The restrictions in relation to fishing that have been imposed are likely a major contributor to the abundance of corals as the use of destructive fishing methods is common in the Gulf (KFUPM/RI, 2009). The coral colonies are dominated by boulder corals (*Favia pallida* and *Favites* sp.); however there are also common occurrences of *Siderastrea savignyana, Platygyra daedalia, Turbinaria peltata, Cyphastrea serailia, Anomastrea irregularis, Acropora* sp., *Coscinaraea columna,* and *Psammocora contigua*. Coral can also be found north of Jubail, towards Batina Island as shown in Figure 6-17, but it is not known if corals exist within or near the Port area.

6.4.7 Marine Flora and Fauna

Marine flora and fauna can be sensitive to minor changes in their environment. It is important to understand the existing conditions prior to the commissioning of industrial processes that have the potential to impact upon species in the vicinity (UNEP, 2009).

6.4.7.1 Zooplankton

A vital role within marine ecosystems is fulfilled by zooplankton; the link between phytoplankton and higher trophic levels including fish. The role that zooplankton play in the marine environment is vital, providing for the transfer of energy between primary producers to higher trophic levels of the ecosystem (Priddle, *et al.*, 2003).

Within the Ras Tanura area a total of 76 different species of zooplankton were identified; 59 of which are prevalent in coastal waters and 67 prevalent in offshore waters. *Molluscan veligers* were the most common zooplankton identified in coastal waters and Copepoda were the most abundant zooplankton of offshore waters. Overall, Copepoda were the dominant group, contributing to 47% of the zooplankton population detected. The high abundance of *molluscan veligers* is indicative of the study area providing a good spawning and nursery ground for bivalves and gastropods. The investigation also indicated that the study area was a good nursery ground for all major penaeid prawns, which are an important shellfish resource caught by local fishing industry.

6.4.7.2 Benthic Organisms

Benthic organisms provide an indication of the health of an aquatic ecosystem as they provide a vital role of facilitating the recycling of nutrients via the deposition and breakdown of organic matter (Montagna & Kennicutt, 2002). The sessile lifestyle of benthic organisms can lead to them becoming susceptible to natural and anthropogenic induced changes in their environment in that they need to adapt or they will die. It is for this reason that the presence and abundance of benthic organisms can provide an indication as to the health of the marine environment.

Forty-one species of macrobenthic organisms were identified; polychaete worms comprised 50%, followed by crustaceans (29%) and molluscs (14%). Population abundance varied across the area from 380 ind./m^3 to 10,590 ind./m^3. Approximately 79% of stations exhibited abundances of greater than 1,000 ind./m^3. The highest average abundance of macrobenthic species was seen in the muddy sand habitat with, on average, 3,785 ind./m^3. Generally, the macrobenthic population indicated that the environment was considered healthy.

6.4.7.3 Mammals

Marine mammals fill an important role within the marine environment in that they occupy three roles; consumer, prey and detritus. The absence of marine mammals has the potential to impact top-down and bottom-up food chain interactions (Pfister, 2004).

The project site lies on the Arabian Gulf coast, an area where the Dugong (*Dugong dugong*) is found. Known locally as Atopom or Sea Cow, the Dugong inhabits shallow coastal waters and feeds on a variety of Sea-grasses (*Halodule* or *Diplanthera* spp). The dugong is identified as 'vulnerable' on the IUCN Red List of Endangered Species (IUCN, 2008). The species is threatened by hunting for its meat, leather and oil, and also by contamination from oil spills and other pollution incidents. The species is strongly protected by the Saudi

Arabian Government by the Hunting, Protection and Investment Regulation of the Live Aquatic Resources in the Regional Waters of the Kingdom.

Dugong presence in the area has not been confirmed, however, dugongs have been often sighted at Tarut Bay, south of Jubail. Dugongs feed predominantly on seagrass species.

In addition to the dugong there are several frequently sighted marine mammals in the Arabian Gulf including the fin whale (*Balaenoptera physalus*), Brydes whale (*B.edeni*), Minke whales (*B. acutoristrata*) orca whale (*Orcinus orca*), bottle-nose dolphin (*Tursiops aduncas*) and spotted dolphin (*Stenella attenuata*). Finless porpoises (*Neophocaena phocaenoides*) and humpback dolphin (*Sousa chinensis*) sightings have also been reported along the east coast (KFUPM/RI, 2009).

6.4.7.4 Birds

No Red List species have been noted in the study area, however the area offshore of the project site has not been investigated as part of this study, but it is possible that it has some value in contributing to wider feeding grounds for seabirds such as the cormorant, terns and gulls that either nest or overwinter in parts of the Arabian Gulf. The Gulf holds internationally important concentrations of several seabirds, many of which nest on the numerous islands. The region holds special importance for the Socotra Cormorant (*Phalacrocorax nigrogularis*), which is listed as Vulnerable on the IUCN Red List of Threatened Species, although as mentioned no Red List species have been noted in the study area.

The bird species included on the IUCN Red List of Threatened Species mentioned in Important Bird Areas of the Middle East account for Tarut Bay (Evans 1994) are:

- Pallas's Fish-eagle *Haliaeetus leucoryphus* - 2 records: November 1979 and January 1987. Present IUCN status is Vulnerable.

- White-tailed Eagle *Haliaeetus albicilla* - 2 records: 1 July 1950 and 1 October 1978. IUCN status: Least Concern.

6.4.7.5 Marine Reptiles

Five of seven of the world's turtle species are present within the Arabian Gulf (Stensgaard, 2007). The green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles are known to nest on beaches within most Gulf States. The leatherback (*Dermochelys coriacea*), olive ridley (*Lepidochelys olivacea*) and loggerhead (*Caretta caretta*) are seen within the Gulf, however, less frequently than the green and hawksbill turtles (Stensgaard, 2007). These species also nest off the coast of Oman.

Habitat and the presence of a reliable food source are the drivers for the existence of a turtle population. The green turtle feeds predominantly on the seagrass *Halodule univervis* and exists predominantly within the shallow waters of seagrass areas ([Miller 1989] within KFUPM/RI, 2009). The hawksbill turtle feeds on molluscs and bryozoans and typically dwells within coral reef habitats ([Miller 1989] within KFUPM/RI, 2009). If the requirements of both the green and hawksbill turtles are present within the Jubail Industrial area, then it is likely that these turtles have some presence within the area of the development.

6.4.8 Fish

Abundant fish populations were seen throughout the dredging study off Ras Tanura (KFUPM/RI, 2009). Although part of the Ras Tanura region is subject to a no-fishing restriction, which applies to a significant area of the coral and seagrass habitat, as some fishing methods employed in the area have been known to damage these habitats.

Twelve families of fish were represented in the trap catches; *Pomacanthidae, Lutjanudae, Nemipteridae, Haemulidae, Lethrinidae, Siganidae, Echeneidae, Sparidae, Gerreidae, Ariidae, Carangidae* and *Cheloniidae*. The family *Portunidae* (swimming crabs) was also represented.

The coralline regions of the area supported populations of *Pomacanthus maculosus*, *Acanthopagrus bifasciatus, Lethrinus lentjan, Scolopsis graham, Diplodus argus, Chaetodon spp., Apogon spp*. goatfishes (*Mullidae*), *labriids* and *gobiids*.

6.4.8.1 Fisheries Industry

The major fishing areas along the Saudi coast of the Arabian Gulf are located mainly along the northern side particularly the offshore regions off Manifa. The fishermen depend on this fishing ground exclusively for the capture of the green tiger prawn (*Penaeus semisuclatus)*. The major fishing harbours of the Saudi Arabian Gulf coast are Jubail, Manifa, and Qatif. The major fish markets are also located in Jubail, Ad-Dammam, and Qatif. There are about 21 major fish landing centres along the Arabian Gulf in the Kingdom (KFUPM/RI, 2009).

Ecosystem health and productivity are paramount in supporting a successful fisheries industry. The main fishery centres of Saudi Arabia are based at Jubail, Tarut Island and Qatif. Most operate using traditional equipment.

6.5 Key Habitats Characterization

The baseline ecological study has been used to identify the key habitats (or ecological features) and associated species of the study area, which may be potentially affected by the project development. These key habitats will be considered as the ecological receptors when assessment the impact significance.

Criteria were developed to assess the 'ecological value' of those key habitats/ecological receptors potentially affected by the project. The criteria used for valuing ecological receptors are provided in Table 6-5 below.

Table 6-5 Criteria for Valuing Ecological Receptors

Level of Value	Criteria (Examples)
Local	Areas of semi-natural vegetation or habitat considered to appreciably enrich the habitat resource within the context of the Project site and surrounding area. Sustainable populations of uncommon or declining species.
Provincial	Areas of habitat considered to enrich the habitat resource within 50 km of the Project site or within a defined geographic area of the country. Provincially designated or protected sites. Sustainable or strong populations of nationally scarce species (would be defined according to the size of the country and information available, e.g., species occurring in less than 5% of the land surface of the country).
National	Nationally designated or protected sites. Best examples of habitat within the country (e.g., the largest area of a particular habitat, a good example of a threatened or declining habitat). Strong populations of rare or nationally threatened species (e.g., a species occurring in less than 1% of the land surface of the country).
Regional (the Arabian Peninsula)	Sites or habitats internationally recognised but not necessarily designated or protected (e.g., Important Bird Areas). Strong populations of endemic or near-endemic species or subspecies to the Arabian Peninsula. Extensive areas of semi-natural vegetation or habitats characteristic of the Arabian Peninsula.
International	Internationally designated sites or habitats. Nationally significant populations of globally threatened or endangered species (e.g., IUCN Vulnerable or Endangered Red Data Book species). Sites supporting >1% of a biogeographical population of a species or subspecies.
Not Valued (Negligible)	Species, population or habitat not meeting any of the above criteria.

The key habitats are listed in Table 6-6, together with summary details of their ecological attributes, biodiversity value and legal status, as well as with the ecological value assigned to each of them according to Table 6-5.

Table 6-6: Summary Information on Key Habitats/Ecological Receptors. Evaluation Table

Habitat /feature	Flora	Associated fauna	Extent, biodiversity value and status	Legal and policy status	Global Value
Offshore marine environment	Not investigated*	Dugong Turtle Seabirds, e.g. gulls, terns, Socotra Cormorant, Migratory birds Cretaceans	The area offshore of the RTIP Complex will form only a very small contribution to the feeding grounds or territories of these species.	Regional policies and agreements concerned with protection of the Gulf and its wildlife. Dugong and Socotra Cormorant listed as Vulnerable (IUCN Red List).	International
Sand sheet habitat of the project site	*Salsola sp.* *Haloxylon salicornicum* *Lycium shawii* *Panicum turgidum* *Phoenix dactylifera* (date palm)	Typical desert communities of birds, sand-dwelling reptiles and small mammals	A widespread and commonplace habitat in the Gulf; here the value is diminished through high grazing pressure and human disturbance.	The habitat is not protected. None of the species occurring or likely to occur are nationally or internationally protected.	Local

6.5.1 Marine Environment

The regional marine environment is of International value because it supports globally important populations of mammals, birds and other species. Whilst its presence in Jubail is unconfirmed, the Dugong is listed as Vulnerable on the IUCN Red List of Threatened Species and is included in Appendix II of the Bonn Convention on Migratory Species and in Appendix I of CITES. The Socotra Cormorant is endemic to the Arabian Gulf and the south-east coast of the Arabian Peninsula. It is listed as Vulnerable on the IUCN Red List on account of its restricted world distribution, the small number of breeding sites and recent declines through human persecution and other factors. The main colony in the Gulf is situated on the Hawar Islands off Bahrain, a Ramsar site. The species is protected under the Convention on Migratory Species through the African-Eurasian Waterbird Agreement (AEWA).

Jubail is host to a Marine Wildlife Sanctuary, comprising a variety of marine habitats. In addition the dredging study undertaken in 2009, 50km south of Jubail, indicated that the region is diverse in its marine ecology and lacking in sediment contamination. As such the ecological value of the region should be considered as moderately high. The reliance of the local community upon the region through the fisheries industry should also be considered as significant in the assessment of impacts resultant of the RTIP at Jubail project.

On a local level the Jubail Port Area may show a different condition due to discharges, spills, the presence of breakwaters and other features that alter local circulation and flushing. Whilst data from the Ras Tanura region is useful in understanding relatively undisturbed nearshore sediments, site specific data would be required from the Port Area to fully assess baseline conditions near the proposed project facilities.

6.5.2 Sand Sheet Habitat of the Project Site

The sand sheet habitat occurring within the project site is an example of a type of habitat which is very widespread throughout the Arabian Gulf, especially along the eastern seaboard of Saudi Arabia and the United Arab Emirates. Most of the species associated with the habitat are also generally common and widespread, but in certain parts of the region, rare or threatened species may occur or may be supported by the habitat to some extent (e.g. species of gazelles, some migratory birds of prey).

It was not possible within the scope of the field study to confirm all species composition of the vegetation or make a detailed list of fauna present on the site, but it is likely that given the degraded nature of the site and high level of human influence that no rare or threatened species would occur. As described in the baseline description the site is likely to support common desert species of breeding, migratory and wintering birds together with resident mammals and reptiles, particularly species associated with sandy areas.

Habitats observed on the RTIP Site also extends outside the site to cover areas of the surrounding lands and regional area as observed in the Google Earth images and during travel around the site during field surveys. For these reasons the habitat observed are considered to be of Local value.

7 NOISE BASELINE

7.1 Overview

This section presents the identification of existing noise sources and sensitive receptors that could be affected by the noise generated by the project; the findings of the noise baseline survey; and its evaluation in light of applicable criteria.

A noise baseline investigation has been conducted to characterize existing ambient noise levels in order to assess the potential impacts of noise levels related to the different phases (construction, commissioning, operation, decommissioning & abandonment) of the RTIP. In addition, the areas that could potentially be affected by noise from RTIP activities have been reviewed to identify potential noise-sensitive receptors.

Noise produced during the lifetime of the project can potentially have a significant effect on the background noise level. The significance of the effect depends on the magnitude of the noise generated, the distance to noise-sensitive receptors, and the presence of any noise attenuating features at the source, along the noise path, or at the receptors. The impact on the noise environment associated with activities conducted during RTIP can potentially be significant.

In addition, there are also differences in the level of impact that day-time and night-time noise sources have on potential receptors. During the night-time, exterior background noise levels are generally lower than daytime noise levels which results in a greater noise level increase over the existing background noise level when the source of noise is steady over both day and night. High night-time noise is also more likely to cause sleep disturbance. Therefore, noise during the night-time has a larger impact than during the day-time.

The RTIP Site will occupy an area of approximately 576 hectares (ha) on a greenfield site identified as part of the future Jubail Industrial City II, located next to the existing JIC (at approximately 3 km). It will also occupy a tank farm in the Jubail Industrial Port.

Access to the port was not provided, therefore, the noise baseline study has been focused on the main site of the Complex and its surroundings.

The development of Jubail II will be carried out in four phases. The first phase was already completed in 2007; at the end of its development Jubail II will have the capacity to site 22 industry plots over 5,500 ha. During these four phases primary and secondary and support industries, as well as accommodation areas and infrastructure will be developed.

The area in which the main site of the RTIP Complex will be built is designated as industrial and is currently under development. When the noise measurement campaign was performed, an electric substation was under construction in the northern corner of the Site. A contractor camp was also located in the Site, close to the northeast boundary. These likely affected the measured noise levels.

RTIP site is surrounded by the following:

- Jubail Export Refinery (SATORP) under construction to the north-east;
- Jubail II undeveloped areas to the west and south;
- Road 274 to the south-east;
- BeeA'h industrial / chemical landfill facility to the east corner of RTIP site.

The nearest sensitive receptors to the RTIP complex are the following inhabited areas:

- Construction camp located at approximately 1.5 k south of the RTIP Site, close to a farm area;
- Jubail prison, located at approximately 3.8 km east of the RTIP Site;
- Jubail Old Town, at approximately 13 km north-east of the RTIP Site; and
- Jubail Community Area, located at approximately 17 km north of the RTIP Site.

The applicable noise standards for the RTIP Complex are those from the Royal Commission Environment Regulations, Volume I and II. Additionally, the World Bank noise limits have been included as a reference (World Bank, 2007a.)

7.2 Noise Definitions

As noise levels can vary over a given time period, various descriptors are used to quantify them. Noise descriptors measured during the noise campaign are the equivalent sound level (L_{eq}) and statistical noise levels (L_{max}, L_{min} and L_n).

The L_{eq} is defined as the level of a steady sound that has the same energy as the observed fluctuating sound. In other words, L_{eq} is an average of the time-varying sound energy for a specified time period. Statistical noise metrics are used to provide insight as to the noise level distribution over the measurement period. L_{max} and L_{min} are the maximum and minimum sound levels measured during any given time period. The L_n is the sound level that is exceeded n percent of the time during the measurement period. For example, L_{90} is a measurement that represents the noise level that is exceeded during 90 percent of the measurement period. Similarly, the L_{10} represents the noise level exceeded for 10 percent of the measurement period.

Definitions of technical noise terms used in this section are summarised in Table 7-1.

In determining the daily level of environmental noise, the difference in response of people to daytime and night-time noises must be considered. During the night-time, exterior background noise levels are generally lower than the daytime levels. However, most household noise also decreases at night and exterior noise becomes more noticeable. Furthermore, most people sleep at night and are sensitive to noise intrusion.

Table 7-1 Definitions of Acoustical Terms

Term	Definitions
Decibel (sound pressure level), dB	A unit describing the amplitude of sound, equal to 20 times the logarithm to the base 10 of the ratio of the pressure of the sound pressure (which is 20 micropascals or 20 micronewtons per square metre).
A-Weighted Sound Pressure Level, dB (A)	The sound pressure level in decibels as measured on a sound level meter using the A-weighted filter network. The A-weighted filter de-emphasises the very low and very high frequency components of the sound in a manner similar to the frequency response of the human ear and correlates well with subjective reactions to noise. All sound levels in this report are A-weighted.
Equivalent Noise Level, L_{eq}	The average (on a sound energy basis) A-weighted noise level during the measurement period.
Minimum Noise Level, L_{min}	The minimum A-weighted noise level during the measurement period.
Maximum Noise Level, L_{max}	The maximum A-weighted noise level during the measurement period.
Percentile Noise Level, L_n	The noise level exceeded during n % of the measurement period, where n is a number between 0 and 100 (e.g., L_{90}).
Ambient Noise Level	The composite of noise from all sources near and far. The normal or existing level of environmental noise at a given location.
Intrusive	Noise that intrudes over and above the existing ambient noise at a given location. The relative intrusiveness of a sound depends upon its amplitude, duration, frequency and time of occurrence and tonal or informational content as well as the prevailing ambient noise level.

Source: California Department of Transportation, 1998

7.3 Noise Sources

Current sources of environmental noise within the RTIP Complex are of two types:

- Natural sources of environmental noise (e.g. blowing wind and sand, birds and insects);
- Man-made sources of environmental noise in the RTIP Complex including activities associated with the construction of an electric substation in the northern corner of the Site (earth movement, unloading of material, vehicle operation and movement, traffic), and activities associated with the contractor camp located close to the northeastern boundary of the Site.

Current sources of environmental noise located outside the RTIP Complex but which could potentially affect baseline noise in these areas are the following:

- Refining and gas plants in the vicinity of RTIP complex, such as Berri Gas Plant;
- Activities associated with the BeeA’h landfill, close to the eastern corner of the RTIP Site;
- Construction activities of the Jubail Export Refinery (SARTOP), occurring close to the north eastern boundary of the RTIP Site;

- Traffic associated with the road network in the area (Route 274, which runs parallel to the south eastern boundary of the RTIP Site, Dammam-Jubail Highway and Jubail-Abu Hadriah Highway);

- Activities associated with the mixed used area located south east of the RTIP Site: Mega Coat Factory, agricultural activity, contractor camps).

Figure 7-1 shows the locations of these sources relative to the RTIP Complex.

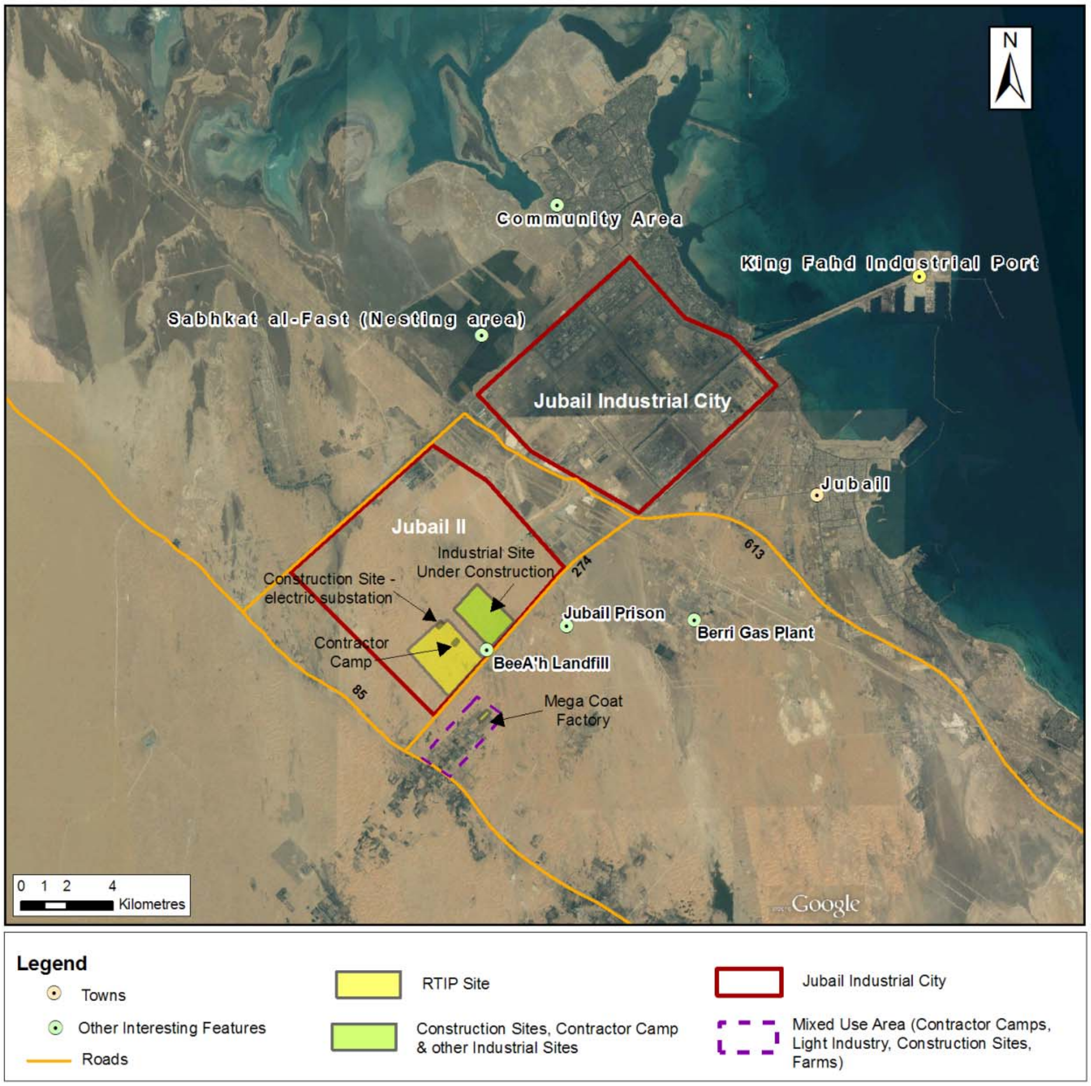

Figure 7-1 Location of Noise Sources and Noise Sensitive Receptors, RTIP

Source: Google Earth 2006 image modified by CH2M HILL

7.4 Noise Sensitive Receptors

The main potential noise sensitive receptors identified are those mentioned in section 7.1 (construction camp, Jubail Prison, Jubail Old Town and Jubail Community area).

Table 7-2 presents the minimum distances between RTIP Site and the noise sensitive receptors and their directions with respect to the RTIP Site. Figure 7-1 shows them in a map together with the main existing noise sources.

Table 7-2 Minimum Distance from RTIP Complex to Noise Sensitive Receptors

Noise Sensitive Receptors	Distance* (km) and Direction
Construction camp	1.5 (South)
Jubail Prison	3.8 (East)
Jubail Old Town	13 (North-East)
Jubail Community area	17 (North)

Source:
CH2M HILL estimations based on satellite images
Note
**Approximate distances.*

7.5 Methodology

A noise survey has been carried out by CH2M HILL on behalf of Kellogg Brown Root (KBR) at the site of the proposed new RTIP Site, at its boundaries and at the nearest inhabited areas.

The survey included long term noise monitoring (72 hours, three continuous 24 hour periods) at 7 locations (L1 to L7); 5 onsite and 2 offsite. Time history was recorded at intervals of 5 or 10 minutes for the long term environmental noise monitoring. The L_{95}, L_{90}, L_{50}, L_{10}, and L_5 noise descriptors were recorded for each interval along with L_{eq} and L_{max}. L_{min} was measured in certain locations.

This monitoring was supplemented by 19 short term measurements (S1 to S19), including 7 outside the RTIP Site, 9 on the Site boundary and 3 inside the Site. The short period measurements (spot measurements) have been recorded in 1/3rd octave band levels without any frequency weighting scale. The overall A-weighted L_{eq} level was also measured. The spot measurements were undertaken during a 10 minute time period.

The location of the monitoring points was limited by several factors such as access permissions, location of oil infrastructure (pipelines and fences), and ground conditions preventing vehicular access. CH2M HILL had permission to measure in the RTIP site at Jubail 2; within a farm owned by the owners of the Mega Coat Factory, and near the Jubail prison. CH2M HILL did not have a permit for conducting noise monitoring in the general area, or at the harbour.

Figure 7-2 show the locations of the long term and short term noise measurements with the identified sensitive receptors and main noise sources. Coordinates of the measurement locations are shown in Table 7-3 and Table 7-4.

The short term measures were taken during the field visit carried out on 12th November 2010 between 9:00 and 16:30. The long term survey was carried out between 4th and 13th November 2010.

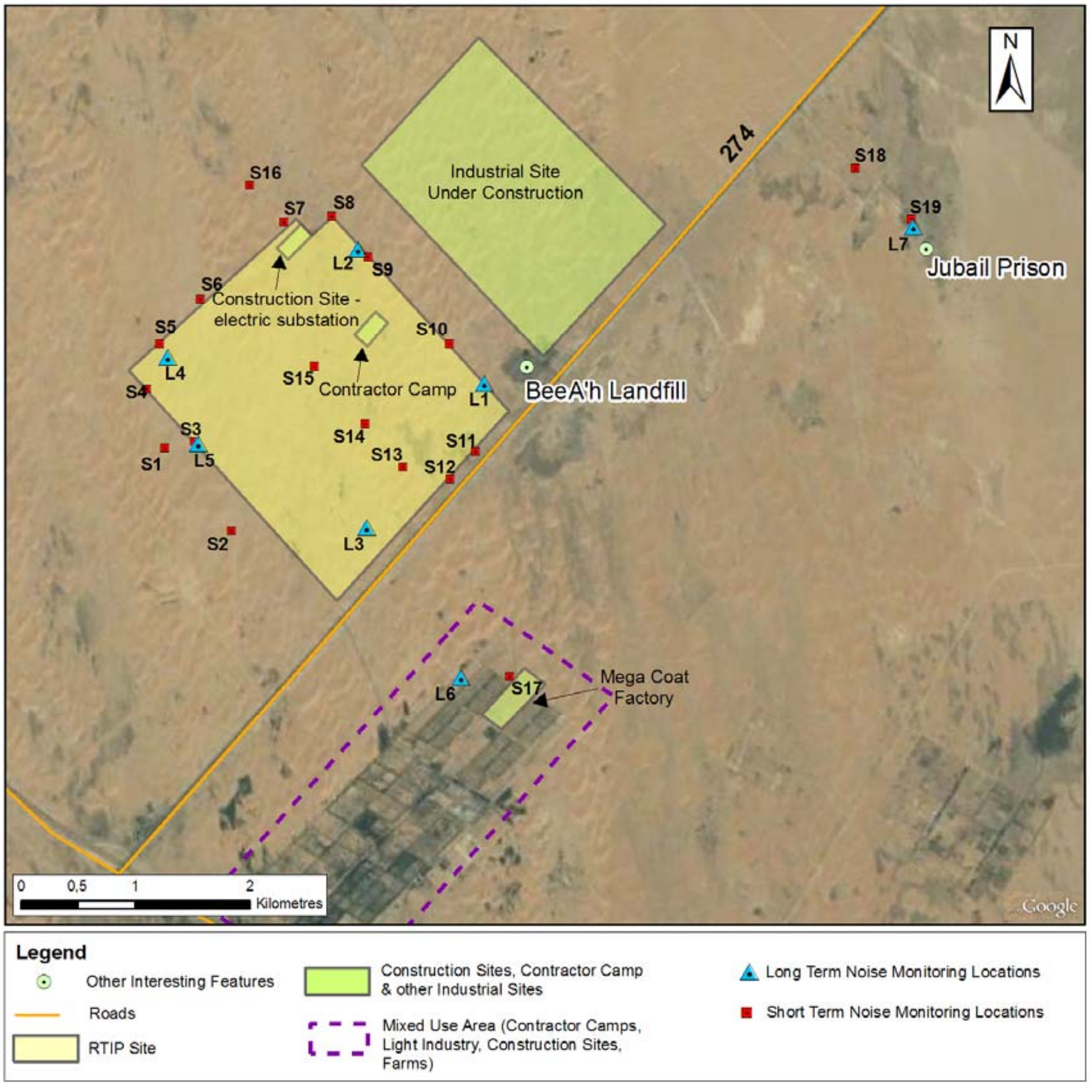

Figure 7-2 Long and Short Term Monitoring Locations, RTIP

Source: Google Earth 2006 image modified by CH2M HILL

Three noise meters compliant with the requirements of the American National Standards Institute (ANSI) S1.4 for Type 1 precision sound level measurement instrumentation, were used in the measurement campaign:

- Cirrus Research (CR) CR:811C - This noise meter was used for performing long term measurements in locations 1, 4 and 7. To ensure the accuracy of the measurements, the sound level meter was calibrated prior to use with a CR:515 class 2 acoustical calibrator, and the calibration was checked after each period of use.

- Brüel & Kjaer 2250 - This noise meter was used for performing long term measurements in locations L2 and L5. It was connected to a Brüel & Kjaer 4189 microphone. To ensure the accuracy of the measurements, the sound level meter was calibrated prior to use with a Brüel & Kjaer 42310 acoustical calibrator, and the calibration was checked after each period of use.
- Brüel & Kjaer 2250 Light - This noise meter was used for performing long term measurements in locations L3 and L6 as well as the short term measurements. This noise meter was connected to a Brüel & Kjaer 4950 microphone. To ensure the accuracy of the measurements, the sound level meter was calibrated prior to use with a Brüel & Kjaer 42310 acoustical calibrator, and the calibration was checked after each period of use.

Except for specific cases in which the equipment needed to be protected from sand dust, the microphone was placed at a position of 1.2-1.5 meters above the local ground elevation and away from reflective vertical surfaces. Wind induced microphone noise was minimised using a windscreen. The time weighting was set to fast. Field calibration was carried out for each set of measurements. All noise monitoring equipment used during the survey carried valid calibration certificates. Calibration certificates for each of the noise meters are included in Appendix C.

Location description and coordinates of the measurement points, measurement dates, topography, and wind speed, description of significant continuous noise sources nearby and of any other factors that could potentially affect noise measurements are included in Table 7-3 and Table 7-4. Photographs of the long term monitoring locations and surroundings are presented here after:

Figure 7-3 L1: Eastern Corner of the Site
Source: Alheit, 2010

Figure 7-4 North View From L2: Jubail Export Refinery (SARTOP) Under Construction
Source: Alheit, 2010

Figure 7-5 L3: Close to the Southern Corner of the Site
Source: Alheit, 2010

Figure 7-6 View of Road 274 from L3
Source: Alheit, 2010

Figure 7-7 L5: Close to the Western Boundary of the RTIP.
Source: Alheit, 2010

Figure 7-8 L6: Farm Adjacent to the Mega Coat Factory
Source: Alheit, 2010

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Figure 7-9 View of Jubail Prison from L7

Source: Alheit, 2010

7.6 Results

Table 7-3 summarizes the coordinates and the observations of the Long Term Noise Monitoring locations as well as the Leq (72h) and the average of the 10 minute L_{10} recorded in each location. The hourly Leq data are tabulated in Appendix C. Table 7-4 compiles the coordinates and Leq (10min) and L_{10} (10 min) for each Short Term Monitoring location. The 1/3rd octave band data for each 10-minute measurement are tabulated in Appendix C. Table 7-3 locates both short term and long term monitoring locations on a map.

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Table 7-3 Long Term Noise Monitoring Locations

Site Number: Receiver Location	Coordinates (WGS84)(1)		Dates	Wind Speed(2)	L_{eq} dBA (72h)	L_{10} dBA (72h)	Comments
	Easting	Northing					
L1: eastern corner of the site, near the adjacent BeeA'h waste facility	350683	2980431	04/11/2010 05/11/2010 06/11/2010 07/11/2010	Strong Breeze Strong Breeze Strong Breeze Strong Breeze	50	50	Wind noise was the most significant constant noise source to the human ear. Traffic noise from Road 274 (approximately 300m southeast) is the most prominent man made background noise. Noise from the construction site located to the northeast of the RTIP Site was faintly audible above the noise generated by wind. Intermittently louder noises could be heard from the construction site, such as reversing trucks. Occasionally noises from the RTIP site could be heard, such as trucks and vehicles entering the site from the main access road located approximately 300m to the southwest. The sand on site is very fine, and the strong wind generated lots of windblown dust. The noise monitor and microphone were placed inside a cardboard box, open at the top, for protection.
L2: close to north eastern boundary of the RTIP site, between the construction area of the electric substation and the contractor camp.	349583	2981605	05/11/2010 06/11/2010 07/11/2010 08/11/2010	Strong Breeze Strong Breeze Strong Breeze Gentle Breeze	50	51	It was very windy during the 5 – 7 Nov period, to the extent that the wind noise was the most significant constant noise source to the human ear. The most significant source of man-made noise was the transformer substation construction site located about 300m to the northwest. A diesel generator was running continuously. Noise from the construction site located to the northeast of the measurement point was faintly audible above the wind noise. Intermittently louder noises could be heard from the construction site, such as reversing trucks. Occasional vehicle traffic (mostly light vehicles, but sometimes trucks) passed by the road approximately 20 m to the northeast of the monitoring location.

Table 7-3 Long Term Noise Monitoring Locations

Site Number: Receiver Location	Coordinates (WGS84)(1)		Dates	Wind Speed(2)	L_{eq} dBA (72h)	L_{10} dBA (72h)	Comments
	Easting	Northing					
L3: close to the south western corner of the RTIP Site	350089	2979613	04/11/2010	Strong Breeze	51	53	Wind noise was the most significant constant noise source. Traffic noise from the Road 274, located about 300m to the southeast of the monitoring point was the most prominent background man made noise. Trucks and light vehicles passed by occasionally on the access road. The microphone stand was broken, so on 04 and 05 Nov it was placed on the box containing the outdoor monitoring kit at a height of approximately 50cm. Some noise may have been generated occasionally by technicians opening the lid of the outdoor monitoring kit box to check the noise monitor. On the morning of 06 Nov noise measurement was briefly interrupted to fix the microphone to the microphone stand.
			05/11/2010	Strong Breeze			
			06/11/2010	Strong Breeze			
			07/11/2010	Strong Breeze			
L4: towards northwestern corner of the site, close to one of the main roads running through the site from northern to southern end.	347780	2980817	07/11/2010	Strong Breeze	51	51	Trucks and light vehicles pass by regularly on the main site access road from the northwest, which is located approximately 200m to the northeast of the monitoring point. Strong wind and rain occurred around 2pm on 08 Nov, lasting about half an hour. For most of the rest of the day the wind was a gentle breeze. The noise monitor and microphone were placed inside a cardboard box for protection. The box was placed on the floor with the top open.
			08/11/2010	Gentle Breeze			
			09/11/2010	Calm			
			10/11/2010	Light Breeze			
L5: towards western boundary of the RTIP site	348128	2979859	08/11/2010	Gentle Breeze	44	45	Trucks and light vehicles pass by regularly on the main site access road running from the northwest to the sand loading area located in the southern corner of the site, which is located approximately 500m to the northeast of the monitoring point. Occasionally trucks and light vehicles pass by on an access road from the southwestern side of the site, approximately 30m northwest of the monitoring location.
			09/11/2010	Calm			
			10/11/2010	Light Breeze			
			11/11/2010	Light Breeze			
L6: within a farm adjacent to Mega Coat Factory	350639	2980720	08/11/2010	Gentle Breeze	50	51	Traffic noise from Road 274, located approximately 500m to the northwest, was faintly audible. So was occasional noise from the industrial sites and accommodation camps located to the southeast of
			09/11/2010	Calm			

Table 7-3 Long Term Noise Monitoring Locations

Site Number: Receiver Location	Coordinates (WGS84)(1)		Dates	Wind Speed(2)	L_{eq} dBA (72h)	L_{10} dBA (72h)	Comments
	Easting	Northing					
			10/11/2010	Light Breeze			the farm. Rainstorm with strong wind and rain took place around 2pm on 08 Nov; lasting about 30 min. Microphone fell over once due to high wind.
			11/11/2010	Light Breeze			
L7: Access road to Jubail Prison, about 200m from the prison gate.	354441	2981801	10/11/2010	Light Breeze	47	48	Traffic noise from the highway (Road 274), located approximately 500m to the northeast was audible. Occasional traffic passed by the monitoring point on the way to the prison parking lot. A dozer was doing earthmoving work in the general vicinity of the prison on 10 Nov.
			11/11/2010	Light Breeze			
			12/11/2010	Gentle Breeze			
			13/11/2010	Gentle Breeze			

Source:

CH2M HILL, 2010

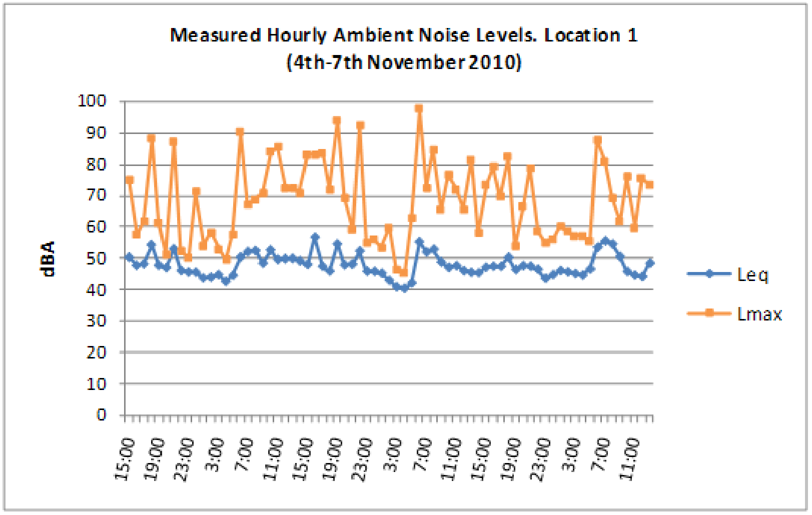
Notes:

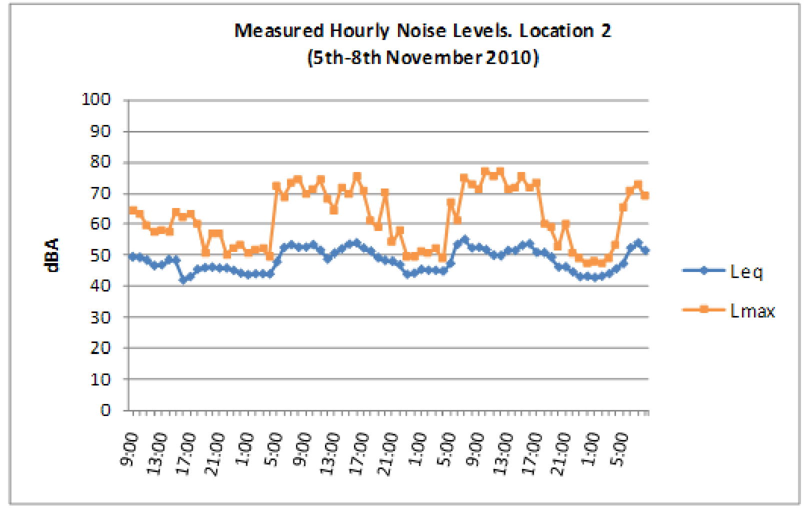
(1) Coordinate System: WGS 1984 UTM Zone 39N

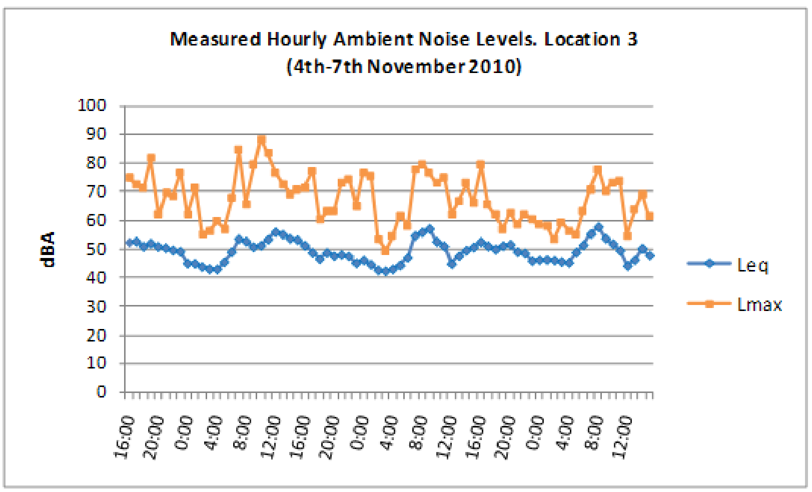
(2) Average daily wind speed estimates based on observed land conditions following the Beaufort Wind Force Scale (NOAA, 2010) as follows:

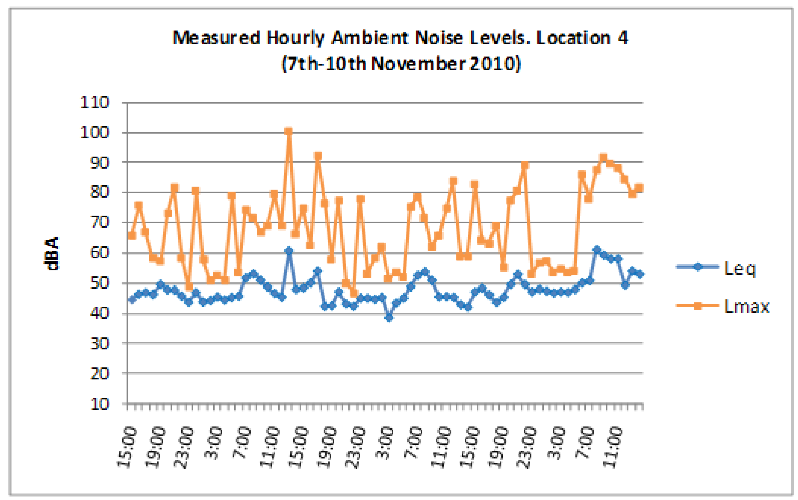
- *Strong Breeze (6): Large branches in motion; whistling heard in telegraph wires; Wind speed:10.8-13.8 m/s*
- *Gentle Breeze (3): Leaves and small twigs in constant motion; wind extends light flag; Wind speed:3.4-5.4 m/s*
- *Light Breeze (2): Wind felt on face; leaves rustle; ordinary vanes moved by wind; Wind speed:1.6-3.4 m/s*
- *Calm (1): Calm. Smoke rises vertically; Wind speed < 0.3 m/s*

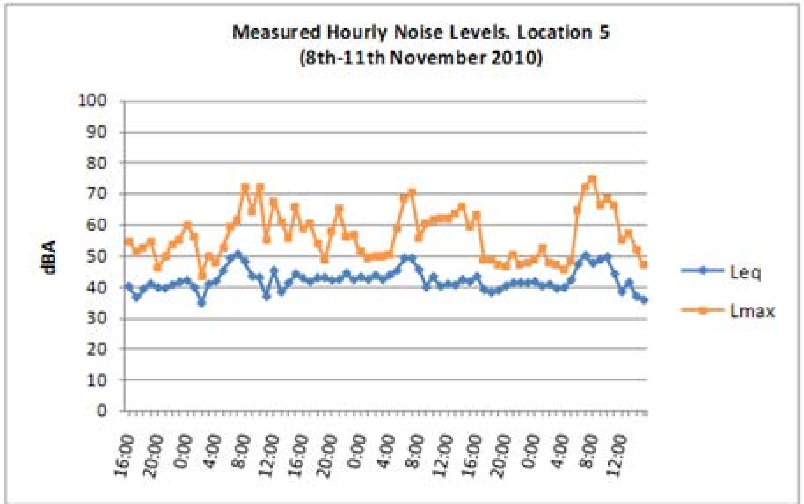
Appendix C-1 summarises the measured noise levels during the continuous noise level survey, it includes the L_{eq} hourly, the L_{eq} (24h) and the L_{eq} (72h).

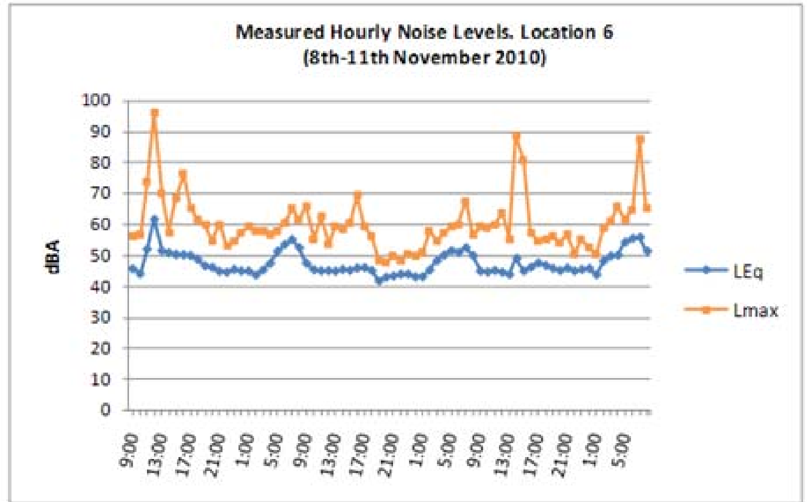









Measured Hourly Noise Levels. Location 5
(8th-11th November 2010)
dBA
Leq
Lmax


Measured Hourly Noise Levels. Location 6
(8th-11th November 2010)
dBA
LEq
Lmax

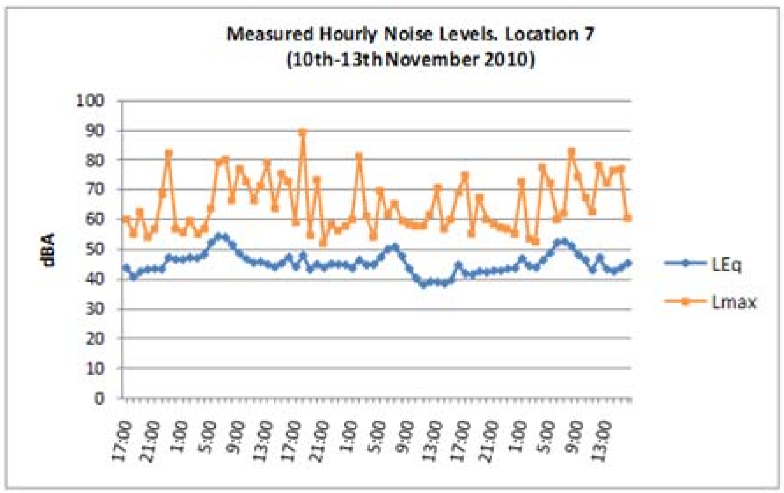

Measured Hourly Noise Levels. Location 7
(10th-13th November 2010)
dBA
LEq
Lmax

Figure 7-10 depicts the results of the continuous noise level measurements. From the measurement data, it is apparent that the existing average noise levels ($L_{eq,}$ [72h]) at the RTIP Complex range between 44 and 51 dB (A).

Noise levels are quite homogeneous along the site and main man-made sources proved to be the following:

- Construction activities taking place during the measurements: construction of an electrical substation in the northern corner of the site and construction of the Jubail Export Refinery (SARTOP), limiting with the north eastern boundary of the RTIP Site. These activities affected mainly the noise levels measured in locations L1 and L2;

- Traffic on Road 274 has a significant influence on the noise levels measured in Locations L1 and L3;

- Traffic on the main access road (trucks and light vehicles) has a significant influence in noise levels measured in Locations L4 and L5, being more noticeable in L4, where the maximum L_{eq} (72h) (51 dBA) was measured.

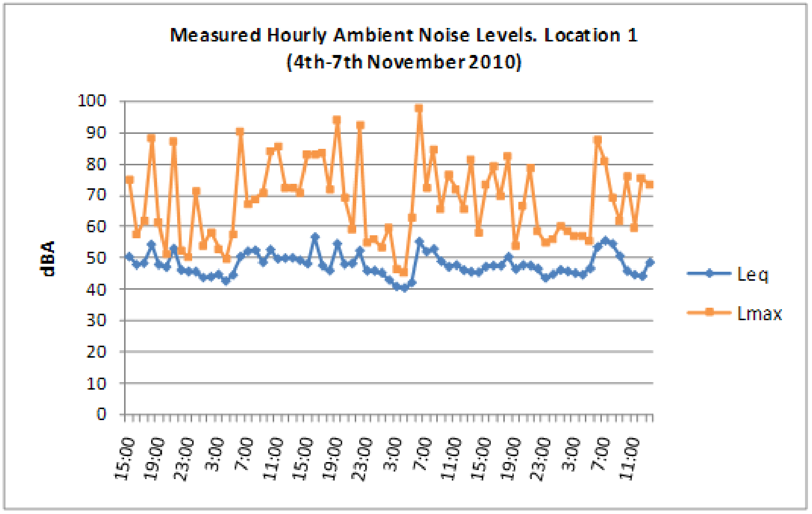
It is worth noting that while periods of high wind speed were avoided as far as was practicable, wind speed was high during the long term noise measurements in locations L1, L2, and L3 (see Table 7-3), being perceived as the main source of noise during the measurements. Windscreens were used in all the measurements, and in some cases, the noise meter was located in an open box in order to protect it from strong wind and sand (See comments in Table 7-3). Long term measurements in locations L1 and L4 were performed with the noise meter and microphone inside an open box located on the floor.

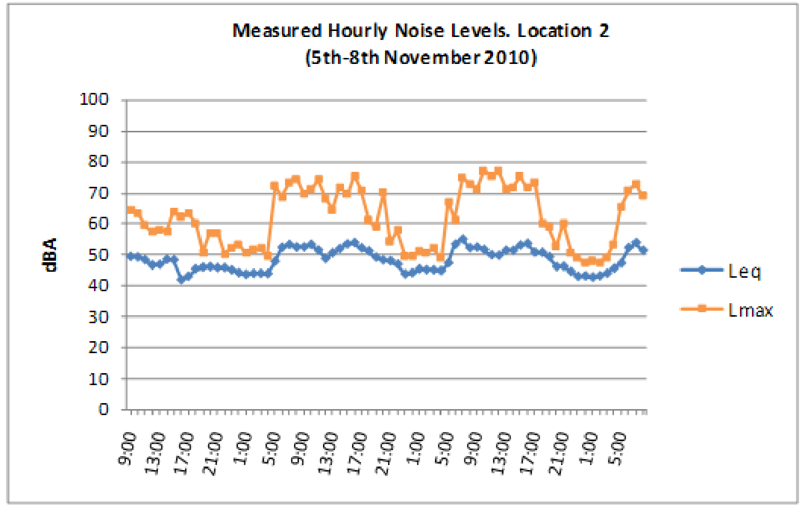
The measured L_{eq} (72h) were between 49 and 51 dB(A) except in Location L5, where the minimum level was measured (44 dBA). This measurement point was located more than 500m away from the closest significant noise source (traffic associated with the main access road) and wind speed was from mild to calm.

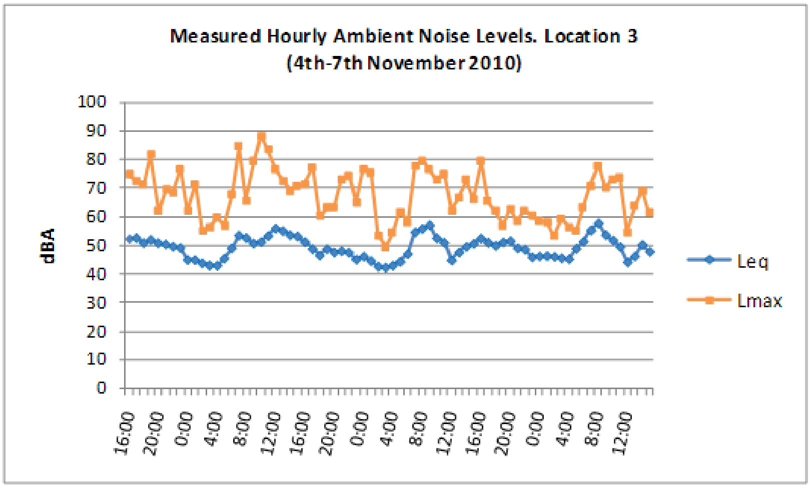
The noise levels (L_{eq} [72h]) measured in the offsite locations, close to sensitive receptors are defined by the following sources:

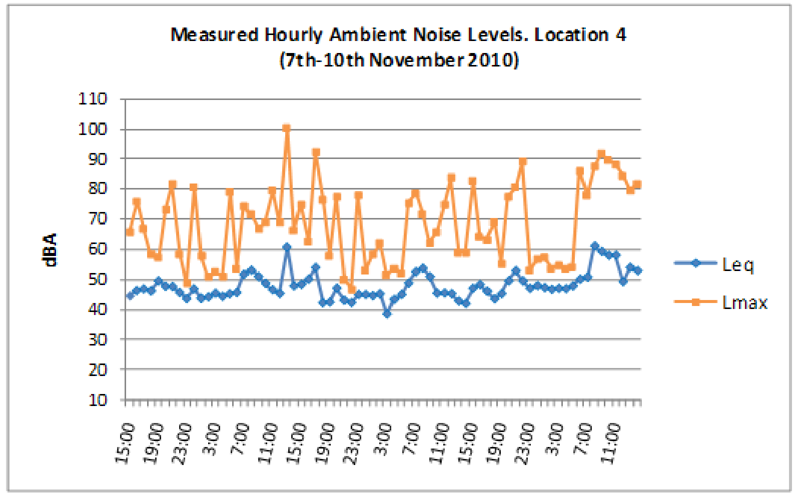
- Location L6 (Farm southeast of the RTIP Site): 274 Road traffic and occasional noise from industrial sites and accommodation camps (human activity, traffic, generators, etc.) located SE from the monitoring location was faintly audible. No significant noise from the Mega Coat Factory, which appeared to be idle at the time of the measurements, was perceived and noise from construction/industrial sites located further away was more noticeable. On day 2 when the wind was calm, the most noticeable sounds at L6 were birds and insects.

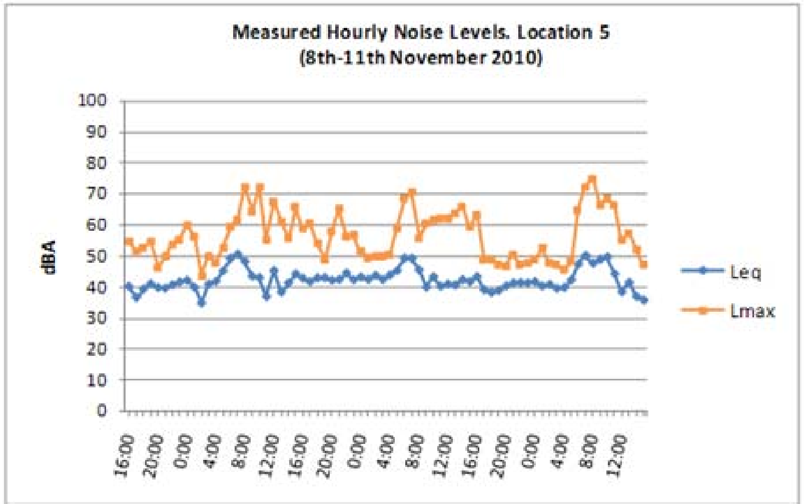
- Location L7 (Jubail Prison): 274 Road traffic, occasional vehicles circulating close to the monitoring point, on their way to the prison parking lot and dozer activity in the vicinity.

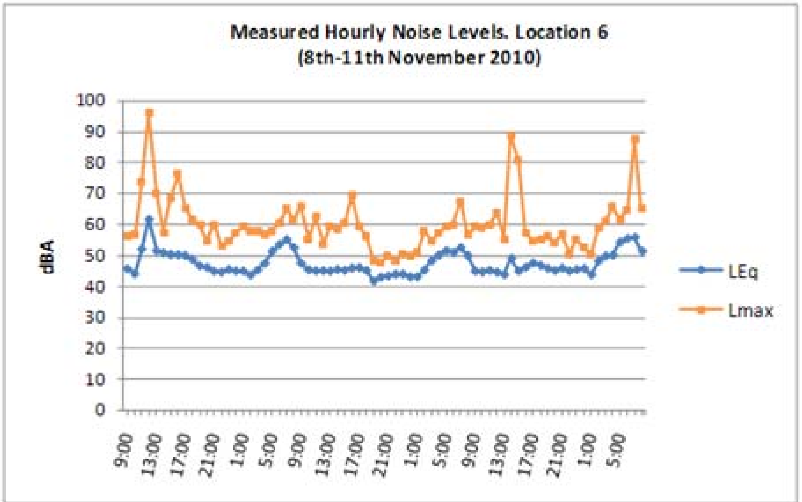

Measured Hourly Ambient Noise Levels. Location 1
(4th-7th November 2010)
dBA
Leq
Lmax


Measured Hourly Noise Levels. Location 2
(5th-8th November 2010)
dBA
Leq
Lmax


Measured Hourly Ambient Noise Levels. Location 3
(4th-7th November 2010)
dBA
Leq
Lmax


Measured Hourly Ambient Noise Levels. Location 4
(7th-10th November 2010)
dBA
Leq
Lmax





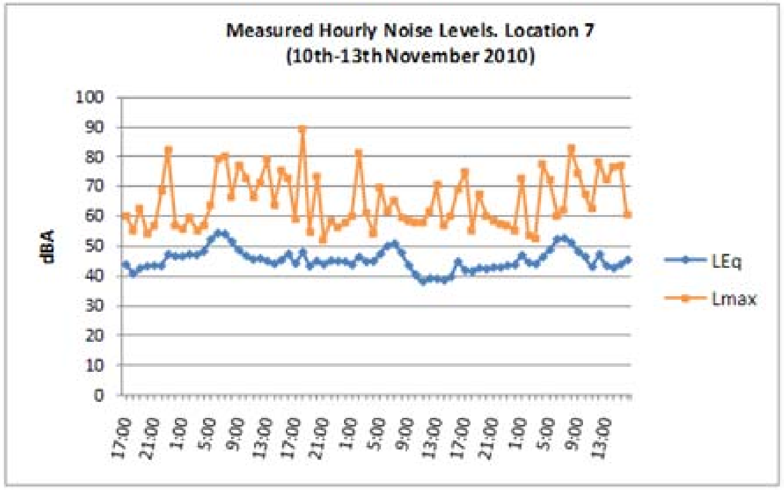


Figure 7-10 Results of Continuous Noise Level Measurements

The results of short term monitoring are listed in Appendix C-2. This Appendix presents the spot measurements in unweighted 1/3rd octave band sound pressure levels and the overall A-weighted L_{eq} (10min). In addition, Table 7-4 summarizes the L_{eq} (10 min), the L_{10} (10 min) and the coordinates of the spot noise measurements, as well as the main characteristics of the measurement point, main sources and significant events observed.

Because of the duration of short term measurements, 10 minutes, it is not possible to establish the characteristics of the background noise levels in these locations. However, these measurements do provide a general idea about current noise levels. Given that the short term measurements have been recorded in 1/3rd octave band levels, they could be useful to identify pure tones if questions about current conditions arise in the future.

The measured equivalent noise levels (L_{eq} [10 min]) ranged between 33 dB (A) and 59 dB (A). This wide variance is considered to be associated mainly with the occurrence of loud single events such as significant traffic passing by or heavy vehicles circulating close to the measurement point.

Equivalent noise levels (L_{eq} [10 min]) measured in the RTIP Site and its boundaries vary within the range of the values shown in the previous paragraph.

The maximum 10-minute equivalent noise level, 59 dB(A), was measured in Location S3, and was due a truck passing by a road adjacent to the monitoring point.

Equivalent noise levels of less than 40 dB(A) (typical of undeveloped areas with no significant noise sources nearby) were measured in several locations near the RTIP Site boundaries (S4, S5, S6, S7, S8 and S16). During these measurements no discernible noise apart from faint noise from construction sites nearby and traffic was noted. Wind speed was light to mild.

Two short term measurements were undertaken close to the Jubail Prison, in locations S18 and S19. Equivalent noise levels (L_{eq} [10 min]) measured were 55 and 47 dB(A) respectively. The main source was traffic from Road 274. These levels show dependence on single events such as heavy vehicles passing by in the measurement periods and are determined by the proximity of receptors to the road. These measurements are considered representative of the noise levels in the area. L_{eq} [72 hours] measured in the area (Location L7) was 47 dB(A), and as shown in Appendix C and in Figure 7-10, hourly equivalent levels varied from 38 to 54 dB (A).

One short term measurement was undertaken close to the farm located south east of the RTIP Site, adjacent to Mega Coat Factory. The Mega Coat Factory, dedicated mainly to pipe painting and treatment, is shown in Figure 7-2 and appeared to be idle while the measurements were being taken.

The measured noise equivalent level (L_{eq} [10 min]) was 39 dB(A). This value is not considered representative of the equivalent noise levels in the area. As shown in Appendix C and in Figure 7-10, hourly equivalent levels calculated from the long term measurements in Location L6 vary from 42 to 62dB(A) due to traffic associated to Road 274 and activities associated to the industrial sites and accommodation camps located south east of the monitoring point. As mentioned, noise from the Mega Coat Factory was not significant during the measurement period.

Table 7-4 Short Term Noise Monitoring Locations

Location (WP)	Coordinates		Location Description	Comments		L_{eq} dBA	L_{10}dBA
	Easting	Northing		Wind conditions(1)	Sources of Noise		
S1 (WP16)	347899	2979868	Outside southwestern boundary. Topography Flat.	Light breeze from the northwest	Ongoing construction noise from adjacent construction site on northeastern boundary was the most significant noise source. Occasional vehicle traffic from road 274 and from roads on site took place.	45	46
S2 (WP17)	348483	2979147	Outside southwestern boundary, near southern corner. Topography flat in all directions except northeast, where there are low dunes (approximately 20m).	Light breeze from the northwest	Ongoing construction noise from adjacent construction site on northeastern boundary was the most significant noise source. Occasional vehicle traffic from road 274 and from roads on site took place.	42	43
S3 (WP18)	348115	2979889	On southwestern boundary (storm water trench). Topography flat in all directions except southeast, where there are low dunes (approximately 20m high).	Light breeze from the northwest	Ongoing construction noise from adjacent construction site on northeastern boundary was the most significant noise source. Occasional vehicle traffic from road 274 took place. A truck passed by on road adjacent to monitor while monitoring.	59	51
S4 (WP22)	347557	2980247	Outside southwestern boundary, near western corner. Topography flat in all directions.	Light breeze from the northwest	Faintly audible noise from construction site on northeastern boundary was the only discernable noise.	34	37
S5 (WP23)	347801	2980814	On northwestern boundary near western corner. Topography flat.	Light breeze from the northwest	No discernable noise except for wind.	34	37
S6 (WP26)	348207	2981175	On northwestern boundary. Topography flat.	Gentle breeze wind from the northwest	No discernable noise except for wind.	36	40
S7 (WP27)	348938	2981848	On northwestern boundary, near northern corner. Topography flat.	Gentle breeze wind from the northwest	No discernable noise except for wind.	33	36
S8 (WP29)	349359	2981897	On northeastern boundary, near northern corner. Topography flat.	Gentle breeze wind from the northwest	Generator and other noise from electricity substation construction site in northern corner of site.	39	42

Table 7-4 Short Term Noise Monitoring Locations

Location (WP)	Coordinates		Location Description	Comments		L_{eq} dBA	L_{10}dBA
	Easting	Northing		Wind conditions[(1)]	Sources of Noise		
S9 (WP32)	349678	2981543	On northeastern boundary. Topography flat.	Gentle breeze wind from the northwest	Generator and other noise from electricity substation construction site in northern corner of site was audible. No significant noise from the construction site on northeastern boundary was perceived.	40	43
S10 (WP 33)	350386	2980780	On northeastern boundary, towards eastern corner. Topography flat.	Gentle breeze wind from the northwest	Generator noise and other noise from construction site in middle of the site was audible.	42	45
S11 (WP 34)	350593	2979863	On southeastern boundary. Topography flat.	Gentle breeze wind from the northwest	Traffic noise from Road 274 (approximately 200m to the southeast) was audible.	51	55
S12 (WP 35)	350366	2979624	On southeastern boundary. Topography flat.	Gentle breeze wind from the northwest	Traffic noise from Road 274 (approximately 200m to the southeast) was audible.	52	54
S13 (WP 37)	349983	2979707	On road through middle of site. Topography flat.	Gentle breeze wind from the northwest	Traffic noise from Road 274 (southeast) was audible.	45	47
S14 (WP 38)	349649	2980081	On road through middle of site. Topography flat.	Gentle breeze wind from the northwest	Faintly audible noise from construction site on the northeastern boundary and on site construction sites were the only discernable noises. Traffic noise from Road 274 (southeast) faintly audible.	41	43
S15 (WP 39)	349207	2980582	On road through middle of site. Topography flat.	Gentle breeze wind from the northwest	Faintly audible noise from construction site on northeastern boundary and on site construction sites were the only discernable noises.	42	45
S16 (WP 40)	348642	2982170	Northwest of site boundary. Topography flat all around.	Gentle breeze wind from the northwest	Faintly audible noise from construction sites and highways was audible.	38	41
S17 (WP 41)	350916	2977878	In farm area. Topography flat all around.	Light breeze from the northwest	Faintly audible noise from construction sites and Road 274 was audible.	39	40
S18 (WP 42)	353940	2982313	Adjacent to access road to Jubail prison. Topography flat all around.	Gentle breeze wind from the northwest	Noise from Road 274 was audible.	55	51

Table 7-4 Short Term Noise Monitoring Locations

Location (WP)	Coordinates		Location Description	Comments		L_{eq} dBA	L_{10}dBA
	Easting	Northing		Wind conditions[1]	Sources of Noise		
S19 (WP 43)	354424	2981874	Adjacent to access road to Jubail prison. Topography flat all around.	Gentle breeze wind from the northwest	Noise from Road 274 was audible.	47	44

Notes:

Coordinate System: UTM WGS84 39N

(1) Wind speed estimates based on observed land conditions during the 10 minute measurements following the Beaufort Wind Force Scale (NOAA, 2010) as follows:

- *Gentle Breeze (3): Leaves and small twigs in constant motion; wind extends light flag; Wind speed:3.4-5.4 m/s*
- *Light Breeze (2): Wind felt on face; leaves rustle; ordinary vanes moved by wind; Wind speed:1.6-3.4 m/s*

Source: Field visit carried out 12th November 2010

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7.7 Comparison of Current Noise Levels to Criteria

The relevant guidelines for the evaluation of noise levels are detailed in Section 7, Royal Commission Environmental Regulations. In addition, the World Bank standards will be used as guidance of limits for this project (World Bank, 2007a).

The results from the noise monitoring are compared to the noise criteria provided in Table 7A of Royal Commission Environmental Regulations (RCER) and the World Bank guidelines in Table 7-5. The night-time period is the most restrictive because exterior background noise levels are generally lower than during daytime and evening periods, which results in a greater noise level increase over the existing background noise level. The noise criteria provided in RCER are L_{10} levels, which represents noise level exceeding during 10% of the measurement period.

Applicable noise limits considered in the RTIP Site and its boundaries are those defined by the RCER for Industrial zoning (see Table 7-5) and by the World Bank for Industrial Areas.

The surroundings of the measurement location L6, in the farm adjacent to Mega Coat Factory are characterised by the presence of construction activities of permanent housing units, of contractor yards and laydown areas and of temporary contractor accommodation camps. The noise limits considered are those defined by the RCER for Commercial (see Table 7-5).

Applicable noise limits considered in the proximities of the Jubail Prison (noise measurement location L7) are those defined by RCER and World Bank for Residential Areas.

The existing ambient noise levels within the RTIP Site and in its boundaries are below the World Bank noise criteria for all the long term monitoring results.

The L_{eq} noise levels registered in the Farm (measurement location L6) are below the RCER and World Bank noise criteria. In the proximities of Jubail Prison (measurement location L7) measurements are over the night-time standard for the World Bank Guidelines but comply with the World Bank standards established for day and evening periods and with the RCER noise limits.

Night exceedances are associated to peaks of traffic that took place every day, between 5:00 and 7:00 am, inclusive.

Table 7-5 Comparison of Noise Levels to National and International Standards

Location	Area Designation(1)	Existing Noise Levels				RCER(2) L_{10} dB (A) (72 hours)	World Bank Guidelines (LEq)	
		L_{eq} dB (A)			L_{10} dB (A)		Day(6)	Night(7)
		Daytime(3)	Evening(4)	Night(5)	72 hours			
L1	Industry	50	49	49	50	75	70	70
L2	Industry	51	46	49	51	75	70	70
L3	Industry	52	49	49	53	75	70	70
L4	Industry	53	48	48	51	75	70	70
L5	Industry	43	42	45	45	75	70	70

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Table 7-5 Comparison of Noise Levels to National and International Standards

Location	Area Designation(1)	Existing Noise Levels				RCER(2) L_{10} dB (A) (72 hours)	World Bank Guidelines (LEq)	
		L_{eq} dB (A)			L_{10} dB (A)		Day(6)	Night(7)
		Daytime(3)	Evening(4)	Night(5)	72 hours			
L6	Commercial	51	45	51	51	65	70	70
L7	Residential	45	44	49	48	50	55	45

Notes:
Shaded values exceed criteria.
(1) According to the RCER
(2) RCER limits are L10 noise limits,
(3) Refers to the time period between 07.00 and 19.00 hours According to the RCER
(4) Refers to the time period between 19.00 and 23.00 hours
(5) Refers to the time period between 23.00 and 07.00 hours
(6) Refers to the time period between 7.00 and 22.00 hours
(7) Refers to the time period between 22.00 and 07.00 hours
Sources:
Field visit carried out between November 4th and November 13th 2010
Royal Commission Environmental Regulations, Volume I and II (RCER,2010)
World Bank "Environmental, Health, and Safety General Guidelines, 2007"(World Bank, 2007a)

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8 WASTE MANAGEMENT BASELINE

8.1 Overview

Waste management is recognized as an integral and critical component of the EIA. A review of existing waste facilities and management practices in the Eastern Province, the region in which the RTIP site is located, was undertaken as part of the baseline survey to determine the waste disposal options. This section presents the findings of this baseline review covering both local and regional solid and liquid hazardous and non-hazardous waste treatment and/or disposal facilities.

A detailed review of the relevant legislation relating to waste management is provided in Section 2 – Policy, Legal and Administrative Framework.

8.2 Definition of Wastes

The classification and determination of the solid waste type and category will follow the RCER-2010. This regulation provides guidance to determine hazardous and non-hazardous waste classifications and their treatment/disposal method(s).

According to RCER-2010, waste can be classified into four categories, as shown in Table 8-1. This constitutes a more detailed classification than that offered by the Basel Convention, which only classifies wastes into hazardous and non-hazardous wastes.

Table 8-1 Classification of Waste as Defined by the RCJY

Waste Type	Definition
Hazardous Wastes	There are any solid, semi-solid, liquid, gaseous wastes or combination of such wastes, which may because of its quantity, concentration, physical or chemical characteristics, pose a hazard to human or environmental health and well being when improperly treated, stored, transported, disposed or otherwise managed. They shall also include: • All wastes with the hazardous properties as defined in Section 4.1 of the RCER-2010 including commercial chemical products, off-specification products/chemicals, containers and spills residues. • Any waste if after application of the test TCLP(1) , they contain contaminant concentrations equal to or greater than those listed in Table 5-A of the RCER-2010. • Any wastes identified as hazardous by PME(2)
Non Hazardous Industrial Wastes	Any solid, liquid, semi-liquid or gaseous materials or wastes resulting from industrial, mining and agricultural operations and sludge from industrial, agricultural or mining, water supply treatment, wastewater treatment or air pollution control facilities, provided that they are not hazardous, municipal or inert wastes as otherwise defined in these regulations.
Municipal Wastes	They include garbage, refuse, food waste, office waste, waste vegetation and other decomposable material resulting from operation of residential, commercial, municipal, industrial or institutional establishments and from community activities.
Inert Wastes	Any wastes which are not biologically or chemically active in the natural environment, such as glass, concrete and brick materials, broken clay and manufactured rubber products.

Table 8-1 Classification of Waste as Defined by the RCJY

Waste Type	Definition

Notes:
(1) Extraction by Toxicity Characteristics Leachate Procedure (TCLP) as detailed in USEPA 40CFR Part 261 subpart D, section 261.35, dated 16 August 1991.
(2) *Refer to "General Environmental Regulations and Rules for Implementation" of Presidency of Meteorology and Environment of Kingdom of Saudi Arabia; 15 October 2001 (PME, 2001).*
Source:
Royal Commission Environmental Regulations 2010. Volume I - Regulations And Standards. Environmental Control Department (RCER, 2010)

8.3 Methodology

Observations made during the field investigations, together with a desk-based search for information in official web pages, have been the two main sources of information for the preparation of this baseline study. Sections 8.4, 8.5 and 8.6 provide an overview of the information available on each of the facilities investigated.

The local hazardous waste disposal and sanitary landfill facilities located in Jubail were visited as part of the environmental baseline field investigation undertaken by CH2M HILL in November 2010. The facilities visited included the BeeA'h hazardous waste disposal facility, the EDCO hazardous waste disposal facility, and the RCJY sanitary landfill. CH2M HILL conducted an interview with the manager of the EDCO hazardous waste disposal facility, as well as a site visit. An interview and site visit could not be arranged for the BeeA'h and RCJY facilities due to the availability of facility staff, but contact details were obtained of resources that could provide information.

The following is a list of the local (i.e. located in Jubail) solid and liquid hazardous and non-hazardous waste disposal facilities, which are discussed in more detail in Section 8.4:

<u>Liquid Waste Treatment Facilities:</u>

- Marafiq Wastewater Treatment Facility. Location: Jubail.

<u>Solid Waste Treatment Facilities:</u>

- National Environmental Preservation Co (BeeA'h). Hazardous Waste Landfill and Thermal Treatment Facility. Location: Jubail, adjacent to RTIP site;

- Environmental Development Co. Ltd. (EDCO) Hazardous Waste Landfill. Location: Jubail, opposite BeeA'h hazardous waste landfill facility;

- Royal Commission for Jubail and Yanbu (Operated by Twaiq). Sanitary Landfill. Location: Jubail, 14km NE of the RTIP site.

Figure 8-1 presents the location of the local solid and liquid waste treatment and disposal facilities at Jubail.

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Figure 8-1 Location of Local Waste Treatment and Disposal Facilities
Source: Google Earth 2006 image modified by CH2M HILL

Previously, a number of regional waste and wastewater treatment and/or disposal facilities were visited as part of a field investigation undertaken by the Owner's Environmental personnel in April 2008 (Dow 2008). It is understood that the main objective of this investigation was to benchmark the Owner's facilities. However, observations and conclusions drawn can also be used to determine the sites´ suitability for the treatment and disposal of wastes arising from the proposed RTIP facility, if necessary.

During these visits, Dow representatives attended meetings with several company representatives, and general observations were made in each facility regarding aspects such as: their operation; methods used to minimise environmental impacts; conformance to national and international protocols, etc.

The following is a list of the regional solid and liquid hazardous and non-hazardous waste disposal facilities, which are discussed in more detail in Section 8.5:

Waste Water Treatment Plants:

- Safwa Wastewater Treatment Facility. Location: Safwa, approximately 58km to the southeast of the RTIP site;
- Dhahran Wastewater Treatment Facility. Location: Dhahran, approximately 95 km to the southeast of the RTIP site.

Recycling companies:

- Saudi Paper Manufacturing Company. Recycles paper and cardboard. Location: Dammam; approximately 98 km to the southeast of the RTIP site.
- Golden Asia Co Ltd. Recycling centre for paper, plastic, cardboard, and aluminium. Location: Dammam; approximately 98 km to the southeast of the RTIP site.
- Dammam Scrap Est. Reuse of metal scrap products. Location: Dhahran; approximately 95 km to the southeast of the RTIP site.
- Ansar Munir. Plastic Recycling Factory for plastic scrap material such as LDPE, HDPE and PE Scrap. Location: AlShifa Industrial Area, Riyadh; located approximately 200km southwest of the RTIP site.

Solid Waste Treatment Facilities:

- Saudi Environmental Works. Location: Abqaiq; approximately 120 km to the southeast of the RTIP site.

Other:

- Saudi Cement Company. Cement plant which provides waste incineration services. Location: Dammam; approximately 98 km to the southeast of the RTIP site.

Figure 8-2 presents the location of the regional waste treatment and disposal facilities described in this baseline report.

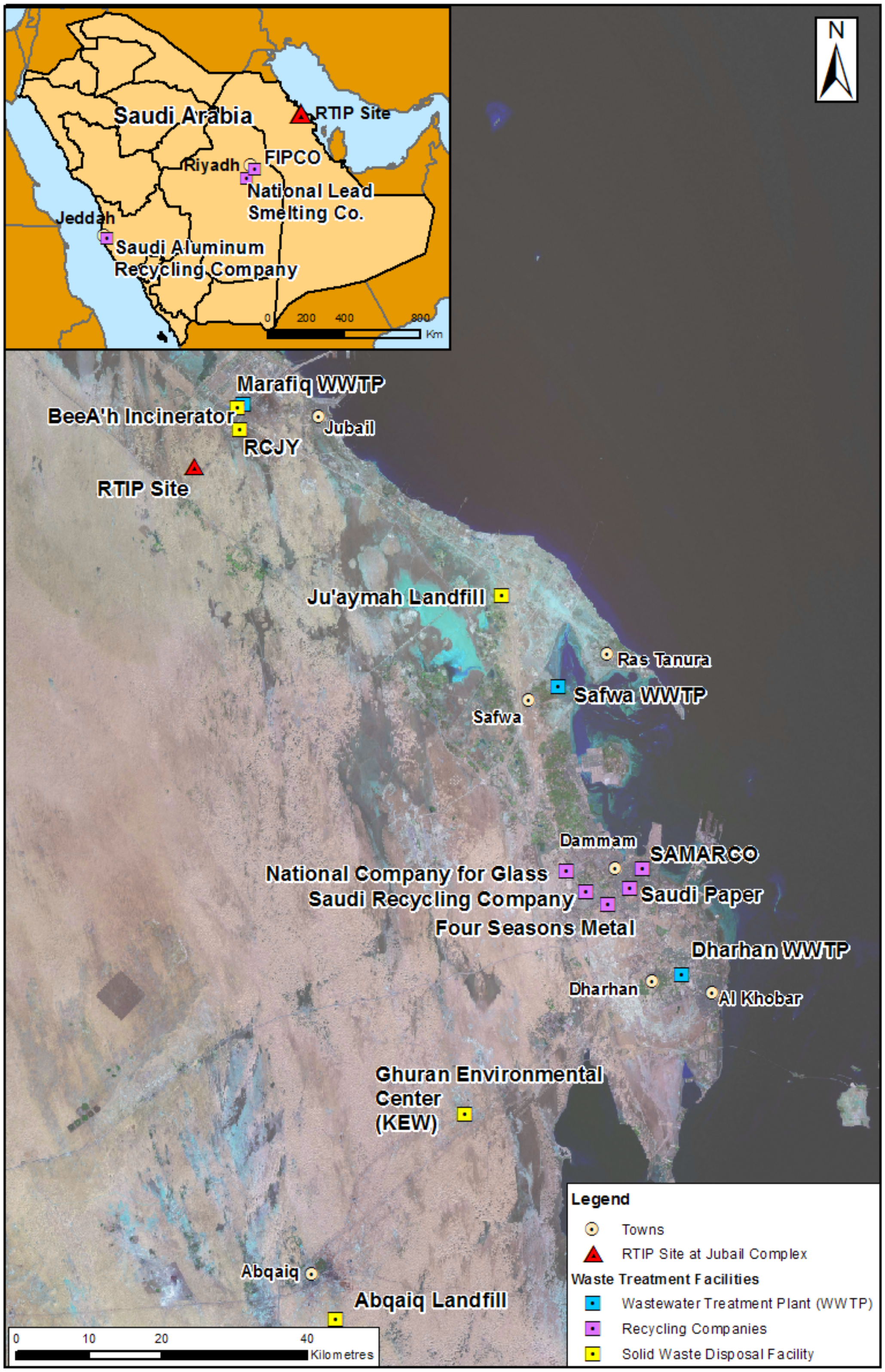

Figure 8-2 Location of Regional Waste Management Facilities on the East Coast of the KSA
Source: Landsat 2000 image modified by CH2M HILL

8.3.1 Limitations

As a limitation to this study, it should be noted that information available for these facilities is heterogeneous and generally limited, so further research should be undertaken in the future if any of these facilities are planned to be used by the RTIP.

8.4 Local Waste / Wastewater Treatment and/or Disposal Facilities

8.4.1 Local Solid Waste Disposal and Treatment Options

8.4.1.1 RCJY Sanitary Landfill

The RCJY developed and constructed a sanitary landfill area in Jubail city. The RCJY Sanitation Department is responsible for solid waste management and associated operations and development in Jubail. The RCJY sanitary landfill, operated by Twaiq, is located along Abu Hadriya Road, approximately 14km northeast of the project site (Figure 8-1). The sanitary landfill can accept municipal wastes (non-hazardous) and inert wastes.

Municipal wastes include garbage, food wastes, office wastes, waste vegetation and other decomposable material resulting from operation of residential, commercial, municipal, industrial or institutional establishments and from community activities.

Inert wastes include wastes which are not biologically or chemically active in the natural environment, such as glass, concrete and brick materials, broken clay and manufactured rubber products.

The facilities at the RCJY sanitary landfill include security, a weigh scale house, a diesel filling station, a leachate treatment facility, a maintenance workshop and administrative offices. The sanitary landfill is equipped with a leachate collection system, a leachate neutralization system, and leachate disposal lagoon facilities (Scribd, 2009).

The waste collection and its transportation at Jubail is performed by a contractor, called *Al-Khudari Establishment*, hired by the municipality to collect, transport and dispose of municipal solid waste for Jubail city. Like other areas in the province, all the trucks and automatic compactors are owned by the Municipality and the contractor is responsible for maintaining the vehicles and equipment. The refuse composition data indicates a high percentage of glass, metals, and wood (Khan *et al*., 1987). The containers vary in size from 200 litres to $20m^3$. Some barrels are also used. The contractor serves the different parts of the city as follows:

- The residential areas are served once a day;
- The main streets are served twice a day;
- The commercial areas are served 3 times a day.

In addition, the RCJY encouraged private entrepreneurs to develop waste disposal facilities. These facilities are discussed in Sections 8.4.1.2, 8.4.1.3 and 8.4.2.4.

8.4.1.2 National Environmental Preservation Company (BeeA'h)

The National Environmental Preservation Company (BeeA'h) has nearly twenty years of direct experience in hazardous waste management, site assessment and cleanup, hazardous waste treatment and disposal and environmental testing services in assisting industrial, commercial and public sector clients (BeeA'h, 2009a).

BeeA'h's facilities include a thermal treatment facility and a hazardous waste landfill site, which are located adjacent to the RTIP site. BeeA'h also provides waste handling and transportation services, producing the corresponding Material Safety Data Sheet (MSDS) for each waste type.

BeeA'h holds an ISO 14001 certificate, and serves the following clients amongst other: Saudi Aramco (SA), Saudi Chevron, Shell, SABIC Affiliates, National Industrialization Company, Tasnee, Halliburton, PEMREF Petromin-Mobil, EPA Transportation Inc., together with the RCJY, Saudi Government Ministries, hospitals, clinics and universities (BeeA'h, 2009a). In total, the BeeA'h has the capacity to treat 80,000-100,000 Kilo ton per annum (kta) of solid wastes, out of which approximately 25,000 kta are incinerated at the Thermal Treatment facility and the rest is landfilled. (Murdoch, 2009)

BeeA'h provides hazardous waste transportation resources, assuming total liability for all material accepted (BeeA'h, 2009).

According to BeeA'h, the services are provided in accordance with the prescriptions of relevant International Conventions and the requirements of the appropriate transport authority.

The BeeA'h Landfill

The BeeA'h hazardous waste landfill includes the following installations: Class I and II landfill cells; evaporation ponds; an equalization pond, truck wash, and weigh scale facilities. The installations are contained within a fenced area, thus providing access control (BeeA'h, 2009a).

The BeeA'h Thermal Treatment Facility

The original Thermal Treatment facility had a capacity of approximately 12,000 kta in 2008, but has since been expanded by BeeA'h, with the addition of a new rotary kiln incinerator in 2009. The new facility is designed for 20,000-22,000 kta solids, with 30-40% over capacity in the design.

The new incinerator utilises rotary kiln technology with an evaporative cooler, automated bag house and state-of-the-art emission controls which meets Best Available Control Technology (BACT) requirements. The rotary kiln with automated feed systems can incinerate 2.35MT/hr mixed wastes in the primary combustion chamber for a maximum heat release of 20,000 $Btu/ft^3/hr$ with a secondary combustion ensuring Destruction Removal Efficiency (DRE) of greater than 99.9999% at a temperature of 1250ºC. Resultant ash is stabilized and confined to a lined chemical landfill (BeeA'h, 2009a).

8.4.1.3 Environment Development Company

The Environment Development Company (EDCO) owns and operates a hazardous waste storage facility which is located in Jubail industrial city, opposite the BeeA'h facility (refer to Figure 8-1). EDCO's facility provides the following hazardous waste management services:

- Treatment in accordance with the standards of the RCJY, PME and USEPA;
- Stabilization and solidification, with sampling and analysis before final disposal;
- Chemical and physical treatment of highly corrosive liquid wastes, with sampling and analysis before final disposal;
- Disposal in class I landfill cells (double lined, with leachate collection and removal system, and leachate detection system);
- Disposal in class II landfill cells (single lined, with leachate collection and removal system, and leachate detection system);
- Disposal of low solid, low organic content aqueous wastes;
- Temporary storage of containerized wastes that are awaiting treatment (on concrete pads with drainage and collection basin for spill containment).

EDCO plans to install a rotary kiln type hazardous waste incinerator for thermal / combustion treatment of hazardous wastes.

8.4.2 Local Wastewater Treatment Plants

Following is a summary of the three wastewater treatment plants visited in April 2008 by representatives of Dow. Where available, information from this report has been expanded with information collected from official websites.

8.4.2.4 Marafiq Wastewater Treatment Facilities

The Marafiq Private Utility Company operates two Wastewater Treatment Plants: the Industrial Wastewater Treatment Plant (IWTP), and the Sanitary Wastewater Treatment Plant (SWTP). Both plants are located in Jubail Industrial City, approximately 20 km to the northeast of the RTIP site (see Figure 8-1). Information about these facilities has been gathered from the Marafiq web page (Marafiq, 2010).

The IWTPS has a design capacity of 60,000 cubic meters per day, and treats incoming industrial wastewater from industries in the Jubail Industrial City (JIC). The SWTP has a design capacity of 72,000 cubic meters per day, and treats incoming sanitary wastewater from industries, the community area and Jubail town.

All wastewater from JIC is collected through a pipeline network into 220 Lift stations and 58 Pump Stations, all located within the Community and Industrial Area. Wastewater is then delivered to the two treatment plants. Both plants use Preliminary, Secondary and Biological Treatment Processes. Treated water is filtered and chlorinated for disinfection.

According to Marafiq's webpage, some of the treated water from both plants is utilized for Irrigation and Industrial use. The guidelines for Wastewater and Irrigation water are maintained as per Royal Commission laid down Jubail Management Procedures (JMP) parameters.

The following photographs present details of the Marafiq Wastewater Treatment Facility visited in April 2008:

Figure 8-3 Surface Aerator
Source: Dow, 2008

Figure 8-4 Aerators and Clarifiers Installed Directly in the Sand Base
Source: Dow, 2008

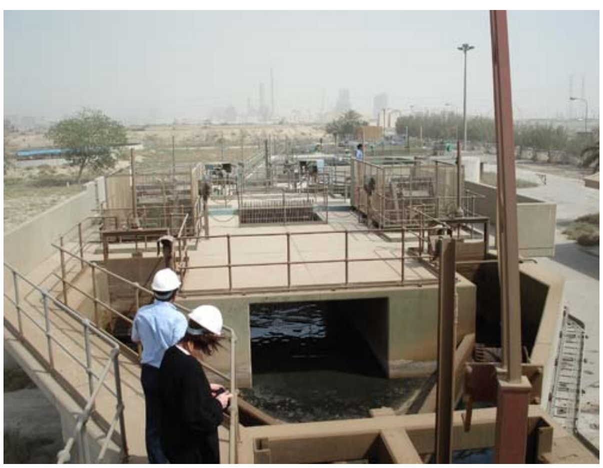

Figure 8-5 Inlet Infrastructure
Source: Dow, 2008

Figure 8-6 Horizontal Sand Filter
Source: Dow, 2008

8.5 Regional Waste / Wastewater Treatment and / or Disposal Facilities

8.5.1 Safwa Wastewater Treatment Plant

The Safwa Wastewater Treatment Plant (hereinafter Safwa WWTP) is located in Safwa (see Figure 8-2), approximately 58km to the southeast of RTIP. This is a municipal facility which treats wastewater from the local community with a hydraulic flow of 16,000 m^3/day. The following photographs present details of the different units of the Safwa WWTP visited in April 2008.

Figure 8-7 Secondary Clarifier
Source: Dow, 2008

Figure 8-8 Drying beds
Source: Dow, 2008

Figure 8-9 Laboratory
Source: Dow, 2008

8.5.2 Dhahran SA Treatment Plants

Two wastewater treatment plants are owned and operated by Saudi Aramco in Dhahran, approximately 95 km to the southeast of the RTIP site. The North Sewage Treatment Plant (NSTP) treats sewerage streams from the local community and industries within the area, (Wang *et al*, 2005), and is located opposite King Fahd University of Petroleum and Minerals

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(KFUPM) in Dhahran (see Figure 8-2). The Advanced Wastewater Treatment Plant (AWTP) is situated within the Saudi Aramco Dhahran community area (Mac Construction, 2000).

In 2006, Saudi Aramco undertook an expansion of both facilities. As a result, the AWTP was expanded to recycle 10 million gallon per day (mmgd) of high quality tertiary water for irrigation purposes. The expansion activities at the AWTP included a new 6 mmgd continuous backwash filter, a 1.5 million gallon storage tank, a new irrigation pump station and tertiary distribution piping. In addition, the NSTP was expanded to treat 10 mmgd. The expansion of the NSTP included the installation of two additional settling tanks and a bypass overflow line to divert effluent to an emergency pond during heavy rains. The effluent pumped out of the Dhahran NSTP (about 3 mmgd of the secondary effluent) is pumped to the AWTP and treated at a tertiary level for use in irrigation throughout the community's planted areas (landscaping, sports fields, parks, common green areas in housing developments, roadside strips and other uses). The expansion project also replaced the hazardous chlorine gas previously used in both plants with sodium hypochlorite (ArabNews, 2009 and Taylor, 2009).

The expansion undertaken on the Dhahran NSTP and AWTP was planned to add 40 percent to the two plants' combined treatment volume capacity (ArabNews, 2009).

One of the sites visited during the field investigation undertaken by the Owner's Environmental personnel in April 2008 was recorded as "the Dhahran wastewater treatment plant". It was not specified if this name made reference to the NSTP or the AWTP. However, due to the notes taken and the observations made, our interpretation is that the NSTP was visited.

8.5.3 Regional Recycling Plants

According to World Bank estimates, tens of billions of dollars will be invested in the waste management and environmental sectors in the Middle East over the next 10 years. Accordingly, the market for waste management technologies and products in Saudi Arabia is growing rapidly. Recycling in Saudi Arabia is a common topic for discussion. Adding to this increased attention is the fact that the country's industrialization and urban growth have increased levels of pollution and wastes (HUB-4 Magazine, May 2009).

Limited information is available regarding recycling companies in the Eastern Province. The main recycling companies identified are:

- The Saudi Paper Manufacturing Company is based in Dammam and is known to recycle paper. One of its primary activities is the collection of waste paper (used newspapers, magazines, books and cartons) and its reuse in the manufacturing of paper rolls (Saudi Paper, 2009);

- Golden Asia Co Ltd operates a recycling centre in Dammam that accepts paper, plastic, cardboard, and aluminium;

- Dammam Scrap Est is a buyer-seller of all scraps products based in Dhahran. They act as intermediaries to facilitate the re-use of aluminium, copper, nickel scrap, non metal scrap, and precious metals (Recycle in me, 2007a);

- Ansar Munir is a Plastic Recycling Factory located in AlShifa Industrial Area, Riyadh. They buy plastic scrap material such as Low-Density Polyethylene (LDPE), High-Density Polyethylene (HDPE) and Polyethylene (PE) Scrap (Recycle in me, 2007b).

It should be noted that over the past decades, Saudi Aramco (SA) has launched a number of recycling programs in the RTIP area. These programs are aimed for SA employees and their families, and extend out to educational forums provided to students at local schools. For example, in 2006 compact red, yellow and green recycling bins were distributed to households in Dhahran along with matching recycling bags. Employees and their families were asked to use the bins to collect plastic, glass and aluminum so that these materials may be reused (About Us, 2006).

According to the site visit performed in April 2008, SA works in the area with a recycling company for paper and cardboard and another for plastics, glass and alumina (Dow, 2008). It is understood that RTIP will contact SA and learn more about these companies, in order to develop a consistent and collective approach to recycling management.

8.5.4 Regional Solid Waste Disposal and Treatment Options

Following is a brief description of the municipal solid waste management in the Eastern Province and a summary of the two solid waste treatment and/or disposal facilities visited by Dow in April 2008. Where available, information from this report has been expanded with information collected from official websites.

8.5.4.5 Municipal Solid Waste Management in the Eastern Province

Waste management sites and facilities are operated and managed by private companies or the local municipality, with PME currently providing an advisory role in their operation.

Waste collection and its transportation at Dammam is performed by the contractor *Al-Yamamah Establishment* that is contracted with the municipality to collect, transport, and dispose the municipal solid wastes (MSW) for the city. The contractor transfers the refuse generated by the city to a landfill which is located about 5 km north along Abu Hadriya Road from the junction of Abu Hadriya and Ibn Khaldoun Roads. Scrap metals are disposed at a separate location close to the garbage disposal area.

8.5.4.6 Saudi Environmental Works Ltd. (SEW)

Saudi Environmental Works Ltd. (SEW) was created in 1994, and it is the largest environmental services company in Saudi Arabia. It manages a total of three landfills, out of which only one is located in the Eastern Province; the Abqaiq landfill, located five kilometres south of Abqaiq city and approximately 120 km to the south of RTIP.

The Abqaiq landfill is a trench type sanitary landfill, constructed in 1994. It is segregated into three sections: a solid and construction section, a domestic waste section and a sludge disposal section. The users of this facility include Saudi Aramco and the local municipality.

The geology underlying the landfill consists of mainly sandstone, sandy marl, sand, clay and sandy limestones. Four main aquifers can be found beneath the Abquaiq area: the Neogene Formation and the Alat member of the Dammam Formation; the Khobar aquifer is a member of the Dammam Formation; the confined Umm Er Radhuma (UER) Formation; and the confined Wasia Formation. Three monitoring wells were installed in the vicinity of the Abquaiq landfill in 1994 (ABLF-1, ABLF-2 and ABLF-3). Water from these wells is sampled annually, and the analysis results evidence a certain degree of contamination. This is shown in the increased levels of Total Dissolved Solids (TDS) and TOC contamination (Al-Khaldi, 2008).

8.5.5 Saudi Cement Company (SCC)

The Saudi Cement Company (SCC), in business since 1961, operates two cement plants in the Eastern Province of KSA. The two plants, namely Hofuf Plant and Ain Dar Plant are about 35 km apart and are both at an approximate distance of 140 km from the RTIP site. The exact location of the Ain Dar Plant is unknown. The location of Hofuf Plant is shown in Figure 8-2. The two sites have a total of ten operating kilns, representing a total capacity of 14,000 tonnes/day. SCC acquired an ISO 9001-2004 certificate in 1996 for both plants and ISO 14001-2004 in 2004 (SCC, 2008).

During the field inspection undertaken in April 2008, a meeting with SCC in their head office in Dammam was held between the Dow field team and SCC’s staff. In this meeting, the Dow personnel were told that waste material from RTIP could be used as a fuel or as a grinding aid in the SCC Plants (Dow, 2008).

9 SOCIAL BASELINE

9.1 Introduction

The social aspects baseline survey was compiled in order to provide an understanding of the social and cultural context in and around the project area and to identify and characterise the receptors that may be impacted by the RTIP project in Jubail II, an extension of the Jubail Industrial City (JIC). This section describes the social, cultural, and economic characteristics on a national and regional level including demography, economic activity, infrastructure, land use, available resources (markets, etc.), education, and religion. Each characteristic is assessed by reviewing existing published information primarily from the Ministry of Economic Planning and the Ministry of Municipal and Rural Affairs, Vice Ministry Office for Planning and Programs.

To the extent possible and available, local data have been included. However, limitations in data availability do not permit a thorough local baseline description. During the field survey carried out in November 2010, the field team visited JIC, Jubail II and Jubail old town. The information collected during the field effort, is included in the subsequent sections.

The present section does not include baseline information on archaeological and cultural heritage. Those tasks are addressed in Section 10, Archaeological and Cultural Heritage. Information regarding solid waste and wastewater management and treatment facilities at national, regional, and local level is included in Section 8, Waste Management Baseline Conditions. However, some description of the waste facilities is included in the following sections.

9.2 Background

The KSA is an absolute monarchy located in the southwest portion of Asia, in a geographic area commonly known as the Middle East. With a total area of about 2.15 million km² (830,000 square miles), the KSA is the largest country in the Arabian Peninsula, occupying nearly 80 percent of the peninsula. As noted in Figure 9-1, it is bordered in the north by Jordan, Iraq, and Kuwait, in the east by the Arabian Gulf, in the south-east and south by Qatar, the United Arab Emirates, Oman, and Yemen, and in the west by the Red Sea. Saudi Arabia's Red Sea coastline extends about 1,760 kilometres (km) (1,100 miles) while its Arabian Gulf coastline extends approximately 560 km (350 miles). Arabic is the official language of KSA although English is widely spoken.

Figure 9-1 Project Location and Provinces in Saudi Arabia

Source: Produced by CH2M HILL, 2010

9.3 Methodology

The following approach was adopted in compiling the socio-economic information for the baseline study. CH2M HILL collected and integrated data primarily obtained from the Central Department of Statistics and Information of the Ministry of Economic and Planning in KSA and conducted a desk study and literature review of existing studies and reports, satellite images, websites, and articles.

Additional information on socioeconomic aspects of the area under study (at regional and local levels) was obtained via the following:

- Personal observation during the survey conducted at the project area on 9th and 10th November 2010 by Dr. Elhassan of Hail University;
- Contact with local and regional authorities;
- Contact and interviews with inhabitants of the study areas.

9.3.1 Literature Overview

An extensive information search was carried out to obtain all available information for the socioeconomic assessment. The National Library[1] search provided information on economic activities and social data. Remaining information and documentation was obtained from existing studies and reports, relevant web sites, articles, and interviews. A listing of these sources is included in Section 25 References.

9.4 Limitations

The following limitations were encountered while conducting the socioeconomic assessment:

- Lack of current information on future plans and future development of the areas under study, at both regional and local levels;
- Lack of current published statistical data of social aspects at both regional and local levels, such as incomes on governmental and private sector jobs, tourism, recreation, number of parks, municipal waste management, number of mosques, cemeteries, and information on health statistics (epidemiological data). General information about the Eastern Province was often the only data found;
- Lack of data and inaccessibility of some areas of the RTIP Project for social and security reasons;
- Lack of current literature on socioeconomic aspects of the project area at both regional and local levels.

9.5 Geopolitics

The Modern KSA was formed in 1932 by King Abdel-Aziz al-Saud, after the unification of the Kingdom of Hejaz and Nejd; however, the first Saudi state was established in 1744 when Shaikh Muhammad bin Abdul Wahhab and Muhammad bin Saud formed an agreement designed to restore the pure teachings of Islam to the Muslim community. By 1824, Turki bin Abdullah Al-Saud established the capital in Riyadh and created the second Saudi state. Later, in 1865, the Ottoman army invaded parts of the Saudi state that was ruled at that time by Turkis's grandson, Abdulrahman, resulting in the family leaving the country. The family resided in Kuwait until 1902, when Abdulrahman's son, Abdulaziz retook Riyadh and captured the Hijaz, including Makkah and Madinah.

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[1] National Library (*Biblioteca Nacional*), 2007, Madrid (Spain)

Since then and as declared in the Basic Law of Government of 1992 (Al-Nizam al-Asasi li al-Hukm), the progeny of King Abd Al Aziz Al Saud have governed the country. This law also declared the Qur'an as the constitution and that the country shall be governed on the basis of the Sharia (Islamic Law).

The present King Abdullah bin Abdel-Aziz, who ascended to the throne in 2005, combines legislative, executive, and judicial functions, and serves also as Prime Minister, presiding over the Council of Ministers (Majlis al-Wuzara'). The Council is responsible for foreign and domestic policies, defence, finance, health, and education, and together with the King constitutes the legislative and executive authority. There is no Parliament, but the Consultative Council (Majlis al-Shura), formed by 150 members designated by the King (Royal Embassy of Saudi Arabia, 2008), acts as advisor in the Kingdom's significant subjects.

In terms of economy, Saudi Arabia is the world's leading oil exporter, and has the largest proven crude oil reserves in the world (International Energy Agency, 2005). The value of this resource has provided sound financial backing for the country's economy. As shown by the economic indicators noted in Table 9-1, Saudi Arabia has had low but relatively steady levels of population growth and steadily increasing GDP during the past five years.

Table 9-1 Selected Economic Indicators of the Saudi Economy

Indicators	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Estimated population (in million)	22.67	23.1	23.68	24.24	24.81	25.37
GDP at current prices (billion Riyals)	938.8	1,182.5	1,335.6	1,439.5	1,758	1,409.1
GDP at constant prices of 1999 (billion Riyals)	722.2	762.3	786.3	812.4	848.5	841.1
Inflation rate (consumer prices)	0.3	0.7	2.2	4.1	9.9	5.1
Aggregate money supply M3 (billion riyals)	496.1	553.7	660.6	789.8	929.1	1,028.9
Average price of Arabian Light oil (US$)*	34.53	50.15	61.05	68.74	94.77	61.38
Riyal's real effective exchange rate (2000=100)	84.4	82.3	80.8	78.5	97.7	105.7
Actual government revenue (billion riyals)	392.3	564.3	673.7	642.8	1,101.0	509.8
Actual government expenditure (billion riyals)	285.2	346.5	393.3	466.2	520.1	596.4
Exports of goods** (billion Riyals)	472.5	677.1	791.3	874.4	1,175.4	697.3
Import of goods CIF (billion Riyals)	117.7	223.0	261.4	338.1	431.8	358.4
Ratio of current account surplus to GDP	33.8	39.8	27.8	24.3	27.8	6.1
Current account (billion Riyals)	317.3	337.5	371.0	350.0	496.2	85.4

Notes:
** OPEC's sources.*
*** Including oil export+ other exports (of which re-export + bunker oil).*
Source:
Saudi Arabian Monetary Agency (SAMA) -46th Annual Report (2010)

When comparing indicators such as Gross Domestic Product (GDP), inflation rates, and imported and exported goods the equivalents in other Gulf Cooperation Countries (GCC) (as shown in Table 9-2), Saudi Arabia's economic strength is apparent. For instance, a GDP comparison demonstrates the economic strength that the KSA holds in the region.

Table 9-2 Economic Indicators in GCC Countries

	UAE		Oman		Qatar		Kuwait		Bahrain		KSA	
Indicators	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**	**2008**	**2009**
Nominal GDP at current prices (billion $)	254.4	228.3	60.3	59.4	100.4	82.3	148.2	127.0	21.9	20.6	472.3	372.3
Inflation rate (consumer prices)	12.3	1.6	11.8	3.4	15.1	-4.9	10.6	4.0	3.5	2.8	9.9	5.1
Exports of goods (FOB)	239.2	174.7	37.7	29.8	54.9	33.2	78.0	50.2	17.3	11.9	313.4	192.2
Import of goods (FOB)	176.3	144.5	20.7	18.4	25.1	20.9	22.9	20.5	14.2	9.6	100.6	86.4
Ratio of current account balance to GDP*	8.8	-1.8	9.1	1.5	14.1	0.9	43.7	21.7	10.3	2.7	27.9	6.0
Current account	22.3	-4.0	5.5	0.9	14.2	0.7	64.8	27.6	2.3	0.6	132.3	22.8

Notes:
Billions of US$
** Ratio of surplus/deficit to GDP at current prices*
Source:
Saudi Arabian Monetary Agency (SAMA) -46th Annual Report (2010)

9.6 National Socio-Economic Data

9.6.1 Population and Demographics

The total population in KSA according to the Saudi Ministry of Economy and Planning was 24,807,273 in 2008, according to mid-year estimates (SAMA, 2009). The 2009 CIA World Factbook estimates a population growth rate of 1.848% in 2009 for the KSA. The growth rate in other GCC countries for the same year is estimated as follows: UAE: 3.689%, Kuwait. 3.547%, Oman: 3.138%, Qatar: 0.957%, and Bahrain: 1.285%. In comparing these data, it is noted that the growth rate in KSA is one of the lowest in the GCC countries.

The most recent data provided by the Central Department of Statistics (mid-2009 estimates) (SAMA, 2010) for population distribution by age and nationality is presented in Table 9-3.

Table 9-3 Population by Age and Nationality (2009)

Age Group	Saudi	% of Age Group	Non-Saudi	% of Age Group	Combined	Age Group % of Total Combined
0-4	2,422,337	83%	510,737	17%	2,933,074	12%
5-9	2,206,337	83%	456,353	17%	2,662,690	10%
10-14	2,123,482	84%	392,528	16%	2,516,010	10%
15-19	2,021,949	87%	306,007	13%	2,327,956	9%
20-24	1,842,042	85%	324,360	15%	2,166,402	9%
25-29	1,620,502	71%	670,062	29%	2,290,564	9%
30-34	1,401,592	55%	1,140,008	45%	2,541,600	10%
35-39	1,163,593	52%	1,094,478	48%	2,258,071	9%
40-44	962,402	55%	797,123	45%	1,759,525	7%
45-49	763,981	60%	511,170	40%	1,275,151	5%
50-54	601,423	66%	313,885	34%	915,308	4%
55-59	441,081	72%	173,056	28%	614,137	2%
60-64	330,874	83%	69,089	17%	399,963	2%

Table 9-3 Population by Age and Nationality (2009)

Age Group	Saudi	% of Age Group	Non-Saudi	% of Age Group	Combined	Age Group % of Total Combined
65-69	239,681	87%	34,945	13%	274,626	1%
70-74	167,858	92%	15,546	8%	183,404	1%
75-79	108,835	91%	10,686	9%	119,521	0%
+ 80	125,277	92%	10,233	8%	135,510	1%
Total	**18,543,246**		**6,830,266**		**25,373,512**	**100%**

Source:
Saudi Arabian Monetary Agency (SAMA) -46th Annual Report (2010)

As indicated by data on the chart, the overall age structure of KSA is young, with 41.5 percent of the population being between the ages of 0 and 19 years. Only 1.7 percent of the population is 70 years of age and above. A reason for this data may be found in the health improvements in the last couple of generations, which has led to a reduction in infant mortality. In terms of immigrants, the higher proportion of inhabitants is between the ages of 25 to 54, which correspond with the appropriate age range for working adults. Also, more than 25% of the KSA's population is not Saudi born. Many of these non-Saudis are employed in the oil industry.

The birth rate is 19.43 births per each 1,000 persons (CIA, estimations for 2010b), and the death rate 3.34 deaths per each 1,000 persons (CIA, 2010b). The Infant mortality rate is 16.73 deaths per 1,000 live births, consisting of 19.19 male deaths per 1,000 live male births and 14.14 female deaths per 1,000 live female births (CIA, estimations for 2010b). These data may be compared with the equivalents in some neighbouring countries, such as the GCC, as it is noted in Table 9-4.

Table 9-4 Population Indicators

Indicators	UAE	Oman	Qatar	Kuwait	Bahrain	KSA
Birth rate /1,000 population	15.98	23.9	15.54	21.64	16.81	19.43
Death rate /1,000 population	2.08	3.47	2.44	2.29	4.37	3.34
Infant mortality rate (total) /1,000 live births	12.3	16	12.24	8.75	14.76	16.73
Infant mortality rate (male) /1,000 live births	14.38	16.28	13.02	9.35	17.01	19.19
Infant mortality rate (female) /1,000 live births	10.12	15.71	11.41	8.13	12.44	14.14

Source:
CIA World Factbook, 2009 (CIA, 2010a)

In order to increase government efficiency and to promote the development in all the regions and their social service programmes, in 1992 the country was divided into 14 provinces, as noted in Figure 9-1, defining their administrative structure, ways of government, and governor's roles and responsibilities. These 14 provinces or regions (Manatiqah) are: Riyadh, Makkah, Madinah, Qasim, Eastern Province, Asir, Tabouk, Hail, Northern Border, Jizan, Najran, Al-Baha, Al Qurayyat, and Al-Jouf. In each of these provinces, there is a province governor designated by the King. The Makkah region has the largest population of KSA, followed by Riyadh region and the Eastern Province.

The city with the highest population and also the financial capital is Riyadh, with an estimated 4,087,152 inhabitants in 2005. The next largest cities are Jeddah with 2,801,481, Makkah with 1,294,106, Madinah with 918,889, Damman with 744,321, and Taif with 521,273 (SAMIRAD, 2008a). This population distribution is related to the economic development of each city. For example, Riyadh, the largest city, leads nationally by producing about 35 percent of the national GDP and the industrial investment is growing by 3.1 percent per year while Jeddah, the second largest city, has the second largest GDP in the country (MEED, 2007).

9.6.2 Religion and Ethnicity

The official religion of the Kingdom of Saudi Arabia is Islam. Throughout the Moslem world, the country has special significance as the birthplace of the Islamic faith. Moreover, the Kingdom is the custodian of the holy cities of Madinah and Makkah, towards which Moslems direct their prayers. These factors, together with the adhering to Sharia (Islamic Law), have made Saudi Arabia one of the main upholders of Islamic principles (McMinn, Robertson, & Reda, 1983).

9.6.3 Gender Distribution

The data available in the Central Department of Statistics and Information of the Ministry of Economy and Planning shows that the number of males and females is roughly proportional across the provinces, although the presence of a significant foreign male workforce is evident in the 15 to 64 age group. The most populated provinces are Makkah, Riyadh, and the Eastern Province as presented in Table 9-5, which shows the population distribution by gender and Administrative Area in 2008.

Table 9-5 Population by Gender & Administrative Area

Administrative Area	Total	Males	%	Females	%
Al-Riyadh	5,835,613	3,309,008	56.70	2,526,605	43.30
Makkah Al-Mokarramah	6,097,077	3,412,396	55.97	2,684,681	44.03
Al-Madinah Al-Monawarah	1,614,644	880,219	54.51	734,425	45.49
Al-Qaseem	1,077,068	598,406	55.56	478,662	44.44
Eastern Region	3,545,644	2,012,736	56.77	1,532,908	43.23
Aseer	1,756,625	946,419	53.88	810,206	46.12
Tabouk	735,682	400,501	54.44	335,181	45.56
Hail	551,523	290,715	52.71	260,808	47.29
Northern Borders	294,896	157,962	53.57	136,934	46.43
Jazan	1,253,089	647,923	51.71	605,166	48.29
Najran	449,186	239,980	53.43	209,206	46.57
Al-Baha	387,717	198,186	51.12	189,531	48.88
Al-Jouf	382,070	206,718	54.10	175,352	45.90
Total	**23,980,834**	**13,301,169**	**55.47**	**10,679,665**	**44.53**

Source:
Ministry of Economy and Planning, 2007

More recent data (estimates for 2009) are provided in the CIA's World Factbook, which confirms, as shown in Table 9-6, the nearly equivalent distribution of male and female inhabitants within the Kingdom.

Table 9-6 Sex Ratio (2009)

Age	Male/ Female
At birth	1.05
Under 15 years	1.04
15-64 years	1.27
65 years and over	1.03
Total population	**1.17**

Source:
CIA World Factbook, 2009 (CIA, 2010b)

The age structure is shown in Table 9-7.

Table 9-7 Age Structure (2008)

Years	Percent (%)	Male	Female
0-14	38.0	5,557,453	5,340,614
15-64	59.5	9,608,032	7,473,543
≥ 65	2.5	363,241	343,750

Source:
CIA World Factbook, 2009 (CIA, 2010b)

9.7 National Economic Activity

9.7.1 General

The national economy of Saudi Arabia is primarily based in the petroleum sector, which accounts for approximately 80% of government budget revenues, 45% of GDP, and 90% of export earnings; private sector activities account for another 40% of GDP. Foreign workers play an important role in the national economy, particularly in the petroleum and service sectors; the number of foreign workers is currently estimated at 6.4 million. The Saudi government exerts strong controls over major economic activities in the country. On a global level, Saudi Arabia possesses more than 20% of the world's proven oil reserves, ranking as the world's top exporter of petroleum, and plays a leading role in OPEC (CIA, 2010b).

Economic activity rose during the oil boom in the 1970s and 1980s impelled by the revenues generated from the oil exports. This resulted in the Kingdom being transformed into one of the richest areas in the region (Arab Media Watch, 2005). Consequently, per capita income and GDP per capita were among the highest in the world, as shown in Table 9-8.

Table 9-8 GDP per Capita

Year	Top 5 Countries (with Highest Rates of GDP per Capita and Saudi Arabia)	GDP Per Capita ($US)
1975	United Arab Emirates	17,250
	Kuwait	10,530
	Switzerland	8,670
	Luxembourg	8,200
	Saudi Arabia	7,920
1985	United Arab Emirates	20,170
	Switzerland	17,950
	United States	17,540
	Norway	16,730
	Denmark	15,860
	Saudi Arabia position: 25	8,520

Table 9-8 GDP per Capita

Year	Top 5 Countries (with Highest Rates of GDP per Capita and Saudi Arabia)	GDP Per Capita ($US)
1995	Luxembourg	32,780
	Norway	27,900
	United States	27,820
	Switzerland	25,340
	Denmark	23,860
	Saudi Arabia position: 37	11,380
2000	Luxembourg	56,290
	Norway	35,130
	United States	34,160
	Ireland	30,100
	Denmark	29,310
	Saudi Arabia position: 37	12,580
2002	Luxembourg	61,190
	Norway	36,600
	Ireland	36,360
	United States	35,750
	Denmark	30,940
	Saudi Arabia position: 37	12,650

Source:
Globalis, 2009

Beginning in the 1990s with the stagnation of oil prices, the per capita GDP remained relatively constant (as shown in Table 9-8), reflecting a national economic dependence on the oil sector.

As noted in Table 9-9, the GDP resulting from economic activities in different sectors is increasing but a majority is still petroleum and natural gas based.

Table 9-9 GDP by Type of Economic Activity

Producers' values at current prices (SR million)

A- Industries and other producers except producers of government services:

	2002	2003	2004	2005	2006	2007*
1. Agriculture, forestry & fishing	36,101	36,454	37,187	38,280	39,373	40,130
2. Mining and quarrying:	236,926	294,111	384,469	571,008	669,002	722,927
a) Crude petroleum & natural gas	234,206	291,326	381,582	567,992	665,857	719,636
b) Other	2,720	2,785	2,886	3,016	3,145	3,291
3. Manufacturing:	72,975	86,267	95,827	110,706	123,912	136,003
a) Petroleum refining	20,434	29,732	32,435	39,453	43,710	46,418
b) Other	52,541	56,535	63,392	71,253	80,202	89,585
4. Electricity, gas and water	9,303	9,870	10,406	11,020	11,664	12,419
5. Construction	44,739	47,137	51,141	54,946	59,139	64,721

Table 9-9 GDP by Type of Economic Activity

Producers' values at current prices (SR million)						
6. Wholesale & retail trade, restaurants and hotels	51,735	53,856	58,132	62,759	67,868	73,762
7. Transport, storage & communication	31,934	33,224	35,667	38,429	41367	45078
8. Finance, insurance, real estate & Business services:	82,072	85,843	91,218	97,784	104,798	110,146
a) Ownership of dwellings	44,989	45,979	47,950	50,012	52,223	54,776
b) Other	37,082	39,863	43,268	47,772	52,575	55,370
9. Community, social & personal services	24,124	25,114	26,478	27,855	29,203	30,663
10. Less: Imputed bank services	14,714	15,244	15,950	16,739	17,575	18,280
Sub total	**575,195**	**656,632**	**774,575**	**996,048**	**1,128,750**	**1,217,571**
B- Producers of government services:	**124,486**	**139,929**	**155,371**	**176,350**	**180,571**	**185,135**
Total except import duties	**699,680**	**796,561**	**929,946**	**1,172,399**	**1,309,321**	**1,402,706**
Import duties	**7,385**	**8,087**	**8,825**	**10,115**	**11,065**	**11,300**
GDP	**707,067**	**804,648**	**938,771**	**1,182,514**	**1,320,386**	**1,414,006**

Note:
** Preliminary data*
Source:
Ministry of Economy and Planning 1993 & 1998-2008

The economy in the Kingdom has been guided, since 1970, by a series of ongoing five-year development plans that aim to build a modern economy capable of producing previously imported consumer and industrial goods. Through these plans, the government has sought to allocate its petroleum income to transform its relatively undeveloped, oil-based economy into a modern industrial state while maintaining traditional Islamic values and customs.

Although economic planners have not achieved all their goals, the economy has progressed rapidly. Oil wealth has increased the standard of living of most Saudis, however, the Kingdom is aware of its economic dependence on oil, and, as mentioned, is prioritising the economic and geographic diversification of the country. The focus of the diversification is through the construction of six economic cities whose goals will be to increase total GDP by 20 percent by 2020. If Saudi Arabia's diversification programmes are successful, the future of the economy will be much more dependent on local Saudi achievements and production, rather than just the oil price (MEED, 2007).

One of the key contributors to continuing the growth of the Saudi economy will be lowering the unemployment rate; the mismatch between the job skills of Saudi graduates and the needs of the private job market at all levels remains the principal obstacle to economic diversification and development. According to the latest study conducted by the General Statistics Department (GSD), there are nearly 470,000 unemployed Saudi men and women in KSA, accounting for approximately 12 percent of the total Saudi work force, which is estimated to be 3,900,589. By gender, the number of unemployed Saudi men and women reached 292,905 and 176,113, respectively (Abdul Ghafour, 2007). Currently, the government is trying to reduce the high levels of unemployment by expanding and diversifying the economy by developing non-oil sectors, such as mining, manufacturing, and services.

Approximately, 41 percent of Saudi workers are in the services sector, and 1 percent in the industrial, chemical, and food sectors. The structure of private sector employment is shown in Table 9-10.

Table 9-10 Structure of Employment in the Private Sector, Selected Years (percent)

	1975	1980	1985	1990	1995	2002
Total for producing sector	65.8	55.5	54.0	35.4	35.9	37.8
Total for service sectors	34.2	44.5	46.0	64.6	64.0	62.2
Community, social and personal services as % of total service	44.9	52.1	47.6	55.4	56.7	57.9
Total private sector	**100**	**100**	**100**	**100**	**100**	**100**

Source:
Ministry of Economy and Planning, 2003b

9.7.2 Agriculture

Agriculture in KSA contributes only a small fraction (4%) of the Saudi GDP and employs a comparable proportion of the workforce. The cultivatable area in 1992 was 52.7 million hectares (ha), which is approximately 25 percent of the total area of the country. However, the cultivated area was only 1,608,000 ha in the same year, of which 1,512,000 ha consisted of annual crops and 95,500 ha consisted of permanent crops with wheat being the primary cultivated grain, followed by sorghum and barley (FAO, 1997).

Half of the cultivated land consists of rain-fed dry farming, 40 percent in tree crops, and the remainder is irrigated. Most of the irrigated areas utilize underground water. Surface irrigation is practiced on the old agricultural lands, which represents 34 percent of the irrigated area and sprinkler irrigation is practiced on about 64 percent of the irrigated areas (FAO, 1992).

Table 9-11 shows the production (in tons) and cultivated areas (ha) of the main crops in 2007 and 2008 according to the Ministry of Agriculture, as presented in the 46th Annual Report of the Saudi Arabian Monetary Agency (SAMA, 2010).

The primary cultivated product is grain, accounting for 48.3% of the total cultivated area and 25.1% of total agricultural production in 2008; the primary cultivated grain is wheat.

Table 9-11 shows that there has been a slight decrease in production, while the cultivated area has dropped by almost 10%. This implies a greater production rate per cultivated hectare.

The most significant decline in cultivated area was in response to government policy for reducing water-intensive crops, particularly grains and fodder, thereby affecting barley and wheat. Corn and green fodder are notable exceptions to this decline, both showing increases of 20.7% and 11% respectively, for cultivation, as well as millet, with an 8.2% increase in cultivation.

It's important to note that KSA is one of the world's largest date producers, as shown in Table 9-11.

Table 9-11 Cultivated Area and Production

Crops	Production (1,000 tonnes)		Growth (%)	Area (hectares)		Growth (%)
	2007	2008		2007	2008	
Wheat	2,559	1,986	-22.4	450,330	326,161	-27.6
Sorghum	6	7	16.7	3,440	3,061	-11.0
Millet	233	252	8.2	96,173	103,572	7.7
Corn	135	163	20.7	23,892	28,966	21.2
Barley	28	24	-14.3	4,554	3,964,	-13.0
Sesame	5	5	0.0	3,261	3,114	-4.5
Other grain	1	1	0.0	421	426	1.2
TOTAL GRAIN	**2,967**	**2,967**	**-17.8**	**582,071**	**469,264**	**-19.4**
Tomato	478	478	9.2	14,782	14,699	-0.6
Watermelon	393	393	-7.4	19,455	17,618	-9.4
Other vegetables	1,725	1,725	4.9	77,926	76,706	-1.6
TOTAL VEGETABLES	**2,596**	**2,696**	**3.9**	**112,163**	**109,023**	**-2.8**
Dates	983	986	0.3	155,734	157,074	0.9
Other	599	630	5.2	73,689	75,439	2.4
TOTAL FRUITS	**1,582**	**1,616**	**2.2**	**229,423**	**232,513**	**1.3**
Green Fodder	2,688	2,984	11.0	151,301	160,808	6.3
GRAND TOTAL	**9,833**	**9,734**	**-1.0**	**1,074,958**	**971,608**	**-9.6**

Source:
Saudi Arabian Monetary Agency (SAMA), 2010

9.7.3 Industry

The main industrial activity of the Kingdom consists of crude oil production, petroleum refining, basic petrochemicals production, production of ammonia, industrial gases, sodium hydroxide (caustic soda), cement, fertilizer, and plastics. Mining, commercial ship repair, and commercial aircraft repair are also significant activities.

In order to take advantage of the large oil reserves of the Kingdom as well as achieve the Kingdom's aim of economic diversification and expansion, the industrial cities of Jubail and Yanbu were created. Jubail Industrial City (JIC) currently encompasses a number several industrial facilities and factories, a desalination plant, a seaport, high schools, and one college. The Yanbu Industrial City supports refineries, a petrochemical complex, and manufacturing, and associated facilities

Another City to be constructed is the King Abdullah Economic City near Jeddah, which will cover an area of approximately 17,000 ha. The economic city will include a seaport, an industrial park, a central business district, an educational area, and residential areas.

Mining is another industry the government is seeking to develop, as geologic reconnaissance mapping in the west has revealed deposits of gold, silver, copper, zinc, lead, iron, titanium, pyrite, magnetite, platinum, and cadmium. According to the Petroleum and Mineral Resources Ministry, 196 mining exploration licenses were awarded to private firms in 2006. Moreover, the Saudi Arabian Mining Company (Maaden) launched a fertiliser and aluminium complex in Ras

Al-Zour city that could make the city the third industrial city after Jubail and Yanbu. Since its establishment in 1997, Maaden has set up five gold mines, which it says are profitable, and plans to open a sixth by 2009 (MEED, 2007).

9.7.4 Exports

KSA's exports consist mainly of petroleum and petroleum products. Major imports are machinery and transport equipment, foodstuffs, animals, and chemical products. During 2006, the exports reached 208,000 millions of US dollars while the imports were lower accounting for 143,000 millions of US dollars. The main export trading partners are the US (17% of exports), Japan (16.8%), South Korea (9%), and China (7%), and the main imports are sourced from the US (13% of imports), Japan (10%), Germany (8%) and United Kingdom (7.4%) (Spanish Ministry of Industry, Tourism and Trade, 2007).

9.8 National Utility Infrastructure

The Kingdom's electricity provision is in the hands of Saudi Electricity Company (SEC), which was created in April 2000. Before then, there were several different companies in charge of providing electricity, such as Saudi Consolidated Electricity Company (SCECO) which controlled the distribution network, with subsidiaries in the east, west, north, south, and central regions of the country (MEED, 2007).

An overview of services provided by administrative region is presented in Table 9-12.

Table 9-12 Services Survey in Administrative Regions (2005)

Province	Public Electricity	Public Water	Phone	Post Office	Telephone Service	Banking Services	Travel Agency
Riyadh	1,301	320	731	158	28	28	18
Makkah	1,327	141	188	76	30	30	10
Al-Madinah	321	15	161	39	22	22	7
Al-Qaseem	450	105	169	55	11	11	9
Eastern Region	**230**	**166**	**153**	**68**	**21**	**21**	**31**
Aseer	3,524	82	687	104	29	29	11
Tabouk	48	28	51	20	17	17	8
Hail	445	51	122	40	10	10	2
North. Bord	28	23	15	22	10	10	4
Jazan	--	--	--	--	--	--	--
Najran	1,229	293	195	35	11	11	9
Al-Baha	217	4	27	14	9	9	3
Al-Jouf	1,128	40	211	24	13	13	6
Total	**10,248**	**1,268**	**2,710**	**655**	**211**	**211**	**118**

Source:
Ministry of Economy and Planning, 2005

Access to the internet within the Kingdom was available from March 1997. The entity responsible for the introduction was the King Abdulaziz's City of Science and Technology, specifically the Internet Services Unit (ISU), responsible for establishing regulations and policies required to provide this service (Al-Alwani, Abdulkareem Eid Salamah, 2003).

Internet users in the Kingdom increased from approximately 1 million in 2001 to about 6.4 million by the end of 2007, with a penetration rate of 26 percent of the total population and an average annual growth rate of 36 percent. This rapid growth was attributed to increased public awareness of the internet, growth in broadband services and decreased costs of computers and internet services (SAMA, 2008).

9.9 National Transportation Infrastructure

KSA has a public transport system, the Saudi Public Transport Company (SAPTACO), which was established in 1979. This company operates a fleet of 2,714 buses carrying out 579 daily scheduled trips inside and outside the Kingdom (SAMIRAD, 2008b).

The length of roads constructed as of 2006 was 167,600 km. The most important inter-city highways are ([SAMIRAD, 2011), [SaudiOnline, 2010], [Torrents of Arabia, 2011]):

- Dammam - Abu Hadriya - Ras Tanura Highway (257 km)
- Khaybar - Al Ola Highway (175 km);
- Makkah - Madinah Al Munawarah Highway (421 km);
- Riyadh - Dammam Highway (383 km);
- Riyadh - Sedir - al Qasim Highway (317 km);
- Riyadh - Taif Highway (750 km);
- Taif - Abha-Gizan Highway (750 km);
- Medina - Tabuk Highway (680 km);
- Jeddah - Al Leith - Jizan Highway (775 km);
- Jeddah - Makkah Highway (80 km);
- Al-Qassim-Hail Highway (305 km);
- Hail –Aljouf highway (360km).

In addition to this, after the Saudi Urban Transport Conference held on 19th to 22nd February 2011, the Ministry of Municipality and Rural Affairs is set to construct 6,600km of new roads this year at a cost of $3 billion. This will involve the maintaining and asphalting of existing roads as the construction of new ones (Ministry of Municipal and Rural Affairs, 2011).

The railway is a less developed means of transportation in the Kingdom, due to the vast distances to be covered and environmental conditions. The National Railways Company is the main Saudi railways organization (formerly the Saudi Arabian Railway Corporation established in 1976). Currently, the Kingdom’s railway consists of a single track, covering 570 km from

Riyadh to Dammam in the Eastern Province, which was opened in 1951, another line joining Hofuf with Riyadh which was opened in 1985, and the recently completed mineral route from Al-Jalamid to Jubail (see Figure 9-2).

According to the Saudi Railways Organization, there are currently four expansion programs which include;

- **Haramain High Speed Rail Project**: Involves a 450km rail link between Makkah (Mecca) and Madinah. This is considered one of the most important transport projects within the Saudi railway network given the on growing number of pilgrims year after year to the holiest place in Islam, the Mecca. Expected opening on 2012.

- **Land Bridge Project**: This is a 950km-long railway line for the cargo and passengers which aims at connecting the red sea with the Arabian Gulf to be expected for 2015.

- **North – South Line Project**: It is a 2,400km passenger and freight rail line originating in the capital city Riyadh, in the northwest of the country, to Al Haditha, near the border with Jordan. It is the largest railway construction and the longest route in the world. The mineral route running from Jalamid to Jubail had already been laid.

- **Gulf Cooperation Council Railway project**: This idea emerged in 2000, where railway network will link the GCC six countries (kingdom of Saudi Arabia, United Arab Emirates , Qatar , Oman , Kingdom of Bahrain , and Kuwait). It is expected that the total length of the network will be about 2000 km starting from the Iraq-Kuwait border and up to Oman passing through Qatar , Saudi Arabia , in parallel to the coast of the Arabian Gulf.

Figure 9-2 below shows Saudi Arabian Railway and Expansion Projects.

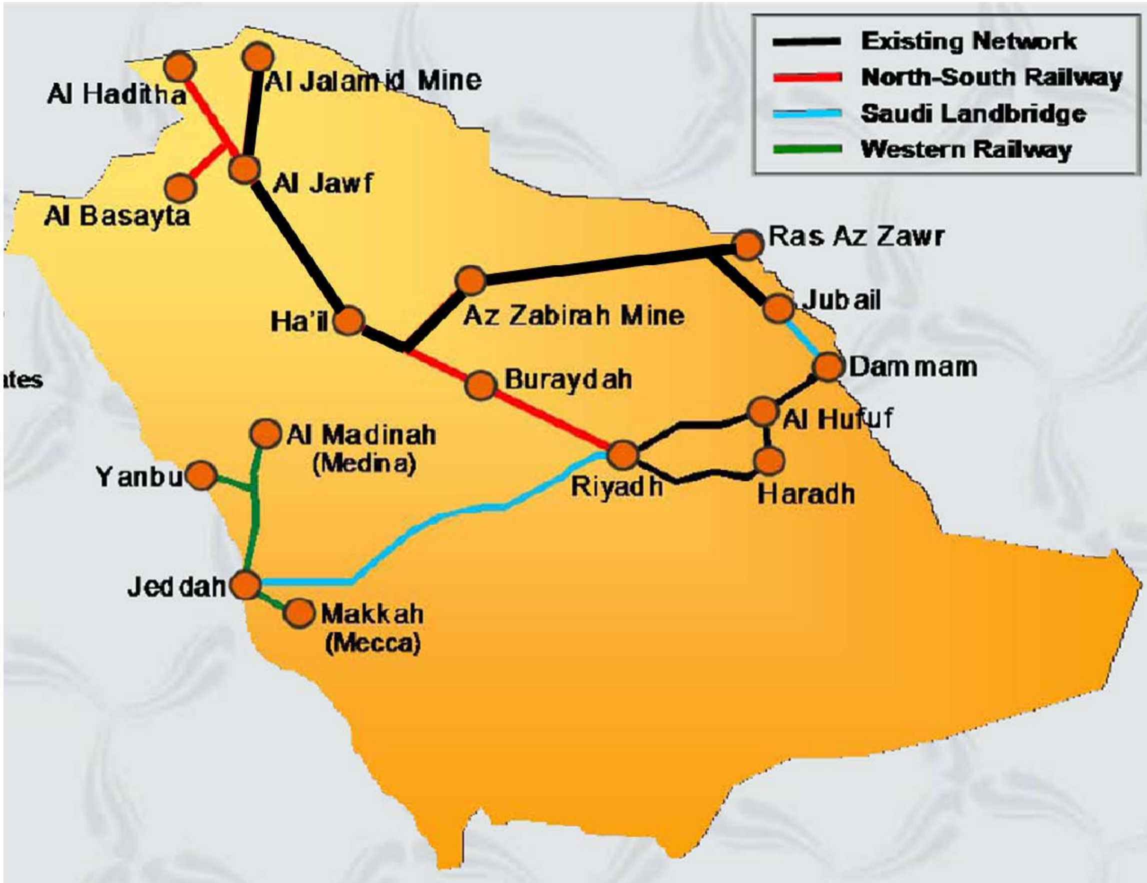

Figure 9-2 Saudi Arabia Railway and Expansion Projects

Source: SAR, 2010, modified by CH2MHILL 2011 to represent the completed track of the mineral route from Al Jalamid mine to Jubail

There are six commercial ports in KSA situated at Jeddah, Dammam, Jizan, Dhiba, Jubail and Yanbu, and two industrial ports at Jubail (King Fahd Industrial Port) and Yanbu (King Fahd Industrial Port) (Saudi Ports Authority, 2008). Additionally, there are some minor ports within the Kingdom.

Finally, civil aviation has grown rapidly, and Saudi Arabian Airlines, which began operating in 1945, has a 139 aircraft fleet including the latest and most advanced wide bodied jets presently available including B747-400s, B747-300s, B747-100s, B777-200s, Airbus A300-600s, MD-11s, and MD90s.

9.10 National Education

The Ministry of Education was established in 1953 and is responsible for planning and developing the educational system within the Kingdom. Education is free and available for all Saudi citizens and residents in the country. The current education system consists of grade levels: six years of elementary school, three years of middle school, and three years of secondary school. Upon completion of the secondary school, the students take a general examination. Those who pass the exam are able to enrol in colleges or universities (Abdulkareem Eid Salamah Al-Alwani, 1998).

Illiteracy within the Kingdom has been significantly reduced, from 64.3 percent in 1974 to 19.9 percent in 2000. For comparison, the illiteracy in neighbouring countries is UAE: 22.1 percent, Bahrain: 13.5 percent, Oman: 18.6 percent, and Kuwait: 6.7 percent (CIA, 2010a).

School enrolment by gender in the KSA is shown in Table 9-13.

Table 9-13 Enrolment by Gender and Education Level (1975 - 2002)

	Number of students (males and females) , 000s								**Average annual growth Rate (%)**		
	(1975)				**(2002)**						
	Male	**Female**	**Total**	**Gender ratio****	**Male**	**Female**	**Total**	**Gender ratio****	**Male**	**Female**	**Total**
Primary & Intermediate levels	510	261	77	2.0	1807	1622	3429	1.1	5.0	7.3	5.9
Secondary level	32	10	42	3.2	433	409	842	1.1	10.5	15.3	12.2
Tertiary level	31 7	7	38	4.4	232	255	487	0.9	8.0	14.8	10.3
Other (*)	100	33	133	3.0	126	168	294	0.8	0.89	6.59	3.13
Total	673	311	984	2.2	2598	2454	5052	1.0	5.33	8.3	6.5

Source:
Ministry of Economy and Planning, 2003
** Includes adult education and special education*
***Number of males per one female*

9.11 National Health

The information provided in this section is primarily based on a review of the World Bank's publications on occupational and community health and safety associated with the operation of petroleum refining facilities. Other information and documentation was obtained from existing studies and reports and relevant web sites.

The MOH is divided into four major levels: the national level located in Riyadh; the regional level located in thirteen regions (Riyadh, Makkah, Qasim, Asir, Jizan, Madinah, Northern Border, Eastern Region, Hail, Tabouk, Al-Baha, Al-Jouf, and Najran); district levels, and local level (EMRO, 2006).

The Ministry of Health (MOH) is the main agency responsible for both the provision of health-care and setting of overall policies for the entire health-care system. Each of the thirteen health regions are led by a Regional Director General for Health Services and supervises one or more health provinces and are responsible for public health as well as the management of tertiary care hospitals and primary health centres. The district level has management functions and a local level consists of health care centres and secondary institutions (Al-Jubani, Bukhait, 1994).

Primary health care services are provided through the 1,786 health care centres located throughout the Kingdom. Curative care is provided to all members of society, through the referral system, extending from the general practitioner up to the level of advanced technology-based specialist services, through a broad base of general and specialized hospitals.

The private sector and other government agencies that provide direct health care for specific segments of the population account for the remaining services. The private sector consists of hospitals, dispensaries, laboratories, pharmacies, and physiotherapy centres located throughout the Kingdom (UNDP, 2003). An overview of the health infrastructure in the country is shown in Table 9-14.

Table 9-14 Health Infrastructure (1970 - 2002)

Indicator	**(1970)**	**(2002)**	**Index (1970=100)**
Total number of hospitals	74	331	447
Total number of hospitals beds	9,039	47,242	523
Total number of physicians	1,172	32,683	2,789
Total number of nursing staff	3,261	68,097	2,088
Total number of allied health personnel, including pharmacists	1,741	40,475	2,325
Total number of health care centres	591	3,627	614

Source:
Ministry of Economy and Planning, 2003b

Improvements in health services over the years have led to a reduction in the incidence of communicable diseases and in infant mortality and under-five mortality rates. Additionally, international statistics show the KSA to be among the three countries in the world that have achieved the largest increases in life expectancy (UNDP, 2003).

Recent studies have demonstrated, however, the prevalence of childhood bronchial asthma among Saudi school children. The studies also indicate that the disease has a higher prevalence in industrial, agricultural, and urban areas as compared to desert and rural areas (Al-Dawood, 2000).

9.12 Regional and Local Socio-Economic Baseline

9.12.1 Introduction

A regional and local socio-economic analysis has been carried out to provide information on population, land use, current development activities, community structure, distribution of income, goods and services, recreation, public health, cultural properties, tribal people and customs, aspirations, and attitudes.

The RTIP site is located in Jubail II, an extension of the JIC in the Jubail Governorate, Eastern Province of Saudi Arabia.

The name Jubail applies also to a town in the Eastern Province of Saudi Arabia located on the Arabian Gulf, the Jubail old town, as shown in Figure 9-3, below. The RTIP site is located south west of Jubail old town and south of JIC that serves as a major Industrial centre for Saudi Aramco.

The baseline analysis includes information on a local level: covering a radius of 20 km from the RTIP site to include the community areas of JIC and Jubail old town in the Jubail governorate, to be referenced hereafter as Jubail, and on a regional level: the Eastern Province and Greater Dammam, which includes the cities of Dammam, Al Khobar and Dhahran, and Ras Tanura and Safwa in the Eastern Province, between Dammam and Jubail. Figure 9-3 shows the RTIP site location, as well as the location of the closest populated areas, which have been analysed in the regional and local approach.

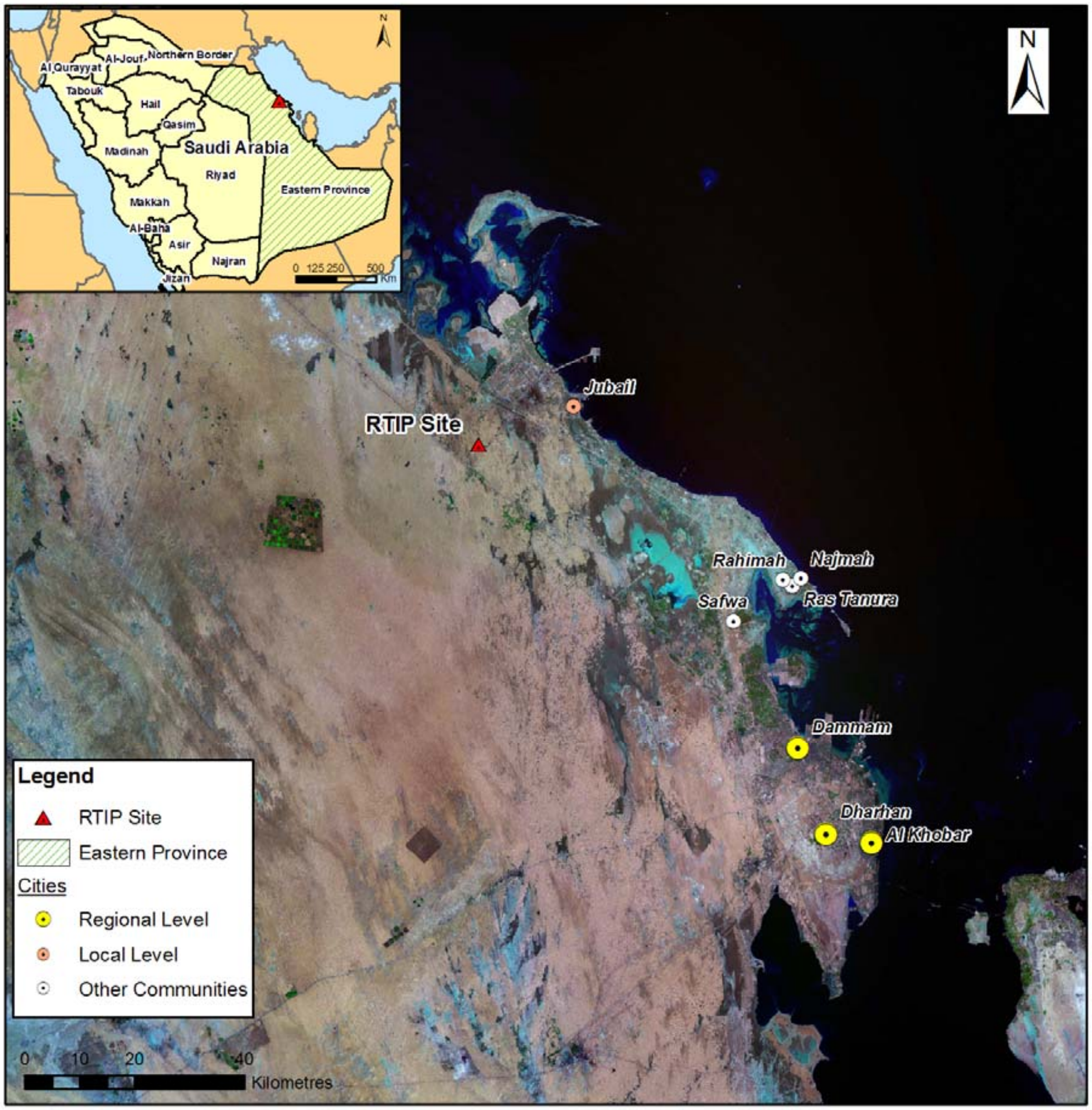

Figure 9-3 Project Location and Nearest Populated Areas in the Eastern Province

Source: Landsat images (2000) from NASA modified by CH2MHILL

9.12.2 Regional

The Eastern Province is the largest province of Saudi Arabia, located in the eastern portion of the country on the Arabian Gulf coast, and has land borders with Kuwait, Qatar, the United Arab Emirates, Oman, and Yemen. It has an area of 710,000 km² and a population of 3,360,157 (per the 2004 Saudi Arabia preliminary census). Its capital is Dammam, and its governor is Prince Mohammed bin Fahd bin Abdul Aziz al-Saud.

The southern part of the province, with more than half of the area, belongs to the largely uninhabited Rub' al Khali (Empty Quarter) desert.

The Kingdom's main oil and gas fields are located onshore and offshore in the Eastern Province. Notable among these are the Qatif oilfield and the largest crude increment in the world, the Qatif Project. Petroleum from the fields is shipped to many countries from the oil port of Ras Tanura and is also used as feedstock in numerous industrial plants in Jubail.

Saudi Arabia's second major product, date (fruit), also forms a large part of the Eastern Province's economy. Every year thousands of tonnes of dates are harvested from the date palms in the giant oases of Al-Hasa and Qatif.

9.12.2.1 General information

Greater Dammam includes the cities of Dammam, Al Khobar and Dhahran. Dammam city belongs to Dammam Governorate, as shown in Figure 9-4. It is the largest city in the Eastern Province and third largest in Saudi Arabia after Riyadh and Jeddah. It is surrounded by the Arabian Gulf to the north, east, and south and extends westwards to the Dahna desert.

In the past, the area was inhabited by small villages with subsistence economy based on fishing and pearling. Some historical sources indicate that the Dammam area has been inhabited since 2000 B. C.

At the beginning of the 19th century Dammam was an important seaport. Its importance increased after the discovery of oil and the related economic boom. Since then, the three urban centres of the Dammam area, Dammam, Al Khobar, and Dhahran, witnessed great expansion which led to unification of the three cities and formation of one urban centre, “Dammam Urban Centre”.

Figure 9-4 Satellite Image Showing Dammam

Source: Ministry of Higher Education, Atlas of the KSA, 1999

9.12.2.2 Population

It is difficult to determine the population of each of the three cities in the Dammam area as there is an overlap between the residential and working areas of the three cities. In general, Dammam is an attractive working place to great numbers of people from inside and outside the Kingdom. Thus, a remarkable increase in population has been noted. Dammam Governorate's total population tripled in size from approximately 200,000 in 1984 to 600,000 in 1992, and continued to increase to 744,631 in 2004. Hence, Dammam has become one of the five largest cities in the Kingdom, with an annual growth rate of 3.6% (Ministry of Information, n. d).

As a result of the architectural activities in the Dammam region, the urban area seems to extend along the Arabian Gulf with some voids, clearly indicating high population density in some areas and low in others.

Table 9-15 through Table 9-17 show information registered in the 2004 Population Census (Ministry of Economy and Planning, 2004) with regards to population, number of occupied houses at a regional and local level, and the type of houses in the Eastern Province, including the cities of Al Khobar and Dhahran.

Table 9-15 Population According to 2004 Census

Administrative units		Population
Governorate	**City**	
Dammam		**744,631**
	Dammam	744,321
Al Khobar		**455,541**
	Al Khobar	165,799
	Dhahran	97,446
Jubail		**224,430**
	Jubail	222,544
Ras Tanura		**43,338**
	Ras Tanura	41,458
Qatif		**474,573**
	Safwa	45,202

Source:
Ministry of Economy and Planning. Central Department of Statistics, Preliminary results of population census 2004

Table 9-16 Number of Occupied Houses and Population Distribution

Administrative units		Occupied Housing	Population		
Governorate	***Centre**		Males	Females	Total
Dammam		**129,891**	**450,804**	**293,827**	**744,631**
	Dammam	129,891	450,804	293,827	744,631
Al Khobar		**88,751**	**274,158**	**181,383**	**455,541**
	Al Khobar	37,117	101,818	63,981	165,799
	Dhahran	15,386	55,175	42,741	97,916
Jubail		**39,311**	**137,233**	**87,197**	**224,430**
	Jubail	39,309	137,233	87,197	224,430
Ras Tanura		**7,081**	**26,476**	**16,862**	**43,338**
	Ras Tanura	7,079	26,476	16,862	43,338
Qatif		**68,553**	**257,944**	**216,629**	**474,573**
	Safwa	11,516	42,224	33,347	75,571

Source:
Ministry of Economy and Planning. Central Department of Statistics, Preliminary results of population census 2004
Note:
**Centre: administrative unit in which governorates are divided. Each centre includes a number of population settlements (municipalities, cities) linked administratively to it.*

Table 9-17 Houses Occupied by Families in the Eastern Province (2000)

Traditional house	Villa	Floor in villa or in house	Apartment	Other	Total
65,210	134,095	47,225	175,184	43,250	464,964

Source:
Central Department of Statistics & Information (CDSI), Ministry of Economy and Planning, Statistical Yearbook, 2000. (CDSI, 2000)

9.12.2.3 Employment Profile

Most of the labour force in Dammam is employed in the oil industry, commerce, fishing, and the government sector. It is known that the oil industry development led to an expansion of commercial activities. It attracted farmers and pastoral nomads from rural areas and encouraged them to migrate and settle in urban areas.

The growth of urban centres and development of administration, transportation, and service industries resulted in various business opportunities in those centres. People with capital were also attracted to business opportunities and invested in industry.

There is no current information on unemployment rates in the Dammam area. Statistics on the number of Saudi and non-Saudi workers per sector in the Eastern Province for 2006 and 2007 are displayed in tables Table 9-18 and Table 9-19 below.

Table 9-18 Saudi Employees (15 years and over) by economic activity in the Eastern Province

Economic Activity	2006	2007
Agriculture, Hunting, Forestry & Fishing	12,198	10,672
Petroleum & Minerals	54,387	72,302
Manufacturing	42,552	39,563
Electricity, Gas & Water	13,072	7,663
Construction	23,474	18,441
Wholesale & Retail Trade	47,459	52,755
Restaurants & Hotels	3,148	2,027
Transportation & Communication	27,907	28,436
Banking & Insurance	9,475	10,408
Real Estate & Business	21,149	18,668
General Administration	202,655	181,316
Education	98,232	94,881
Health & Social Services	22,429	3,3066
Others	5,665	4,067
Total	583,799	574,265

Source:
Ministry of Economy and Planning, 2007b

Table 9-19 Non Saudi Employees (15 years and over) by economic activity in the Eastern Province

Economic Activity	2006	2007
Agriculture, Hunting, Forestry & Fishing	19,607	40,529
Petroleum & Minerals	9,605	6,610
Manufacturing	40,200	80,169
Electricity, Gas & Water	4,942	4,190
Construction	154,153	116,734
Wholesale & Retail Trade	111,320	108,253
Restaurants & Hotels	17,590	53,196
Transportation & Communication	13,978	11,841
Banking & Insurance	2,002	253
Real Estate & Business	27,888	20,870
General Administration	1,855	4,271
Education	16,829	18,657
Health & Social Services	22,080	17,820
Others	111,361	147,580
Total	553,410	630,973

Source:
Ministry of Economy and Planning, 2007b

9.12.2.4 Economic Activity

Economic activity in Dammam centres on agriculture, fishing, trade, and services. Dammam has become one of the three most industrially developed cities in the Kingdom, the other two being Riyadh and Jeddah.

Agriculture

Private farms do not produce sufficient vegetables to meet the region's requirements and the shortfall is made up by purchasing products from Al-Ahsa and the Central region.

Cattle and poultry farms produce enough meat, milk, and eggs to meet most of the region's requirements. As noted in Table 9-20, there has been little overall change in areas that are used for cereal production and steady increases in agricultural area used. The same can be said about all the crops (see Table 9-21).

Table 9-20 Estimated Area and Production of All Cereals in the Eastern Province (2004-2006)

2004		**2005**		**2006**	
Production (ton)	Area (ha)	Production (ton)	Area (ha)	Production (ton)	Area (ha)
205,434	46,721	204,372	48,262	215,566	47,801

Source:
Ministry of Economy and Planning, 2007b

Table 9-21 Estimated Area (ha) of All Crops in the Eastern Province

2004	**2005**	**2006**
68,153	69,298	71,911

Source:
Ministry of Economy and Planning , 2007

Fishery

In the past, Dammam was rich in fish stocks. Unfortunately, coastal development has had a diminishing effect on fishing. For this reason, many fishermen have taken up other occupations, most notably in the oil industry. The Saudi Fishery company uses advanced technology to catch and market its catches in the Eastern and Central regions.

There have been increases in the number of workers and in the income brought into new towns, such as Rahimah, beside those existing towns such as Dammam, that attracted most of these workers and this has encouraged meat, fish, and poultry markets. People from rural areas as well as Qatif, and Jubail brought their catch and livestock to those new centres for high return on their products.

Figure 9-5 Main Fishing Centres on the Kingdom's Eastern Coast. Traditional Fishing Areas and Main Collection Centres

Source: Ministry of Higher Education, Atlas of the KSA, 1999

Industry

The discovery of oil led to fundamental socioeconomic changes in the life of people, the population, and in the role of towns and urban centres. With the increased demand for labour and the increase in income level, a new private sector emerged. The private sector was encouraged to invest in local industries and trade to meet the economic needs for the whole country, in general, and the region, in particular.

A number of industrial cities have been set up in Dammam: the first industrial city, the second industrial city, Alkhideriyya, and Dallah Industrial centre.

In terms of income generated, manpower requirements, and its contribution to the region's prosperity, it is the state-owned oil industry which has done most to improve living standards throughout the Eastern Province.

Other industries in the Province include quarrying, metal industries, fertilizers, petrochemicals (chemical and plastic products), construction materials, and food and beverages industries. However, at present, there is no any information on the number of people who work for these industries in the Dammam area.

Trade and Services

Trade and services constitute a vital part of the economy in Dammam. This is partly because of the King Abdulaziz seaport in Dammam and the Dammam to Riyadh railway line. For these reasons, a large number of the area's inhabitants are involved in trade. The importance of trade is also reflected in the number of first-class hotels, and branches of the Kingdom's major banks and state banks set up to promote development in the Kingdom.

At Dammam city, there are many markets and commercial centres as Al-Waha Mall, Al-Shati Mall, Marina Mall, Al-Shira Mall, Al-Hayat Plaza, and Al-Dammam Plaza. Many commercial centres are currently under construction. There are also old popular markets as Al-Hab market in al-Dawasir quarter, Suq Makkah in Al-Suq quarter, and Suq Al-Haraj in Al-Qadisiyah quarter (RGME, 2009).

9.12.2.5 Transportation Infrastructure

The expansion of the oil industry resulted in the establishment of a wide transportation system where Dammam is the centre of the system.

Roads

In light of the urban and economic importance of the Dammam area, a modern network has been built to link the area with nearby cities and the rest of the road network.

The Saudi Public Transport Company (SAPTCO) is responsible for operating the country's inter-city bus service. The company was established in 1979 and operates a fleet of over 2000 buses in large urban centres as Riyadh, Jeddah, Dammam, Madinah and Makkah and between cities and towns across the country, transporting more than 3,000,000 passengers annually. In addition, there are international routes, used by approximately 500,000 travellers each year.

Railway

In the Dammam area, the railroad serves as a significant link to other cities, including Abqaiq Hofuf and Riyadh. It became a unifying link in moving people and goods.

The general railway corporation has made two major achievements:

- A custom terminal has been built in Riyadh so that goods containers bound for the central province can be transferred direct from Dammam; and
- A second railway track has been built from Dammam to Riyadh via Hofouf.

Ports

Ports in the Dammam area include the King Fahd International Airport and Dammam's King Abdulaziz seaport. The King Fahd Bridge connects the Kingdom with Bahrain, which was previously reachable only by air or sea.

Dammam Port is the largest on the Arabian Gulf. It has become the Kingdom's main eastern seaport outlet for importing and exporting goods. It is connected to Riyadh via a railway line (562 km long), passing through Hafouf, Haradh, and Al-Kharj.

King Abdulaziz seaport began as a small port built to import equipment used in oil exploration. But as part of the Kingdom's rapid process of development, the seaport was expanded until it became the Kingdom's main eastern sea outlet. It has quays to handle a variety of types of ships. Its facilities include multi-purposes cranes, 8 container lifts, 168 mobile cranes, 28 container carriers, a 1600 metres (1 mile) long quay for small ships, a quay for fishing boats, an elevator for 1500 ton ships, pollution disposal facilities, a water desalination plant with a daily capacity of 900 cubic metres, and a training centre.

The seaport has a ship repair dock. A 3 kilometre long jetty extends from the port into the sea. This port can handle two ships at a time and is the starting point for the Dammam Riyadh railway line.

In 1994, Dammam was visited by 2,022 vessels and imported 6,603,817 tons. In 2000/2001, King Abdulaziz Port handled 13,740,338 tons of cargo (The Saudi – Malaysian Consortium, 2005).

One of the most important airports in the Dammam area is King Fahd International Airport. It is located about 50 km from the centre of Dammam and is designed to meet the requirements of the entire province. It covers an area of 760 square km. Thus, it is the Kingdom's largest airport in terms of area and facilities.

9.12.2.6 Utility Infrastructure

Telecommunications

In Dammam, as in other areas of the Eastern Province, mobile communication services are provided by STC, Mobily, and Zain. The three have launched 3G services to their customers.

STC also provides landlines through its Al-Hatif services, and provides internet access through Saudi Data.

Table 9-22 provides data on the number of phones in operation in Dammam. Statistical data for 2007 show that the total number of card and coin operated telephones in Dammam was about 1,718 (Table 9-23). Mobile telephone lines reached 449,497 people (Table 9-24), while DSL lines reached 12,283 in the Eastern Region or Province (Ministry of Economy and Planning, 2007).

Table 9-22 Phones in Operation In Dammam Region: 2003-2007

	2003	2004	2005	2006	2007
Dammam	362886	390974	720993	426494	438081

Source:
Ministry of Economy and Planning, 2007

Table 9-23 Coin and Card Operated Telephones in Dammam Region: 2003-2007

	2003	2004	2005	2006	2007
Dammam	3,880	3,744	4,888	3,299	1,718

Source:
Ministry of Economy and Planning, 2007

Table 9-24 Mobile Telephone lines in Dammam Region: 2003-2007

	2003	2004	2005	2006	2007
Dammam	335,326	419,241	445,367	437,796	449,497

Source:
Ministry of Economy and Planning, 2007

There are several popular TV and radio stations, such as Dammam TV and the radio stations Radio Sawa, Studio One 91, 4 FM, broadcast from Aramco, Bahrain Radio 96.5 FM, and AFRTS and Nilesat satellite channel operators (RGME, 2009).

Water, Energy Supply and Waste Management

The Dammam area depends mainly on underground water for its drinking water source. The area also benefits from the Al-Azizia desalination plant which produces 190,000 cubic metres per day. The main uses of water are for human consumption and agricultural and industrial use.

Table 9-25 shows the number of consumers by water source, on a regional level, in the year 2000. Table 9-26 shows the quantity of water desalinated by desalination plant in the Eastern Province (2003-2007) and Table 9-27 shows water consumption (in thousand cubic metres) and number of subscribers in Dammam from 2003 to 2007. There has been a remarkable increase in consumption (though not in additional subscribers which has maintained at a steady level) over time.

Table 9-25 Houses Occupied by Families & the Number and Persons by Water Source in the Eastern Province: 2000

	Water Source					
	Total	**Other**	**Water container**	**Well**	**Water Truck**	**Public**
No. of families	46,4964	1,551	183,678	1,831	149,955	127,949
No. of persons	3,008,913	12,659	1,094,048	9,678	1,154,910	737,618

Source:
Ministry of Economy and Planning, 2000

Table 9-26 Quantity of Water Desalinated, by Desalination Plants in the Eastern Province 2003-2007

Plant	Jubail	Al Khobar	Al-Shoqiq
2003	362,847	131,317	35,609
2004	385,846	132,448	36,847
2005	383,000	140,475	36,849
2006	364,853	143,845	36,828
2007	361,245	146,484	36,690

Source:
Ministry of Economy and Planning, 2007

Table 9-27 Water Consumption and Number of Subscribers in Dammam city: 2003-2007 (Quantity in thousand cubic metres)

	No. of Subscribers	Water Quantity
2003	44,413	89,923
2004	46,677	91,212
2005	46,677	261,803
2006	48,765	285,766
2007	37,094	290,324

Source:
Ministry of Economy and Planning, 2007

The Dammam area receives its power supply from the Saudi consolidated electrical company in the Eastern Province (SCECO Eastern) which has installed main electrical connections and high tension networks. Within the Dammam area and its proximity there are electric power plants at Batina, Al Khobar, and Azizia in the south.

Economic development has resulted in increased production of waste, which has become a common problem in Saudi Arabia. Waste of various types are produced in great quantities by various activities, these are summarized in Table 9-28.

Table 9-28 Types of Waste

Waste	Detail
Controlled	Waste that must be managed and disposed of in line with waste management regulations. It includes municipal, commercial, and industrial wastes.
Municipal	Includes all wastes under the control of municipalities.
Household	Includes regular waste from household collections.
Industrial	Includes waste from factories and industrial plants.
Commercial	Includes waste from wholesalers, shops, offices and catering business.
Agricultural	Includes waste from farms and market gardens.
Construction and demolition	Includes any waste from the construction, repair, maintenance and demolition of buildings and structures.
Mines and quarries	Includes materials such as overburden, rock and minerals.

Source:
The Saudi – Malaysian Consortium, 2005

Waste management sites and facilities in the KSA are operated and managed by private companies or the local municipality, with the Presidency of Meteorology and the Environment (PME) currently providing an advisory role in their operation.

9.12.2.7 Education

Published data on numbers and percentages of children in schools in the Dammam region are shown in Table 9-29 to Table 9-32.

In addition to governmental and private elementary, intermediate and secondary schools, Dammam has universities including Dammam University, King Fahd University for Petroleum and Minerals, Scientific Institute (Imam Mohammed Ibn Saud University), Open Arabian University, Technology College, College of Science and Arts for girls, Society College, Teachers' College, Health Sciences Academy, General Administration Institute, and Prince Mohammad Bin Fahad University

Table 9-29 Male Education- Governmental Sector (Public Education and Quranic schools)

Dammam	Elementary		Intermediate		Secondary	
	Pupils	Schools	Pupils	Schools	Pupils	Schools
	27,390	70	12,029	43	9,332	22

Source:
Ministry of Economy and Planning, 2007b

Table 9-30 Male Education- Private Sector (Public Education and Quranic Schools)

Dammam	Elementary		Intermediate		Secondary	
	Pupils	Schools	Pupils	Schools	Pupils	Schools
	5,920	21	1,755	16	1,828	11

Source:
Ministry of Economy and Planning, 2007b

Table 9-31 Female Education- Governmental Sector (Public Education and Quranic Schools)

Dammam	Elementary		Intermediate		Secondary	
	Pupils	Schools	Pupils	Schools	Pupils	Schools
	29,510	72	13,823	35	11,751	25

Source:
Ministry of Economy and Planning, 2007b

Table 9-32 Female Education- Private Sector (Public Education and Quranic Schools)

Dammam	Elementary		Intermediate		Secondary	
	Pupils	Schools	Pupils	Schools	Pupils	Schools
	3,236	26	740	12	735	5

Source:
Ministry of Economy and Planning, 2007b

9.12.2.8 Religious Facilities

The Saudi citizens are Moslem and care for mosques and contribute to building new mosques in the area. The Ministry of Religious Affairs also provides financial support to religious organizations which also receive private endowments.

There are more than 120 mosques in the Dammam area and more than 30 Friday or congregational mosques (Al-Gaoud, 2002). The Ministry of Pilgrimage in the Kingdom regulates and maintains Hajj and Umrah facilities, tourist companies, and the operation of travel agencies that make travel arrangements for pilgrims visiting the Holy Places in the Kingdom of Saudi Arabia.

9.12.2.9 Tourism and Recreational Facilities

Dammam's tourist attractions and coastal recreation centres, such as the corniche, King Fahad Park and Aramco centre, attract vacationing tourists from Riyadh and Qaseem. Dammam has developed several tourism and recreational facilities, including:

- Beaches with chalets, motels, restaurants, shopping areas, car parks, camping areas, and moorings for small boats;
- A tourism area in Half Moon Bay Beach that includes chalets, swimming pools, and playgrounds.

City gateways are lined with landscaping and careful attention to planning has been undertaken to preserve the city's heritage and select architecture that is culturally compatible.

There are numerous public gardens located throughout Dammam. These parks include playgrounds, potable water, and toilet facilities. King Fahd Park is the biggest park in the Kingdom (it has a variety of recreational facilities and administration offices). Al-Marina seafront property development project is one of the most important landscaping and recreational projects in Dammam area. It extends from Half Moon Bay to Tarut Island.

The General Presidency for Youth Welfare has set up a coastal centre at Dammam's Half Moon Bay beach, consisting of recreational areas for sporting activities. The centre has a special section for sea sports.

Another tourist destination is the Dammam National Museum, located on the 4th floor of the public library, across from the sports stadium (Prince Mohammed bin Fahd Stadium), which contains exhibits detailing the culture of the area.

Statistical data on sports and literary clubs shows that there are about 34 sports clubs and two literary clubs in the whole Eastern Province (Ministry of Economy and Planning, 2007a).

9.12.2.10 Health Facilities

Dammam has well developed public health facilities, including a 402 bed central hospital, a 42 bed tuberculosis hospital, and a 261 bed maternity and paediatrics hospital. The bed space of government and privately operated hospitals is shown in Table 9-33. There are also 111 public primary health care centres, 21 clinics and dispensaries, and one psychiatric hospital (Al-Gaoud, 2002). There is also a 300-bed private hospital (Ministry of Information, n.d.).

Table 9-33 Governmental and Private Sector Hospitals

Dammam	**Population Number**	**Governmental (number)**			**Private (number)**		
		Physicians	Beds	Hospitals	Physicians	Beds	Hospitals
	745,658	690	1162	5	453	579	4

Source:
Ministry of Economy and Planning, 2007b

The Saudi Red Crescent Society in the Dammam area is also equipped with many ambulances and medical facilities.

Table 9-34 Primary Care Health Centres, Private Clinics, and Red Crescent Societies

Dammam	**Total population**	**Governmental**		**Private**		**No. of R. Crescent centres**
		No. of Physicians	**No. of H. centres**	**No. of Physicians**	**No. of clinics**	
	745,658	98	21	539	48	6

Source:
Ministry of Economy and Planning, 2007b

9.12.2.11 Ras Tanura (Najmah, Rahima)

General Information

Ras Tanura (previously known as Rahima) is a city in the Eastern Province of Saudi Arabia located on a peninsula extending into the Tarut Bay of the Arabian Gulf. Ras Tanura is located 40 km south of the modern industrial port city of Jubail and north across Tarut Bay from the old port city of Dammam (30 km). Ras Tanura currently has an oil refinery, two ports for the shipment of oil, a gas plant, a plant for the production of sulphur, and a steam power station.

Figure 9-6 Satellite Image Showing Ras Tanura

Source: Google Earth, accessed 14/9/2009

Population

According to the 2004 census projections the total population of the Ras Tanura Governorate was 43,338 persons (CDSI, 2009); and approximately 71% of these were Saudis (Rastanura-baladia.gov, 2009). The Najmah compound is one of four residential compounds built by Saudi Aramco in the 1940s and the only one located on the Gulf itself. The Ras Tanura Refinery occupies the eastern part of Ras Tanura. Other important quarters are: Al-Rawdha, Ridhwa, Danah (in the centre), Al-Muntazah, Ghurtubah, Al-Zuhoor (in the west), Andalus and Al-Bustan (in the south), and Al-Fayha in the north.

Today Ras Tanura is a settlement of multi-ethnic cultures and backgrounds. The robust increase of the oil sector and the related economy in the past 60 years has resulted in increased emigration from other parts of Saudi Arabia as well as foreign workers from the United States, United Kingdom, Middle East, and Asia. The expatriate population is mainly composed of males, living without their families, in the 25-55 year age group [CDSI, 2007; KFUPM, 2008].

The residents of Ras Tanura dwell in about 7,300 predominantly modern concrete housing units and buildings in planned dwellings in the nine districts of the town, company compounds, or other settlements, such as Ghazlan, Sahaba (Sheab), and Gawan (KFUPM,2008).

Employment Profile

Most of Ras Tanura's inhabitants work for Saudi Aramco; the Saudi Electrical Company, SABIC; in education, for the armed forces; or in other trades and businesses.

Table 9-18 and Table 9-19 show the number of Saudi and non-Saudi workers on a regional level during 2006-2007.

Economic Activity

Economic activity in Ras Tanura is driven mainly by huge petrochemical complexes and shipping terminals. The primary source of income for Ras Tanura residents is employment in industrial developments, especially Saudi Aramco, which employs approximately 70% of the labour force (KFUPM, 2008).

Residents are also engaged in support activities related to this development, including fishing, services, education, business, and semi-skilled support occupations. Some of the labour force is also employed as teachers, health workers, municipal workers, and government employees. Most residents are skilled and educated and work in the government and for local businesses. Some local tribal members of the Al-Hawajer and Khawaled are engaged in seasonal pasturing. The expatriate workers are mainly employed in professional, skilled and un-skilled occupations, fishing, and domestic work (KFUPM, 2008).

Construction

Activity in the construction sector has recently risen consistently due to the rapid rise in demand for housing. The major investments in housing and real estate are coming from the private sector, the operating companies in the town, and the government (KFUPM, 2008).

Agriculture

The Ras Tanura Governorate is known for producing fruits, vegetables, dates and other crops. Statistical data on agricultural products at Ras Tanura is not available. Information on agricultural areas and their production of cereals and crops from 2004 to 2006 is available on a regional level (Table 9-20 and Table 9-21).

Fishing

The fishing sector generated an estimated SR 3.7 million/day revenue (based on 2008 catch of 433 tons per day). Fishermen from the Safwa and Qatif areas fish as much as 3 to 5 km offshore of Ras Tanura town. Ras Tanura has one retail fish market. Ras Tanura has also been known for its pearl-fishing industry (KFUPM, 2008).

Commercial Sector

The commercial sector in Ras Tanura has been steadily growing. The number of businesses grew from 360 in 1986 to about 4,560 in 2008, including all types of activities such as restaurants, hotels, malls, stores, and other retail goods and service outlets (Ministry of Economy and Planning, 2008).

Public Health

The Governorate has a 50 bed hospital, two primary health care centres (belonging to the Ministry of Health), 4 private clinics (Table 9-33 and Table 9-34), a Saudi Aramco health care centre, a Saudi Red Crescent centre, and a quarantine centre. They provide primary and some specialized healthcare facilities to district residents. Major medical cases are normally referred to better-equipped hospitals in Dammam, Al-Khobar, Qatif, and Jubail (KFUPM, 2008). The most relevant illnesses are allergies and bronchial asthma. A further illness known in the area is sickle cell anaemia. Records of epidemical diseases at Ras Tanura are not accessible.

9.12.2.12 Safwa

General Information

Safwa region is administratively a part of the Qatif governorate in the Eastern Province. It lies on the extreme north of Qatif, on latitude 26º 39′ 50′′ north and longitude 49º 57′ 1′0′′ east (Al-Ubaid, 1993). It is located about 15 km from Qatif, beside the asphalt road connecting Dhahran and Ras Tanura.

Population

The city of Safwa flourished as a result of its location on the asphalt road leading to Dhahran and Ras Tanura. It also acquired special significance as a result of its location in close proximity to oil refineries. After the 1970's oil boom its urban architecture extended to occupy all the agricultural areas in its vicinity. The population of Safwa City according to the 2004 Population Census was 45,202.

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Figure 9-7 Satellite Image of Safwa

Source: Google Earth, accessed 25/5/2009

Employment Profile

After the 1970's oil boom, oil production centres attracted the agricultural labour force. Agriculture including the date palm groves was neglected. Inhabitants of Safwa work in both the public and private sectors of economic activities for the oil and gas industries and related community infrastructure. Unfortunately no statistical data are available on the number of workers per sector. Regional level data are, however, presented in Table 9-18 and Table 9-19.

Economic Activity

With respect to agriculture, the satellite image clearly shows the existence of cultivated fields in the north eastern part of Safwa (Figure 9-7). Though urbanism is nowadays diminishing Safwa agricultural lands, it is known that the area played a significant role through centuries of the old system of agriculture. It fostered the dynamic growth of settlements besides pearling activities.

As a result of the availability of sufficient funds and the development of the oil industry, great numbers of water wells were made available in the region and this resulted in a parallel growth of interest in the expansion of agriculture. New agricultural centres in Safwa and Qatif improved farming methods, mechanization, use of commercial fertilizers and scientific land drainage opened a new dimension in agriculture and farming (Al-Doussari, 1999). Qatif is known as the most important agricultural and fishing area in the KSA (SAMIRAD, 2009). As such, the area has a thriving agricultural sector, producing a wide range of crops, including dates, limes, cereals, bananas, grapes, pomegranates, figs, tomatoes, okra, radishes, and onions. Qatif has the largest fishing centre in the Arabian Gulf, making it the primary source of fish for the Kingdom (TSN, last accessed on 2009). The area is also well-known for its traditional markets (suqs), such as the weekly Thursday Market "Suq Alkhamees" and "Suq Waqif". Recognized for its agricultural and fishing production, the economy of the Qatif region has shifted towards the oil industry.

Public health

There are reportedly six health care centres and two clinics, all managed by the Ministry of Health. Available published health data on hospitals and the private sector's role in the growing city of Safwa is displayed on Table 9-33 and Table 9-34.

9.12.3 Local

9.12.3.1 General Information

The old town of Jubail lies approximately 90 km northwest of Dammam, (see Figure 9-3) (Ministry of Economy and Planning, 2007). Nowadays, it is a modern industrial port city on the coast of the Arabian Gulf, which previously served as a transit point for trading caravans. It was known to be an area for pearl diving and fishing.

Jubail is located on a coastal plain slightly about 14 meters above sea level on average. It was originally a small fishing village that later developed and flourished after the construction of a nearby gas separator plant. It grew largely after the establishment of JIC, which is the largest centre of petrochemical industries in the Middle East. JIC lies about 10 km to the north-west of the old town of Jubail. In addition to the industrial city and Jubail town, Jubail includes landmarks such as the King Fahd Industrial Seaport, the trading port, and a fishing port.

Figure 9-8 below shows the different areas in JIC, including primary industries (in red), the secondary industries (peach), support and light manufacturing industries (pink), community areas (orange), infrastructure and port facilities (grey), open spaces/buffer zones (green), recreational areas (in dark blue), and Saudi Aramco / SEC corridors (light grey).

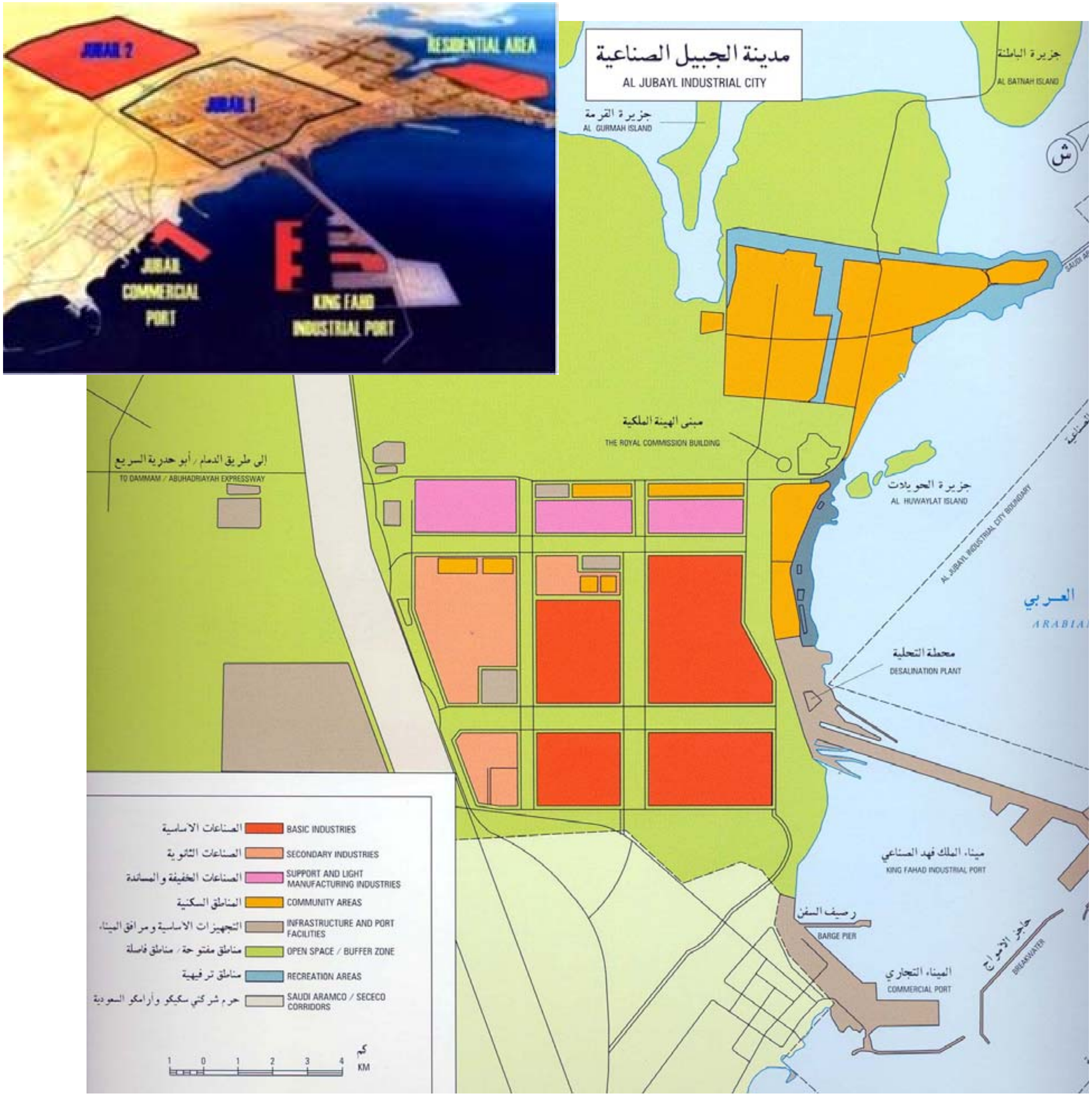

Figure 9-8 JIC Plan

Source: Ministry of Higher Education, Atlas of the Kingdom of Saudi Arabia, 1999

The development of Jubail II is currently underway and divided into four phases which are to be completed by 2022 at an expected cost of SR 14 billion, financed mainly by international investment.

The overall responsibility for developing and operating JIC has devolved to the Jubail Directorate of the Royal Commission for Jubail and Yanbu. More detailed information on Jubail II is available on the Royal Commission for Jubail and Yanbu website (RCJY, 2010a). The Royal Commission is responsible for the construction and operation of basic infrastructure facilities and public services required by industry and the permanent community.

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9.12.3.2 Population

The population of Jubail, including both Jubail town and JIC community areas, according to the 2004 census (Ministry of Economy and Planning, 2004b) is 222,544 (Table 9-35). It is considered one of the most rapidly growing cities in Saudi Arabia whose growth is largely attributed to employment opportunities in petroleum industries and supporting utilities and services.

Table 9-35 Population According to 2004 Census

Administrative units	Population
Jubail	222,544
Total Jubail Governorate	*224,430*

Source:
Ministry of Economy and Planning, 2004b

Housing

The residential area of the Jubail town includes main quarters as Al-Mirqab, Al safa, Al Hamra, Al Danah, Taybah, Al Joharah and Ad Dakhl Al Mahdud.

The residential area in JIC lies to the north of the industrial area along the coast to a 46 km distance. It includes eight main quarters: Alhiwailat, Al-Difi, Al-Fanateer, Al-lulou, Jalmoudah, Mardoumah, Al-Fasl and Al-Shati (Al-Boainayn, 1994).

Figure 9-9 below shows the location of the future community areas (in yellow) in the JIC. These areas will accommodate up to 50,000 new residents by 2024 (Arab News, 2006).

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Figure 9-9 JIC and Jubail II Plan

Source: RCJY, 2010b

Table 9-36 shows the number of occupied houses and population distribution by gender in Jubail (Ministry of Economy and Planning, 2004). The number of occupied houses reached 39,311 in year 2000, supporting a total population of 224,430. Thus the average number of people in each household is nearly 6 persons.

Table 9-36 Number of Occupied Houses and Population Distribution In Jubail

	Total	Females	Males	Occupied houses
Jubail (1)	224,430	87,197	137,233	39,311

Source:
Ministry of Economy and Planning, 2004
Notes:
(1)Includes both Jubail town and communities at JIC

9.12.3.3 Employment Profile

Most residents of Jubail work in the petroleum industry, government sectors, commerce, or fishing. Local data on the numbers of workers in these sectors is unavailable; regional and national level data were presented in Table 9-18 and Table 9-19 of section 9.12.2.4.

9.12.3.4 Agriculture and Fishery

Limited local information on the agricultural and fishery activities in Jubail is available. Regional information was included in section 9.12.2.4.

In the past, Jubail was rich in terms of fish stock. Unfortunately, coastal development has had a diminishing effect on fishing. For this reason, many fishermen have taken up other occupations, most notably in the oil industry. Nevertheless, Jubail still represents an important fishing area in the Arabian Gulf, combining traditional and commercial fishing. The number of artisanal vessels in Jubail is 387, which is the highest in all the landing ports of the Arabian Gulf Coast (FAO, 2003).

Figure 9-10 Fishing Boat Docked at Jubail

Source: Elhassan 2010

9.12.3.5 Industry

JIC is one of two major industrial cities in Saudi Arabia. JIC has more than 19 primary and 21 secondary industries in operation, as well as support facilities managed by the Saudi Basic Industries Corporation (SABIC). These installations include firms such as:

- The Saudi iron and steel company (Hadeed);
- The Saudi methanol company (AR-RAZI);
- Jubail fertilizers company (SAMAD);
- Jubail petrochemical company (KEMYA);
- Arabian petrochemical company (PETROKEMYA);
- Saudi Kayan;
- Jubail United Petrochemical Company (JUPC);
- Saudi Aramco Total Refining and Petrochemical Company (SATORP-under construction).

9.12.3.6 Trade and Services

Trade and services constitute a vital part in the economy in Jubail. This is partly because of the King Fahd Commercial Seaport, fishing port, and JIC (petrochemical industries). For these reasons, a large number of Jubail residents are involved in trade. The importance of trade is also reflected by the large numbers of branches of the Kingdom's major banks and state banks setup to promote development in the Kingdom.

Figure 9-11 A View of King Fahad Commercial Port
Source: Elhassan 2010

9.12.3.7 Transportation Infrastructure

An ancient caravan land route called Al Kanhari used to link Jubail with other parts of Saudi Arabia (Al-Obaid, 1984). The recent expansion of the oil industry resulted in the establishment of an improved road transportation network in Jubail. A branch of the Saudi Landbridge Project is proposed to connect Jubail to Dammam.

In light of the urban and economic importance of the Jubail area, a modern network has been built to link the area with nearby cities and the rest of the Kingdom's road system. The most important among these roads is Dammam (Dhran) –Jubail Road.

Jubail town has modern streets, the most important of which are Jeddah Street, King Faisal Street, Al Madinah Al Munawarah Street, Al Amir Muhammed Street, King Abdulaziz Road, As Sittin Street, Road, King Abdullah Road, Prince Mohammed bin Fahd Road, King Fahd Street, Prince Naif Bin Abulaziz Road, and Al Lulu Road.

A port complex has been set up in Jubail town to import and export products. The largest of these is King Fahd industrial port, which lies at the northern tip of the 9 kilometres long industrial causeway. The annual handling capacity of the port is over 50 million tons of bulk liquids, plus 10 million tons of other materials.

The Jubail commercial port in 1994 was visited by 1,215 vessels and imported 1,127,112 tons. In 2000/2001, the port handled 2,145,676 tons of cargo (The Saudi – Malaysian Consortium, 2005).

Jubail has an airport that covers an area of 250 square kilometers. It is built to meet all the town's requirements, including air cargo and passenger services. In spite of this airport, the town is also being served by King Fahd International (Dammam) airport which is approximately 60 km away.

9.12.3.8 Utility Infrastructure

Telecommunications

In Jubail, as in other areas of the Eastern Province, mobile communication are provided by STC, Mobily, and Zain. The three have launched 3G services to their customers. STC also provides landlines through its Al-Hatif services, and provides internet services through Saudi Data. A telecommunication network has been setup in the city, together with a microwave network, a coaxial cable and international telex networks.

Table 9-37 provides data on number of telephone users in Jubail. Statistical data for 2007 shows that the total number of card and coin operated telephones in Jubail is about 439 (Table 9-38). Mobile telephone lines reach 121,949 (Table 9-39).

Table 9-37 Phones in Operation and Capacity in Jubail: 2003-2007

Jubail	Telephones Capacity					Telephones in Operation				
	2003	2004	2005	2006	2007	2003	2004	2005	2006	2007
	151618	163989	--	174060	83727	93194	103478	--	114409	119091

Source:
Ministry of Economy and Planning, 2007

Table 9-38 Coin and Card Operated Telephones in Jubail: 2003-2007

Jubail	2003	2004	2005	2006	2007
	949	934	--	766	439

Source:
Ministry of Economy and Planning, 2007

Table 9-39 Mobile Telephone Lines, by Type of Communication System in Jubail: 2003-2007

Jubail	2003	2004	2005	2006	2007
	100,567	122,213	128,044	120,549	121,949

Source:
Ministry of Economy and Planning, 2007

Water, Energy Supply and Waste Management

Jubail receives its drinking water from the saline water conversion corporation's desalination plant, which also serves Riyadh and is the Kingdom's largest desalination plant. Jubail consumes 500,000 cubic metres of drinking water daily (Ministry of Information, n.d). This includes human consumption and industrial and agricultural use. There is no published data on distribution per use. There is a network of facilities for receiving, storing, and distributing the water consumed by the town.

JIC receives its power supply from the Saudi consolidated electrical company in the Eastern Province (SCECO Eastern) which has installed main electrical connections and high tension networks. Secondary distribution networks for all parts of the city were installed by the Royal Commission for Jubail and Yanbu.

Marafiq, the power and utility company for Jubail and Yanbu, provides seawater cooling systems, desalinated and treated water systems, and sanitary and industrial wastewater treatment systems to JIC. The Marafiq facilities comprise of the following (Marafiq, 2010):

- Sea water cooling facility: two pumping stations near to the shore and a distribution canal connected to the users through underground lateral pipes;
- Potable water facilities: two desalination plants, two reverse osmosis plants, as well as storage tanks, pumping stations and distribution water lines ;
- Wastewater facilities:

- The Industrial Wastewater Treatment Plant (IWTP) is designed to treat incoming industrial wastewater from Industries in the Jubail Industrial City. It has a design capacity of 60,000 cubic meters per day.

- The Sanitary Wastewater Treatment Plant (SWTP) is designed to treat incoming sanitary wastewater from Industries, the Community area and Jubail town. It has a design capacity of 72,000 cubic meters per day.

Solid waste collection and transport at Jubail is performed by a contractor (Al-Yamamah Establishment), hired by the municipality to collect, transport, and dispose of the municipal solid waste (MSW) for Jubail town (Environment Director at Jubail Municipality, personal information). Like other areas in the province, all the trucks and automatic compactors are owned by the Municipality and the contractor is responsible for maintaining the containers during performing services. The refuse composition data indicates a high percentage of glass, metals, and wood (Khan et al., 1987). The containers vary in size from 200 litres to 20m^3. The contractor servers the different parts of the city as follows:

- The residential areas once a day;
- The main streets are served twice a day;
- The commercial areas are served 3 times a day.

The RCJY also developed and constructed a sanitary landfill in Jubail town.

Other companies at Jubail such as EDCO, Twaiq, Yamamah and BeeA'h have sanitary and hazardous waste landfills. They treat all hazardous waste received by its operating facilities in accordance with treatment standards and technologies approved by the Royal Commission of Jubail and Yanbu, Presidency of Metrology and Environmental (PME) and United States Environmental Protection Agency (USEPA).

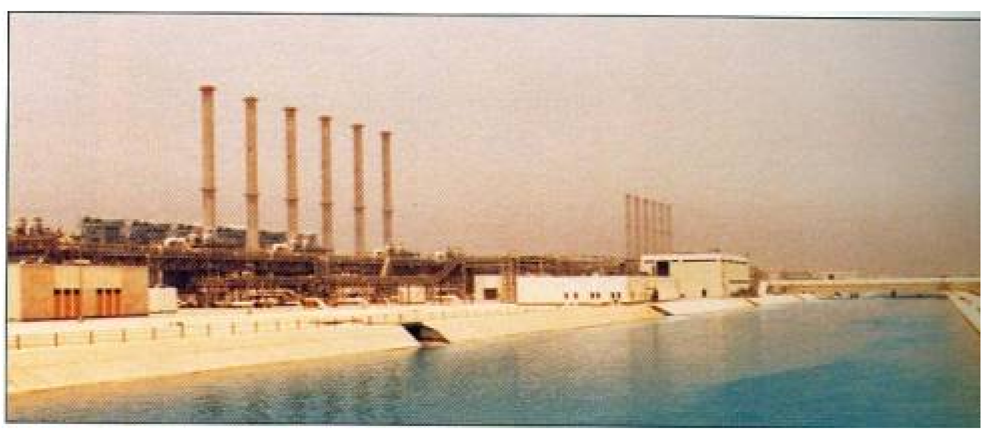

Figure 9-12 Jubail Desalination Plant

Source: Ministry of Higuer Education, Atlas of the Kingdom of Saudi Arabia, 1999)

9.12.3.9 Education

There are a number of primary, intermediate, and secondary schools, including Quranic schools, in Jubail. Statistical data on number of children in schools, per gender, stage and school type is displayed on Table 9-40 to Table 9-44.

There are also primary and intermediate Arabic language schools for non-Arabs. The Royal commission's human resources set up a development institute to provide training in areas (occupations) that are required.

In addition to governmental and private elementary, intermediate and secondary schools, some schools have been established for expatriates, such as the International Indian School and Jubail American and British schools.

Figure 9-13 Alhwaylat Elementary School

Source: Elhassan 2010

Table 9-40 Male Education- Public Education and Quranic Schools in Jubail

Jubail	Elementary		Intermediate		Secondary	
	Pupils	**Schools**	**Pupils**	**Schools**	**Pupils**	**Schools**
	9,571	18	3,134	9	2,883	5

Source:
Ministry of Economy and Planning, 2007

Table 9-41 Male Education- Private Sector (Public Education and Quranic Schools) in Jubail

Jubail	Elementary		Intermediate		Secondary	
	Pupils	Schools	Pupils	Schools	Pupils	Schools
	299	2	61	1	123	1

Source:
Ministry of Economy and Planning, 2007

Table 9-42 Female Education- Governmental Sector (Public Education and Quranic Schools)

Jubail	Elementary		Intermediate		Secondary	
	Pupils	Schools	Pupils	Schools	Pupils	Schools
	1,046	16	3,395	8	3,531	7

Source:
Ministry of Economy and Planning, 2007

Table 9-43 Female Education- Private Sector (Public Education and Quranic Schools)

Jubail	Elementary		Intermediate		Secondary	
	Pupils	Schools	Pupils	Schools	Pupils	Schools
	369	4	73	3	167	3

Source:
Ministry of Economy and Planning, 2007

Table 9-44 Female Education- Private Sector (Public Education and Quranic Schools)

Jubail	University Colleges and Universities		Secondary	
	Males	Females	Males	Females
	1	1	3363	1673

Source:
Ministry of Economy and Planning, 2007

9.12.3.10 Religious Facilities

There are more than 50 mosques in Jubail (Al-Gaoud, 2002). The Great Mosque of Jubail is located on the King Faisal Road. Other larger mosques in the area are the Mohammad Al Nikhailan, Omer Ibn Adulaziz, Osman Ibn Afan, and Abu Bakr AlSidiq mosques.

9.12.3.11 Tourism and Recreational Facilities

JIC has a 204 square kilometre park area located west of the industrial area. Recreation has been considered when planning and building the residential area, and sports clubs have been built in some districts. Greenery and landscaped areas and recreation parks are found throughout the city. The city has beautiful beaches along the Arabian Gulf. The city contains a well known intercontinental hotel and several minor hotels and furnished apartments and flats.

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Figure 9-14 A View of Jubail Corniche
Source: Elhassan 2010

9.12.3.12 Health Facilities

The RCJY has implemented several health care programs, including the construction of hospitals, primary health care centres (clinics), and centres for environmental and occupational health. There are also health education, first aid, and infectious disease prevention centres. The al-Hewailat in Jubail is a 200 bed hospital fully equipped with a comprehensive range of health care facilities. There are also three other hospitals: Jubail General Hospital Al-Manie Hospital (Al-Huwalat District), shown in Figure 9-15, and Al-Mouasat Hospital – Al-Deffi, Al-Andalus District.

There are no data on the primary illnesses in the area or those treated in the hospitals. Table 9-45 and Table 9-46 provide information on the medical staff and facilities at hospitals in Jubail.

Table 9-45 Governmental and Private Sector Hospitals in Jubail

Jubail	**Population Number**	**Governmental (number)**			**Private (number)**		
		Physicians	Beds	Hospitals	Physicians	Beds	Hospitals
	224,481	362	902	4	128	270	3

Source:
Services Directory 2007

Table 9-46 Primary Care Health Centres, Private Clinics, and Red Crescent Societies

Jubail	**Total population**	**Governmental**		**Private**		**No. of R. Crescent centres**
		No. of Physicians	**No. of H. centres**	**No. of Physicians**	**No. of clinics**	
	224,481	35	5	90	9	1

Source:
Services Directory 2007

Figure 9-15 Jubail General Hospital

Source: Elhassan 2010

9.12.4 RTIP Site

9.12.4.1 General Description

The RTIP site will occupy an area of approximately 5.76 km² or 576 ha of land in Jubail II, as well as a tank farm and loading and unloading facilities at the King Fahd Industrial Port (KFIP).

The RTIP site is currently unfenced, guarded, and used partly for temporary residence by local visitors who come to ponds and palm grove areas to hunt birds on weekends. During the study, it was noted that many companies are working on the site presumably for the RCJY. The present extensive works on the site which include site development and earth works are being carried out by Al Harbi and Al-Osais companies.

Apart from Jubail town and JIC community areas, there are temporary camps of companies and workers on the north eastern side of the site. BeeA’h industrial landfill lies at the south eastern corner of the project area. Opposite the BeeA’h landfill, the EDCO industrial landfill is under construction. Both facilities provide waste disposal facilities to the current and future industries in JIC and Jubail II. To the southeast of the site there are temporary fenced workers camps, two wastewater facilities in open areas, and camps belonging to local companies and factories.

The location of the site was chosen due to its proximity to feedstock resources and the facilities and infrastructure in industrial Jubail which are the subject of further expansion in accordance with future plans.

The vision for the comprehensive civil and industrial JIC development includes:

- Recycling water, delivery of seawater for cooling, distribution of electrical and telecom networks;

- Building a system to transport feedstock between the national network company and to recycle product gases and liquids;
- Construction of a transportation spine to transfer industrial products to King Fahad Industrial Port;
- Expansion of King Fahad Industrial Port by adding new berths and cargo storage and handling facilities;
- To improve Jalmoudah residential neighborhood and expand amenities.

Photos of the RTIP site preparation taken during the field survey in November 2010 are shown in Figure 9-18 to Figure 9-20.

Figure 9-16 Sanitary Landfill Operated by Twaiq Company North of the RTIP site
Source: Elhassan 2010

Figure 9-17 A View of BeeA'h Sanitary Landfill on the Northern Eastern Side of the RTIP, Jubail II

Source: Elhassan 2010

Figure 9-18 Earth Works (Levelling) and Sand Dunes at the Site Project

Source: Elhassan 2010

Approximately 95% of the RTIP site is vacant land. There are current construction preparation activities conducted by Saudi Aramco and RCJY contractors. A small proportion of the site is currently occupied by Saudi Aramco contractors as workshops, fabrication, and storage areas. The details of the Royal Commission Contractors observed at the site are as follows:

- Al-Harbi;
- Al Osais;
- Abdul Hadi and Al Moaibed Eng. Co.

Approximately 70% of the surface of the RTIP site has been changed through leveling, filling, geotechnical boreholes for checking soil capacity, deep excavations, and drilling. Heavy trucks and bulldozers are being used on the site (Figure 9-18). Cemented structures and deep trenches of drainage system are observable (Figure 9-19). A network of temporary roads dissects the site. Paved and unpaved routes extend along east west and north- south of the site. Pipelines and cement structures are scattered on the site surface.

A small proportion of the area has been used for dumping of demolition debris and /or construction wastes, such as asphalt, concrete wastes, building wastes, broken glass bottles, tyres, and plastic. Some storage tanks were recorded at the south east corner of the site.

Parts of the site are covered by small palm groves located close to water surfaces and ground water ponds on the southern and central parts of the site (Figure 9-24). These water sources are in use and many water tankers were observed at these locations taking water (possibly to project areas). The north western side of the site is occupied by a number of temporary camps of engineering companies.

Remnants of intact surfaces are located mainly on the south east of the site. They are covered by sand dunes and sparse to moderate growth of native vegetation.

On weekends, recreation activities such as riding dune motorcycles, and hunting were found to occur on the site around palm groves and temporary structures of local citizens in their vicinity.

Figure 9-19 A View of RTIP Site at Jubail II Showing the Cemented Drainage System and Earthworks
Source: Elhassan 2010

Road 274 runs by the southern side of the RTIP site. The site is also dissected by a network of internal land roads. Electricity towers surround the site from its south eastern and north eastern sides. Other areas of interest in the vicinity of the site are as follows:

- The sanitary BeeA'h landfills, located on the north eastern corner of the site (Figure 9-17).
- Electricity power station, located at the south eastern corner of the site.
- EDCO sanitary landfill located opposite BeeA'h sanitary landfill.
- Jubail prison, just four kilometres east of the site.
- Sanitary landfill operated by Twaiq Company (Figure 9-16) located 14 kilometres to north east.
- Farms of palm dates, lemon and acacia located two or three kilometres south east of the site (Figure 9-26).
- Workers temporary camps, south east of the site and close to the farms.

Figure 9-20 A View of the Site Showing Deep Excavated Area and Manmade Mounds

Source: Elhassan 2010

Figure 9-21 A View of Remnants of Intact Surface and Levelled Area

Source: Elhassan 2010

Figure 9-22 A View of the Site Showing Static Underground Water Surface

Source: Elhassan 2010

Figure 9-23 A View of the Site Showing a Further Static Underground Water in the Project Area

Source: Elhassan 2010

Figure 9-24 View of a Small Palm Grove in the RTIP, Jubail II

Source: Elhassan 2010

Figure 9-25 A View of Part of Intact Surface (Covered with Vegetation)
Source: Elhassan 2010

Figure 9-26 A View Inside the Farms Adjacent to the Project Area
Source: Elhassan 2010

10 ARCHAEOLOGY AND CULTURAL HERITAGE BASELINE

10.1 Introduction

An archaeology and cultural heritage baseline study was compiled in order to identify existing or potential archaeological resources and cultural heritage, at the RTIP Site that may be impacted by the project. Archaeological resources and cultural heritage are defined as:

- Archaeological resources refer to any material remains or physical evidence of past human life or activities, including the record of the effects of human activities on the environment (NPS, 2008);

- According to the UNESCO, the term cultural heritage has evolved with time to expand beyond monumental remains *"Recent decades have seen the concept of heritage – much like that of culture – undergoing a profound change. Having at one time referred exclusively to the monumental remains of cultures, heritage as a concept has gradually come to include new categories such as the intangible, ethnographic or industrial heritage" (*UNESCO, 2009*).*

In this section of the EIA Report, the potential cultural heritage and archaeological resources at RTIP site are assessed as a result of the baseline study.

The conservation of resources has been made possible in part by their identification through archaeological and historical site surveys conducted as part of environmental assessment processes and the integration of heritage values into the development process. Cultural heritage is sometimes incorporated into the development process and the programme supported by the United Nations Educational, Scientific and Cultural Organization (UNESCO).

The World Heritage List (UNESCO) seeks to encourage the identification, protection and preservation of cultural and natural heritage around the world, which is considered to be of outstanding value to humanity.

10.2 Methodology

10.2.1 Overview

The main goal of the baseline study, focused on the RTIP Site, is to identify the archaeological and cultural heritage areas that may be affected by the project and to locate and document all archaeological and cultural heritage resources that may exist in the study area.

In order to carry out the archaeological and cultural heritage study for the RTIP Site (a total area of 5.76 km^2), a combination of both a desktop study (literature search) and limited physical site "walk-over" survey was undertaken by Dr. Ahmed Abuelgasim El-Hassan, an Archaeologist and lecturer at Hail University, and a cultural heritage specialist.. The physical site survey was conducted for the project area, which also included a buffer area of 10 km around the RTIP site.

10.2.2 Desktop Study / Literature Search

Prior to the walk-over survey, the cultural heritage specialist carried out a literature review, which included publications and official websites of the study area. Dr. Abuelgasim El Hassan studied some recent historical and geographical sources which included studies conducted by the Saudi Directorate of Antiquities and Museums carried out in Jubail II at Jubail Industrial City and its vicinity. This desk study and literature research enabled the cultural heritage specialist to obtain preliminary data about archaeological/cultural resources of the Site and its adjacent areas. Eighteen archaeological sites of interest were identified during the literature review, 11 national and seven regional archaeological sites. However, no local archaeological sites of interest were identified within the project area.

The archaeology and cultural heritage baseline study included a desktop study followed by reconnaissance of the project area from 10 to 11 November 2010 to confirm the findings of the literature review. Due to the high disturbance and lack of evidence for the presence of archaeological and/or cultural artefacts during the site survey, no excavation work was conducted.

The desktop study was conducted to identify and review the available information sources which included:

- Collection and interpretation of relevant literature including that available on websites;
- Knowledge of the archaeology of the area from Dr. Ahmed Abuelgasim El-Hassan's experience and existing studies and reports; and
- Satellite imagery from Google Earth and Landsat 2000.

Gathered information was assessed to determine the potential presence of archaeological and cultural heritage resources in the RTIP Site and its vicinity. This was followed by a physical site survey.

10.2.3 Limited Reconnaissance

A physical "walk-over" site survey was conducted from 10 to 11 November 2010 for the proposed location of the RTIP site and a buffer area of 10 km around the site. Before the commencement of the survey, the satellite image of the RTIP Site their features, and immediate surroundings were analysed in order to plan the ground survey. The initial reconnaissance of the RTIP Site was carried out by car together with walking over some parts of the site using GPS (Garmin) to locate any possible visible cultural/archaeological resources.

The survey was carried out according to the satellite images and the literature review. The following methodology was used to conduct the initial site survey:

- Identify any obvious cultural or archaeological features, which may be present in the RTIP Site, and provide photographs where appropriate;
- Map the locations of these features using overlay diagrams on a map of the RTIP Site

- Report on findings;
- Comment on the likelihood of whether other features, not detected in the initial survey, may be present at the project area. The assessment is based on the specialist's knowledge of the archaeology of the RTIP Site and its vicinity, previous surveys carried out in the area, and published literature;
- Recommend whether further investigations are necessary, with justification.

Dr. Ahmed Abuelgasim El-Hassan followed the above methodology to survey potential archaeological and cultural sites and reduce reporting biases.

Additional limitations included:

- The research used to identify potential archaeological and cultural resources is supported by information publicly available in published literature and on the internet. Therefore, unknown or undiscovered archaeological and cultural artefacts are not included within this study;
- During the initial field survey, some areas were inaccessible for security reasons and others were covered by rubble, wastes from building materials and roads;
- Most of the study area and its vicinity have been altered by human activities and very little of the natural landscape remains.

10.3 Archaeology

10.3.1 National

The Kingdom of Saudi Arabia's (KSA) archaeological heritage is currently safeguarded by the Department of Museums and Antiquities, which has excavated, catalogued and preserved many pre-historic and historic sites. Important archaeological work is also carried out by the Department of Archaeology at King Saud University in Riyadh (WSP, 2005).

The KSA is rich in ancient inscriptions. They form a priceless resource for the study of the region's cultural and linguistic heritage. Throughout the country, inscriptions were etched, engraved, pecked, or even sometimes carved in bas-relief on stones or on the rock-faces of cliffs and hills (WSP, 2005).

The national and regional archaeological sites of Saudi Arabia identified as part of the literature search are described in the following section (Hadas, April 2008) and presented in Figure 10-1. It should be noted that Jawan Chamber Tomb and Tarut Island are considered both national and regional archaeological sites. Mada´in Saleh, found in Madinat in western Saudi Arabia, is the only national site shown on the map that is included on the UNESCO World Heritage List.

Figure 10-1 National and Regional Archaeological Sites

Source: UNESCO, 2010

- The Holy City of Makkah, which lies inland 73 kilometres east of Jiddah, is the place where the Prophet Muhammad was born and the city to which he returned after the migration to Madinah in 622 AD. The Holy City houses the Kaa'bah, in the corner of which is set the Black Stone which marks the starting point for the seven circum-ambulations of the Holy Mosque which every hajji must complete (The Circle for Publishing & Documentation, 2000);

- The ancient town of Qaryat is situated at about 700 km southwest of Riyadh. Its archaeological ruins are known as al-Fau, which were excavated and housed at the King Saud University Museum in Riyadh. Due to some text found during excavations, it is known that Qaryat was the capital of Kinda Kingdom from the 1st century BC to the 4th century AD. The town was an important trade post, as it was located in the junction of old caravan roads for spice and frankincense, so it became a very important point because it was the only way to pass from west to south of Arabia through the Tuwaiq mountains (The Circle for Publishing & Documentation, 2000);

- Al-Rajajil, also called the place of the "Erected Stones" is located in the province of Al-Jaouf, being the nearest town Sakaka and the nearest village: Al Jauf. These columns are believed to be primarily a religious site or second-class graves (Aud Al Malki, Accessed on November 2009). The standing stones are believed to be over 5,000 years old. The taller stones have Thamudic (early Arabian script used from 1500 BC to the 4th or 3rd century BC) inscriptions and are aligned to sunrise and sunset. Their presence makes the area of great interest for archaeologists (An Introduction to Archaeology of Saudi Arabia, 1975);

- Meda'in Saleh is located in the northwest of KSA. This Nabataean city has ancient remains, Al-Hijr, consisting of tombs spread out over 13.4 kilometres. The tombs of Al-Hijr are on the World Heritage List (UNESCO). Archaeological finds include pottery, glasswork, stone cisterns, cooking vessels and coins. In ancient times, the site was a famous trade route between South Arabia and Petra. After the Thamud (the original inhabitants), the Nabateans (which date between the 2nd century BC and the 2nd century AD) made of this place the southern capital to control Arabia. The city has a siq (main entrance), city walls, towers, water conduits and cisterns. It is also found magnificent tombs of Medain Saleh, which are carved in sandstone mountains located 22 km northeast of Al-'Ula (The Circle for Publishing & Documentation, 2000);

- Dumat-Al-Jandal (ancient In Assyrian) dates from 845 BC and was the old capital of Arab kingdoms. It was an ancient city located in the Al Jawf province that served as an important trading centre for caravans going toward Syrian markets. In Assyrian records dating from 845 BC, Adumatu (modern Dumat Al-Jandal) is mentioned as the capital of the Arab kingdoms. The original walls of the ancient town of Adumatu demonstrate that it was larger than the modern town of Dumat Al-Jandal (The Circle for Publishing & Documentation, 2000);

- Tayma is the most significant site in the north-eastern region of KSA. The ancient town is situated at about 264 km southeast of Tabuk, an old oasis containing a wide range of archaeological sites dating from the prehistoric to the Islamic period. Some ancient inscriptions were also found dated from the 6th century BC and other antiquities of the early Islamic period (The Circle for Publishing & Documentation, 2000);

- Excavations in Najran also known as al-Ukhdud, have revealed that this city was a well developed agricultural area but also an important trade point that flourished at the beginning of the first millennium BC, situated in the centre of many caravan routes. Many remains have been found here, such as a fortification with the exterior wall built of finely shaped stones containing watch holes or arrow slots, a few buildings inside, and the oldest mosque in Najran. Animal figures and inscriptions are depicted on rocks. Several graves, foundations of houses, and different types of artefacts, dating from Byzantine, Umayyad, Abbasid and later periods have also been discovered outside the fortified area (The Circle for Publishing & Documentation, 2000);

- Al Rabadhah is an early Islamic archaeological site, located some 200 kilometres north east of Al-Madinah Al-Munawarah. Archaeological excavations have been conducted by KSU (King Saud University), and as a result, it is known that Al-Rabadhah contains new information on the nature of certain elements of the Islamic civilization during the early phases of Islam (Al Rashid, 1980);

- The Jawan Chamber Tomb, on the Arabian Gulf coast, was excavated in 1952 by employees of an oil company. It contained a number of objects including gold, bronze, iron and ivory, dating from at least 2,000 years ago (The Circle for Publishing & Documentation, 2000);

- Gerrha (Al Jarha' in Arabic) was strategically situated on the trade routes passing north from what is now Oman and through Yabrin, dated from the 3rd century BC to 300 AD (The Circle for Publishing & Documentation, 2000);

- Tarut is a historic island, the second largest island in the Arabian Gulf. It was a trading city and port for more than 7000 years. The most famous discoveries related to pottery on the island date from 4500 BC and 3000 BC (The Circle for Publishing & Documentation, 2000).

10.3.2 Regional

The Jubail Industrial City II, an extension of the existing Jubail Industrial City, is located in the eastern province of the KSA along the Arabian Gulf coast. It is approximately 90 km north of Dammam. Historically, this area was a transit point for trading caravans and it was famous for pearl diving and fishing. Today, the area serves as an important industrial port to the Arabian Sea and is the main industrial centre for petrochemical products.

The earliest archaeological evidence of human settlement found in the Jubail area and in its vicinity dates back to the sixth millennium BC and is known as the Ubaid culture. This evidence was found at the site of al-Dawsariyya which lies south east of Jubail Industrial City. Similar types of sites have been discovered at many locations in the eastern province (Ayn Qanas, Abu Khamis, Ayn Alseeh, Tarut, etc). Indeed, over 40 sites of Ubaid culture were found in the eastern province. Ubaid sites are well known in southern Mesopotamia and the Arabian Gulf region. Figure 10-1 shows the regional sites around the Jubail Industrial City II.

At Tarut in Qatif area, many sites were found that date to the 4th millennium BC and belong to the Hafiat, Early Heally, Umm al-Nar, Dilmun and Medianite cultures. Bronze Age and late Iron Age sites were found at Tarut, Dhahran burial mounds and surface sites in the eastern province. Archaeological remains of early Arabian kingdoms were found in the eastern province sites in Tarut, south Dhahran tumuli tombs, Ayn Jawan, Thaj and some surface sites. From pre-Islamic times until 1521 AD, the entire region of the eastern province was mostly known as the Province of Bahrain. Under Ottoman rule, the inhabited areas of the eastern province had been known as Al-Ahsa. In 1914, it was conquered by the Saudis. Many historical sources refer to the eastern province as Hasa and Qatif because the most famous cities of Qatif and Al-Hasa were located in these provinces. Most other cities, notably Dammam, Khubar, Dhahran, Jubail and Ras Tanura, were built in the 20th century and did not exist before Saudi Arabia's oil production.

Seven notable regional archaeological sites discovered in the vicinity of Jubail Industrial City II area and the Eastern Province are described below, as shown in Figure 10-1. Regional sites are identified in Figure 10-1 with white and pink circles. Jawan Chamber Tomb and Tarut Island are considered both national and regional archaeological sites.

- The Ayn Jawan Chamber Tomb (Figure 10-2) is situated on the Arabian Gulf coast, close to Ras Tanura, and was found accidentally in 1943 by employees of an Aramco company. Findings include a number of objects, including gold, bronze, iron and ivory, dating back some 2,000 years;

Figure 10-2 Ayn Jawan Tomb

Source: Directorate of Antiquities and Museums, 2003

- Al-Dawsariyya lies south east of Jubail Industrial City and about one and half kilometres from the Gulf coast. It represents the largest Ubaid site ever known in the Arabian Peninsula. Its remains include Ubaid pottery, stone tools, bones of domesticated and undomesticated animals, shells and fish bones;

- Al-Defi site lies in Jubail Industrial city (27° 04 49° 34). It was located about 10 km from Abu Ali Island on the western side and Ras Al-Defi at the coast. The site´s location near the coast indicates that it was probably a sea-port. The archaeological excavations indicate that the site was flourishing during several historical periods. It was found to have cultural links with Haj, Al-Fau, south Dharan and Fialaka (Al-Hajeri, 1989).

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- Tarut Island is the second longest island in the Arabian Gulf and was a trading city and port for more than 7000 years. Discoveries on the island include remains dating from the Ubaid Neolithic period (6th millennium BC) to the late Islamic era; 17th to mid 18th century AD);

- South Dhahran burial mounds (Figure 10-3 and Figure 10-4 can be dated to three periods, the earliest of which go back to the third millennium BC. The second phase was dated to the beginning of the second millennium BC. The occupation of the site continued to the end of the 6th century AD. The phenomenon of stone structures exists in the whole of the Arabian Peninsula, as well as outside of it (Figure 10-5);

Figure 10-3 Dhahran Burial Tumulus

Source: Directorate of Antiquities and Museums, 2003

Figure 10-4 Ceramic Incense Burner from Dhahran Burials

Source: Directorate of Antiquities and Museums, 2003

Figure 10-5 Stone Structures and Stone Tumuli at Yabrin

Source: Directorate of Antiquities and Museums, 2003

- Jawatha is located in Al-Ahsa Governorate at a distance of 18 km towards the north-eastern corner of al-Hafuf city. It was known as city of Bani Adul Qays. It was found accidentally under the foundations of the walls of the upper Jawatha mosque which was built subsequently after the sands hid landmarks of the old mosque. Jawatha mosque has been dated to 629 A.D. to 886 AD;

- The site of Thaj lies to the far south-west of the port of the old city of al-Jubayl. This archaeological site is located at a sabkha[1] area), which reaches a total area of 4 km^2. An ancient route known as al-Kanhari used to pass by the site of Thaj ("*crown*" in Arabic). It begins at al-Jubail port, extends westwards to Darb al-Judi and crosses Eastern and Central Arabia. Thaj was a trading centre for staging caravans and supplying them with water and food. The site contains remains of an ancient city (Figure 10-6) surrounded by an outside wall, fortified with projecting turrets and buttresses. Preliminary studies carried out inside the city walls revealed five main residential phases that can be dated to the period between 500 BC and 300 AD.

Figure 10-6 Circular Stone Structure, Possibly Associated with a Tomb – Thaj

Source: Directorate of Antiquities and Museums, 2003

10.3.3 Local

As detailed in Section 3, Project Description, the RTIP Site consists of a main complex and port facility. The project site is approximately 5.76 km^2 and it is located 16 km southwest from the

[1] A supratidal environment of sedimentation formed under arid to semiarid conditions on restricted coastal plains just above normal high tide level, characterised of evaporate salts, tidal flood and Aeolian deposits (Glossary of Geology, 3rd ed, 1990)

centre of Jubail City. The site is surrounded by main asphalt roads to the north and east (shown in Figure 10-7), and new roads are under construction on the western edges of the site. The site is bordered by a sanitary landfill to the northeast, an electrical power station to the southeast and vacant areas with sand dunes overlying a limestone surface to the north, west and south.

The surface of the RTIP Site and surrounding areas are largely disturbed, which mainly occurred from preparation for the Jubail Industrial City II Project. A majority of the site´s natural landscape has been changed over a course of several years from earthwork activities, such as ploughing, levelling, backfilling, excavations for drainage systems, and soil testing (see Figure 10-8 and Figure 10-9). Past and current uses for the RTIP Site include waste areas (as shown in Figure 10-10) for building materials, such as gravel, earth, stones, cement, asphalt etc., and living quarters for some camps of workers on the northern western side of the site. A few areas of the project area are covered with low shrubs, sand dunes, small palm groves, and static underground water surfaces (shown in Figure 10-11, Figure 10-12, and Figure 10-13).

Figure 10-7 Asphalt Road within Project Area

Source: Elhassan, 2010

Figure 10-8 Disturbed Area from Previous Earthwork

Source: Elhassan, 2010

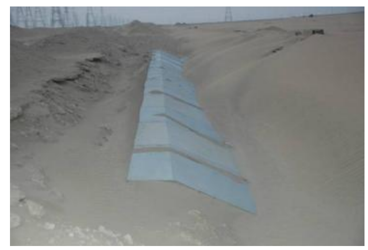

Figure 10-9 Previous Excavations for Cement Drainage System

Source: Source: Elhassan, 2010

Figure 10-10 Waste Area for Building Materials

Source: Elhassan, 2010

Figure 10-11 Shrub and Sand Dune Area
Source: Elhassan, 2010

Figure 10-12 Small Date Palm Grove
Source: Elhassan, 2010

Figure 10-13 Static Water Surface Area
Source: Elhassan, 2010

After a thorough inspection of the project area including disturbed and levelled areas for remnants of archaeological objects (including potsherds, glass, stone tools, animal and human bones), no archaeological artefacts were found. The extensive archaeological survey conducted in 1977 by the Saudi Directorate of Antiquities and Museums in this part of the Eastern Province also did not reveal any archaeological/cultural resources in the project area. Later fieldworks, conducted by the Deputy Directorate of Antiquities and Museums, in the vicinity of the project area were confined only to sites several kilometres away from the sea shore. This indicates that historically, the sea level was probably higher than it is today, and areas near the seashore, such as RTIP Site, were previously (approximately 4,000 – 7,000 years ago) underneath sea water.

10.4 Historical and Traditional Cultural Heritage

10.4.1 National

The cultural heritage of Saudi Arabia is largely influenced by Islamic heritage, the role of the country as a trade centre, and Bedouin traditions. Cultural heritage is sometimes incorporated into the development process, such in the historic buildings of "Old Jeddah." The protection of cultural heritages has been entrusted to the Department of Culture at the Ministry of Culture and Information.

Other institutions that promote culture include:

- King Fahd Library in Riyadh, which offers one of the largest collections of rare manuscripts on Arabic and Islamic literature, and is a premier research facility in the Middle East;
- National Museum in Riyadh, which is the largest museum in Saudi Arabia; and
- Saudi Arabian Society for Culture and Arts (responsible for protecting and developing the KSA´s culture).

The Department of Museums and Antiquities has the responsibility of safeguarding the Kingdom's cultural heritage. In 2003, the department was transferred from the Ministry of

Education to the Supreme Commission for Tourism (SCT). Moreover, several educational centres develop archaeological researches, such as the Department of Archaeology at King Saud University in Riyadh.

The KSA places emphasis on preserving its Islamic archaeological heritage. The Holy Mosque in Makkah is the holiest site of Islam, and the Prophet's Mosque in Madinah the second holiest city in Islam, as it is the burial place of Muhammad. In addition to Makkah and Madinah, there are a large number of mosques within the KSA, such as those built by the first caliphs after the death of the Prophet Muhammad, which have been subject to restoration.

The restoration of the old Qasr Al-Hokm area in Riyadh and old Dariya, is an example of the KSA's commitment to maintaining and preserving its cultural heritage for the benefit of its citizens. Similar restoration work of old quarters has been undertaken in Jeddah, Hail and other cities around the KSA.

10.4.2 Regional

Jubail Industrial City lies on the coast of the Arabian Gulf, which remains a major route for trade between Asia, Africa and Europe. Cultures flourished in this region from prehistoric periods to current times due to the availability of water, fertile lands and the strategic location of the Gulf area.

In addition to archaeological sites of different periods which tend to be located around water and other resources, there are many traditional heritage sites in the region such as:

- Al-Uqair port, 200 km south of Dammam. It contains an important archaeological site, remains of traditional architecture and relatively recent Saudi architectural buildings;

- Al-Ahsa region which includes: Qasr Ibrahim at al-Hafuf (Figure 10-14), Qasr Sahoud north of al-Hafuf, Qasr Khuzam (Figure 10-15), Qar al-Muhairis Geraidan citadel and Qasr al-Waziya ;

Figure 10-14 The Qasr Ibrahim Congregational Mosque

Source: Directorate of Antiquities and Museums, 2003

Figure 10-15 Great Towers of Qasr Khuzam

Source: Directorate of Antiquities and Museums, 2003

- King Abdulaziz palaces at Al Qita, and Um Aqla;
- Jabir citadel near Dammam;
- Tarut citadel (Figure 10-16) and, Qasr Dareen in Tarut Island (Figure 10-17).

Figure 10-16 The Western Façade of Tarut Citadel

Source: Directorate of Antiquities and Museums, 2003

Figure 10-17 Dareen Palace

Source: Directorate of Antiquities and Museums, 2003

10.4.3 Local

The potential cultural heritage resources desktop study and physical survey of the RTIP Site did not reveal the presence or likely presence of cultural resources at the project site or its surroundings. Therefore, it is unlikely that cultural resource features will be present at the project site and that future detailed investigations/surveys would identify additional cultural resources.

11 IMPACT ASSESSMENT CRITERIA

11.1. Introduction

This section provides the criteria for assessing the potential impacts resulting from the RTIP. Common criteria definitions are provided as well as impact assessment criteria for each study area, i.e., air quality and meteorology, onshore physical, biological resources, noise, waste management, marine environment, socio-economic aspects, and archaeological and cultural heritage.

11.2. Criteria Definition

Environmental impacts will be defined against a set of criteria. The criteria adopted in this EIA report are similar to those used in other EIA projects successfully delivered by CH2MHILL. The criteria have been however adjusted to reflect the current situation at the planned Project site, as well as the scope of the project, and client requirements.

These criteria used are also aligned with criteria integrated in other impact assessment methodologies established by European Directives (Directive 85/337/EEC as amended by 97/11/EC and 2003/35/EC on the assessment of the effects of certain public and private projects on the environment); and impact assessment guidelines developed by international organizations such as the Institute of Environmental Management and Assessment (IEMA) which promotes best practices standards in environmental management, auditing and assessment.

Figure 11-1 summarised the determination of the potential significance of the impacts assessed through the combination of the set of criteria considered. The criteria presented in Table 11-1 will consider the following factors:

- **Frequency**: Occurrence of activity producing the impact (e.g., continuous, frequent, infrequent or rare);
- **Likelihood**: Probability of impact occurrence (e.g., 100%, 50%, 0%);
- **Extent**: Spatial extent of the impact (e.g., local, provincial, regional, national, or international);
- **Duration**: Extent in time of the impact. Short term impact (less than life of project), medium term impacts (equal to the lifetime of the Project) and long term impacts (greater than the lifetime of the Project);
- **Magnitude**: Impact magnitude defined in relation to the limit criterion specified by the Owner (where this is based on regulatory criteria), the RCER, the Presidency of Meteorology and Environment (PME) or international standards, e.g.:

  1. Very low: Parameter <10 percentile of limit criterion;

2. Low: Parameter 10 to 50 percentile of limit criterion;
3. Medium: Parameter 50 to 100 percentile of limit criterion;
4. High: Parameter 100 to 200 percentile of limit criterion;
5. Very high: Parameter >200 percentile of limit criterion.

In the absence of definitive quantitative criteria, magnitude is defined by narrative descriptions relating to the impact type.

- **Type of impact*:*** Positive or negative effect; direct or indirect action.

- **Potential significance*:*** A combination of all the factors described in the preceding bullets is used to determine the type and significance of a potential impact prior to mitigation. Defined as low, medium or high separately for each resource/environment in subsequent sections.

- **Mitigation Measures:** As part of the impact assessment process, mitigation measures are suggested to minimise the potential significance of impacts identified. Two different types of measures have been distinguished, as follows:

  - *Mitigation Measures Type I.* Measures to be taken to manage potential impacts considered significant or highly significant. Following application of these measures, residual impacts are expected to be lower and therefore, acceptable. These measures, or alternative measures with similar effect on the impact, are crucial for the development of the project.

  - *Mitigation Measures Type II*. Recommended measures that could be taken to manage impacts classified as Insignificant, but that could be even lower following implementation of some additional measures. These measures can be considered as good management practices.

- **Residual Significance:** Following the application of mitigating measures, the assessment process is also applied to the residual impact to establish an overall impact significance following all feasible and cost-effective measures. Inferences of the residual impact level are as follows:

  - "Low" denotes a low-level impact that should be continuously improved whenever possible. No further mitigation required but commitment to good management practices is required;

  - "Medium" denotes a medium-level impact, tolerable risk. Check that the residual impact has been subject to all practicable feasible and cost-effective mitigation, including redesign of the project; and

  - "High" denotes a high-level impact, intolerable risk. Check that the residual impact has been subject to all possible feasible and cost-effective mitigation, including redesign of the project. If the impact remains high, then compensation or offset measures must be applied

11.3. Assessment Criteria

11.3.1. General

Table 11-1 presents the terminology used to describe and rank environmental and social impacts according to the categories defined above. This provides an understanding of the basis on which an impact is ranked as either beneficial, moderately adverse, strongly adverse, insignificant, etc. Figure 11-1 presents how these criteria are combined in order to assess the potential environmental and social impacts identified.

Table 11-1 Terminology Used to Describe Environmental and Social Impacts

CATEGORY	TERMINOLOGY	DEFINITION
Scope of Impact[(1)]		
Frequency	Continuous Frequent Infrequent Rare	Uninterrupted or on a daily basis Once or more per day Less than once per day Single event / less than once per year
Likelihood	Certain Likely Unlikely No impact	Impact possibility estimated to be 100% Impact possibility estimated as > 50% but < 99% Impact possibility estimated as > 0% but < 50% Zero estimated possibility of impact
Extent	Local Provincial Regional National International	Within 2 km of site boundary Within Jubail Industrial City [(3)] Outside Jubail Industrial City but < 100 km away Within KSA Outside KSA
Duration	Short Medium Long	< life of project life of project > life of project
Magnitude[(2)]	Very low Low Medium High Very high	Parameter < 10% limit criterion Parameter 10 to 50% limit criterion Parameter 50 – 100% limit criterion Parameter 100 – 200% limit criterion Parameter > 200% limit criterion
Type of Impact		
Effect	Positive Negative	Beneficial impact Detrimental impact
Action	Direct Indirect	Impact caused solely by activities within scope of project Impact caused by activities partly outside scope of project
Potential Significance		
Significance	Low Medium High	Any low or medium magnitude impact that is unlikely to occur or is of short duration. Any medium magnitude impact that is certain or likely to occur and of medium or long duration. Also, any high magnitude impact that is unlikely to occur, of short duration, or local in extent. Any high magnitude impact that is certain or likely to occur, of medium or long duration, and regional in extent.

(1) All terms are characteristics of the impact(s), except the Frequency which refers to the Activity as noted in page 11-1. For

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Table 11-1 Terminology Used to Describe Environmental and Social Impacts

CATEGORY	TERMINOLOGY	DEFINITION

example, duration refers to duration of impact, not the activity causing it.
(2) *Definition given is for resources in which numerical criteria are used to evaluate impacts.*
(3) *Including Jubail I and Jubail II as well as Jubail town*

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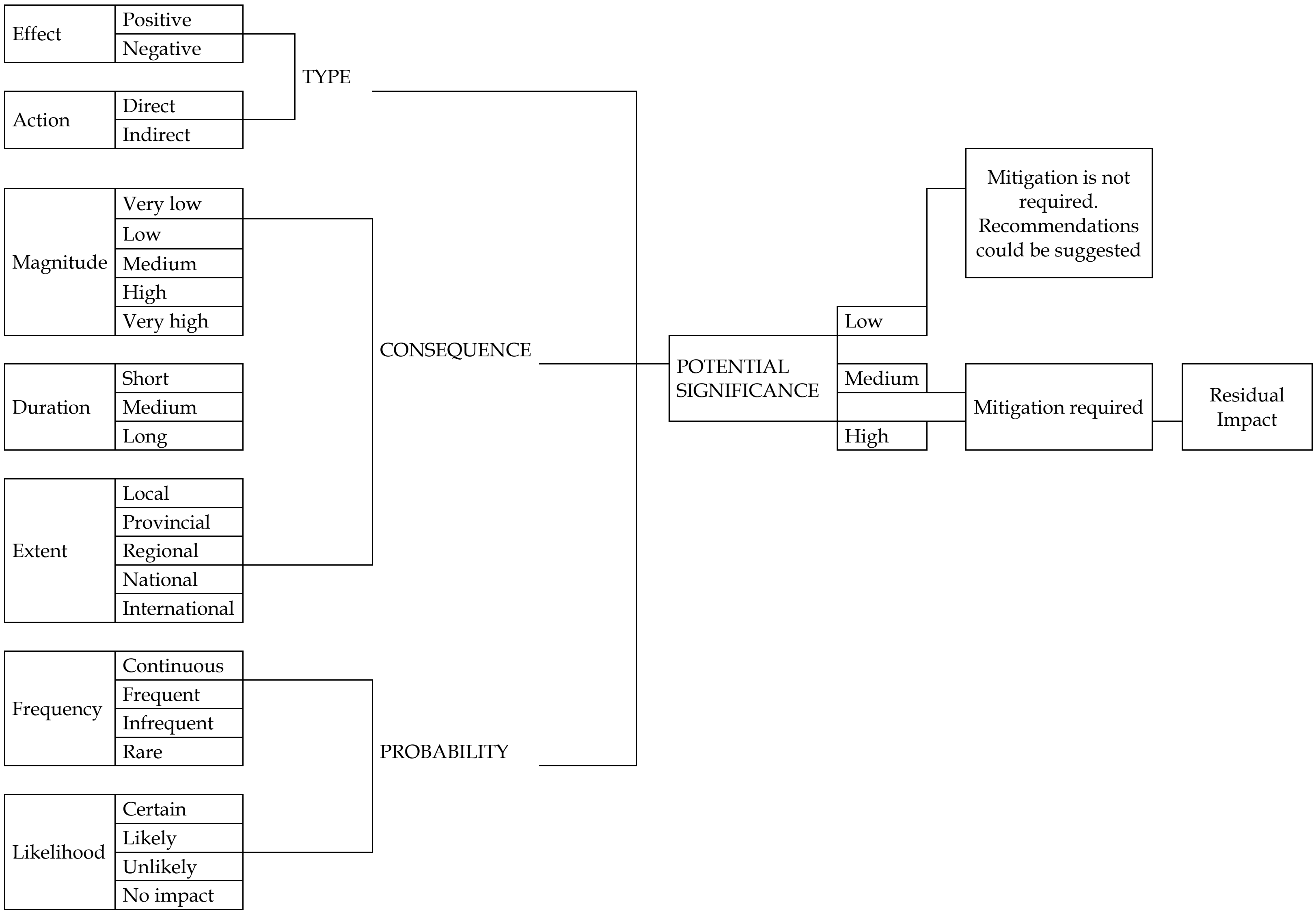
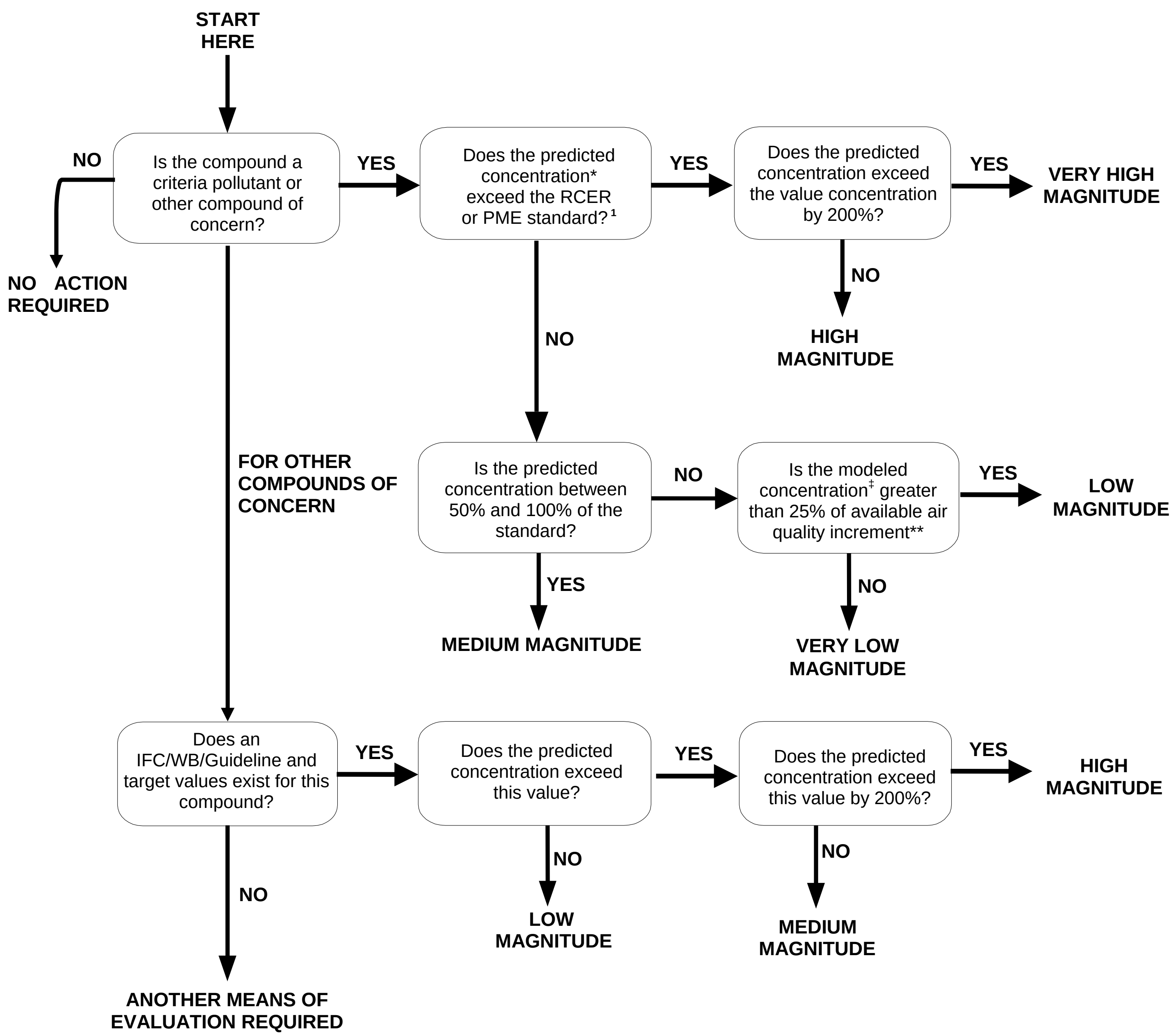


Figure 11-1 Summary of the Determination of Potential Significance

11.3.2. Air Quality & Meteorology

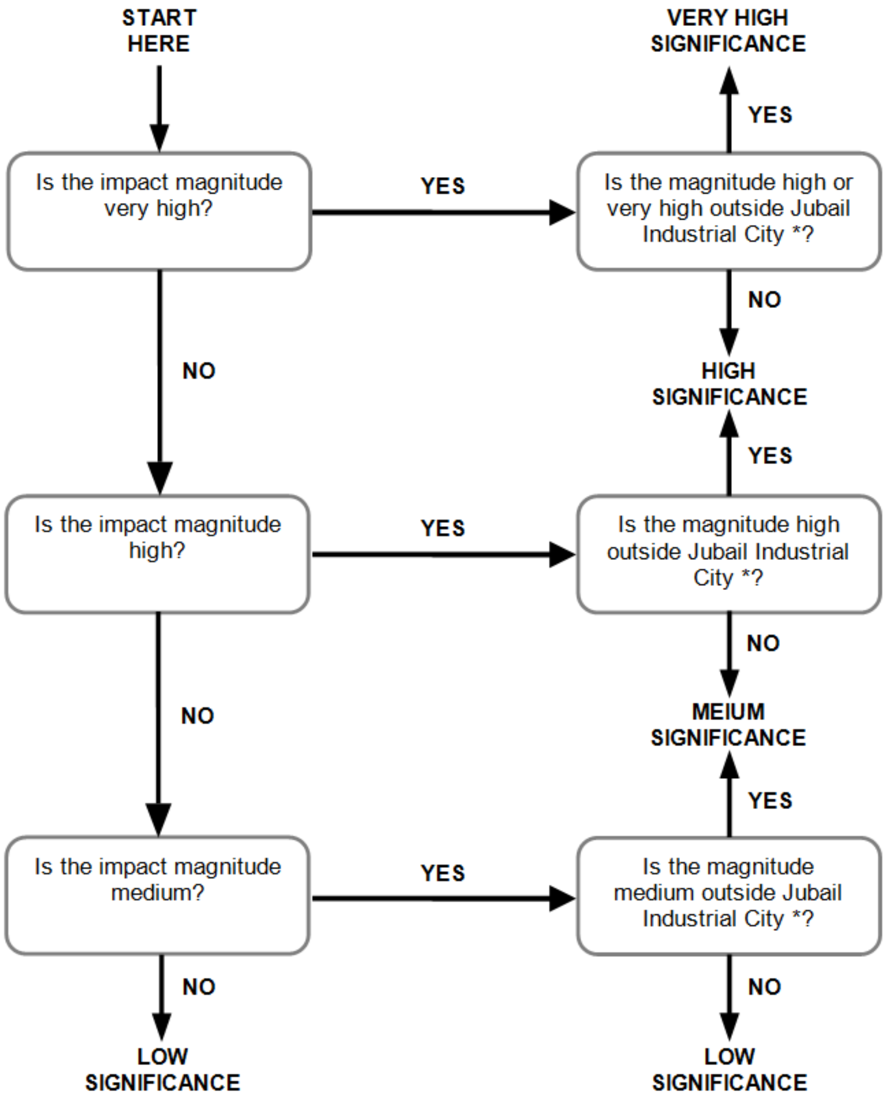
The criteria definitions of impacts on air quality and meteorology are presented in flow charts. A flow chart of the decision tree for impact magnitude assessment of emissions to air is presented in Figure 11-2 and a flow chart of the decision tree for significance assessment of emissions to air is presented in Figure 11-3.



* The predicted concentration is the sum of the baseline and the modelled concentration at the nearest AQMS location.
** Modeled concentration is the contribution from the facility emissions and does not include the baseline concentration.
‡ Available Air Quality Increment for each pollutant is defined as the difference between the baseline pollutant concentration and the ambient air quality standard for that pollutant.

Figure 11-2 Decision Tree for Impact Magnitude Assessment of Emissions to Air

[1] National standards have been used in the assessment of impact magnitude in accordance with World Bank Guidelines (International Finance Corporation (IFC), Environmental, Health, and Safety (EHS) Guidelines, General EHS Guidelines: Environmental, Air Emissions and Ambient Air Quality Sec 1.1, 30th April 2007)



* The predicted concentration is the sum of the baseline measured at the nearest monitoring station location and the modeled concentration outside the industrial area (conservative assessment).

Figure 11-3 Decision Tree for Significance Assessment of Emissions to Air

11.3.3. Onshore Physical Environment

The magnitude definition for onshore physical environmental impacts is shown in Table 11-2.

Table 11-2 Magnitude Definitions for Onshore Physical Environment Impacts

Component	Definition of Impact Magnitude		
	Low	**Medium**	**High**
Topography and drainage characteristics	Compaction of surface soils / emplacement of hardstanding over < 25% of site area.	Emplacement of hardstanding and/or managed drainage system over 50% of site area	Alteration of hydrological response of catchment.
Subsurface lithology	Addition of foundation materials / reworking / removal of soils altering the shallow geological succession. (Low to Medium)		Significant mining or exploitation of certain formations, e.g., quarrying activities.
Nutrient content of soils	Minor changes to individual nutrient levels not appreciably changing the total nutrient worth of the soil.	Alteration resulting in the need for soil additives to sustain agricultural viability of soils.	Total and irreversible decimation of soil value for agricultural purposes.
Hydrogeology	Minor alteration to groundwater table not resulting in measurable changes to groundwater flow direction.	Local diversion of groundwater and minor changes to hydrogeological properties only, e.g., due to subsurface structures.	Alteration of groundwater regime beneath site, e.g., change in direction of groundwater flow, introduction / removal of major preferential flow pathways.
Soil / water chemistry	Minor alteration of chemical make-up, slight increase in total contaminative potential.	Significant increase in concentration of toxic metals and hydrocarbons presenting a minor risk to water resources, marine organisms[1] or site users.	Major degradation of soil / water quality providing ongoing contamination source and / or resulting in unacceptable risk to water resources (including marine organisms[1]) and / or human health.

Notes:
1) Risk to marine organisms and marine water quality is by contaminant migration within groundwater beneath the site.

11.3.4. Biological Resources

Ecological impact assessment is concerned with evaluating the *net* effects on the integrity of an ecological receptor (such as a species, population, community or habitat). Table 11-3 shows the criteria used to define the type and magnitude of impacts on ecological receptors. These are based on currently accepted guidelines produced in the UK (IEEM, 2006).

There are three categories for negative (adverse) impacts and two for positive (beneficial) impacts.

Table 11-3 Ecological Impact Assessment Criteria for Magnitude & Type of Impact

Magnitude/type	**Criteria**
High	The change is likely to cause a permanent adverse effect on the integrity of an ecological receptor.
Medium	The change adversely affects the valued ecological receptor, but there will probably be no permanent effect on its integrity.
Low	Minimal or no effect.
Medium Positive	The change is likely to benefit the receptor in terms of its conservation status, but not so far as to achieve favourable conservation status.
High Positive	The change is likely to restore an ecological receptor to favourable conservation status, or to create a feature of recognisable value.

The term "favourable conservation status" used in the definition of positive impacts is derived from the European Community Habitats Directive but the concept can be usefully applied to ecological impact assessment.

A habitat can be said to have achieved favourable conservation status when:

- Its natural range and the area it covers within that range are stable or increasing;
- The specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue for the foreseeable future.

For a species, the conservation status is favourable when:

- The population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats;
- The natural range of the species is neither being reduced nor is likely to be reduced in the foreseeable future;
- There is, and will probably continue to be, a sufficiently large habitat to maintain its population on a long-term basis.

Criteria for determination of impact significance are set out in Table 11-4 and follow the usual approach of using geographical scope in order to assign levels of significance of effects. It should be noted that the geographical terms used here are similar to those used in the grading of impact extent (see Table 11-1), but the definitions are different and the two sets of terms

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should not be confused. "Regional" significance is defined here to relate to the wider Arabian Peninsula region (Kuwait, eastern Saudi Arabia, Bahrain, Qatar, United Arab Emirate (UAE) and northern Oman). It is important to consider Saudi Arabia in this wider context, particularly with respect to its characteristic types of vegetation and its bird population.

In addition to "low", "medium" and "high" categories used elsewhere in this EIA, a "very high" level of significance is also used, e.g., in the case of impacts having a significance outside national boundaries.

Table 11-4 Ecological Impact Assessment Criteria for Significance of Impact

Magnitude	Ecological Significance				
	International	**Regional (the Arabian Peninsula)**	**National (KSA)**	**Provincial (within 50 km radius)**	**Local (within RTIP)**
High	Very High	Very High	Very High to Medium	High to Medium	Medium to Low
Medium	High to Low	High to Low	High to Low	Medium to Low	Low
Low	Low (no impact)	Low (no impact)	Low (no impact)	Low (no impact)	Low (no impact)
Medium Positive	High to Low	High to Low	High to Low	Medium to Low	Low
High Positive	Very High	Very High	Very High to Medium	High to Medium	Medium to Low

The "ecological value" criteria used in this EIA report are provided in Table 11-5.

Table 11-5 Criteria for Valuing Ecological Receptors

Level of Value	Criteria (Examples)
Local	Areas of semi-natural vegetation or habitat considered to appreciably enrich the habitat resource within the context of the RTIP site and surrounding area. Sustainable populations of uncommon or declining species.
Provincial	Areas of habitat considered to enrich the habitat resource within 50 km of the site or within a defined geographic area of the country. Provincially designated or protected sites. Sustainable or strong populations of nationally scarce species (would be defined according to the size of the country and information available, e.g., species occurring in less than 5% of the land surface of the country).
National	Nationally designated or protected sites. Best examples of habitat within the country (e.g., the largest area of a particular habitat, a good example of a threatened or declining habitat). Strong populations of rare or nationally threatened species (e.g., a species occurring in less than 1% of the land surface of the country).
Regional (the Arabian Peninsula)	Sites or habitats internationally recognised but not necessarily designated or protected (e.g., Important Bird Areas). Strong populations of endemic or near-endemic species or subspecies to the Arabian Peninsula. Extensive areas of semi-natural vegetation or habitats characteristic of the Arabian Peninsula.

Table 11-5 Criteria for Valuing Ecological Receptors

Level of Value	Criteria (Examples)
International	Internationally designated sites or habitats. Nationally significant populations of globally threatened or endangered species (e.g., IUCN Vulnerable or Endangered Red Data Book species). Sites supporting >1% of a biogeographical population of a species or subspecies.
Not Valued (Negligible)	Species, population or habitat not meeting any of the above criteria.

11.3.5. Noise & Vibration

Table 11-6 and Table 11-7 present the definition of magnitude criteria for environmental noise impacts and the significance of noise impact assessment. Section 07 – Noise Baseline Conditions provides additional comments and background information on noise.

Table 11-6 Definition of Magnitude Criteria for Environmental Noise Impacts

Noise Level at Location of Receptor	Magnitude of Impact
Below or up to applicable noise limits	Low
1 to 5 dBA above applicable noise limits	Medium
> 5 dBA above the applicable noise limits	High

Table 11-7 Significance of Noise Impact Assessment

Frequency	Magnitude		
	Low	Medium	High
Continuous	Low	Medium	High
Frequent	Low	Low	Medium
Infrequent	Low	Low	Low
Once	Low	Low	Low

11.3.6. Waste Management

Table 11-8 presents the criteria used for defining magnitude of impact from hazardous wastes and Table 11-9 presents the criteria used for defining significance of waste impact. Section 8- Waste Management Baseline Conditions presents a listing of waste inventory used during the assessment.

Table 11-8 Criteria Used for Defining Magnitude of Waste Impact

CRITERIA	SCORE	DEFINITION
Quantity	1	<10 tonne/day (solid) or <100 m^3/d (liquid)
	2	10 to 100 tonne/day (solid) or 100 to 500 m^3/d (liquid)
	3	>100 tonne/day (solid) or >500 m^3/d (liquid)
Mobility	1	Immobile or possible to clean up quickly
	2	Can migrate if not cleaned up
	3	Very mobile
Persistence	1	Short term effect (if cleaned up)
	2	Medium term effect or long term intermittent
	3	Long term / continuous effect
Hazard	1	Non-hazardous material
	2	Hazardous material and contact is limited
	3	Hazardous material and contact is possible
Location	1	On site
	2	On site and environs
	3	Off site
Ranking *(based on sum total of score)*	11- 15	High
	8 – 11	Medium
	5 – 8	Low

Table 11-9 Criteria Used for Defining Significance of Waste Impact

CRITERIA	SCORE	DEFINITION
Likely contact with receptor	1	Little chance
	2	Indirect contact possible
	3	Direct introduction
Hazard	1	Unlikely to cause an impact
	2	Could cause an impact
	3	Likely to cause an impact
Liability	1	No liability to clean up
	2	Limited clean up / liability
	3	Receptor or source will need clean up
Ranking *(based on sum total of score)*	7 – 9	High
	5 – 7	Medium
	3 - 5	Low

11.3.7. Marine Environment

The magnitude definitions for marine sediment and water quality impacts is presented in Table 11-10 and the significance criteria for marine sediment and water quality impacts is presented in Table 11-1. Background information is provided in Section 6.4 – Marine Environment.

Table 11-10 Magnitude Definitions for Marine Sediment and Water Quality Impacts

Component	Definition of Impact Magnitude		
	Low	**Medium**	**High**
Sediments/ geology	Minor alterations in bottom topography, grain size distribution, mineralogy, and/or total organic carbon. No increase in metals or hydrocarbons.	Major alterations in bottom topography, grain size distribution, mineralogy, total organic carbon, metals and/or hydrocarbons. Metal and hydrocarbon concentrations may be elevated, but are not likely to affect marine organisms.	Major alterations in bottom topography, grain size distribution, mineralogy, total organic carbon, metals, and/or hydrocarbons. Elevated metal and hydrocarbon concentrations are likely to affect marine organisms.
Water quality	Minor alterations in one or more water quality parameters. No increase in concentrations of metals, hydrocarbons, or other toxic substances.	Major alterations in one or more water quality parameters. Concentrations of metals, hydrocarbons, or other toxic substances may be elevated, but are not likely to affect marine organisms. Temporary loss of amenity	Major alterations in water quality parameters. Elevated concentrations of metals, hydrocarbons, or other toxic substances are likely to affect marine organisms. Longer term loss of amenity
Flora/Fauna	No presence of biotopes in the area and therefore minimal or no effect on fauna/flora could occur. Minor or no effect on the normal behaviour of the marine organisms.	Major alteration in small areas of seagrass and macroalgal beds. Major alteration on large areas of benthic communities with high recovery rate and high resilience to perturbation. Negative alteration on the normal behaviour of marine organisms but minor effect on those organisms of high conservation values.	Major alteration on areas with large expanse of seagrass and macroalgal beds. Major alteration in areas with presence of corals that are considered as possible spawning and nursery grounds for some of the commercially important species. Negative alteration on the normal behaviour of marine organisms that have high conservation values (sea turtles, cetaceans, dugongs, etc.).

11.3.8. Socio Aspects

The magnitude definitions for socio-economic and cultural aspects are outlined in Table 11-11.

Table 11-11 Definitions of Impact Magnitude for Socio-Economic Factors

Category		Definition
Negative	High	• Major impact on livelihood of individuals (loss of livelihood resources) • Considerable impact on access to community facilities/utilities (resettlement of households) • Considerable consequence on the economy (no employment opportunities or use of local supplies/services. Local or regional economic recession. • Major impact on human wellbeing (e.g., serious injury, fatality, etc.) or to indigenous people. Diseases with potential to cause multiple fatalities; highly infectious diseases like HIV/AIDS, exposure of large populations to toxins at acute levels or known human carcinogens. • Permanent total disability or isolated fatalities resulting from diseases capable of irreversible damage with serious disability, road traffic accidents, and severe psychological stress leading to suicide.
	Medium	• Moderate impacts on livelihood (restriction of access to livelihood resources) • Medium impact on access to community facilities & utilities (restricted access) • Moderate impact on the economy (moderate use of local supplies/services) • Medium impact on human well being (injury to individual, noise, odour, dust) or to indigenous people. • Diseases capable of irreversible health damage, partial disability without loss of life. • Adverse health effects that need prolonged continuous or intermittent medical attention.
	Low	• Limited impact on human health & wellbeing (occasional dust, noise/vibration disturbance) and indigenous people • Some impact on livelihood (some tension between local & non-local workforce, limited restriction to livelihood resources) • Some impact on access to community facilities & utilities (restricted access for a limited duration) • Some impact on the economy • Short-term nuisances. • Minor illness with full recovery in a few days that do not lead to chronic diseases.
	Very Low	• Very limited impact to human health & wellbeing (possible nuisance due to occasional odours) • Very limited disruption caused to livelihood (no noticeable impact on access to livelihood resources) • Limited impact in accessing community facilities & utilities (possible inconvenience, electricity supply disruption) • Negligible impact on wider economy at a local, regional and national level
Positive	Low	• Some improvement to human health & wellbeing and/or indigenous people. • Benefit to livelihood (some employment opportunities) • Limited improvements to infrastructure, access to community facilities & utilities • Some impact to the economy (limited use of local supplies & services)
	Medium	• Moderate Improvement to human health & wellbeing and/or indigenous people. • Medium benefit to livelihood (moderate employment opportunities) • Improvements to infrastructure, access to community facilities & utilities • Medium impact to the economy (some use of local supplies & services)
	High	• Major improvement to human health & wellbeing and/or to indigenous people. • Major benefit to livelihood (large scale employment opportunities) • Large scale improvements to infrastructure, access to community facilities & utilities • Major impact to the economy (extensive use of local supplies & services)

It should be noted that the geographical terms used for assessing the extent of socioeconomic impacts are different in number and definition to those used in the grading of impact extent (see Table 11-1) as noted below.

Local: Within 20 km from the RTIP site to include JIC and Jubail
Regional: Farther than 20km from the site boundary, within the Eastern Province
National: Within KSA
International: Outside KSA

If indigenous groups are identified as part of this social impact assessment, further criteria to define the geographic area of potential impact will be defined and tailored to the characteristics of the group.

11.3.9. Archaeological and Cultural Heritage Aspects

The magnitude definitions for archaeological and cultural aspects are outlined in Table 11-12.

Table 11-12 Definitions of Impact Magnitude for Archaeological and Cultural Factors

Category	Definition
High	• Loss or degradation of any archaeological wealth existing on site (ground clearance damaging any existing subsurface artefacts) • Erosion of tradition & cultural values, severe restriction in access of cultural/historical sites
Medium	• Some degradation of any archaeological wealth existing on site • Moderate impact on tradition & cultural values (restriction in access to sites of cultural/historical significance)
Low	• Limited impact on any archaeological wealth existing on site • Some impact on tradition & cultural values (access of cultural/historical sites restricted to limited extent).
Positive	• Intact artefacts exhumed during site development, documented and preserved • Improvements & protection of cultural sites and access to same

12 AIR QUALITY & METEOROLOGY IMPACT ASSESSMENT

12.1 Introduction

This section describes the methodology, impacts and associated measures proposed to mitigate potential offsite impacts on ambient air quality during construction, commissioning, operation, upset and emergency conditions and decommissioning of the RTIP. Secondary impacts such as photochemical reactions with ozone formation are also considered and assessed, from a qualitative perspective. Catastrophic events, such as plant fires, are not considered in the air impact assessment as these tend to be temporary in nature and associated impacts on ambient air quality are therefore generally short-term. Such events are usually assessed as part of the hazard assessment for the complex. A description of both the impact assessment methodology including detailed project emissions and results are presented in [redacted]

The RTIP complex will be located in Jubail Industrial City, a designated industrial area with the nearest residential receptors being located at 1.5 km from the site boundary in the construction camps and farms south from the site.

Ambient air concentrations have been predicted based on anticipated emissions from the RTIP complex by means of air dispersion modelling applying the AERMOD programme developed by the U.S. EPA. This Gaussian dispersion model is a successor to ISCST3 and incorporates the latest understanding of the atmospheric boundary and the influence that this has on plume dispersion, providing refined concentration estimates over a wide range of meteorological conditions and modelling scenarios. AERMOD includes two data pre-processors for streamlining data input. AERMET, a meteorological pre-processor, computes boundary and other necessary parameters for use with AERMOD and accepts data from both on-site and off-site sources. The AERMOD model has been developed and validated by the U.S. EPA for regulatory use and has been widely adopted internationally.

The model estimates the maximum ground level concentrations, averaged over time periods specified by the user. AERMOD includes a continuous treatment for characterizing dispersion based on similarity theory, as compared to ISCST3's use of discrete stability classes. The Monin-Obukhov length (L) is used as the stability parameter, and is computed by the AERMET meteorological pre-processor. For each hour of meteorological data, the model estimates the ground level concentration value for every source and receptor combination.

Receptor grids plus discrete receptors at the nearest residential areas and the locations of the ambient air monitoring stations were modelled to determine the ground level air concentrations resulting from the RTIP complex emissions to air. At this stage of the project no emissions data relating to existing and proposed facilities at Jubail Industrial City are available, therefore no cumulative modelling has been performed.

Generally, when short-term exposure leads to adverse effects, short-term averaging times are recommended. In other cases, exposure-response knowledge is sufficient to recommend a long-term arithmetic mean. This frequently occurs for contaminants which accumulate in the body. A similar situation occurs for effects on vegetation and certain guidelines are set to protect vegetation as well as human health. It is generally assumed that human health protection will also protect wildlife. The establishment of a short-term arithmetic mean based criteria for a particular contaminant does not preclude the establishment of a long-term criteria in addition, and vice versa.

Details of the dispersion modelling methodology adopted and results obtained are included in [redacted]

The methodology for assessment of magnitude and significance of impacts is presented in Section 11 Impact Assessment Criteria. The assessment of impacts is summarised and tabulated in Section 20 Summary of Impacts (Table 20-1), the magnitude and significance of each impact are also summarised below at the end of each subsection (***in bold italic***). Next to each magnitude/significance statement and for ease of reference, each issue is identified by a unique number which is repeated in Table 20-1 and subsequently in Tables 21-1 (Mitigation Table) and 22-1 (Monitoring Table), where applicable.

The general approach for the definition and implementation of mitigation measures follows the General EHS Guidelines (World Bank 2007a). Projects with significant point and fugitive sources of air emissions, and potential for significant impacts to ambient air quality, should prevent or minimize impacts by ensuring that:

- Emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, the current WHO Air Quality Guidelines, or other internationally recognized sources in the absence of nationally legislated standards;

- Emissions do not represent a significant portion of the relevant ambient guidelines or standards. The EHS Guidelines suggests 25 percent of the applicable air quality standards (or 25% of the available increment for non-degraded airsheds) to allow additional, future sustainable development in the same airshed.

12.2 Project Emissions

The U.S. EPA AERMOD dispersion model was applied to point sources emissions for criteria pollutants, area sources for fugitives and to selected point sources for other compounds with health impact and odour annoyance. The model was run in U.S. EPA regulatory default mode.

Receptor spacing was chosen according to guidance from the TCEQ (1999). Receptors were located along the RTIP complex boundary and out to 50 km from the site (fine grid close to the site and coarser grid with increasing distance).

Additional discrete receptors were located at the nearest residential locations and sensitive areas and the location of the AQMS #6. A list of the receptors and coordinates is included in [redacted]

The U.S. EPA recommends (US Code of Federal Register 40 CFR Part 51, 15 April 2003) that as a minimum, one year of onsite meteorological data or five years of representative preferably consecutive years from the most recent, readily available period of meteorological data from the nearest National Weather Service (NWS), or equivalent, station should be used to make modelling predictions. It is stated that site-specific data, if one year or more is available, is preferred. Due to the fact that no site specific data which contains all the necessary parameters was available, meteorological files over 5 years using AQMS# 6 as the on-site meteorological station and Dammam International Airport station as a regional off-site station have been prepared.

The predicted ground level concentrations are those resulting from the RTIP complex emissions. Following IFC/WB guidelines (World Bank, 2007a), the project has committed to generate emissions that do not contribute a significant portion to the attainment of the RCER ambient air quality standards for criteria pollutants, to allow for additional, future sustainable development in the same airshed. A general rule, IFC Guidelines suggests twenty five (25) percent of the applicable air quality standards (or 25% of the available increment for non-degraded airsheds) to allow future development; RTIP used that as an objective as far as practicable.

Therefore, in order to determine the impact of the complex on current ambient air quality, the predicted values from the modelling are compared to 25 percent of the available ambient air quality increment calculated as the difference between the baseline values as included in the Ambient Air Quality Baseline Section 4 and the corresponding RCER ambient air quality standard, for the criteria pollutants; and to the existing regulatory criteria, namely those specified by RCER or other regulatory agencies as described in the sections below, for the other compounds.

Results of the dispersion model runs are then compared to the regulatory criteria, namely those specified by RCER and others as described in [redacted]

12.3 Construction

12.3.1 Dust Emissions

Heavy construction is a source of dust emissions that may have substantial temporary impact on local air quality.

The construction of the RTIP complex will involve site preparation activities, which include the following: clearing and grubbing; demolition of existing structures (ditches, unfinished culverts and duct backs); backfilling & compaction; removal of surplus soil; and construction of off-plot and on-plot access roads, fencing and gates. It is expected that during this operations, the movement of large amounts of overburden material will take place, which will inevitably generate dust, particularly in a dry environment such as that of KSA.

High elevation material in the South-West corner of the site shall be used as fill across the site in order to avoid import from other sources. This prospective borrow pit on the south west quadrant of the site is approx 8m higher than the current site elevation.

The total cut volume of soil of the whole site is expected to be 4.7MM m^3, out of which 1.7MM m^3 will be used for backfilling and compaction. The surplus of 3MM m^3 of soil will be disposed at an authorized disposal site within the JIC located approximately 30 km from the site.

Once foundations and surface structures have been completed, fugitive dust impacts will be associated with the operation of vehicles over unpaved areas of the site and unpaved roads. Approximately 200 trucks on average will be in operation during the site preparation activities and they will be operating 12 hours a day, 6 days a week, for 10 months.

Construction planning has not progressed to the point that activity levels at the site could be determined; therefore a screening level analysis was conducted using AERSCREEN. The modelling results have been included i[redacted]

Baseline concentrations for particulate matter indicate that PM_{10} concentrations currently exceed the RCJY standards. $PM_{2.5}$, which is a better indicator for anthropogenic suspended particles, also currently exceeds the RCJY standards. Moreover, the particulate concentrations will inevitably be influenced by natural windblown dust.

During the construction phase, dust emissions from set-up and other construction activities will result in predicted concentrations below the RCJY standards. However, the impact of construction activities on dust levels, considering the high background concentrations in a desert environment, which cannot be mitigated by the RTIP project, is likely to be high in magnitude and significant on or near the plant property boundary,. Dust impacts outside the RTIP site are below the RCJY standard as expressed as PM_{10} but exceed the standard when added to the already high background concentrations.

Air Impact from Dust Emissions (refer to Issue A1) –High Magnitude, High Significance close to RTIP but construction would add little to existing dust levels outside plant property boundary.

In view of the existing high levels of dust, dust control measures will need to be implemented during construction as a mitigation measure as recommended in the General EHS Guidelines (World Bank, 2007a). These measures would include the use of covers, water suppression for control of loose material or unpaved road surfaces, or increased moisture content for open material storage piles. It is recommended that each of the EPC Contractors should develop and submit for RTIP approval, a dust control plan to minimize dust emissions during site development.

The EPC contractor will also develop an Air Quality Management Plan and Emissions Monitoring/Testing Plan during construction phase.

Additionally, RTIP construction site impacts are not expected to be unusual in comparison to most construction sites in the KSA. Construction sites that use good dust suppression techniques and well-maintained vehicles typically do not cause violations of air quality criteria off-site.

12.3.2 Exhaust Emissions

Gaseous emissions will arise from vehicle exhausts during site construction and from vehicles transporting materials. Emissions from these vehicles will include oxides of nitrogen, carbon monoxide, particulates and hydrocarbons.

Approximately 200 trucks on average will be in operation during the site preparation activities for 10 months. Other equipment anticipated to be used during this phase is included in Table 3-2 of the project description section 3-9.

On top of that and according to the RTIP Traffic Study Construction Report (KBR, 2010), 2,002 bus movements are expected daily during the period of peak workforce, to transport workers from the camps to the main site. In addition, there will be 1,200 owner personnel being transported to and from the EPC and OWNER/ PMT offices area, accounting for 80 bus movements; and 2,000 construction workers being transported to the KFIP, or 76 daily bus movements to and from the KFIP.

Combustion emissions from vehicles have been considered to be minor in relation to the emissions from existing combustion sources in the Industrial City and those emissions that will be produced during operation of the RTIP complex. Moreover, combustion emissions from vehicles will be released close to ground level (i.e. close to the breathing zone of receptors) but generally in open areas where rapid dispersion and dilution will occur. Such emissions are limited to the duration of the construction phase.

The magnitude of exhaust emissions associated with construction activity is likely to be low outside Jubail II and JIC, with the maximum concentrations occurring on or near the site boundary. Moreover, baseline concentrations for nitrogen dioxide and carbon monoxide are well below the RCJY ambient air quality standards, whilst particulate matter, both PM_{10} and $PM_{2.5}$, standards are exceeded. Consequently, the assessment of the magnitude will largely be dependent on the latter parameter.

Therefore, close to the construction site or the roads used by the project to transport materials and personnel, without mitigation, the impacts would be of medium to high magnitude and medium to high significance (according to the pollutant). Modern, well-maintained, vehicles should be used as a mitigation measure, as well as the implementation of the manufacturer recommended engine maintenance programs as stated in the General EHS Guidelines (World Bank, 2007a). These measures would reduce impacts to medium magnitude and significance close to RTIP complex and inside the industrial city next to the roads used by the project, and low magnitude and significance outside JIC.

Air Impact from Exhaust Emissions (refer to Issue A2) –High Magnitude, High Significance close to RTIP complex and inside the industrial city; Low Magnitude and Low Significance (outside Jubail Industrial City).

12.4 Commissioning and Operation

This section presents the emissions sources at the RTIP complex, the measures already designed to limit emissions, if available and the potential air quality impacts during commissioning and operation.

12.4.1 Emission Sources

The principal functional units that have associated air emissions to be considered in this impact assessment are:

- Unit 103 Mixed Feed Cracker Unit;
- Units 140 and 145 - Aromatics Pygas Hydrogenation and Extraction Units;
- Unit 209 – Chemicals I Envelope Shared Systems;
- Unit 210 – Chlor-Alkali Unit;
- Unit 250/ 255 - Ethanolamines and Ethyleneamines Units;
- Unit 265 - Butyl Glycol Ethers Unit;
- Unit 270 - Ethylene Oxide Unit;
- Unit 299 - Ethylene Oxide and Derivatives Envelope Shared Systems;
- Unit 305 – Nitric Acid Unit;
- Unit 309 – Chemicals II Envelope Shared Systems;
- Unit 310 – DNT/SAC Unit;
- Unit 320 – Toluene Diisocyanate Unit;
- Unit 325 – Mononitrobenzene Unit;
- Unit 330 – Aniline Unit;
- Unit 340 - Polymeric Methylene Diphenyl Di-isocyanate Unit;
- Unit 345 – Formalin Unit
- Unit 350 – Third Party Hydrogen Peroxide;
- Unit 395 - Propylene Oxide Shared Systems;
- Units 455, 460 and 470 – Solution Polyethylene and Elastomers Units;
- Unit 465 – High Pressure Low Density Polyethylene Unit ;
- Unit 530 - Steam Generation;
- Unit 779 - Thermal Treatment;
- Site Development and Logistics Units (Tanks Farms); and
- Third Party Industrial Gases Units

The stack parameters, tanks and area sources in each of these units and the pollutant emissions rates used in the modelling analysis are presented in [redacted]

12.4.2 Point Sources and Fugitives for Criteria Pollutants

This section summarizes the potential air quality impacts at the point of maximum concentration off-site of the RTIP complex but within 50 km and at discrete off-site receptor locations (See [redacted]. Modelled concentrations were negligible at 50 km, therefore no far-field modelling beyond 50 km was considered necessary.

Point sources and fugitives emissions, when applicable, emanating from the RTIP complex have been modelled for five criteria parameters: SO_2, NOx, CO, PM_{10}, and $PM_{2.5}$ under two operating scenarios. More detail on the selection of these scenarios is included in [redacted] Two operating scenarios were selected for the main modelling study based on the different emission rates considered for short term averaging periods (1-hr, 8-hr and 24-hr) and long term averaging period (annual) of the modelled pollutants. A description of the scenarios for each parameter is included in the subsequent sections.

The modelling results for the 5 criteria pollutants are included in Table 12-1. The predicted impacts are discussed on a pollutant-specific basis.

Table 12-1 Maximum Modelled Ground Level Concentrations for RTIP from 2005 to 2009

Parameter (µg/m³)	**Average Time**	**Baseline**	**Available Increment (µg/m³)**	**25% of Available Increment**	**RTIP Modelled * (µg/m³)**	**Ambient Air Quality Standards**	
						National RCJY	**WHO**
NO_2	1-hour	212	448	112	120	660 (1)	200
	Annual	28.1	71.9	18	5.67	100	40
SO_2	1-hour	44.3	686	171	161	730 (1)	--
	24-hour	30.2	335	83.7	44.6	365 (5)	125(2) 50(3) 20(4)
	Annual	8.75	71.3	17.8	5.80	80	--
CO	1-hour	3,450	36,550	9,138	402	40,000 (1)	--
	8-hour	1,140	8,860	2,215	146	10,000 (1)	--
PM_{10}	24-hour	4,077	0	0	22.7	150	150 (2) 100 (3) 75 (6) 50 (4)
	Annual	305	0	0	2.55	50	70 (2) 50(3) 30 (6) 20 (4)

Table 12-1 Maximum Modelled Ground Level Concentrations for RTIP from 2005 to 2009

Parameter ($\mu g/m^3$)	Average Time	Baseline	Available Increment ($\mu g/m^3$)	25% of Available Increment	RTIP Modelled * ($\mu g/m^3$)	Ambient Air Quality Standards	
						National RCJY	WHO
$PM_{2.5}$	24-hour	950	0	0	8.05	35	75 (2) 50(3) 37.5 (6) 25 (4)
	Annual	180	0	0	0.96	15	35 (2) 25(3) 15 (6) 10 (4)

Notes:
(1) Not to be exceeded more than twice in 30 days
(2) Interim target-1
(3) Interim target-2
(4) Guideline value
(5) Not to be exceeded more than once per year
(6) Interim target-3
(7) Shaded cells represent that the modelled concentrations exceed the 25% of the available increment
Abbreviations:
RCJY = Royal Commission for Jubail and Yanbu
WHO = World Health Organization
-- = Not determined
$\mu g/m^3$ = Microgram per cubic metre

Nitrogen Dioxide

Modelling Scenario Annual Average Emissions

To estimate RTIP complex emissions during the normal operating scenario, the sum of the average annual NOx emissions from all the NOx emission sources during normal operations of the RTIP complex were calculated. This represents the total average annual NOx emissions from the RTIP complex. This modelling scenario considers all NOx emissions sources within the RTIP complex to be operating at their design capacities, except the Mixed Feed Cracker Unit furnaces and the Steam Generating Boilers. The operations for the cracking (or pyrolysis) furnaces in the Mixed Feed Cracker (MFC) Unit (Unit 103) and the steam boilers in the Steam Generation Unit (Unit 530) for this scenario are described below.

In the MFC Unit (Unit 103), there are seven identical gas feed furnaces and five identical liquid feed furnaces. During normal plant operations, six gas feed furnaces and four liquid feed furnaces operate at 80% of their design capacities. One of the gas and liquid feed furnaces will be operating in the hot standby mode at 30% of their design capacities. All the furnaces use hydrogen-rich fuel gas as the fuel, which is a mixture of natural gas and hydrogen.

There are six identical steam boilers installed in pairs in the Steam Generation Unit (Unit 530). Each pair of steam boilers has a common flue gas treatment section, which includes a Selective Catalytic Reduction (SCR) unit for NOx emissions reduction; Flue Gas Desulfurization (FGD) Unit to remove SOx as well as particulate matter; and followed by an elevated Stack for releasing the treated flue gas to atmosphere. There will be three stacks, each servicing two boilers. During normal plant operations five boilers operate at 80% of their design capacities. For fuel, the boilers utilize 380cSt heavy fuel oil (HFO) with a sulphur content of 3.8 wt%. The boilers may also burn Py-Oil generated in the MFC Unit that does not contain sulphur, along with the HFO.

Modelling Scenario for Hourly Maximum Emissions

The maximum hourly NOx emissions from the RTIP complex have been calculated based on the ten furnaces in the MFC Unit, i.e. six gas feed furnaces and four liquid feed furnaces, operating at their design capacities. The other MFC furnaces, one gas feed and one liquid feed will be operating in the hot standby mode at 30% of the design capacity.

Five steam boilers will be operating at 110% of their design capacity and the other NOx emission sources will be operating at their design capacities.

The modelling results for both annual and hourly emissions are included in Table 12-1; a complete set of modelling results including concentrations at the selected discrete receptors is included in [redacted]

The modelling results for the maximum hourly emissions indicate that ground level concentrations of NO_2 are below the RCJY ambient air quality standard and below 50% of the standard when added to the baseline. The modelled concentration marginally exceeds the suggested IFC guideline of 25% of the available increment near the RTIP complex boundary, leading to a low magnitude impact. Outside the site boundary, the modelled concentrations when summed to the baseline are below 50% of the standard, and furthermore, the modelled concentration is below the 25% of the available increment, therefore the magnitude of the impact would be very low. The modelling results for average annual emissions do not exceed the RCJY ambient air quality standards for annual averaging periods, and they do not exceed 25% of the available air quality increment. Therefore, the overall magnitude of the impact has been considered low close to the RTIP site and very low outside the Jubail Industrial City II (Jubail II), as well as the impact significance.

Air Impact from NO_x Emissions (refer to Issue A3) – Low Magnitude; Low Significance close to RTIP complex; Very Low Magnitude and Low Significance outside Jubail II.

Use of Low NOx burners (LNBs) for steam boilers and mixed feed cracking unit ethylene furnaces, to minimize the NOx formation via means of enhanced combustion designs such as combustion temperature reduction and reducing oxygen concentration to minimize thermal NOx formation, or Selective Catalytic Reduction (SCR) for steam boilers, thermal treatment units, and Nitric Acid Unit to reduce NOx emissions that have been formed during the combustion process, are already included in the design of the RTIP complex.

Other measures such as the application of Ultra Low NOx burners (ULNBs) were considered but they were not considered economic and technically feasible for the project.

Sulphur Dioxide

Modelling Scenario for Hourly Maximum Emissions

The largest source of SO_2 emissions from the RTIP complex is the Steam Boilers (>90% of the total SO_2 emissions from the RTIP complex) as they burn heavy fuel oil with typical sulphur content of 3.8wt% and a maximum of 4.5wt%. The maximum hourly SO_2 emissions from the RTIP complex is expected to occur when the boilers are operating at their full capacities firing heavy fuel oil with 4.5wt% sulphur content.

This occurs during the MFC Unit Start-up condition when the steam demand from the RTIP Units is at the highest. During this period, five steam boilers will be operating at 110% of their design capacities.

At start-up mode, five gas feed and two liquid feed pyrolysis furnaces in the MFC Unit will be operating at 65% of their design capacities. Sales gas (natural gas) will be utilized as fuel by the furnaces while in start-up mode. A maximum sulphur content of 20gr/100scf for natural gas is considered.

This short-term operating condition will also be considered for modelling the 24-hour averaging period for the ambient air quality for SO_2 and will define the project's maximum short term SO_2 emissions.

Modelling Scenario Annual Average Emissions

The annual average emissions modelling scenario for SO_2 is the same operating condition for the RTIP complex as used for annual average modelling scenario for NOx.

The sulphur content for the heavy fuel oil is considered as 3.8wt% for estimating the annual average SO_2 emissions from the steam boilers.

Dispersion modelling indicates that ground level SO_2 would not significantly increase the existing levels of SO_2. The modelled concentrations of SO_2 for all the averaging periods are well below the RCJY ambient air quality standards and less than 25% of the available air quality increment, for receptors inside and outside JIC and Jubail II. Therefore the impact magnitude is low as well as the impact significance.

Air Impact from SO_2 Emissions (refer to Issue A4) – Low Magnitude, Low Significance.

Use of Flue Gas Desulphurization (FGD) systems to treat the boiler flue gas as it is a well established technology and has a high SO_2 removal rate at up to 95%.

Carbon Monoxide

The operating scenario considered for modelling 1-hour and 8-hour maximum averaging periods for CO emissions from the RTIP complex are the same as considered for modelling the hourly maximum NOx emissions.

Modelled concentrations of CO are well below the RCJY ambient air quality standards for the two operating scenarios. The concentrations are less than 25% of the available increment. Therefore, the magnitude of the impact from CO emission can be regarded as low, as well as the impact significance.

Air Impact from CO Emissions (refer to Issue A5) – Low Magnitude, Low Significance.

Techniques incorporated into the design of the RTIP complex to lower CO emissions include complete combustion via furnace design, monitoring, process control, and maintenance to ensure complete combustion from the boilers. The project design also includes application of design operating temperature of 1100°C with more than 2 seconds of residence time at normal operating conditions for the Thermal Treatment Units (TTUs). No additional mitigation measures are proposed.

Particulate Matter (PM_{10} and $PM_{2.5}$)

The operating scenarios considered for modelling a 24-hour averaging period for PM_{10} and $PM_{2.5}$ emissions from the RTIP complex is the same as considered for the hourly maximum NOx emissions.

The operating scenarios considered for modelling the annual average concentrations of PM_{10} and $PM_{2.5}$ emissions from the RTIP complex is the same as considered for the annual average NOx emissions.

The modelling results for $PM_{2.5}$ and PM_{10} for the two averaging periods are included in [redacted]

As noted in Table 12-1, the predicted ground level concentrations of PM_{10} and $PM_{2.5}$ are well below the RCJY ambient air quality standards. However, when the predicted concentrations are summed with the existing high background PM_{10} and $PM_{2.5}$ levels registered for both parameters at the AQMS#6 (which cannot be mitigated by the project), this results in a potentially very high magnitude and high significance impact.

Air Impact from PM_{10} Emissions (refer to Issue A6) – Very High Magnitude, High Significance.

Air Impact from $PM_{2.5}$ Emissions (refer to Issue A7) – Very High Magnitude, High Significance.

The project design includes FGD to treat the boiler flue gas to reduce particulate matter (PM) emissions. Other techniques applied to the TTUs consist of excluding liquid wastes from manufacturing units that contain inorganic chemical constituents that could produce PM. The gaseous emission control devices used for the TTUs such as water spray quench, HCl water absorber tower, and caustic scrubber also contribute to PM reduction. However, given the high baseline concentrations, no amount of mitigation on point source PM emissions (which are very low) will reduce the general PM_{10} and $PM_{2.5}$ issue in the local environment.

Additionally, in order to reduce particulate matter during loading/unloading activities and/or during storing of raw materials, the project will apply measures such as: closed hanger, shield spraying system etc, to avoid dust emissions from the sources with RC prior approval.

12.4.3 Health Screening

Significant point sources and fugitives have been modelled to estimate concentrations of Ammonia, Aniline, Benzene, Chlorine, Ethylene Oxide, Formaldehyde, Hydrogen Chloride

(HCl), Phosgene, Toluene and Xylene to assess their potential impact on public health and with respect to odour nuisance. From those, Benzene, Ammonia, Chlorine, Formaldehyde, Toluene and Xylene are included in Table 2A and Table 2A-1 of the RCER. The others, which are not included in the RCER or IFC/WHO standards, are compared with the American Conference of Governmental and Industrial Hygienists (ACGIH) threshold limit value (TLV) and the Louisiana Toxic Air Pollutant Ambient Air Standards (Louisiana DEQ, 2011).

The maximum predicted concentrations for Aniline, Ethylene Oxide, HCl and Phosgene, are located at the site boundary within a designated industrial area, which effectively means that RTIP workers or workers from other facilities will be subject to the highest predicted concentrations during their work hours. Therefore it was decided to compare the resultant modelling concentrations with the ACGIH TLV expressed as a time-weighted average; this is defined as the concentration of a substance to which it is believed nearly all workers can be exposed day after day for a working lifetime without ill effect. On the other hand, the maximum predicted concentrations at the discrete receptors have been compared to the Louisiana DEQ. The Louisiana DEQ standards provide alternative reference ambient air quality standards for the pollutants of concern beyond the site boundary, since there are no corresponding RCER standards for these pollutants.

Benzene

Benzene emissions are assessed because of its carcinogenic properties. The primary sources of benzene emissions are organic storage tanks and leaks from piping systems and equipment. An additional, although very minor source, would be emissions from combustion sources.

The estimated benzene emissions for the RTIP complex are included in [redacted] which shows the results of modelling using AERMOD. The receptor locations were generally selected on the basis of nearest points of habitation in view of the assessment being based on long term risk to the population, rather than short term maximum concentrations associated with acute impacts. A risk level approach was applied to the predicted concentrations according to a methodology promulgated by the U.S. EPA, who generally refer to acceptable risk being in the range 10^{-4} (1 in 10,000) to 10^{-6} (1 in 1,000,000). The risk calculation for the general population is based on an estimate of the number of additional cancer cases per year expected from a 70-year exposure to projected complex emissions.

Cancer risk levels for benzene exposure have been included in [redacted]

In Table 12-2 the predicted modelled concentration for the maximum obtained concentration has been compared, with the corresponding RCJY Standard.

Table 12-2 Summary of Impact Predictions for Benzene

Location	Baseline	RTIP Modelled * (μg/m³)	Modelled as % Criteria	RCJY
Annual Average				
Maximum	--	*4.60*	92%	5μg/m³
Notes: *Maximum value from the 5 years of meteorology modelled* *Acronyms:* *RCJY =Royal Commission for Jubail and Yanbu*				

It is evident that ground level Benzene would increase the ambient benzene concentration at the site boundary. However, for the specific off-site receptors the annual average is well below the RCJY standard. Moreover, the RTIP complex meets the most stringent 1 in 1,000,000 criteria at most of the discrete receptor locations. Just those receptors located nearby the RTIP site (at less than 5 km from the site) do not comply with the most stringent 1 in 1,000,000 risk level. However they still meet the $1x10^{-5}$ criteria. Therefore, the magnitude of the impact from benzene emissions is medium near to the RTIP complex and low at the off-site receptors considered to be population centres.

Air impact (refer to Issue A8) – Medium Magnitude, Medium Significance close to RTIP complex; Low Magnitude, Low Significance outside the industrial city.

In order to reduce benzene emissions to the lowest feasible level some additional mitigation measures are suggested.

- Loading or discharging of aromatics (or aromatics-rich streams) from road tankers, rail tankers, ships and barges should be provided with a closed vent systems will be connected to a flare system;
- All equipment and piping systems should be designed to ensure a high level of containment and to minimise fugitive emissions. This involves seal-less or double/tandem sealed machinery, low loss valve packing, use of spiral wound jointing materials, and minimum use of flange connections. Equipment that handles benzene shall be designed to limit the exposure risk to an acceptable level.
- Fugitive emissions from piping and equipment will be mitigated by using a LDAR monitoring program as required by RCER 2010;
- Tankage of benzene will be a fixed roof venting to a flare system.

Parameters included in the RCER

Table 12-3 includes the modelling results and standard comparison for Formaldehyde, Toluene, Ammonia, Chlorine, Xylene and Toluene. For these compounds, no background concentrations were available. The modelled concentrations are directly compared to the RCJY standard.

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Table 12-3 Summary of Impact Predictions

Parameter	RTIP Modelled * ($\mu g/m^3$)	RCJY Standard	Modelled as % Standard
30-minute Average			
Formaldehyde	37.9 (1)	100	37.9%
Toluene	265 (1)	1,000	26.5%
1-Hour Average			
Ammonia	664	1,800	36.9%
Chlorine	19.5	300	6.50%
24 Hours Average			
Xylene	0.87	4,800	0.02%
1 week Average			
Toluene	52.1 (2)	260	20.0%

Notes:
** Maximum value from the 5 years of meteorology modelled*
*(1)Calculated as X(30 min) = X(1-hr) * (60/30)^0.2 = X (1-hr) * 1.15*
*(2) Calculated as X(1week)=X(24hr 2nd highest)*1.9*
Acronyms:
RCJY =Royal Commission for Jubail and Yanbu

The modelled concentrations are all below 50% of the applicable RCJY standard. Therefore the magnitude of the impact for those compounds is low as well as the significance.

Air Impact from Formaldehyde Emissions (refer to Issue A9) – Low Magnitude, Low Significance.

Although the impact significance is low, some measures have been included in the Project design to reduce emissions:

- In Formalin Unit (Unit 345) point source emissions (process tail-gas and product tank losses) are controlled by catalytic oxidation;
- For fugitive emissions, equipment specifications include high-integrity sealing systems for pumps, compressors, and valves and use of proper types of O-ring and gasket materials for formaldehyde service;
- From the Ethylene Oxide Unit, formaldehyde vapours originating from process is sent to the TTU for incineration;
- A LDAR Program to monitor and control fugitive emissions will be implemented as required by RCER 2010;

Some of these measures are as recommended by the IFC. No additional mitigation measures were feasible.***Air Impact from Toluene Emissions (refer to Issue A10) – Low Magnitude, Low Significance.***

Mitigation measures similar to that for Issue A8 will be implemented to minimise emission.

Air Impact from Ammonia Emissions (refer to Issue A11) – Low Magnitude, Low Significance.

Although the impact significance is low, some measures have been included in the Project design to reduce emissions:

- For fugitive emissions, equipment specifications include high-integrity sealing systems for pumps, compressors, and valves and the use of the appropriate types of O-ring and gasket materials for ammonia service;
- A LDAR Program to monitor and control fugitive emissions will be implemented as required by RCER 2010.

Air Impact from Chloride Emissions (refer to Issue A12) – Low Magnitude, Low Significance

Although the impact significance is low, some measures have been included in the Project design to reduce emissions:

- Connection of vent streams from absorber, storage and loading/unloading systems to a recovery system (e.g., condensation, water scrubber) and/or to a vent gas treatment (e.g., thermal/catalytic oxidizer, TTUs);
- Minimization of vent streams from storage tanks by backventing on loading/unloading and treating the polluted streams by thermal or catalytic oxidation;
- For fugitive emissions, equipment specifications include high-integrity sealing systems for pumps, compressors, and valves and use of the appropriate types of O-ring and gasket materials for chlorine service;
- A LDAR Program to monitor and control fugitive emissions will be implemented as required by RCER 2010**.**

Air Impact from Xylene Emissions (refer to Issue A13) – Low Magnitude, Low Significance.

Mitigation measures similar to that for Issue A8 will be implemented to minimise emissions.

Other Compounds

Table 12-4 includes the summary of ground level concentrations for Aniline, Ethylene oxide, Hydrogen Chloride and Phosgene. There are no background measurements for these compounds, therefore the modelled concentrations are compared directly with the corresponding standard.

Table 12-4 Summary of Impact Predictions

Location	RTIP Modelled* (μg/m³)	Standard ACGIH TLV (μg/m³)	Modelled as % Standard
Aniline 8-Hour Average			
Maximum	303	7,600	6.50%
Ethylene Oxide 8-Hour Average			
Maximum	139	1800	7.72%
Hydrogen Chloride 15- minutes Average (1)			
Maximum	108	7500	1.44%
Phosgene 8-Hour Average			
Maximum	7.13	400	1.78%

Notes:
** Maximum value from the 5 years of meteorology modelled*
*(1) Calculated as X(15 min) = X(1-hr) * (60/15)^0.2 = X (1-hr) * 1.32*

None of the modelled concentrations approach 50% of the corresponding standard. Accordingly the magnitude of the impact and significance is low.

Air Impact from Aniline Emissions (refer to Issue A14) – Low Magnitude, Low Significance.

Even though the impact significance is low, the following mitigation measures have been proposed:

- Point source emissions of aniline are controlled by Thermal Treatment in Unit 779 and alternatively vented to Flare;
- In regards to fugitives, equipment specifications include high-integrity sealing systems for pumps, compressors, and valves and use of appropriate types of O-ring and gasket materials for aniline service;
- A LDAR Program to monitor and control fugitive emissions will be implemented as required by RCER 2010.

Air Impact from Ethylene Oxide Emissions (refer to Issue A15) – Low Magnitude, Low Significance.

Even though the impact significance is low, the following design features have been incorporated in the Project to minimise emissions:

- Ethylene & Methane are flashed off from the carbonate solution in to minimize HC emission from the CO_2 vent to atmosphere;
- Pumps with double mechanical seals or sealless pumps are utilized for the Ethylene Oxide (EO) service. Vents from seal system are captured and sent to waste gas header to TTU;
- Ethylene Oxide storage tanks are equipped with a vent recovery collection system to route the EO containing gas back to the process using the vent gas compressor;

- Minimization of the number of flanged connections, and installation of metal strips around flanges with vent pipes sticking out of the insulation to allow monitoring of Ethylene oxide release;
- EO detectors are used at potential leak area and building HVAC intake to buildings. Examples: EO storage tanks transfer pumps as well as HVAC intake to MCC building;
- A Leak Detection and Repair (LDAR) Program to monitor and control fugitive emissions will be implemented as required by RCER 2010.

Air Impact from Hydrogen Chloride Emissions (refer to Issue A16) – Low Magnitude, Low Significance.

Even though the impact significance is low the project design has included equipment and piping systems with a high level of containment to minimise point and fugitive emissions:

- In the Isocyanates Units, the point source emissions are controlled primarily by Thermal Treatment in Unit 779 and alternatively by a Mitigation Scrubber System including a Process Scrubber and a backup Emergency Scrubber, both using a strong caustic solution to react/destroy HCL. A backup option when Thermal Treatment is not available is routing the scrubber exhaust to Flare;
- In regards to fugitives, equipment specifications include seal-less or double/tandem sealed machinery, and minimum use of flange connections;
- Process equipment that handles HCL shall be designed to limit the exposure risk;
- A LDAR Program to monitor and control fugitive emissions will be implemented as required by RCER 2010.

Air Impact from Phosgene Emissions (refer to Issue A17) – Low Magnitude, Low Significance.

Even though the impact significance is low, the project design has included equipment and piping systems with a high level of containment to minimise point and fugitive emissions:

- Point source emissions are controlled primarily by Thermal Treatment in Unit 779 and alternatively by a Mitigation Scrubber System including a Process Scrubber and a backup Emergency Scrubber, both using a strong caustic solution to react/destroy phosgene. A backup option when Thermal Treatment is not available is routing scrubber exhaust to Flare;
- In regards to fugitives, equipment specifications include seal-less or double/tandem sealed machinery, low loss valve packing, use of spiral wound jointing materials, and minimum use of flange connections;
- Process equipment that handles phosgene shall be designed to limit the exposure risk and is ultimately backed up by the TDI & PMDI Containment Domes which provide for equipment isolation and conveying significant fugitive emissions to the Emergency Caustic Scrubber for reaction/destruction;
- A LDAR Program to monitor and control fugitive emissions will be implemented as required by RCER 2010.

12.4.4 Ozone

Ground level ozone is formed by the reaction of VOCs and oxides of nitrogen in the presence of sunlight. Ozone at ground level is an aggressive pollutant which can adversely affect human health, interfere with plant growth and damage building materials. Essentially, none of the ozone present in the atmosphere is the result of ozone emissions from ground level into the atmosphere. Ozone is therefore termed a secondary pollutant, distinct from primary pollutants which are emitted directly into the atmosphere.

Since there are no direct emissions of ozone to the atmosphere, policies to reduce ozone exposure operate by steering the photochemical processes involved to produce less ozone, or destroy more ozone, or both. The contribution that VOC emissions make to ground level ozone formation is now widely recognised. Long range transport of ozone and its precursors is an important feature of this problem.

Insufficient data is available to model the effect of the RTIP complex on ozone concentrations in the region, indeed this would involve the use of a photochemical model of the region which is beyond the scope of an EIA for a single complex. In addition to availability of the total VOC emission rates, hydrocarbon emissions from all facilities in the area would need to be speciated into their chemical classes so that the chemical transformations can be accurate represented, and these data are unlikely to be available.

The ambient ozone concentrations already exceed the 1 hour and 8 hour RCJY ambient air quality standard. Therefore it is recommended that measures should be taken to reduce fugitive hydrocarbon emissions and NO_x emissions according to the principles of BAT, so as to limit ozone formation.

The RTIP complex design already includes some measures to reduce fugitive VOC emissions:

- Open-ended valves shall be equipped with a cap, blind flange, plug, or a second valve. The second valve shall always be closed except during sampling;
- Pressure relief valves equipped with rupture disks shall be equipped with a sensor between the valve and the disk to detect leaks;
- Use of double mechanical seal pumps in benzene service.

Measures for the reduction of NO_x emissions were discussed in section 12.4.2 above.

Other measures for fugitive hydrocarbon emissions reduction include the following:

- All storage tanks for VOCs shall be equipped with vapour control provisions in accordance with RCER regulations;
- Fugitive emissions will be minimized by adopting a Leak Detection and Repair (LDAR) program that controls fugitive emissions by regularly monitoring to detect leaks, and implementing repairs within a predefined time period, as required by RCER, and as recommended in the General EHS Guidelines (World Bank, 2007a). The purpose of a

LDAR program is to detect and expeditiously repair equipment that meets a specified leak detection definition. The degree of control efficiency that is assigned to a LDAR program varies as a function of the monitoring frequency and the leak definition. For the purpose of VOC estimation, a quarterly LDAR program is assumed with the following RCER indicated leak definitions:

  - All components in VOC service that register more than 10,000 ppmv VOC;
  - All valves, flanges and connectors in organic HAP service that register more than 500 ppmv VOC.

- Implementing advanced multi-variable control and on-line optimization, incorporating on-line analyzers, performance controls, and constraint controls;
- Recycling and/or re-using hydrocarbon waste streams for heat and steam generation;
- Installing permanent gas monitors, video surveillance and equipment monitoring (such as on-line vibration monitoring) to provide early detection and warning of abnormal conditions;
- Off-gas from hydrogenations should be discharged to a fuel gas network and burnt in a furnace to recover calorific value;
- Adopting closed loop sample systems to minimize operator exposure and to minimize emissions during the purging step prior to taking a sample;
- Adopting 'heat-off' control systems to stop the heat input and shut down plants quickly and safely in order to minimize venting during plant upsets;
- Where the process stream contains more than 1 weight percent (wt%) benzene or more than 25 wt% aromatics, use closed piping systems for draining and venting hydrocarbon containing equipment prior to maintenance; and use canned pumps or, where they are not applicable, single seals with gas purge or double mechanical seals or magnetically driven pumps;
- Minimizing fugitive leaks from rising stem manual or control valve fittings with bellows and stuffing box, or using high integrity packing materials (e.g., carbon fibre);
- Using compressors with double mechanical seals, or a process-compatible sealing liquid, or a gas seal;
- Using double seal floating roof tanks or fixed roof tanks incorporating an internal floating rood with high integrity seals.

12.5 Cumulative Operational Impacts

Cumulative operational impacts are discussed in Section 16.

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12.6 Accidents & Spills

12.6.1 Flaring

The complex will include a total of ten flares. Their source data and the characteristics of each of these flares are provided i[redacted]

The following scenarios have been considered

- Scenario 1: General Power Failure Event;
- Scenario 2: Process Upset.

Table 12-5 summarizes the predicted concentrations for each of these scenarios. The maximum modelled concentration for each criteria pollutant is compared to 25% of the available air quality increment.

Table 12-5 Maximum Modelled Ground Level Concentrations for RTIP from 2005 to 2009

Parameter (μg/m³)	**Average Time**	**Baseline**	**Available Increment (μg/m³)**	**25% of Available Increment**	**RTIP Modelled * (μg/m³)**		**Ambient Air Quality Standards**	
					Emergency Scenario	**Process Upset Scenario**	**National RCJY**	**WHO**
NO_2	1-hour	212	448	112	20.6	15.2	660 (1)	200
SO_2	1-hour	44.3	686	171	2.55	2.25	730 (1)	--
	24-hour	30.2	335	83.7	0.55	0.55	365 (5)	125(2) 50(3) 20(4)
CO	1-hour	3,450	36,550	9,138	112	82.5	40,000 (1)	--
	8-hour	1,140	8,860	2,215	43.3	27.1	10,000 (1)	--

Notes:
(1) Not to be exceeded more than twice in 30 days
(2) Interim target-1
(3) Interim target-2
(4) Guideline value
(5) Not to be exceeded more than once per year
(6) Interim target-3
(7) Shaded cells represent that the modelled concentrations exceed the 25% of the available increment
Abbreviations:
RCJY = Royal Commission for Jubail and Yanbu
WHO =World Health Organization
-- = Not determined
μg/m³ = Microgram per cubic metre

The modelled concentrations for the three parameters considered are well below 25% of the available ambient air quality increment. Therefore the magnitude of the impact on the ambient air quality from those emissions is low as well as the impact significance.

Air Impact from SO_2 Emissions during emergency and process upset (Refer to Issue A18) –Low Magnitude and Low Significance.

Air Impact from NOx Emissions during emergency and process upset (Refer to Issue A19) –Low Magnitude and Low Significance.

Air Impact from CO Emissions during emergency and process upset (Refer to Issue A20) –Low Magnitude and Low Significance.

The following measures are included in the RTIP complex design to minimize flare emissions:

- Appropriate consideration, through technical evaluation, should be given with respect to flare design to ensure safe operation and minimize impact on the community;
- Flares shall be designed for smokeless operation through as much of the operating range as technically feasible;
- Flares primary function shall be to manage unplanned events and start-up and shutdown of units;
- The use of flares as control devices for continuous vent streams is acceptable after other alternatives have been evaluated, considering process safety, cost, etc. For flares used as control devices, the flares shall be designed and operated such that the combined assist fuel gas and waste stream is in accordance with RCER Table 2B specifications;
- Flaring shall be minimised during start-up and shut-downs; Cameras shall be used as a means of flame detection/confirmation for flares. In addition, the continuous imaging (digital recording) of all flares with date and time shall be maintained. Cameras shall also be considered for monitoring other critical equipment, remote loading operations, etc.

Other recommended measures to reduce emissions are as follow:

- Minimization of flaring via an overall emissions reduction strategy. The following flare minimization activities are suggested: flares to be designed in accordance with applicable standards, installing a gas recovery system, using high-integrity relief valves, applying advanced process control, and reducing relief gas to flare by management/good housekeeping practices.

12.6.2 Spills

Spills scenarios were modelled using ALOHA (Areal Locations of Hazardous Atmospheres), which is freely available and is promulgated by the U.S. EPA to assist with emergency planning in the event of releases of chemicals.

The spill scenarios considered include seven products: Benzene, Toluene, Monoethanolamine (MEA), Diethanolamine (DEA), Polymeric Methylene Diphenyl di-isocyanate (PMDI), toluene diisocyanate (TDI), Ethylenediamine (EDA)/DEA, which are stored in tanks or piperacks, which make a total of 11 scenarios. The release scenario is either a catastrophic tank failure and associated release of the product into the containment basin or rupture in a pipe (considered only for benzene), where the spill volume is based on 15 minutes release at the design pumping rate of 58.6 m^3/h.

The spill scenario assumptions and details on the modelling performed are included in Section E.5 o[redacted]

Table 12-6 provides the predicted concentration downwind of the spill, for the eleven spill scenarios considered. The predicted values may then be compared with the Lower Explosive Limit (LEL), Immediately Dangerous to Life or Health (IDLH), as defined by the National Institute for Occupational Safety and Health (NIOSH), and the permissible exposure limits (PEL) established by the Occupational Safety and Health Administration (OSHA) and defined as time weighted average (TWA) airborne concentration to which workers may be exposed for periods up to 15 minutes, with no more than 4 such excursions per day and at least 60 minutes between them.

While the LEL is the primary measure of explosion risk, an additional threshold equal to 60 percent of the LEL has been defined to identify areas where local flame pockets might exist. Areas that are less than 10 percent of the LEL are defined as having no risk from explosion.

Table 12-6 shows that benzene has the greatest downwind impacts both for tank and piperack spills, representing the worst case spill scenario. Therefore, the assessment has been focussed on these two worst case scenarios, a benzene tank failure and a benzene piperack rupture.

Table 12-6 Model Predictions and Comparison with Criteria for Spill Scenarios

Scenario	Spill Location	Contaminant Modelled	Modelling Output			LEL(2) (%)	IDLH(3) (ppm)	OSHA PEL(4) (ppm)
			Criteria(1)	Concentration (ppm)	Distance to Endpoint (m)			
01	Feedstock Storage Tank (Unit 822)	Benzene	LEL	12,000	260	1.2	500	5
			IDLH	500	1,100			
			PEL	5	>10,000			
02	Feedstock Storage Tank (Unit 822)	Toluene	LEL	12,000	83	1.2	500	5
			IDLH	500	568			
			PEL	5	7,200			
03	Interconnecting Piperack (from Unit 822 to Aromatics Unit (Unit 140))	Benzene	LEL	12,000	272	1.2	500	5
			IDLH	500	1,400			
			PEL	5	9,600			
04	Interconnecting Piperack (from Unit 822 to Aromatics Unit (Unit 140))	Toluene	LEL	12,000	255	1.2	500	5
			IDLH	500	1,300			
			PEL	5	8,800			

Table 12-6 Model Predictions and Comparison with Criteria for Spill Scenarios

Scenario	Spill Location	Contaminant Modelled	Modelling Output			LEL(2) (%)	IDLH(3) (ppm)	OSHA PEL(4) (ppm)
			Criteria(1)	Concentration (ppm)	Distance to Endpoint (m)			
05	South Tank Farms (Units 820)	MEA	LEL	31,000	22	3.1	30	3
			IDLH	30	85			
			PEL	3	576			
06	South Tank	DEA	LEL	17,000	91	1.7	200	3
			IDLH	200	781			
			PEL	3	8,600			
07	South Tank Farms (Units 820)	PMDI	LEL	--	--	NE	7.3	0.02
			IDLH	7.3	27			
			PEL	0.02	588			
08	South Tank Farms (Units 820)	TDI	LEL	9,000	31	0.9	2.5	0.02
			IDLH	2.5	77			
			PEL	0.02	2,600			
09	Port Storage Tank Farm (Unit 840)	EDA/DEA	LEL	42,000	Not Exceeded	4.2	1000	3
			IDLH	1,000	113			
			PEL	3	4,900			
10	Port Storage Tank Farm (Unit 840)	PMDI	LEL	--	--	NE	7.3	0.02
			IDLH	7.3	34			
			PEL	0.02	769			
11	Port Storage Tank Farm (Unit 840	TDI	LEL	9,000	49	0.9	2.5	0.02
			IDLH	2.5	119			
			PEL	0.02	5,000			

Notes:
(1)Exposure criteria or explosion threshold
(2)LEL = Lower Explosive Limit; UEL = Upper Explosive Limit, NA = Not Applicable
(3)IDLH = Immediately Dangerous to Life or Health, as defined by NIOSH, determines the need for respiratory protection, NE = Not Established
(4)OSHA = Occupational Safety and Health Administration; Permissible Exposure Limit (PEL), Time Weighted Average (TWA) airborne concentration to which workers may be exposed for periods up to 15 minutes, with no more than 4 such excursions per day and at least 60 minutes between them

Storage Tank Failure

Under the worst case release scenario, explosive concentrations of benzene vapours extend 260 meters downwind, flame pockets may extend 321 meters, and safe gasoline vapour concentrations are reached when the plume reaches 707 meters downwind. Hazardous concentrations of hydrocarbon vapours extend further downwind with concentrations greater than the OSHA PEL extending more than 10 km for the worst case release. The explosive or hazardous plume concentrations do not reach population centres, although they might reach the construction camp/farms or Jubail Prison if the wind was headed in that direction. IDLH concentrations for benzene extend 1,100 meters downwind.

Air Impact from Benzene Storage Tank Failure Spill (refer to Issue A21) –High Magnitude, Medium Significance

Pipe Rack Failure

Under the worst case release scenario explosive concentrations of benzene vapours extend 272 meters downwind, flame pockets may extend 366 meters, and safe gasoline vapour concentrations are reached when the plume reaches 913 meters downwind. Hazardous concentrations of hydrocarbon vapours extend further downwind with concentrations greater than the OSHA PEL extend 9.6 km. The explosive or hazardous plume concentrations do not reach population centres, although they might reach the construction camp and farms or Jubail Prison if the wind was headed in that direction. IDLH concentrations for benzene extend 1,400 meters downwind.

Air Impact from Benzene Pipe Rack Failure Spill (refer to Issue A22) –High Magnitude, Medium Significance

HAZID, HAZOP, etc. assessments will be used throughout the design process. A Spill Prevention and Containment plan needs to be developed and recommendations implemented; therefore mitigation measures for these three spill scenarios should include the preparation and implementation of a spill response plan.

12.7 Other Air Quality Issues

12.7.1 Greenhouse Gases

The United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty produced at the UNCED. The treaty is aimed at reducing emissions of Greenhouse Gases (GHG) in order to combat global warming. KSA became a Party to the Convention in 1994. The treaty included provisions for updates (called "protocols") that would set mandatory emission limits. The principal update is the Kyoto Protocol, which has become much better known than the UNFCCC itself. It contains legally binding emissions targets for Annex I (developed) countries for the post-2000 period. KSA became a signatory to the Kyoto Protocol in May 2005.

The International Energy Agency (IEA) estimates the CO_2 emissions in KSA by sector as follows.

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Table 12-7 CO2 emissions (MMT/year) by sector in 2008, KSA

Total CO2 Emissions from fuel combustion	Electricity and heat production	Other energy industries	Manufacturing industries and construction	Transport	of which: road	Other sectors	of which: residential
389.2	154	46.1	89.1	96	94	4	4
Total: 778.4 MMT/year							
Source: IEA, 2010							

In the RTIP complex the potential sources of GHG emissions include the combustion of fuels in process heaters, boilers, furnaces (combustion sources) and the direct release of process streams to the atmosphere (process vents).

The estimated emissions for combustion and process sources are included in Table 12-8. The GHG are reported in terms of the absolute emission rates of the specific pollutants, as well as in terms of CO_2 equivalent.

Table 12-8 GHG Emissions at RTIP

GHG Parameter	kg/hr	MT/year	CO_2 Equiv. MT/year
CO_2	561,672	3,994,944	3,994,944
CH_4	18	148	3,102
N_2O	99	783	242,658
Total CO_2 Equiv.: 4,240,703 MT/year			
Source: RTIP, 2011			

The principal GHG gas emitted by the RTIP complex is CO_2, as noted in Table 12-8. Therefore the assessment of GHG emissions has been based on this parameter. RTIP project CO_2 emissions represent 0.54% of the KSA GHG emissions reported in 2008.

The total CO_2 emissions that will be generated by RTIP will be approximately 4.24 $x10^6$MT per year. The World Bank (2007b) regards GHG emissions of >100,000 tons CO_2 equivalent per year as significant and recommends that these emissions should be quantified annually as aggregate emissions in accordance with internationally recognised methodologies and reporting procedures. All reasonable attempts should be made to maximise energy efficiency and design facilities to minimise energy use. In addition to energy efficiency and associated emissions reductions, carbon capture and storage should be considered (World Bank, 2007a, 2007b).

RTIP has incorporated in the design several measures to reduce or mitigate the GHG emissions:

- Energy efficiency and optimization are key considerations in the design of the process units. The use of GHG inventories will be quantified for the project, in accordance with the Kyoto Protocol, by determining the amount of carbon dioxide, methane, and nitrous oxide emissions resulting from combustion or other source releases. In addition, source releases, if any, of hydrofluorocarbons, perfluorocarbons, and suflur hexafluoride will be quantified.

In general, emissions of carbon dioxide will be minimized by efficient combustion processes and by energy optimization measures.

- Energy conservation is being considered and employed at each stage of the process. Energy conservation, as with elimination of waste heat, impacts multiple areas including energy consumption, GHG generation, water consumption and overall capital footprint. All units with large energy demands (greater than 30 MW) will consider a preliminary energy conservation documented review in the feasibility stage to assure major opportunities are explored and understood before more detailed design work begins. Generation of waste heat will be minimized to the extent possible by efficient process design.

Other measures that can be studied and applied if feasible include:

- Carbon capture and storage technologies;
- Heat recovery from cracking furnaces to allow reduction of prime energy consumption;
- Use thermally efficient furnace and heat/energy integration.

12.7.2 Indirect emissions

As mentioned in the Project Description power demand for the RTIP complex is estimated to be around 600MW. The power supply will be provided by the Saudi Electricity Company (SEC) 380 kV grid. The source of this power is presumed to be a variety of power generation units across KSA, which makes the estimation of the associated emissions and the assessment of the indirect emissions from the power consumption of the RTIP complex, unfeasible.

12.8 Decommissioning

At the end of the functional life of the RTIP complex (the operational life of the plant is assumed to be at least 25 years), it will be decommissioned. Any flaring required at that time should be minimised and hydrocarbons removed from tankage for sale or safe and environmentally acceptable disposal. There is no reason to consider that decommissioning activities would be greatly different from construction activities in relation to dust formation and vehicle exhaust gas. Impacts occurring from accidents and spills have previously been discussed in Section 12.1.2.

Air Impact from Dust Emissions (refer to Issue A1) –High Magnitude, High Significance close to RTIP but construction would add little to existing dust levels outside plant property boundary.

Air Impact from Exhaust Emissions (refer to Issue A2) –High Magnitude, High Significance close to RTIP complex and inside the industrial city; Low Magnitude and Low Significance (outside Jubail Industrial City).

13 ONSHORE PHYSICAL IMPACT ASSESSMENT

13.1 Introduction

This section presents an evaluation of the potential environmental impacts on the onshore physical environment which could result from the construction, commissioning, operation and decommissioning activities that are part of the RTIP project.

Project activities and facility/operations design (as described in Section 3 of this EIA) and baseline conditions (as described in Section 5 Onshore Physical Baseline) have all been considered for the assessment of these potential impacts. The significance of impacts on soil and groundwater has been assessed, and where necessary mitigation measures have been identified.

The evaluation considers activities associated with the construction; all project phases; the location of proposed infrastructure (whether temporary or permanent); site preparation activities as well as the resources (internal or external) necessary for their completion.

The evaluation of baseline conditions was conducted with a particular emphasis on the existing site conditions and site observations prior to the start of the RTIP project. Information regarding baseline site conditions included a study of the regional and local geology and hydrogeology; subsurface characterisation by an analysis of existing soil boring logs; physical and chemical characterisation of soil and groundwater quality; aquifer hydrogeological characterisation by undertaking a series of aquifer pump tests in existing monitoring wells and modelling of the quaternary shallow alluvial aquifer underlying the Site (for further details, please refer to Section 5).

The assessment of impacts to the onshore physical environment has covered the soil and shallow groundwater components and those impacts resulting from future site activities and accidental releases of hazardous materials. The basis for evaluating impacts associated with releases of hazardous materials is included in Section 13.2 whilst impacts associated with waste management are discussed separately in Section 16 of this EIA report**.** Considering that the water (industrial and potable) for the project is imported from Marafiq, no impacts on the physical environment are envisaged related to groundwater or fresh surface water extraction.

The assessment of the impacts on the onshore physical environment is summarised and tabulated in Section 20 - Summary of Impacts (Table 20-1), and the magnitude and significance for each impact are also stated below at the end of each subsection (in bold italic). Next to each magnitude/significance statement and for ease of reference, each issue is identified by a unique number which is repeated in Table 20-1 and subsequently in Tables 21-1 (Mitigation Table) and 22-1 (Monitoring Table), where applicable.

13.2 Release Scenario Understanding, Prevention and Limitations

The design of the RTIP facilities and operations includes spill prevention and containment measures for all phases of the project to prevent, to a practical extent, releases of hazardous materials to the physical environmental and to limit the duration and size of any possible release. Spill prevention and containment measures at RTIP aim to prevent the release of hazardous materials to the soil / groundwater and to ensure the response and cleanup time of any possible release are minimised.

The evaluation of impact of releases of hazardous materials requires the formulation of release scenarios and their impact on human or ecological receptors. Each scenario has three components:

- Source: source of releases, type of released material and length of release;
- Pathway: routes that contaminant may take in the physical environment (soil and groundwater, fractures) to receptors; and
- Receptor: ecosystem or humans that are impacted by contaminants that may have originated at RTIP.

All identified scenarios are summarized in Table 13-1. Some identified scenarios were not considered to be possible and were not retained for further evaluation because the transport or exposure pathways were not considered to reach any receptors. A detailed analysis of the sources, pathways and receptors for the possible or retained scenarios is included in Sections 13.2.1 through 13.2.4.

Table 13-1 Source, Pathway and Receptor analysis

Retained for evaluation

Source and release mechanisms	Transport and exposure pathway	Receptor
• Uncontrolled releases of hazardous materials to unpaved soil. • Infiltration of spilled hazardous materials to soil through cracks in pavement or conduits. • Contaminated soil (secondary source).	• Soil to groundwater. • Groundwater flow.	• Terrestrial environment downgradient and within the RTIP project site (soil and groundwater quality).

Considered but not retained for evaluation

Source and release mechanisms	Transport and exposure pathway	Receptor
• Controlled releases of hazardous materials (not part of RTIP's processes).	• Stormwater runoff to soil to groundwater. • Direct human contact with contaminated groundwater or soil (dermal contact or ingestion). • Soil to farming products (through plant uptake).	• Humans in direct contact with contaminated soil or groundwater. • Human consumers of contaminated groundwater. • Human consumers of farming products downgradient of RTIP.

Table 13-1 Source, Pathway and Receptor analysis

	• Soil to groundwater to farming products (through plant uptake). • Soil to air (emissions or dust, evaluated in Section 12).	• Sabkhat Al-Fasl Lagoons (evaluated in Section 14). • The Marine environment (evaluated in Section 14). • Air quality (evaluated in Section 12).

13.2.1 Source and Release Mechanisms

Potential sources of contaminants considered include releases and accidental spills of hazardous materials from RTIP's processes and support activities (such as transportation of hazardous materials on roads outside RTIP). Soil that is contaminated by uncontrolled releases constitutes a secondary source of contaminants to the onshore environment. Controlled releases (such as minute losses during storage or handling or scheduled releases) are not contemplated in this EIA because all waste streams will be the subject of waste management practices (as described in Section 3).

Uncontrolled releases to soil involve the release during a finite period of time of hazardous materials such as fuel, raw materials, feedstock and products due to malfunctioning equipment or accidents (caused by extraordinary weather conditions, human error, or third-party actions). Direct spills on bare soil are considered the primary release mechanism. Infiltration of hazardous materials to soil through cracks in the newly built pavement or conduits is considered a minor release mechanism because the design of the RTIP facilities and operations includes spill prevention and containment measures for all phases of the project to prevent, to a practical extent, releases of hazardous materials to the soil and to limit the duration and size of any eventual release. Spill prevention and containment measures at the RTIP also aim to ensure the response and cleanup time of any possible release are minimised.

Key spill prevention and containment measures (detailed in Section 3 Project Description) include:

- **Process Unit Areas** – All the RTIP Process units (including connections with piperacks) are paved and any spills within a unit will flow to concrete-lined surface drainage systems (SDS) and be contained by the unit's process area drainage sumps.

- **Jetty (Port) Areas** - Spills will be contained in the concrete deck area with curbing. The deck area shall allow for liquid removal by vacuum truck. Marine loading arms (connection to ships) will be equipped with emergency release coupler to cut off the supply of materials from ships in case on a spill.

- **Tank Farms** – Each tank farm area (where tanks hold product with similar characteristics) will be provided with secondary containment for 110% of the volume of the largest tank plus the equivalent of 100mm of rain collected as stormwater. Secondary containment consists of dikes (concrete walls and concrete paving with HDPE liners,) for each group of tanks with similar products. Pumps and compressors in the tank farm areas will be located on concrete pads that will slope to an internal concrete sump (where spilled product can be removed by vacuum truck) and be equipped with SDS in case precipitation overflows the internal sump.

- **Loading and Unloading Areas** – these will be paved and curbed and sumps will be provided to contain any spills and stormwater equivalent to the volume of stormwater produced by 100 mm of precipitation.

- **Hazardous materials storage areas** – all the RTIP hazardous materials and hazardous waste storage areas are paved and any spills within these facilities will be captured by the drainage sumps that are part of the SDS.

- **Stormwater management** includes the grading of surfaces where hazardous material handling may occur in order to conduct stormwater and potential spills into sumps, and the conveyance of the SDS' to the RTIP's Surface Retention Basins (SRBs). Process Area sumps are designed to contain all first-flush stormwater.

- **Piperacks** – Areas under some piperacks are not paved with concrete, but the leaks will be visible/ audible and will trigger the spill containment and cleanup measures contemplated in the EH&S plans. Small volumes of hazardous materials have the potential to reach the groundwater through the soil, but in the case of large spills, the majority of the released material will flow to nearby concrete lined SDSs that will run along the roads and the piperacks, and ultimately to the SRBs.

In the case of any spill reaching the soil, EH&S guidelines and plans call for immediate action to contain and remove spilled materials, so the response time to a spill is considered to be less than 15 minutes.

All facilities are provided with fire prevention systems as well as backup power generators.

Given the existence of these spill prevention and containment measures at the RTIP, no major or catastrophic spill scenarios (such as the release of the full volume of a storage tank) have been retained for evaluation. All releases of soluble solid hazardous chemicals are considered to take place on paved areas and have no impact on soil or groundwater quality.

The source and release mechanisms retained for evaluation are:

- Releases that occur during the transportation (while outside of paved loading/unloading areas equipped with SDSs) of hazardous materials in Intermediate Bulk Containers (IBC) or truck tankers and are less than 20 m3 in volume;

- Releases that may occur during the potential release from the piperacks between the feedstock tank farm and the process units estimated to be up to 14.7 m3 for a release that lasts less than 15 minutes (estimated maximum response time); and

- Minor releases of hazardous materials to soil through cracks in pavement and concrete conduits (such as SDSs, sumps and SRBs). These minor releases are considered to be non-existent during the first years of RTIP operation and have a minor probability of developing throughout the life of the project.

13.2.2 Transport and Exposure Pathways

Transport of contaminants include infiltration in soil and dispersive, advective and diffuse flow through groundwater (transport of contaminants in air or the marine environment are considered in Section 12 and 14, respectively). Exposure mechanisms are those that serve to put potential receptors in contact with contaminants present in soil or groundwater.

Transport mechanisms retained for impact evaluation include gravity flow of contaminants through soil to the shallow alluvial aquifer and dissolved constituents through groundwater to areas hydraulically downgradient of the RTIP project site. From there, contaminants would be absorbed by plants and animals feeding from those plants. The transport mechanisms associated with groundwater flow are characterized by means of groundwater modelling in Section 13.3 and the results of the groundwater model are used to evaluate and quantify impacts associated with this pathway.

Given the existence of extensive spill prevention and containment measures, transportation of contaminants dissolved in stormwater runoff to soil or groundwater was not considered in this assessment whilst spills of undissolved contaminants to soil through cracks in the SDS and SRBs were discussed in Section 13.2.1.

Direct human contact with contaminated soil is not considered as a possible exposure pathway because of extensive pavement and access restrictions to process and materials storage areas. Likewise and given the lack of potable water wells hydraulically downgradient of the RTIP project Site (Section 5), direct human contact with groundwater has not been considered in this assessment either. Intake of contaminants by plants intended for human consumption has not been considered as a pathway to human receptors in this assessment. This is due to lack of agricultural activities in the area (Section 9) due to soils of poor agricultural value downgradient of RTIP (soil quality and agricultural value are reviewed in Sections 5 and 6 of this EIA). Emission of contaminants to the air is evaluated in Section 12.

13.2.3 Receptors

Possible human or ecological receptors that might be affected by possible releases of contaminants to the physical onshore environment are human workers in RTIP (workers and visitors), human inhabitants and terrestrial ecosystems downgradient of RTIP (animals and plants) and aquatic biota in the marine environment.

Human workers were not considered in this assessment because the pathway that would put them in contact with contaminants in soil and groundwater is not considered to be available (given extensive pavement and access control to process and storage areas). As no groundwater extraction wells are used for human or agricultural activity downgradient of the site, human inhabitants are not considered possible receptors.

The only receptor retained for evaluation is the terrestrial ecosystem downgradient of the RTIP site. Please note that impacts to the Sabkhat Al-Fasl Lagoons or to the marine environment have been evaluated in Section 14.

13.3 Groundwater Flow & Spill Modelling

Spill scenarios contemplated in the modelling of pollutant flows through the groundwater in the shallow alluvial aquifer were prepared based on the Project Description (Section 3 of this EIA report) and on professional judgment:

- **Spill of up to 14.7 m³ of benzene or toluene** (different volumes have been modelled) from the piperacks between the feedstock tanks and the process facilities. The modelled spill:
    - Has a duration of less than 15 minutes (estimated time for a visual or audible alarm to prompt the activation of spill prevention and cleanup measures);
    - Takes place in an unpaved area (volumes over 14.7 m³ are expected to flow into the SDS);
    - Results in a volume of benzene or toluene reaching the soil; and
    - The released material is expected to have a very short residence time in the soil and is assumed to reach the groundwater almost immediately.

This is an extremely conservative scenario, given the existence of proper protocols built into the facility's spill prevention and containment program.

- **Spill of up to 20 m3 of toluene or benzene** released from a leaking or ruptured IBC or tanker truck during transportation in an unpaved area or where the spill bypasses the SDS and reaches an unpaved area.

In all cases, pure toluene and benzene will stay as free product, and being less dense than water, will float above the groundwater until its complete dissolution. This is the starting point of the groundwater model, in which a high concentration, equal to the solubility of the product, is assigned. This point source is diluted, dispersed and biodegraded in the direction of the groundwater flow.

13.3.1 Model Setup

The model has been setup using the BIOSCREEN[1] one-dimensional model. BIOSCREEN is a screening model that simulates the transportation of pollutants in groundwater and the natural attenuation of dissolved organic compounds by aerobic and anaerobic reactions. The parameters that were used in the BIOSCREEN model are presented in Table 13-2.

[1] USEPA, 1996. EPA/600/R-96/087. http://www.epa.gov/ada/csmos/models/bioscrn.html

Table 13-2 Parameters used in the BIOSCREEN Model

Parameter	Value	Observation / Source
Hydraulic Conductivity (K)	5.2×10^{-6} m/s	An average K value of 5.2×10^{-6} m/s was selected based on the average value of interpreted aquifer pumping test results conducted at selected temporary groundwater wells at the RTIP project site. Validated pumping tests yield a range of K values between 2.62×10^{-5} m/s and 3.36×10^{-7} m/s. The K value of 5.2×10^{-6} m/s is consistent with the silty materials encountered during site investigations (Section 5).
Hydraulic Gradient (i)	2.1×10^{-3}	A hydraulic gradient of 2.1×10^{-3} was observed based on groundwater elevation measurements collected in October 2010. The maximum gradient was observed in a northerly direction.
Porosity (Φ)	0.2 or 20%	An effective porosity value of 0.2 was assigned based on the RTIP Project Site soil classification of fine sand, silt and clay[2].
Longitudinal dispersivity	10 m (south to north) 1 m (east to west) 0.1 m (vertical)	Dispersivity is a scale and material dependant parameter. Based on professional judgment, a longitudinal dispersivity of 10 m (in the direction of the flow), 1 m (direction transversal to flow) and 0.1 m (vertical direction) are used.
Adsorption (Retardation factor)	2	The retardation factor reflects the mechanisms of adsorption and release of compounds into and from clay and organic materials. A conservative approach consists of applying a low retardation factor allowing higher migration velocity; however, the presence of clay cannot be ignored and is taken into account in the chosen value.
First order decay coefficient	0.7 per year (Benzene) 7 per year (Toluene)	Based on reference[3] and professional judgement.
Model and source geometry	5,000 by 500 feet (1524 by 152.4 m)	This dimension represent the maximum volume considered. The size and the thickness of the source are 15.24 and 3.048 m, respectively.
Product solubility	1.8 g/L (benzene) 0.5 g/L (toluene)	Product solubility in water at 25°C. Data from Toxicological profiles for benzene and toluene from the Agency for Toxic Substances and Disease Registry[4]

13.3.2 Spill Scenario 1: Benzene from Piperack (from Unit 822 to Isocyanates Envelope)

This scenario consists of simulating a 10.7 m^3 spill of Benzene. The duration of the spill is 15 minutes. As a consequence of this release, a plume that is 47.54 m (156 feet) long is simulated by BIOSCREEN (based on a minimum plume concentration of 5 µg/L). The model estimates that after

2 Fetter, 2001. Applied Hydrogeology. Prentice Hall. 396 pp.

3 Newell C. et al., 2009. Calculation and Use of First Order Rate Constants for Monitored Natural Attenuation Studies

4 http://www.atsdr.cdc.gov/toxpro2.html

11 years, the plume length reaches its maximum. The plume will maintain a length of 47.54 m (156 feet) for almost 90 years. After this period, the source will start to naturally attenuate, which is expected to take centuries.

Figure 13-1 shows the relation between time and the length of the plume which is delimited by a minimum concentration of 5 µg/L.

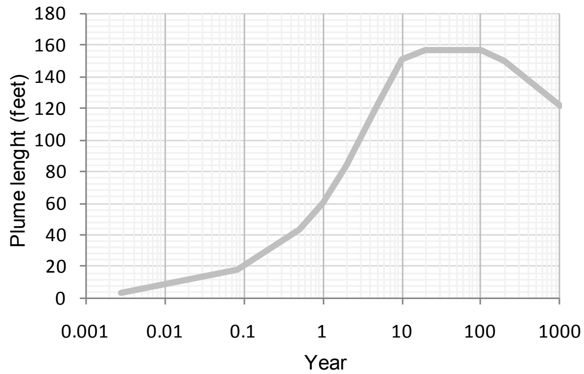

Figure 13-1 Spill Scenario 1 Model
Source: CH2M HILL 2011

13.3.3 Spill Scenario 2: Benzene from Piperack (from Unit 822 to Aromatics Unit)

This scenario consists of simulating a 14.7 m³ spill of Benzene. The duration of the spill is 15 minutes. As a consequence of this incident, a plume that is 47.54 m (156 feet) long is simulated by BIOSCREEN (based on a minimum plume concentration of 5 µg/L). The model estimates that after 11 years, the plume length reaches its maximum. The plume will maintain a length of 47.54 m (156 feet) for almost 150 years. After this period, the source will start to naturally attenuate, which is estimated to take centuries.

Figure 13-2 shows the relation between time and the length of the plume delimited by a minimum concentration of 5 µg/L.

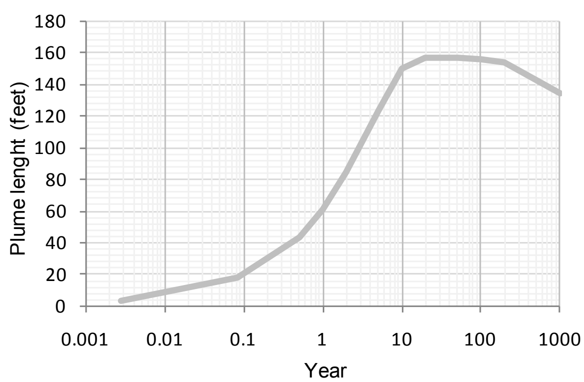

Figure 13-2 Spill Scenario 2 Model
Source: CH2M HILL 2011

13.3.4 Scenario 3: Toluene from Piperack (from Unit 822 to Isocyanates Envelope)

This scenario consists on simulating a 5.2 m³ spill of Toluene. The duration of the spill is 15 minutes. As a consequence of this incident, a 7m (23 feet) long plume is simulated by BIOSCREEN (based on a minimum concentration of 1 mg/L). The model estimates that after 1 year, the plume reaches its maximum length. The plume will maintain a length of 7m (23 feet) for almost 50 years. After this period the source will start to naturally attenuate, which is estimated to take centuries.

Figure 13-3 shows the relation between time and the length of the plume delimited by a minimum concentration of 1 mg/L.

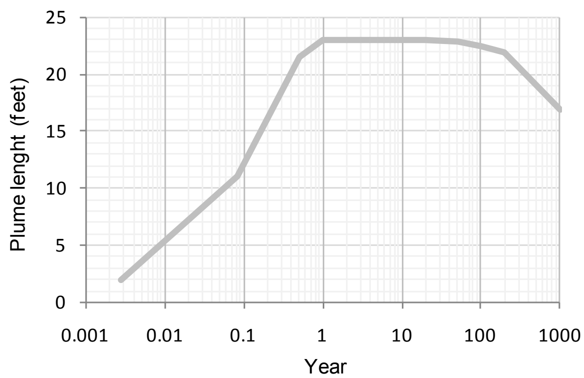

Figure 13-3 Spill Scenario 3 Model
Source: CH2M HILL 2011

13.3.5 Spill Scenario 4: Toluene from Piperack (from Unit 822 to Aromatics Unit)

This scenario consists on simulating a 14.7 m³ spill of Toluene. The duration of the spill is 15 minutes. As a consequence of this incident, a 7m (23 feet) long plume is simulated by BIOSCREEN (based on a concentration of 1 mg/L). The model estimates that after 1 year, the plume reached its maximum length. The plume will maintain a length of 7m (23 feet) for almost 100 years. After this period, the source will start to naturally attenuate, which is estimated to take centuries.

Figure 13-4 below, shows the relation between time and the length of the plume delimited by a minimum concentration of 1 mg/L.

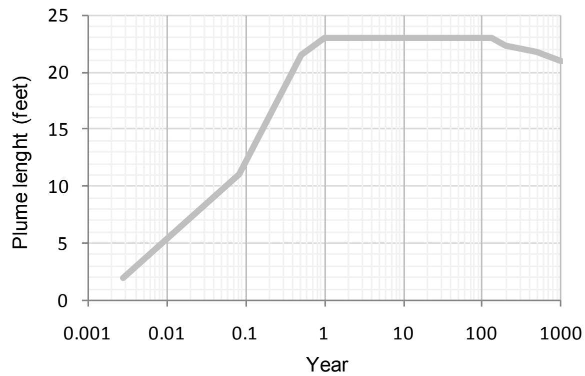

Figure 13-4 Spill Scenario 4 Model
Source: CH2M HILL 2011

13.3.6 Spill Scenario 5: Spill of 20 m³ of Benzene

This scenario represents the case of a benzene release from a tanker truck in an unsecured area. In this case, the release may infiltrate the soil to the groundwater. As a consequence of this incident, a 48.76 m (160 feet) long plume is simulated by BIOSCREEN (based on a minimum concentration of 5 μg/L). The model estimates that after 30 years, the plume reaches its maximum length. The plume will maintain a length of 48.76 m (160 feet) for almost 250 years. After this period, the source will start to naturally attenuate, which is estimated to take centuries.

Figure 13-5 shows the relation between time and the length of the plume delimited by a minimum concentration of 5 μg/L.

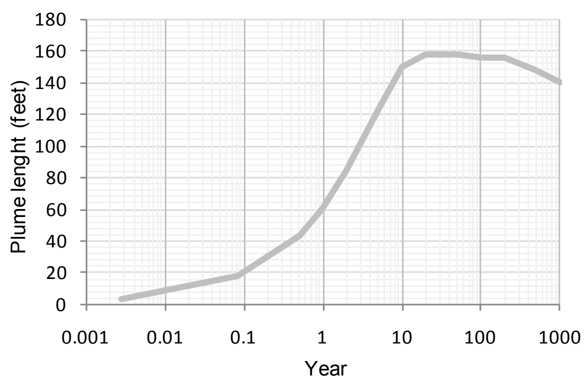

Figure 13-5 Spill Scenario 5 Model
Source: CH2M HILL 2011

13.3.7 Spill Scenario 6: Spill of 20 m³ of Toluene

This scenario represents the case of a toluene release from a tanker truck in an unsecured area. In this case, the release may infiltrate the soil to the groundwater. As a consequence of this incident, a 7.31 m (24 feet) long plume is simulated by BIOSCREEN (based on a concentration of 1 mg/L). The model estimates that after 1 year, the plume reaches its maximum length. The plume will maintain a length of 7.31 m (24 feet) for almost 100 years. After this period, the source will start to naturally attenuate, which is estimated to take centuries.

Figure 13-6 shows the relation between time and the length of the plume delimited by a minimum concentration of 1 mg/L.

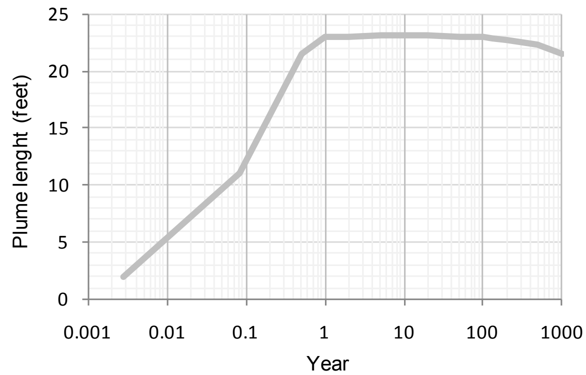

Figure 13-6 Spill Scenario 6 Model
Source: CH2M HILL 2011

13.3.8 Sensitivity Analysis (Increased K for Scenario 2)

A sensitivity analysis on the permeability value has been conducted on Scenario 2. The value of K was increased from 5 x 10^{-6} to 8 x 10^{-6} and 2 x 10^{-5} m/s. The increased K is a realistic possibility if the offsite geological environment is more sandy and gravelly.

13.3.9 Interpretation

<u>Benzene Release Scenarios</u>: Spill scenarios 1, 2 and 5 (Benzene releases from different sources) are conceptually similar. However Scenarios 2 and 5 represent benzene spills that are 40% and 95% more important, respectively, than that of Scenario 1. For Scenarios 1, 2 and 5, the model simulates equivalent (a) times to reach the maximum length of the plume; and (b) maximum plume lengths. The main differences between these scenarios as shown in

Figure 13-7 are (c) the times the maximum plume lengths will remain (longer for Scenarios 2 and 5); and (d) the durations of the tail that reflects the end of the attenuation (longer for Scenarios 2 and 5).

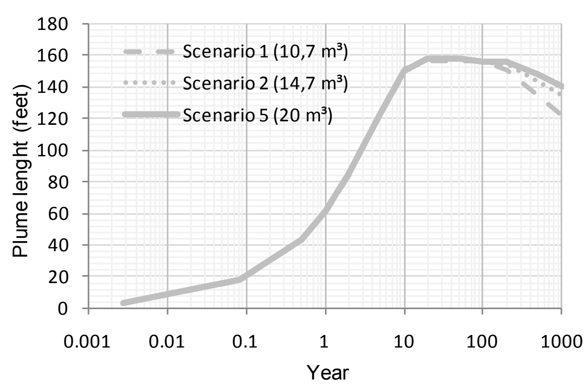

Figure 13-7 Comparison of Benzene Spill Scenarios
Source: CH2M HILL 2011

Toluene Release Scenarios: Spill scenarios 3, 4 and 6 (Toluene releases from different sources) are conceptually similar. However, Scenarios 4 and 6 present spill volumes that are respectively, 300% and 400% more important than Scenario 3. For scenarios 3, 4 and 6, the model simulates equivalent (a) times to reach the maximum length of the plume and (b) maximum plume lengths. The main differences between Scenarios 3, 4 and 6 as shown in

Figure 13-8 are (c) the time the maximum plume length will remain (longer for Scenarios 4 and 6) and (d) the duration of the tail that reflects the end of the attenuation (longer for Scenarios 4 and 6).

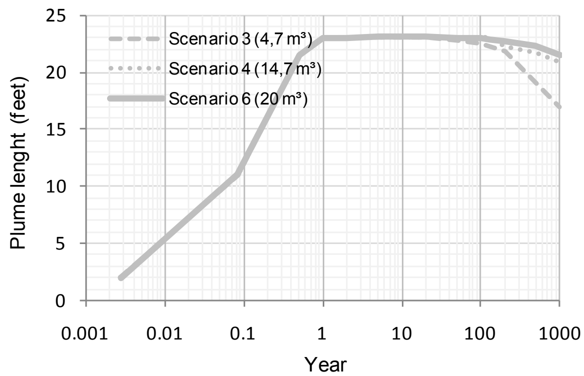

Figure 13-8 Comparison of Toluene Spill Scenarios
Source: CH2M HILL 2011

Comparison between Benzene and Toluene scenarios: The main difference between Benzene and Toluene scenarios are (a) their solubility (three times greater for Benzene); (b) the first order decay coefficient (10 times greater for Toluene); and (c) the intervention concentration limit which is in the order of µg/L for Benzene and mg/L for Toluene.

As a consequence of Benzene's high solubility, the plumes achieve greater lengths from the source. The difference between the plume lengths of Benzene and Toluene is in the same order of magnitude as that between their respective solubilities.

Sensitivity of K (Scenario 2): By increasing K, the plume length is increased, reaching slightly below 350 feet with the highest conductivity (see

Figure 13-9 below is the duration of the plume maximum length is on the other hand reduced with an increased K, however this duration is still in the order of a century. This reduction is due to the fact that with a higher permeability, higher flow rates are achieved as well as an increased "washing away" effect of the product.

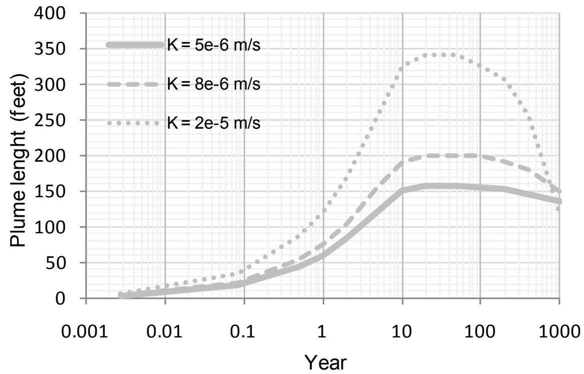

Figure 13-9 Sensitivity of Scenario 2 with respect to the variation in K values
Source: CH2M HILL 2011

Sensitivity of intervention limit (Toluene): The intervention limit for Benzene is in the order of µg/L, whilst in the case of Toluene it is in the order of mg/L. Decreasing the intervention limit for Toluene will increase the length of the plume. Switching from 1 mg/L to 5 µg /L will increase the length by 50 to 100%. For example,

Figure 13-10 refers to the influence of the intervention limit on Scenario 3.

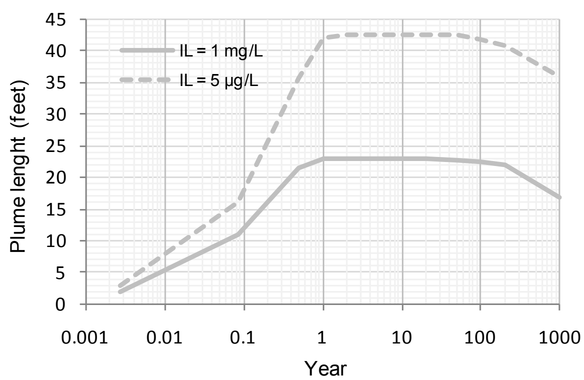

Figure 13-10 Sensitivity of Scenario 3 with respect to variation of intervention limit
Source: CH2M HILL 2011

13.4 Impact Assessment

13.4.1 Construction Phase

13.4.1.1 Overview

Specific activities during the construction phase of the RTIP project, which have the potential to result in environmental impacts to soil and groundwater include (but are not limited to):

- Earth movement, including the excavation of higher terrain areas and backfilling for surface levelling, removal of surplus soil and the laying down of pipelines and cables;

- Excavation and dewatering (if necessary) in order to lay down foundations and/or support piles;

- Facility construction, movement of heavy equipment and general construction traffic. This includes the set-up of associated temporary infrastructure and the storage of construction materials;

- Maintenance of construction machinery (such as washing of concrete and cement mixers, minor repairs of vehicles and heavy equipment, etc.) within or outside the maintenance complex; and

- Storage and distribution of fuels, which have a significant potential to be the cause of spills.

There is a range of potentially polluting substances which may be involved during the construction phase which could have an impact on baseline groundwater quality as a result of accidental spillage. It is however assumed that best practice will be adopted, e.g. appropriate bunding (secondary containment) and security containment for particularly hazardous liquids. The most common pollutant spills are most likely to be of fuel oils. However, it is anticipated that any volume spilled will be minimal and can be adequately contained through the immediate excavation of contaminated sands in less than 24 hours.

Impacts arising from these activities range from the degradation of soil and groundwater as a direct consequence of construction activities, to impacts caused by accidental spills and accidental releases. Given the nature and volumes of hazardous materials present at the RTIP site during the construction phase, only minor spills and accidental releases have been considered.

13.4.1.2 Evaluation of Impact and Mitigation Measures

The following potential impacts on the soil and groundwater resources have been identified during the construction phase:

Negative impact resulting in the degradation of soil quality (primarily through shallow soil compaction) due to earth works, facilities construction, movement of heavy equipment, construction traffic, set-up of associated temporary infrastructure and storage of construction materials (Refer to issue O1) - Continuous, certain, local extent, long duration, low magnitude and low significance.

During the construction activities, earthworks (levelling, excavation, earth movements and backfilling) will compact and degrade the shallow soil within the boundaries of the Site. Construction activities also have the potential to increase the effect of wind and storm water erosion, thus reducing the amount of organic nutrients available for plant growth. It is estimated that approximately 4,700,000 m^3 of soil will be moved during the construction phase within the Site. However, there have been significant earthworks at the site associated with preliminary site preparation by the Royal Commission, and approximately 70% of the surface soils have thus already been compacted (prior to the start of the project). Although there have been impacts arising from prior site preparation, the site geology is nevertheless not of significant interest as the soil is (as described in Section 6) sandy loam with occasional hard pan outcroppings and with low organic content, low levels of nitrogen, phosphorus, potassium and organic content is considered to be of very low agricultural value.

Negative impact on the RTIP water catchment due to the alteration of drainage characteristics (including dewatering) and modification of the storm water flow and recharge regime (refer to issue O2) – Continuous, certain, local extent, long duration, medium magnitude and low significance.

During construction, activities such as levelling, vehicle movements and plant construction may alter rainfall infiltration rates due to soil compaction or the construction of impervious surfaces that will alter natural surface water drainage. After construction, these facilities will alter drainage and infiltration rates for the duration of the RTIP project life. These activities may affect groundwater recharge rates, thus increasing the salinity of groundwater.

Dewatering may be required for the installation of deep sumps and service facilities As the groundwater table at the RTIP site is approximately between 2.2 m to 12.5 m below ground surface (mBGS), dewatering may also affect groundwater flow. Earth movement may increase the effects of storm water erosion and the loading of suspended solids in storm water runoff following heavy rains.

Given the small area (limited to the RTIP site and Jubail Industrial City) that will be impacted by the diminishing recharge rate, the dry climate in the area and the poor quality of groundwater in the shallow aquifer, the significance of the impact is considered low.

Recommended Measures Issue O2

- Provide a temporary or alternative pathway for stormwater drainage during the construction phase, avoiding the elimination or the temporary closure of the natural run-off pathways;

- Ensure that the drainage system is cleaned from time to time, so it is always able to carry the volume of storm water for which it was designed;

- Careful design and planning of construction is suggested, with consideration over the shallow depth of groundwater (which ranges from 2 to 12 mBGS). Careful design of the final land elevations could reduce the requirement to dewater and excavate below the water table;

- If dewatering is required, then appropriate site specific design and planning for the disposal of groundwater is needed. Although the baseline data does not indicate the presence of contaminants in groundwater, sampling and analysis of groundwater is recommended prior to disposal; and

- Develop and implement a groundwater monitoring programme to monitor groundwater quality.

Negative impact resulting in the degradation of soil and groundwater quality due to minor accidental releases and spills of hazardous materials during construction (refer to issue O3) – Rare, likely, local extent, short duration, low magnitude and low impact.

The great majority of materials to be used during the construction phase are considered to be non hazardous and their storage onsite is not considered to create a serious risk of releasing hazardous chemicals into the soil and groundwater. Small quantities of materials such as oil, lubricants, resins, and solvents are expected to be used during the construction phase.

Medium to large amounts of paint and paint solvents are expected to be used in the final phases of construction. In addition, large amounts of fuel and maintenance fluids will be present onsite for the operation and maintenance of vehicles and construction equipment. It is estimated that, on average, over 700 vehicles will be in operation 12 hours a day, six days a week for up to 40 months in addition to a large fleet of construction equipment that includes compressors, generators, cranes, manlifts, forklifts and pumps. The presence of a large fleet of construction equipment and vehicles onsite poses risks of small spills and releases of fuel and maintenance fluids occurring, affecting shallow soil and groundwater. Groundwater models prepared for the RTIP project site indicate that the aerial extent of spilled materials with low solubility remains small in soil and groundwater even if spill measures are not implemented.

In addition to hazardous material releases, there is also a small risk of releases of concrete or cement taking place in areas where the pre-casting of structures takes place. As construction progresses and the number paved roads and surfaces increases, the risk of accidental releases and small spills reaching the soil and the shallow groundwater will decrease. Furthermore, the soil quality at the site is not of significant interest as the land is of very low agricultural worth and nutrient content (Section 6), and the groundwater is not an important resource in the area.

Recommended Measures Issue O3

Prevention and control measures to reduce the risks of contamination include:

- Develop a comprehensive Spill Prevention and Containment Plan (in accordance with RCJY environmental regulations) to ensure safe onsite storage of hazardous materials; handling and containment of accidental spills and releases. The plan shall also address the transfer and disposal of spilled materials as hazardous waste and mitigating measures documented to contain any spills. Continually monitor and re-evaluate the effectiveness of the plan;

- Implement procedures indicating the characteristics and maintenance record of the transportation vehicles to be used, trying to minimize as much as possible potential release/spills related to the bad condition of automotive parts (valves, pumps in the trucks, etc);

- Pre-casting of concrete structures will be conducted in paved areas, with a large enough extent and gradient to prevent the spilling of concrete or cement onto bare soil;

- Designate an offsite fuel distribution facility for construction vehicles and equipment that is equipped with spill containment and prevention measures. If due to project requirements, the refuelling of construction vehicles and equipment needs to take place on the RTIP site, a fuel storage and distribution facility with appropriate spill containment and prevention measures should be built as part of the facilities' temporary infrastructure, and an integrity testing programme (which includes integrity tests and volume balance) should be put in place; and

- Develop and initiate a groundwater monitoring programme to monitor groundwater quality.

Negative impact resulting in the degradation of soil and groundwater quality due to minor accidental releases and spills during maintenance of construction equipment and vehicles (refer to issue O4) – Infrequent, likely, local extent, short duration, low magnitude and low impact .

Due to the large numbers of construction equipment and vehicles at the RTIP site, it is very likely that maintenance activities will occasionally take place. Maintenance activities that can take place at the RTIP site will include small repairs of malfunctioning equipment, emergency repairs of leaking equipment, use of small amounts of lubricating oils and washing of concrete mixers and ready mix trucks.

Small maintenance tasks do not pose a significant risk of impacts to the soil and shallow groundwater as long as the maintenance activities are limited to occasional repairs (such as those needed to repair a leaking pipe or gasket). If the number of maintenance tasks increase, then the risk of small accidental releases and spills will also increase.

The washing of concrete mixers and the interior of ready mix trucks does pose a risk of impacts on soil and shallow groundwater, resulting in their degradation if large amounts of water are used to wash the interior or concrete mixers and tanks; washing takes place in areas without a wash water collection system; and/or if excess cement or concrete are allowed to spill onto the soil. The release of concrete wash water can result in the degradation of shallow groundwater quality by introducing increased amounts of suspended and dissolved solids, and increase the compaction and cementation of soil.

As construction progresses and the number of paved roads and surfaces increases, the risks from accidental releases and small spills will decrease. Furthermore, the site geology is not of significant interest, as the land is of very low agricultural worth and nutrient value (Section 6), and the groundwater is not an important resource in the area.

Recommended Measures Issue O4

Prevention and control measures to reduce the risks of contamination include:

- The RTIP site will have a designated site for the occasional maintenance of vehicles and construction equipment. The maintenance area will have a comprehensive spill prevention and containment plan to ensure the safe handling and containment of accidental spills and releases, onsite storage of hazardous materials and the transfer and disposal of spilled materials. Continually monitor and re-evaluate the effectiveness of the plan;

- Keep construction equipment and vehicle maintenance activities onsite to a minimum. Only emergency repairs (such as those needed to stop a spill of hazardous material) should be conducted outside the maintenance area; and

- Washing of concrete mixers and trucks should only take place in paved or lined areas with appropriate wastewater collection measures. It is recommended that the wastewater generated during washing of concrete mixers and trucks be given sufficient time to allow for the settlement of solids, prior to its treatment and/or disposal. Treatment of the remaining wastewater should take into consideration its pH and dissolved solids load.

13.4.2 Commissioning

13.4.2.1 Overview

Commissioning will involve testing the integrity of storage vessels and pipes with large amounts of water that will be used to hydrotest the integrity of storage vessels, pipes and valves prior to emplacement of raw materials and feed stock. After testing, water will be flushed and pipes and valves will be air blown. It is expected that test water will be disposed of to the Marafiq IWTP.

Hazardous materials are expected to be transported to the site, stored and utilized during different phases of the commissioning phase. The risk of negative impacts on the soil and groundwater due to small accidental releases and spills of hazardous materials is not negligible at the commissioning phase:

- For the process plants, commissioning includes the testing of the plant's systems using a test medium in the lines. It is expected that the test medium for process testing will include materials with the same properties as the raw materials and feed stock, and as such are considered hazardous;

- For all plants, it is anticipated that a small quantity of hazardous construction materials such as oil, lubricants, resins, paint and paint solvents will be used during the commissioning phase (for small modifications, repairs and touch-up); and

- After commissioning and prior to start–up, raw materials and feed stock will be transported to the storage areas of the RTIP site. Solid materials will be transported via different ground, air and maritime transportation routes to the RTIP site. Liquid materials will be transported either via ground or air transportation routes to the RTIP, or via maritime transportation to the RTIP port and from there via pipeline to the RTIP site.

Specific activities during the commissioning phase of the RTIP facility with the potential to cause environmental impacts to soil and groundwater include (but are not limited to):

- Disposal of flushed water after the hydrotesting of equipment;

- Small accidental releases and spills of liquid hazardous materials used as test medium during the commissioning of process plants or during the modification, repair or touch-up of equipment (applicable to any plants or processes where testing reveals that small modifications and repairs are necessary); and

- Small accidental releases and spills of solid or liquid hazardous raw materials and feed stock during their transportation and initial storage at the RTIP Site.

Environmental impacts during the commissioning phase are expected to be minimal given the nature and estimated quantity of materials involved. Impacts arising from these activities are related primarily to accidental spills and releases. Given the nature and volumes of hazardous materials present at the RTIP site during the commissioning phase, only minor spills and accidental releases have been considered.

13.4.2.2 Evaluation of Impacts and Mitigation Measures

The following potential impacts on the soil and groundwater resources have been identified during the commissioning phase:

Negative impact resulting in the degradation of soil and groundwater quality due to minor accidental releases and spills of hazardous materials during commissioning (refer to issue O5) –Rare, unlikely, local extent, short duration, low magnitude and low significance.

Small amounts of hazardous materials are expected to be utilized during the commissioning phase, specifically for testing process plants and for minor repairs, modifications and touch-up. These materials will have to be transported and stored at the site and are expected to be treated as hazardous waste after utilization. The amounts of hazardous construction or testing materials to be utilized during commissioning are small. Because these materials will be utilized after the construction and initial inspection of the facilities (including their containment structures) is complete, it is considered that the potential for spills to impact the soil and ground water is smaller and thus the magnitude and impact of potential spills and accidental releases is considered to be low.

Recommended Measures Issue O5

Prevention and control measures to reduce risks of contamination include:

- Develop a comprehensive Spill Prevention and Containment Plan (in accordance with RCJY regulations) to ensure safe onsite storage of hazardous materials; handling and containment of accidental spills and releases. The comprehensive spill prevention and containment plan shall also address the transfer and disposal of spilled materials as hazardous waste. Continually monitor and re-evaluate the effectiveness of the plan;

- Keeping the amount of stored hazardous materials to the minimum and control access to said materials;

- Perform the majority of repairs within the maintenance complex; and

- Designate an offsite fuel distribution facility that is equipped with spill containment and prevention measures including integrity tested double-wall storage tanks, distribution lines and equipment. If, due to project requirements, any refuelling of construction vehicles and equipment needs to take place on the RTIP site, a fuel storage and distribution facility with appropriate spill containment and prevention measures should be built as part of the facilities' temporary infrastructure and a integrity testing programme (that includes integrity tests and volume balance) should be put in place. Underground storage and distribution equipment should be avoided to the maximum extent possible.

13.4.3 Operation

13.4.3.1 Overview

After commissioning, raw materials and feed stocks, solids, liquid and gases already available at the RTIP site will be introduced into the lines and equipment. Once the start-up operations are successful, the Units are ramped up to the normal operating capacities.

Normal operating activities with the potential to generate impacts to the physical onshore environment include but are not limited to (impacts associated with waste generation and management are included in Section 16):

- Collection and channelling of storm water;
- Use of fuel-powered emergency generators for the production of electricity;
- Transport, receipt and storage of raw materials, feed stock and utilities at RTIP facilities including but not limited to internal and external connections such as the tank farm at the Port Facility, the tank farm at RTIP site, the Third Party solids centre and liquids centre, feed stock tanks, fuel oil storage, water storage tanks, Third Party Truck Inspection and Dispatch (TI&D), and Third Party Container and Marshalling Yard (CMY);
- Process of raw materials and feed stock to produce intermediate and final products at the process plants (the hydrocarbon and chlorine units and the chemicals and plastics derivative units);
- Internal distribution of raw materials, feed stocks, and intermediate and final products through site utilities;
- Packaging, delivery and transport of products from RTIP facilities through internal and external connections to the different points of issue that include the Port Facility, the Third party solids centre and the liquids centre, Third Party TI&D, and Third Party CMY; and
- General maintenance, repair and modifications of equipment at RTIP (in or outside of the Maintenance Complex).

Impacts arising from these activities range from the degradation of soil and groundwater as a direct consequence of normal operations, to impacts caused by accidental spills and releases. Given the nature and volumes of hazardous materials expected to be processed and generated during normal operation at the RTIP facilities, minor and major spills and releases have been considered.

13.4.3.2 Evaluation of Impacts and Mitigation Measures

The following potential impacts on the soil and groundwater resources have been identified for the operations phase:

Negative impact resulting in the degradation of soil and groundwater quality due to accidental releases and spills of hazardous raw materials and feed stock during normal operations at the process plants, during maintenance of equipment, and storage and internal distribution through the utility infrastructure (refer to issue O6) – infrequent, unlikely, local extent, medium duration, medium magnitude, and medium significance.

Normal operations at the RTIP site involve the handling and processing of large amounts of hazardous materials, which gives rise to the potential for minor accidental spills and releases to reach the unsaturated soil and the groundwater. Surfaces and process plants are to be paved and equipped with Unit drainage systems as well as spill prevention and containment measures that include secondary containment (for up to 110% of the total stored volume) for tanks, process units and pipe racks; alarms and emergency response plans. In addition to the Unit drainage systems, the SDS is designed to collect and convey all surface drainage from areas outside of process envelopes and units, to holding or surge basins for later disposal and/or treatment. Surface Runoff (SRO) managed by the Interconnecting Facilities Surface Drainage System (SDS) includes fire water deluge flows, storm water flows and incidental spill event flows in excess of what the unit drainage systems are designed to manage, and is therefore deemed as potentially contaminated. SDS includes ditches and three SRBs. Pumps at the surface run-off basins will direct flows to appropriate destinations based upon water quality characterization. In all cases, the first flush water (with a volume equivalent to the first 30mm of a single rainfall event or the first 30 minutes of a fire water deluge event, whichever is greater) will be treated as contaminated water and will be collected separately in a dedicated unit sump and pumped to the wastewater treatment unit. SRO in excess of this first flush is collected and conveyed via ditches directly to the area's SRBs for management and control of quality before discharge to the RC Drainage Channel or to the wastewater treatment unit, as deemed appropriate. If the quality of the SRO collected in any given SRBs is found to be within the RC discharge standards it will be discharged to the RC Drainage Channel. If contaminated, it will be pumped to the wastewater treatment unit.

Groundwater modelling and spill scenario analysis show that the only instances where spills have the potential to reach the soil and from there the groundwater, is for finite volumes of hazardous materials that can spill from the piperacks or due to the failure of small tanks (IBS and tanker trucks). Groundwater modelling shows that the extent of any plume generated by these materials in groundwater will be limited to less than 50 m from the source area and will not reach sensitive receptors, however, if not remediated, it can have permanence in the groundwater for centuries.

Mitigation Measures Issue O6

Prevention and control measures to reduce risks of contamination include:

- Develop a comprehensive spill prevention and containment plan (in accordance with RCJY regulations) to ensure safe onsite storage of hazardous materials; and handling and containment of accidental spills and releases. The comprehensive spill prevention and containment plan shall also address waste minimization and the transfer and disposal of spilled materials as hazardous waste. Continually monitor and re-evaluate the effectiveness of the plan;

- Visual monitoring of the Surface Drainage System. Prompt repair of malfunctioning equipment. Minimize the volumes of SRO stored at SRBs;

- Implementation of spill detection systems;

- Develop and implement a groundwater monitoring programme to monitor groundwater quality; and

- Perform the majority of repairs (to the extent possible) within the maintenance complex.

Negative impact due to accidental releases and spills of hazardous materials (including fuel) during the transportation of raw materials, feed stocks and products on or off-site (refer to issue O7) – infrequent, unlikely, local, short duration, low to medium magnitude, and low to medium significance.

It is expected that large amounts of hazardous materials are transported to and from the RTIP site, managed and processed. Hazardous solid materials will be transported in trucks to the Third Party owned and operated TI&D area and from there to the solids handling centre or the Container Storage and CMY on the RTIP site. At the Third Party solids handling centre, solids product materials will be transferred using pneumatic transfer equipment to dedicated storage silos or in boxes and bags to warehouses. Shipment of solid raw materials will be done using either long-distance truck transport or short-distance truck transports (from either the Port facilities or from the local cargo airport).

The Solid Waste Unit (Unit 778) will handle all the hazardous wastes generated within the RTIP facility and send them offsite to recycle/ reuse purposes or disposal facilities. In either case, the transportation of solid hazardous materials at the site will take place via newly constructed roads and access routes, which will increase the likelihood of traffic accidents and may result in releases of hazardous materials onto the soil and/or groundwater.

Hazardous liquid materials will be transported to the Port facility by maritime transport and from there, they will be fed into the RTIP feed stock tanks using pumps, pipes and valves. Some liquid hazardous materials will be transported to the site's Third Party liquids centre via tanker trucks. The transfer of liquid hazardous materials will take place using unloading bays with transfer pumps, loading arms and automated filling systems either at the port or at the facility. All Units designated for the receipt/shipment, warehousing, storage and distribution of hazardous materials are to be equipped with a surface drainage system, designed with the purpose of collecting and managing surface runoff and small spills.

The amounts of hazardous materials amenable to spills during loading of raw materials and stocks are expected to be small (maximum tanker volume is 20 m^3). Groundwater modelling and spill scenario analysis shows that the extent of any plume generated by hazardous materials in groundwater will have a limited extent (less than 50 m downgradient from source) and will not reach sensitive receptors, although if not remediated, can remain in groundwater for centuries.

<u>*Recommended Measures Issue O7*</u>

Prevention and control measures to reduce risks of contamination include:

- Develop a comprehensive Spill Prevention and Containment Plan (in accordance with RCJY) for the RTIP facility excluding third party units to ensure safe onsite storage of hazardous materials; handling and containment of accidental spills and releases, and transfer and disposal of spilled materials as hazardous waste. Continually monitor and re-evaluate the effectiveness of the plan; and

- Integrate spill prevention and containment measures into the transportation plans for third-party vendors.

13.4.4 Decommissioning

13.4.4.1 Overview

Specific activities of the decommissioning phase with the potential to cause environmental impacts to soil and groundwater include (but are not limited to):

- Flushing of materials remaining in process plants and transport pipelines and valves for re-utilization or waste management (recovery, packaging and recycling of hazardous materials as hazardous waste is covered in Section 16);

- Dismantling and demolition of infrastructures, including the excavation of underground structures; facility demolition; movement of heavy equipment and general construction traffic. This includes building associated temporary infrastructure such as waste holding pads and the temporary storage and re-utilization of inert demolition waste. Management options for inert demolition waste include crushing the inert debris for re-utilization as fill or as aggregate, recovery and sale of recyclable materials (such as steel), or landfilling the inert construction debris;

- Earth movement for the restoration of surface conditions after deconstruction activities;

- Ex-situ or in-situ remediation of stained or contaminated soils that may be discovered after facility demolition (excavated soils that are to be managed as hazardous wastes are covered in Section 16);

- Maintenance of construction machinery (such as the washing of concrete and cement mixers, minor repairs of vehicles and heavy equipment, etc.) within or outside the maintenance complex; and

- Storage and distribution of fuels for deconstruction equipment from which the potential for spills can arise.

Impacts arising from these activities range from improvement of soil and groundwater quality as a direct consequence of decommissioning activities to negative impacts caused by accidental spills and accidental releases. Given the volumes of hazardous materials present at the RTIP site during the decommissioning phase, only minor spills and accidental releases have been considered.

13.4.4.2 Evaluation of Impact and Mitigation Measures

The following potential impacts on the soil and groundwater resources have been identified during the decommissioning phase:

Positive impact of ex-situ or in-situ remediation of contaminated soil discovered after the demolition of facilities (Refer to issue O8). - Infrequent, likely, local extent, long duration, low magnitude and low significance.

It is possible that after deconstruction and demolition activities are finished, small amounts of stained or contaminated soil are discovered. Considering that (unless a major spills has taken place during the operation of the RTIP Facility) the amounts of soil that may be stained are most likely small, the impact is considered to be positive and the negative impacts of transportation of stained soil (for ex-situ treatment) and energy use for remediation are considered negligible. Given the small volumes of soil that are expected to be discovered to be stained after infrastructure removal is complete, the magnitude and significance of this positive impact is considered to be low.

Positive impact resulting in an increase of groundwater recharge rates after demolition of facilities (Refer to issue O9). – Continuous, likely, local extent, long duration, low magnitude and low significance.

After the demolition of the facilities and the removal of impervious surfaces, rainfall infiltration rates will increase. The increase in groundwater recharge will depend on the compaction of the soil after decommissioning and to the extent to which crushed demolition debris is used as fill. It must be considered that if there is any soil or groundwater contamination remaining on the RTIP site after decommissioning, an increase in groundwater recharge rates through the soil will probably translate into contaminants reaching the groundwater or in an increase in the volume of soil impacted by contamination. It is possible that during the time that decommissioning activities take place, earth movement and demolition activities increase the effects of storm water erosion and the loading of suspended solids in storm water runoff after rain. Given the small area (limited to the RTIP project site) where groundwater recharge will increase after the decommissioning of the installation, the dry climate in the area and the low quality of groundwater, the magnitude and significance of the positive impact is considered low.

Negative impact on general soil and groundwater quality due to decommissioning activities, traffic and the management of inert construction debris (refer to issue O10) – Continuous, certain, local, short, low magnitude and significance.

Decommissioning activities are expected to include the dismantling and demolition of infrastructures, excavation of underground structures and backfill, the deconstruction of paved surfaces, the movement of heavy equipment, and general construction traffic. Temporary storage and re-utilization of inert demolition waste will also take place with crushing and re-utilization as fill. It is possible that some demolition debris will be recovered and recycled. All these activities will take place on soil that has already been compacted and not of significant interest as it has no agricultural value and has a low nutrient content (Section 6).

14 ECOLOGY IMPACT ASSESSMENT

14.1 Introduction

This section presents the results of the assessment of the terrestrial and marine ecology of the site in relation to the potential construction and operational impacts associated with the development of RTIP in the Kingdom of Saudi Arabia (KSA). This impact assessment section has been divided into two independent sub-sections: terrestrial and marine ecology.

The terrestrial ecology baseline investigation is based upon data collected during a field survey undertaken in November 2010 and information from a literature review (desktop study). The marine ecology baseline investigation is based upon a literature review, including the *Environmental Impact Assessment for the Ras Tanura Integrated Project – Dredging* prepared by the Research Institute of King Fahd University of Petroleum and Minerals (KFUPM/RI, 2009). Both sections are also based on prior knowledge of the habitats, flora and fauna of the general region and of other similar areas of the Arabian Gulf region (see Section 6 Ecology for further details on the terrestrial and marine baseline conditions) and on the RTIP design information provided in Section 3, Project Description. Operations and impacts of previous similar developments in KSA were also reviewed.

The marine ecology impact assessment is focused on two areas; Jubail and Ras Tanura, between which the King Fahd Industrial Port (KFIP) is located. Ras Tanura is approximately 50km south of RTIP and provides the regional context for this section. In addition, the potential for long shore current from the Port area to carry a spill of fuel or cargo southward to this area, means that the coastal area between KFIP and Ras Tanura is also considered a potential receptor in the case where a spill or release cannot be contained in the KFIP area. It should be noted that the KFIP has the responsibility to contain spillages or overflows and conduct clean-up operation in case of a pollution incident within the port facilities.

The terrestrial and marine data was used to assess the impacts of RTIP during construction, commissioning, operations, decommissioning and from spills/accidents.

The impact assessment for biological resources follows best practice guidelines published in the UK (Treweek, 1999; Institute of Ecology & Environmental Management [IEEM], 2006) and broadly applicable to other countries. The IEEM defines an ecological impact as the “biophysical or environmental changes that occur as a result of development activities”. The aim of an ecological impact assessment is to:

- Determine the significance of impacts on valued ecological receptors. The significance of an impact depends on the value of the ecological receptor and the scale or magnitude of the impact.

- Demonstrate that proposed developments will meet the legal requirements relating to species, sites or habitats.

Potential impacts on the biological resources from activities during the construction, commissioning, operations, decommissioning and from spills/accidents are assessed in following sections. The biological resources impact assessment is summarised and tabulated in Section 20 – Summary of Impacts (Table 20-1). The magnitude and significance of the impacts are defined according to the criteria presented in Section 11 – Assessment of Impacts and are also stated below at the end of each subsection (in bold italic). Next to each magnitude/significance statement and for ease of reference, each issue is identified by a unique number which is repeated in Table 20-1 and subsequently in Tables 21-1 (Mitigation Table) and 22-1 (Monitoring Table), where applicable.

14.2 Terrestrial Ecology

14.2.1 Construction

Two types of communities were identified on the RTIP site, sometimes mixed with clumps of date palm trees: 1) A community of moderately saline tolerant shrubs; and 2) A community dominated by perennial grasses. The only remaining vegetation outside the project site lies in the southwest corner and along the southern edge, where the same vegetation pattern is repeated. This habitat continues to the west of the site.

14.2.1.1 Terrestrial Impacts - Onsite

During construction, biological resources have the potential to be affected by habitat disturbance, dust, noise, lighting, presence of structures, vehicle traffic and worker activity within the site's boundary. There is also potential for habitat fragmentation due to road cutting and grading, though to a lesser extent due to the minimal vegetation cover at the project site.

Construction activities, such as clearing and grubbing operation, excavation and demolition of existing structures, and vehicle movement will increase noise which may however cause disturbance to local birds and fauna moving within, or close to, the project site. Construction noise will be over a period of 40 months duration but permanent sensitive receptors are not expected to be affected.

The main impact will, however, be the loss of habitat; the main site has a total of 576 Hectares (ha). Approximately 70% of the area of the main site has previously been mechanically graded by other entities, leading to compaction of the surface and loss of natural vegetation. The port facilities will have an area of 24.5 ha, but will require no site preparation; therefore no incremental habitat loss is expected. Additional losses might also be attributed to the process of constructing new temporary and/or permanent camps, laydown areas, roadways, pipelines; these other project areas outside the main site and the port are expected to occupy a maximum of 25 ha (17.8 ha + roadways + pipelines), and most of this land is expected to be undisturbed desert lands. Therefore, total habitat loss associated with construction of RTIP is not expected to exceed 180 ha, and corresponds mainly to the undisturbed area southwestern area of the main site.

The undisturbed 30% of the RTIP site contains an average of 15-20% vegetation cover (maximum of 40% observed). This vegetation consists mainly of a community of moderately saline tolerant shrubs, mixed with a community dominated by perennial grasses, and clumps of date palm trees. It is generally observed to be in poor condition due to waste disposal or over-grazing.

Existing habitats onsite are considered of low ecological value, as they are likely to support low numbers of common desert wildlife species, including resident, migratory and wintering birds together with resident mammals and reptiles. This type of disturbed habitat is widespread throughout the developed areas of the Arabian Gulf region, and present outside the project site, particularly towards the southwestern side of the site, therefore the loss of this type of habitat is considered an impact of local extent as extensive areas of less disturbed habitat occurs to the north and west of the proposed project area.

The RTIP project will result in a minor net impact on the ecology of the surroundings of the project, already disturbed by the Jubail Industrial City because of the low value of the habitats impacted by the project. The project will utilize the existing port facilities and will require no site preparation, thereby avoiding the associated impacts to the coastal zone. Impacts are therefore assessed as being of medium magnitude and of low significance.

In spite of the presence of limited vegetation at the southwestern area of the RTIP site, no animals, like hares and rodents, or signs of them, like tracks, burrows or scats, were seen. It is likely that little or no native herbivorous mammals are currently using the site under the existing conditions. Several vegetation quadrats showed signs of grazing, most likely by goats. It is likely that these better vegetated parts of the site support populations of the more common and widespread small mammal species, including the Red Fox (*Vulpes vulpes*) which could occur on the site, or feral dogs. Although the presence of fauna is likely in this area, the sparse vegetation cover and its current degraded state would result in minimal impact to existing native mammal populations occurring on or adjacent to the project site.

Impacts of construction therefore include removal of vegetation, potential displacement of associated fauna, migratory and breeding birds.

Biological Resources Impact (refer to Issues B1) - Medium Magnitude, Low Significance

Biological Resources Impact (refer to Issues B2, B3, B4) - Low Magnitude, Low Significance

14.2.1.2 Terrestrial Impacts - Offsite

The main RTIP site is approximately 18km from the shoreline, but it will have a tank farm and loading and unloading facilities at the existing Jubail Industrial Port which is located within an ecologically diverse area of the Arabian Gulf.

Vegetation and fauna adjacent to the RTIP site are likely to be impacted due to the effects of dust settlement, vibration, lighting and noise from earth moving vehicles during the construction period (see Section 15 for further details on Noise).

The project site is located in a low-lying area along the eastern coast, where saline soils covered with halophytic (salt-tolerant) shrubs are predominant, though sand sheet areas, areas of standing water or wet mud basins, and beach habitats are also present. Generally, only a very small number of endemic plant species occur in these desert areas and most have large regional ranges.

Vegetation in the vicinity of the main site may be affected by dust from construction; however, desert vegetation has defence mechanisms and tolerance of high dust conditions that are naturally prevalent in the region, in naturally occurring sandstorms.

Increasing lighting and glare could potentially disturb or displace nocturnal fauna foraging around the site. Increased noise due to site grading and excavation may also cause disturbance to fauna and specifically to migratory or breeding birds residing at the coastline area.

The Sabkhat Al-Fasl Lagoons (listed as IBA for its important breeding and migrant populations of waterfowls) are located approximately 10km north of the main site, and the main site will be the area of most construction intensity. This separation distance will attenuate noise, vibration and disturbances from noise, vibration and human activities to some degree, thereby lessening the direct impact on wildlife occurring in this area, considered of high ecological importance (see Figure 15-2 showing noise emission contours over the RTIP site and the surroundings areas in Section 15 Noise Impact Assessment). This impact is considered to be of low magnitude and low significance.

Tarut Bay, also listed as an IBA for its important breeding and migrant populations of waterfowl, is located too far from the RTIP site to consider potential disturbance due to project activities (about 60km southeast of the project site at Jubail).

Biological Resources Impact (refer to Issues B2, B3, B4) - Low Magnitude, Low Significance

Recommended Measures

Construction impacts are likely to be of minor negative significance onsite prior to mitigation and of potential minor negative significance to migratory birds off site. During the 40 month construction period, the land based works should to be assessed in relation to the following issues:

- The impact on vegetation within the footprint of the RTIP operational site;
- The impact on vegetation at locations which are to be used as temporary compounds or storage areas; and
- The effects of construction on other aspects of terrestrial ecology.

The use of modern properly maintained vehicles together with other driving policy measures like minimising off road driving and transporting materials in bulk to minimise trips, should reduce the local impact of emissions on the biological environment from vehicle movement to and from the site during all phases of the project.

14.2.2 Commissioning

Commissioning is likely to increase ambient lighting and noise levels inside and outside the fenceline (for noise, see Section 15 - Noise) due to additional security. Lighting and noise have the potential to disturb local birds and fauna, but as the impact from commissioning will be of relatively short duration, and as there is a lack of sensitive receptors identified on the project site and the proximity of existing neighbouring industries, impacts from the commissioning phase are considered to be of low magnitude and low significance.

The physical presence of the facility is unlikely to present an impact to migrant and breeding birds due to the lack of suitable onsite habitats and the presence of existing neighbouring industries.

Potential effects of elevated air pollution on vegetation from major combustion sources from within RTIP during commissioning are discussed in detail in Operation, Section 14.2.3.

Biological Resources Impact (refer to Issues B5) - Medium Magnitude, Low Significance

Biological Resources Impact (refer to Issues B2, B3, B4) - Low Magnitude, Low Significance

14.2.3 Operation

14.2.3.1 Terrestrial Impacts - Onsite

A number of activities could potentially affect biological resources during the operations of RTIP.

Lighting. Routine operations will require security lighting, which will increase ambient light intensities and glare. Many desert dwelling animals are nocturnal species and are sensitive to light levels, and may avoid areas of high light intensity. Due to the lack of sensitive receptors, potential habitats on the project site and the proximity of existing industries in the vicinity of the project site, it is unlikely that lighting will have a negative impact to nocturnal species. As the effect of lighting would largely apply to only a few individuals, overall the potential impacts are considered to be of low magnitude and low significance.

Overall, the potential impacts of increased light and glare are considered to be of low magnitude and low significance. However, as a good practice measure, perimeter lighting should be fitted with shields and tilted inward towards the facility to minimise glare.

Biological Resources Impact (refer to Issues B4) - Low Magnitude, Low Significance

Noise. Routine operations will generate noise which is expected to reach 60-65 dB(A) at the fenceline of the main site, and will decrease to 45 dB(A) within a 1 km radius. Many desert dwelling animals are sensitive to noise, and may avoid areas of high noise intensity near the fenceline. Due to the lack of sensitive receptors, potential habitats on the project site and the proximity of existing industries in the vicinity of the project site, it is unlikely that noise will have a negative impact to fauna. As the effect of high noise levels would largely apply to only a few individuals, overall the potential impacts are considered to be of low magnitude and low significance.

Biological Resources Impact (refer to Issues B2) - Low Magnitude, Low Significance

Air Pollution. Process facilities may increase pollutants in the vicinity of the RTIP and could affect vegetation, mammals, birds and reptiles. According to the monitoring performed, the background level of ozone concentrations, PM2.5 and PM10 respectively surpass current standards. Therefore and according to the results of the modelling performed, any project emission of PM2.5, PM10 and ozone precursors (NOx and VOCs) will result in an exceedance of the said standards (refer to Section 12 Air Quality Impact Assessment for further details).

Ozone in the lower atmosphere is an air pollutant with harmful effects on the respiratory systems of animals and will burn sensitive plants. High concentrations of ozone cause plants to close their stomata, thus slowing down photosynthesis and plant growth. Ozone may also enter the plants through the stomata and directly damage internal cells.

No special status is assigned to the habitat and fauna on site or in its vicinity, and ozone concentrations, although present in the atmosphere due to the number facilities in operation at the Industrial City, are not expected to significantly impact the coastal areas to the north of the site. Air pollution effect on vegetation has been defined as a negative impact of low magnitude with a low significance, according to the criteria defined in Section 4 - Assessment of Impacts.

Biological Resources Impact (refer to Issue B5) – Low Magnitude, Low Significance

14.2.3.2 Terrestrial Impacts - Offsite

The effects of vehicle movement, dust, and pollution on fauna and flora are not likely to have any serious affects on the areas immediately surrounding the RTIP site. Lighting and glare can however extend into offsite habitats. Lighting should be shielded on the outward side of the fence line or canted to ensure only a perimeter strip is illuminated for security purposes.

Biological Resources Impact (refer to Issue B3) - Low Magnitude, Low Significance

Recommended Measures

Use of modern properly maintained vehicles together with other driving policy measures like minimising off road driving and transporting materials in bulk to minimise trips, in order to reduce the local impact of emissions on the biological environment from vehicle movement to and from the site.

Minimise air emissions during commissioning and operation of RTIP using the BAT approach, which is adopted in the design, to reduce effects of emissions on flora and fauna from RTIP.

14.2.4 Decommissioning

The impacts during decommissioning will be similar to those predicted during site construction in terms of disturbance to mammals and other fauna due to the demolition of structures and subsequent removal from the Site. Should new habitats be created on- or off-site a potential exists for these to be impacted during decommissioning. However, as its duration is short term the effects are likely to be of low magnitude and low significance.

Biological Resources Impact (refer to Issues B2, B3, B4) - Low Magnitude, Low Significance

14.2.5 Accidental Events

From the perspective of biological environment the risk of spills relates mainly to those resulting from a release from vehicles transporting product, diesel or other materials around the site. Product pipelines and waste lines are potential sources of spills to the biological environment, although the likelihood of occurrence is less, the significance would be major. Spills therefore remain a concern notwithstanding spill response efforts to minimize the risk.

As mentioned above, there is the potential for accidents and spills to occur during all phases of this project (construction, commissioning, operation and decommissioning) on the numerous product pipelines and waste lines that lead to and from the RTIP facility which could affect small numbers of wildlife at isolated locations. The impact of releases from waste tanks or stored products or chemicals will be minimised since in addition to providing primary containment, all units and operations will provide and maintain secondary spill containment. Overall however, the potential effect on vegetation and fauna is considered low due to the low potential for its occurrence, low likelihood of a release not being managed and localized impact.

RTIP will take steps to minimize the risk of spills and prepare to respond quickly and effectively should such an event occur. The petrochemical units will form an integrated complex which will include designated oil handling facilities pursuant to the Royal Commission Regulations (RCER). The RCER 2010 requires an Environmental Emergency Response Plan (EERP), supported by appropriate training and exercise initiatives, to be developed and implemented. The scope of the plan will cover both natural incidents and operational accident scenarios including spills, release of hazardous materials, fire and road accidents which may occur during the course of normal / abnormal operations.

No sensitive habitats of value within the project site are likely to be affected by accidental spills, fires or the release of potentially hazardous materials to the environment, as none were identified on the project site. A groundwater transport simulation has been performed for toluene and benzene (which are worst case scenarios spills in terms of toxicity, solubility and density) in the event that a spill reaches the groundwater body (see

Section 13 Onshore Physical Impact Assessment for further details). The results shown that in the event of a spill reaching the saturated zone of the aquifer, the maximum plume length would be 160 feet (approximately 47 meters) and that the plume travel would be so slow that there will be enough time to remove the source and remediate. The maximum plume length would stabilize in a period less than 30 years. Thus, it is highly unlikely that the Sabkhat Al-Fasl Lagoons, located 10 km to the northeast of the site will be impacted should a release to the environment be significant and not managed.

Spills from product pipelines, waste lines and tanks would cause a more significant impact than a release from a vehicle due to the potential size of the release. However, storage tanks will have a secondary containment and bunding to hold 110% of the largest tanks so the chances of any spill breaching the bunded area would be highly unlikely. For offsite pipelines, leak detection should be provided by the implementation of a mass flow balance detection system for above ground hydrocarbon pipelines, in accordance with the requirements of ASME B31.4 Section 451.11. Where installed, flow meters will be required at both ends of the pipelines. Both ends will need to be specified to achieve a degree of repeatability rather than accuracy in order to allow the system to work. In addition, any spill from piperacks will be very brief (before controlled shut-off occurred), would move slowly and any spill is monitored thorough leak detection methods, so in the case of a spill there would be enough time for remediation before any sensitive receptors are impacted. Therefore, although the potential size of the release from tanks and piperacks could be major the impact occurrence is unlikely, while the probability of impact occurrence from vehicle spills is likely but the released volume would be relatively small.

Biological Resources Impact (refer to Issue B6) - Low Magnitude, Low Significance

14.3 Marine Ecology

In this section, potential impacts on marine environment that could arise as a result of the RTIP development in all its phases are discussed.

Impacts resulting from activities that are responsibility of the Engineering, Procurement and Construction (EPC) contractors have been also addressed.

The EPC contractors are responsible for protection of the marine environment during construction at the Port Facilities. EPC contractor prevention and management of marine impacts from surface runoff, accidental events, noise and dust are presented in this assessment.

EPC or Third Party contractors will be fully responsible for the collection, transportation and disposal of their own generated wastes (including wastewater) to either the RC waste facility, Marafiq Sanitary and/or industrial wastewater treatment plants, or an alternate site approved by RTIP and Royal Commission. The EPC contractor shall dispose of waste in accordance with the Royal Commission regulations and will be responsible for their own groundwater/ spill protection measures and spill prevention plan.

Assessment of the potential impacts on marine environment is discussed in the following sections.

14.3.1 Wastewater

This section presents activities and impacts associated with wastewater at both the main RTIP site and the Port site during all phases of the project. The three broad categories of wastewater are sanitary wastewater, process water and surface flow. Figure 3-5 (Section 3.3.4.13, Project Description) presents the process flow of wastewater at the site. It must be noted that impacts from sanitary water that is transferred to Marafiq SWTP, and of water effluents transferred to Marafiq IWTP are not assessed in this section, as treated effluent will be used for irrigation. Excess goes to a “wet area” or “wetland” for ultimate disposal.

Only wastewater effluents that are transferred to the sea have been considered.

14.3.1.1 Process Water

Construction

A concrete batching plant will be used during construction activities at the main RTIP site, and will generate wastewater. The quality of this wastewater will be monitored and if compliant with RCER Table 3C criteria and thresholds it will be discharged to the Royal Commission (RC) Drainage Channel (which carries clean discharges to sea). If, following testing, the concrete batching plant wastewater does not meet the water quality criteria of RCER Table 3C, it will be collected and trucked to Marafiq IWTP for further treatment and eventual discharge. Concrete batching plant wastewater will not be pre-treated before trucking to Marafiq IWTP.

Commissioning

The commissioning phase comprises equipment testing and pipeline and tank hydrotesting at both the main RTIP and Port sites. The potential impact to the marine environment during the commissioning phase is primarily related to hydrotest wastewater. Sourcing freshwater and proper handling hydrotest wastewater is the responsibility of the Owner’s nominated EPC contractors (see Section 3.6.5 of the Project Description.)

The estimated total volume of hydrotest water is 437,533m^3 throughout the duration of the mechanical completion of the process units. Currently, it is planned that the EPC contractors will source freshwater from Marafiq and avoid the use of any chemical additives to the hydrotest water. Should chemical additives be required, they should be selected for their low toxicity to marine life and should be used at concentrations and discharged at a rate which will not cause harmful effects to marine ecology beyond the immediate discharge mixing zone.

If the quality of the hydrotest water collected is found to be within the RCER discharge standards per RCER 2010 Volume-I Table 3C it shall be deemed “clean” and discharged to the Marafiq Seawater Cooling Return Header. Collected hydrotest water shall also be considered for use elsewhere in the plant, if found to be clean enough. This will minimise the net discharge volume of the hydrotest wastewater to the marine environment. In the event that water quality does not meet the Royal Commission standards for direct discharge, it shall be sent to Marafiq IWTP for further treatment and ultimate disposal.

Effluents from Marafiq's IWTP will be used for irrigation. Excess water goes to a "wet area" or "wetland" for ultimate disposal. No discharges to the sea are expected.

RTIP, in coordination with the Marafiq IWTP's management team, will review these activities and associated effluents in order to ensure that incoming wastewater from RTIP construction and commissioning activities can be appropriately received, treated and discharged.

Operation

The wastewater system (Unit 773) is detailed in Section 3.3.4.13 of the Project Description. The main wastewater stream to be generated during the operations phase will originate from the various process units in the RTIP complex, and in addition to this there will be a stream of wastewater generated from the cooling tower blow downs. The process water stream will be first directed to the Unit 773 EQ/DQ tank, after which it will be mixed with the cooling tower blow down wastewater and transferred to the Marafiq IWTP for treatment. Potentially contaminated wastewater from the Port Facilities will be trucked to the Unit 773 EQ/DQ tanks at the main site. In the event that the Marafiq IWTP is unable to receive the treated process wastewater, either in part or in whole, from the RTIP onsite wastewater system, provision has been made in the design for temporary storage. The RCER requires that all facilities discharging to the environment shall have storage capacity to retain 72 hours of effluent. To meet this requirement and enable adequate operation of the system, the EQ/DQ tank is designed to hold 24-hours worth of the total organic process wastewater flow and the Emergency Holding pond will be sized for 48 hours of organic process flow plus 72 hours of cooling tower blow down flow, from which flow will be pumped for subsequent treatment to the Marafiq IWTP at a controlled rate.

In the event that the EQ/DQ tank and the emergency holding pond reach capacity, and the Marafiq IWTP cannot receive RTIP process wastewater, the RTIP wastewater treatment system, and any RTIP systems generating wastewater, would be shut down temporarily. This approach would be required to avoid accidental release of wastewater to the Marafiq IWTP when it is unable to receive such transfers.

Decommissioning

No impacts from general activities at the main RTIP or Port site to the marine environment are anticipated during the decommissioning period as there are no activities that will directly affect the coastline or marine waters. All liquid wastes would be collected and treated during decommissioning, and all tank and line decontamination wastes would be included in the RTIP treatment scheme.

Potential Impacts

Only wastewater found to be within the RCER discharge standards per RCER 2010 Volume-I Table 3C shall be deemed "clean" and discharged to the to the Royal Commission (RC) Drainage Channel or to Marafiq Seawater Cooling Return Header being marine environment the ultimate receptors.

No impact is expected on marine water from process waste water as a result of normal operations. Impacts associated with abnormal/accidental events that could lead to the discharge to RC Drainage Channel or to Marafiq Seawater Cooling Return Header of water that don't comply with RCER 2010 Volume-I Table 3C standards has been assessed in section 14.3.4.

The results of the Environmental Impact Assessment *for the Ras Tanura Integrated Project – Dredging* (KFUPM/RI, 2009) undertaken in 2009, 50km south of Jubail, indicated that the Ras Tanura region is diverse in its marine ecology and lacking in sediment contamination. In the absence of a baseline assessment focusing specifically on the condition of RTIP's marine receiving environment (marine ecosystems from the area of KFIP south to Ras Tanura), this impact assessment assumes they are of similar quality to that of the study area assessed in the Ras Tanura dredging EIA. This assumption is made due to the fact that no significant industrial facilities are present on the intervening coast. As such the ecological value of the region from KFIP south to Ras Tanura should be considered as moderately high. Untreated RTIP wastewater could be discharged to the marine environment during an accidental event with a variety of chemical components in concentrations that could be toxic to any of the marine fauna discussed in Section 6.4 of Ecology Baseline and / or the organisms (flora and fauna) they rely on for survival. However, this would be a highly unlikely event.

The reliance of the local community fisheries industry upon the region should also be considered as significant in this assessment of impacts. Widespread damage or death of these marine organisms would also have an immediate and adverse impact on local fisheries and therefore on the health and livelihood of local communities.

14.3.1.2 Surface Runoff at the Main Site

Surface runoff includes fire water deluge flows, storm water flows and incidental spills event flows.

Construction

At the main RTIP site, potentially contaminated surface flow during construction will be tested and, if required, trucked to the Marafiq IWTP for further classification and appropriate treatment.

Commissioning, Operation and Decommissioning

During commissioning, operation, and decommissioning at the main RTIP site, the Interconnecting Facilities Surface Drainage System will collect and convey all surface drainage from areas outside of process envelopes and units to holding or surge basins.

This system manages all surface runoff in excess of what process unit drainage systems are designed to manage. This excess surface runoff is therefore deemed potentially contaminated.

Potentially contaminated runoff flows over non-process paved/ unpaved areas to open ditches positioned around the process units and along the roadways. These ditches direct the collected runoff via gravity flow to surface runoff basins (SRBs).

Within the process areas, the first flush volume of the surface runoff water will be considered contaminated and will be collected separately in a dedicated unit sump and pumped to the wastewater system, Unit 773 EQ/DQ tank where it will be mixed with process wastewater. Subsequent management of this stream is as described above for process wastewater.

First flush water at the main RTIP site is the volume equivalent to the larger of the following:

- The first 30mm of a single rainfall event falling on the area; or
- The first 30 minutes of a fire water deluge event.

Runoff in excess of the first flush will be collected and conveyed via gravity flow in open ditches to the four area SRBs for management and control of quality (SRB design capacities are described below).

Pumps at the SRBs will direct flows to appropriate destinations based upon water quality characterization. Any contaminated surface runoff generated at the Port facilities during operation will be collected in local sumps and trucked to Unit 773 in the main RTIP site for initial storage and subsequent transfer to and treatment at the Marafiq IWTP.

If the quality of the surface runoff collected in an SRB is found to be within the RCER discharge standards per RCER 2010 Volume-I Table 3C it shall be deemed "clean" and discharged to the RC Drainage Channel.

In the event that water quality does not meet the Royal Commission standards per Table 3C, it shall be pumped to the onsite wastewater system Unit 773, and then pumped to Marafiq IWTP for further treatment and ultimate disposal.

Firewater runoff is likely to contain hydrocarbons, other chemical contamination and fire-fighting foam which will exert a high O_2 demand on receiving waters and is likely to be toxic to marine organisms.

The three RTIP SRBs are sized to contain specific volumes of fire water runoff. For example, the largest firewater flow for SRB-2 is that which would be required for fire water deluge from the Mixed Feed Cracker (MFC, Unit 103) unit. The MFC Unit requires peak firewater deluge at a rate of 4,500 m^3 per hour. Therefore for four hours of fire water deluge at 4,500 m^3 per hour requires a total minimum SRB capacity of 18,000 m3. The total minimum capacities of the remaining SRBs are:

- SRB-1: 14,800 m^3
- SRB-2: 12,000 m^3

These designs would capture fire water volumes assuming that these basins are empty at the start of the fire (this is likely due to the low annual rainfall for the region).

SRBs shall be provided with an inlet diversion gravity overflow to the RC Drainage Channel, in the event of excessive inflow volumes. Surface runoff collected in SRBs will be monitored and released to the RC Drainage Channel only after compliance with RCER Table 3C water quality criteria and thresholds is confirmed and recorded.

The following section presents information on accidental events related to surface runoff.

Surface runoff at Port Facilities

At the Port site, potentially contaminated surface flow during construction and commissioning will be tested and, if required, trucked to the Marafiq IWTP for further classification and appropriate treatment. The EPC Contractors shall be responsible for appropriate surface runoff management during construction and commissioning. Any contaminated surface runoff generated at the Port facilities during operation and decommissioning will be collected in local sumps and trucked to Unit 773 at the main site and subsequently transferred for treatment to the Marafiq IWTP.

No impacts are therefore expected as a result of normal operations. Information on accidental events related to surface runoff is presented in Section 0.

14.3.2 Cooling Water

At the Port facility, there will be no requirement for cooling water. At the main RTIP site, all cooling water will be fresh water from Marafiq, and will be recirculated throughout the site. The cooling water blowdown will be mixed with the other process wastewater streams in Unit 773 and discharged to the Marafiq IWTP. No impacts associated with cooling water are therefore identified.

14.3.3 Vessel Movement at KFIP

14.3.3.1 Construction, Commissioning and Operations

The RTIP Port site includes two dedicated berths at KFIP. Increased ocean-going vessel traffic will occur as a result of the construction, commissioning and operation phases of the Project. Construction and commissioning will require equipment and materials transport via tugboat and barge. The operations phase will require heavy haul ships (2,000 MT capacity) and smaller vessels for containers and break bulk.

Vessel movement causes disturbances to many marine organisms: zooplankton, benthic organisms, fish, marine plant life, birds and other organisms. Vessel-generated waves and propeller action may cause detrimental navigational hazards to marine biota, and potentially compound the turbidity and sedimentation impacts by way of inducing seabed scouring and sediment re-suspension.

Marine impact from vessel movements at KFIP (refer to Issue M1) – Low Magnitude, Low Significance

Frequent vessel movements will mean the impacts also occur frequently. However, the impacts are considered to be of low magnitude and low significance since KFIP is an existing working Port designed to accommodate vessels similar to those servicing RTIP. The impacts would therefore be mitigated by proper routing and operating protocols currently in effect at KFIP. The Owner should ensure KFIP protocols are reviewed and, if necessary, updated, to accommodate RTIP activities.

14.3.4 Accidental Events/Abnormal Operations

14.3.4.1 Abnormal operation of the process wastewater testing equipment

Should wastewater quality testing systems fail and large volumes of concrete batch plant effluent (construction phase), hydrotest water (commissioning phase), potentially contaminated storm water /firewater (operations phase) be transferred to the RC Drainage Channel and Marafiq Seawater Cooling Return Header, the marine environment, as ultimate receptor might be impacted.

The impacts which may arise from discharging the wastewater to the Arabian Gulf depend on the physical and chemical characteristics of the wastewater and the condition of the receiving environment when the effluent is released and will depend on effluents from other industrial sources. Therefore, accurate quantification of the impact is not possible at this stage.

Marine impact from process water discharged to sea, nor meeting the RCER 2010 Volume-I Table 3C standards (refer to Issue M2) – Medium Magnitude, Low Significance.

Recommended measures

RTIP auto-sampling systems and sample points for discharges of wastewater at the point of discharge from RTIP will be installed and maintained.

Wastewater that does not meet the requirements of RCER Table 3C, will be transferred to Marafiq IWTP for further treatment and eventual discharge (irrigation and disposal on wet area/land).

14.3.4.2 Accidental Events during Construction

During construction, large equipment is planned to be shipped into the Jubail Commercial Port and transported to site from there via trucks. Bulk materials will be sent to either the Jubail Commercial Port or Dammam port and transported to site via trucks. The construction materials and equipment transported via sea will be shipped primarily using tugboats and barges. Should accidents occur they will likely be of small volumes of diesel or petrol and likely confined to the local area by port authorities' spill response teams.

Volumes and concentrations of contaminants would be small and cargo would likely be inert, therefore the potential impacts would be of low magnitude and low significance.

Marine impact from accidental release of construction materials, equipment, or mode of transport fuel, (refer to Issue M3) – Low Magnitude, Low Significance.

Accidental events such as loss of cargo (construction equipment and materials) and fuel or chemical spills will be the responsibility of the EPC contractors, third party transporters or the relevant port authorities.

14.3.4.3 Accidental Events during Commissioning, Operation and Decommissioning

During commissioning and operation, import and export operations occur through the Port facility at KFIP (Unit 840 – Port Facilities, see Section 3.3.4.22 of the Project Description). Raw materials will be transported via cargo ships of varying capacity (up to 2,000 megatons) to three berths at KFIP. Raw materials received at KFIP will be temporarily stored if necessary, and transferred via truck or pipeline to the main RTIP site.

Finished product from the main RTIP site will be trucked or transferred via pipeline to the Port site and if necessary, stored temporarily, before transfer to berthed ships. Finished product may also be trucked to the Port site and loaded directly onto ships without the need for temporary storage in the Port tank farm.

The feedstocks to be imported via the Port facility are benzene, toluene, ethyl acrylate, and octene.

Chemical and polymer finished products that will be stored and exported from the KFIP site include propylene glycols, amines, polyols, and urethane chemicals.

Accidental Events Related to Surface Runoff

Should surface runoff basin water quality testing systems fail and if large volumes of contaminated runoff are directed to the Royal Commission Drainage Channel and discharged without treatment, the impact from stormwater or fire water runoff would be of medium magnitude and medium significance. (Section 14.3.1.2 presents information on the management of surface runoff.)

Marine impact from stormwater runoff (refer to Issue M4) – Medium Magnitude, Low Significance.

Marine impact from a major fire onsite and firewater runoff enters the marine environment (refer to Issue M5) – Medium Magnitude, Medium Significance.

Accidental Events During Transport

Raw materials transported from, and finished products transported to foreign markets via shipping pose the risk of a severe spill (liquid or pellet form) due to collision or other vessel failure during transport. A major release of raw materials, finished product or other loss of cargo resulting from a ship collision within the navigation channel could generate a significant impact to the marine environment. All accidental events during transport will be entirely the responsibility of the third-party transport provider.

Marine impact from a direct fuel or chemical spill to sea during transportation (refer to Issue M6) - Medium Magnitude, High Significance.

Third-party transport providers of RTIP incoming raw materials and outgoing finished products will be entirely responsible for proper on-board storage and transport. RTIP third-party transporters must have shipping vessels and equipment in good, well-maintained, condition. Operating procedures that ensure secure containment, appropriate materials management, and adequate equipment and vessel maintenance must be in place. Transporters must abide by all applicable international codes and guidelines. Finally, emergency and spill response plans must be adequate to accommodate RTIP materials and products. Utilizing third-party transport providers that operate in such a manner would prevent and mitigate the potential impacts that could result from a major raw materials or finished product spill. The RTIP Project should therefore incorporate certain considerations into their transport procurement activities. Decisions regarding preferred transport providers should consider the condition of a transport provider's fleet and equipment, and the appropriateness of their operating and emergency procedures to RTIP requirements.

Accidental Events at Port Facilities

The RTIP Team will be responsible of the operation of the King Fahd Industrial Port installations (Port Tank Farm and loading/unloading area) and of the loading/unloading operations, and therefore, the impacts arising from those, including accidental events such as storage tank releases, spills, vessel collisions or other emergencies.

The accidental events that could take place at Port Facilities include:

- the failure of a storage tank and assumed release of full tank volume;
- a marine loading arm accidentally disconnecting to ship during transfer of materials;
- a rupture (hole) in a marine loading arm;
- a break in truck loading or unloading lines; or
- vessel rupture during collision.

Table 14-1 presents the chemicals and volumes of potential spills from tanks at the Port Facilities Tank Farm (Unit 840). The quantity of release (i.e., spill volume) is assumed to be the entire tank capacity. Table 14-2 presents chemicals that will be handled by marine loading arms at KFIP and at the Port Liquids Handling Facilities.

RTIP will need to prepare a spill response plan and/or coordinate with the Saudi Ports Authority on this aspect.

It must be taken into account that design measures to avoid spills have been considered so that there should be minimal spill volumes reaching marine waters:

- The Tank Farm is provided with secondary containment with the same philosophy as at the Main Site;
- Truck Loading/Unloading and the Jetty areas are curbed and containment is provided by sump, so any spill in these areas will be contained;
- The pipelines with have Emergency Block Valves (EBVs);
- The Marine Loading Arms (MLAs) are being provided with Powered Emergency-Release Coupler (PERC) systems.

Storage tanks at the Port Facilities Tank Farm will have a secondary containment and diking to hold 110% of the largest tank volume. The chances of any spill breaching the diked area would be highly unlikely. In addition, any spill from piperacks will be very brief (before controlled shut-off occurred). Therefore, although the potential size of the release from tanks and piperacks could be major the impact occurrence is unlikely, while the probability of impact occurrence from vehicle spills is likely but the released volume would be relatively small.

Marine Loading Arms (MLAs) are the main spill sources that could reach the waters, and the spill volumes associated to the PERC systems are very small (<1m^3).

The chemicals that will be stored at the Port Tank Farm and transferred to/from ships and trucks exhibit a range of behaviours in marine waters. Some are soluble, others insoluble. Some chemicals will float on the sea surface while others will sink. Some are extremely toxic to marine organisms while others are practically non-toxic.

Considering that some of the RTIP chemicals to be stored and handled in large volumes at KFIP are potentially toxic, not biodegradable, and not soluble, the impacts to the marine environment from an accidental tank, jetty topside handling equipment, or vessel collision release are considered to be of high magnitude and high significance.

Marine impact from fuel or chemical spill from trucks, Port Tank Farm, pipelines and jetty topside handling equipment at Port Facilities (refer to Issue M7) - High Magnitude, Medium Significance

Marine impact from fuel or chemical spill from vessel collision or breach at Port Facilities (refer to Issue M8) – High Magnitude, High Significance

Table 14-1 Chemicals and Potential Maximum Volume of Spills

Chemical	**Quantity of Release/Spill Volume (m^3)**
1-Octene	6232
Monopropylene glycol Dipropylene glycol Propylene glycol industrial grade	2309
Butoxy diglycol ether	3817
Butoxy glycol ether	7363

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Table 14-1 Chemicals and Potential Maximum Volume of Spills

Chemical	Quantity of Release/Spill Volume (m^3)
Butoxy triglycol ether	1991
Ethylenediamine Diethanolamine	3817
Monoethanolamine	4253
Triethanolamine	1696
Polyol V-3322	8588
Polyol V-3010	7363
Polyol NC630E Polyol V-4701 Polyol CP-6001 Polyol HF-505	3405
Polyol CPP HL-400	1991
Polyol HL106, HL108 & HL109	503
Glycerine	785
PMDI Refined PMDI Feedstock (polymeric Methylene Diphenyl di-isocyanate)	9908
TDI- T80 TDI-T80C (toluene diisocyanate)	7363
Sulfuric Acid 98%	509
Ethyl acrylate Polyethylene solvent	1539

Source:

RTIP Jubail II, Possible Spill Scenarios, document provided by KBR, April 2011.

Table 14-2 Chemicals to be Handled at Jetty Topsides and Liquid Handling Facilities at KFIP

Chemical	Location of Potential Spill
1-Octene Solvent Ethyl Acrylate Benzene & Toluene MPG DPG PGI DB EB BTG EDA MEA DEA TEA Polyol V-3322 Polyol V-3010 Polyol NC630E Polyol V-4701 Polyol CP-6001 Polyol HF-505 Polyol CPP HL-400 Polyol HL106, HL108 & HL109 Glycerine PMDI Refined PMDI Feedstock TDI- T80 TDI-T80C Sulfuric Acid 98%	Jetty Topsides
1-Octene Solvent Ethyl Acrylate MPG DPG PGI DB EB BTG EDA MEA DEA TEA Polyol V-3322 Polyol V-3010 Polyol NC630E Polyol V-4701	Liquid Handling Facilities at KFIP (truck loading/ unloading)

Table 14-2 Chemicals to be Handled at Jetty Topsides and Liquid Handling Facilities at KFIP

Chemical	Location of Potential Spill
Polyol CP-6001 Polyol HF-505 Polyol CPP HL-400 Polyol HL106, HL108 & HL109 Glycerine PMDI Refined PMDI Feedstock TDI- T80 TDI-T80C Sulfuric Acid 98%	

Source:
- *RTIP Jubail II, Possible Spill Scenarios, document provided by KBR, April 2011.*

Any spills at the jetty topsides will be contained in the concrete deck area with curbing. The deck area shall allow for liquid removal by vacuum truck. Spills from the Liquids Handling Facility will be managed by a secondary containment unit (sump).

Small scale leakage at Port Facilities

At the Port Facilities, impacts due to marine discharges, litter and spillages are regarded as generally small in scale, except for any major accidents such as fuel or chemical spills resulting from ship collision, tank, pipeline or other equipment failure, or other untoward incidents during risk-based activities (e.g. refuelling or transport and transfer of hazardous chemicals). Due to the increased shipping activity at the Port Facilities, the risk of spills from collision or other vessel breach will be higher than existing conditions at KFIP. The impact of any chronic oil discharges and leakage during operations could be significant and may affect various marine species (e.g. zooplankton, fish, reptiles, birds and mammals) in the vicinity of the Port Facilities, or further afield, depending on weather and currents. Ongoing small volume leakages during operations and accidental small volume spills could contact the shoreline, seagrass habitats or coastal reefs due to their close proximity. Mitigation measures have not been recommended as it is assumed this has been addressed in an environmental impact assessment that led to the development of KFIP and any related plans of management.

Marine impact from regular, small volume fuel or chemical leakage from Port Tank Farm and associated equipment and pipelines at Port Facilities (refer to Issue M9) –Medium Magnitude, Medium Significance

Likely Impacts from Accidental Releases

The magnitude of the impact to marine biological resources and water quality would be medium to high (depending on the chemical(s) and volume released), with the loss of marine life and potential longer term impacts to the coral and seagrass habitats along the coastal area north and south of KFIP. A major release of raw materials, finished product or other loss of cargo resulting from a ship collision or vessel failure in the area of KFIP south to Ras Tanura, and potentially beyond, could generate a significant adverse impact to the marine environment. In addition, impacts to marine organisms that pass through the coastal waters from Ras Tanura through the KFIP area to the Jubail Marine Sanctuary are of particular concern. The region is diverse in its marine ecology and lacking in sediment contamination. As such the ecological value of the region should be considered as moderately high. The reliance of the local community fisheries industry upon the region should also be considered as significant in this assessment of impacts.

Details of the Jubail Marine Sanctuary are presented in Section 6.4 of Ecology Baseline. Important ecological values of the Ras Tanura study area, which is a potential receptor of spills and any long-term, ongoing low volume leakages, or other releases, include:

- Good spawning and nursery ground for zooplankton such as bivalves and gastropods (an important link in the food chain of marine ecosystems);
- Good nursery ground for all major penaeid prawns, which are an important shellfish resource caught by local fishing industry;
- The presence of the Dugong (Dugong dugong) occurs here and along the Saudi coast southward. (The dugong is identified as 'vulnerable' on the IUCN Red List of Endangered Species (IUCN, 2008), and strongly protected by the Saudi Arabian Government by the Hunting, Protection and Investment Regulation of the Live Aquatic Resources in the Regional Waters of the Kingdom);
- Frequent sightings of other marine mammals (generally in the Arabian Gulf) including the fin whale (*Balaenoptera physalus*), Brydes whale (*B.edeni*), Minke whales (*B. acutoristrata*), orca whale (*Orcinus orca*), bottle-nose dolphin (*Tursiops aduncas*) and spotted dolphin (*Stenella attenuata*). Finless porpoises (*Neophocaena phocaenoides*) and humpback dolphin (*Sousa chinensis*) sightings have also been reported along the east coast (KFUPM/RI, 2009); and
- Potential habitat for green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles.

Emergency Response

RTIP is responsible for the containment of spillages or overflows and conducting clean-up operation in case of pollution incidents at the Port Facilities.

RTIP would minimise the risk of a major fuel, raw material or finished product spill and prepare to respond quickly and effectively to minimise widespread contamination and impact to the marine environment, should such an event occur. RTIP should work with the Ports Authority to review and update the Port Emergency Plan to ensure capacity for spill response and emergency conditions is adequate for RTIP operations, particularly the shipping, loading, unloading and transportation of raw materials and finished product via truck and pipeline.

RTIP should also liaise with the Saudi Ports Authority in order to assess the adequacy of the existing Port Authority's Spill Response Plan. If required, this plan should be amended and/or expanded to ensure that the existing mutual aid arrangements, established for the response in the event of a spill, are expanded to include RTIP, and that appropriate protection measures are in place for other facilities should a spill occur that could impact any Marafiq or other water intake canals. This should be undertaken in accordance with requirements of World Bank Group, EHS Guidelines (2007a) and International Petroleum Industry Environmental Conservation Association (IPIECA) Guidelines, 2000 & 2006.

RTIP should also prepare a project specific Spill Prevention and Containment Plan, including contingency measures. This plan should be implemented in combination with oil response equipment (e.g. spill kits) prior to construction and regularly reviewed and maintained.

Implementation of these mitigation measures would limit the impacts resulting from a major fuel, raw material or product spill.

14.3.5 Noise at Port Facilities

During construction, frequent noise may result from steelwork erection, offloading of trucks and other vehicles. The on-site equipment type and number will vary daily, depending on the construction schedule and activities. It is not anticipated that there will be any significant, prolonged and/or continuous sources of noise at the Port site.

During commissioning, the highest noise levels would be expected during the commissioning of the new plant, pipelines and new equipment, when it will be necessary to ensure that the pipework is clear of scale and construction debris. It is assumed that the greatest sources of noise at this phase will be related to steam and high-pressure blows. The un-silenced noise levels for line cleaning steam blows will be in the range of 110 to 125 dBA at a distance of 10 meters.

Excessive noise generation during heavy machinery operations, vehicle and vessel movement may have serious implications to marine fish and cetaceans. Sensitive species with high conservation values, such as sea turtles, dugongs and porpoises, were noted to visit or forage in the area 50km south of KFIP (KFUPM, 2009). In addition, high conservation value marine mammal species known to inhabit the Jubail Marine Wildlife Sanctuary to the north of KFIP include dugongs and dolphins. Impacts on the seabirds and shorebirds may also result from noise disturbances.

Marine impact from noise (refer to Issue M10) – Low Magnitude, Low Significance

Although the overall potential impacts on these species, given their known avoidance behaviour, are conceived to be minor in scale, best practice guidelines indicate that appropriate precautions and mitigations should be observed by RTIP and the Saudi Ports Authority.

The Engineering, Procurement and Construction (EPC) contractor shall ensure that all construction equipment has appropriate noise suppression devices installed, and maintained well. For example, all diesel generators shall be provided with acoustic enclosures. The construction site will also be staffed with on-site mechanics to properly maintain the construction equipment and noise suppression devices.

14.3.6 Light at Port Facilities

Lighting that increases the duration or intensity of lights presently onsite at Port Facilities, or lighting that alters natural ambient diurnal light levels, (for example, construction lighting that is used at night or in early morning hours) has the potential to impact aquatic organisms that respond to natural diurnal light patterns.

Marine impact from Light (refer to Issue M11) – Low Magnitude, Low Significance

No mitigation measures are recommended since KFIP is currently a working port with existing lighting.

14.3.7 Airborne Particulates

Construction vehicles will be used to transport construction crews, and to transport equipment and materials to and from the main RTIP site. During operation, trucks will transport raw materials and finished product between the Port and Main RTIP sites.

Depending on prevailing wind direction, increased dust generation from vehicle and equipment use on unsurfaced roads in the area of KFIP will arise construction of the RTIP Port Facilities. Deposition of dust into marine waters increases turbidity and influences light penetration. In addition, dust particles may increase nutrient levels and introduce toxic substances from vehicle and equipment leaks.

Marine impact from Dust (refer to Issue M12) – Low Magnitude, Low Significance

Mitigation measures – The EPC contractor shall develop and implement a Sedimentation and Siltation Monitoring Plan for construction activities at the Port Facilities. In addition, dust suppression activities shall be carried out during all phases of the project to minimise the generation of dust and debris in the jetty area:

- Water will be sprayed regularly on road surfaces to prevent dust generation by vehicles;
- Stockpiles will be visually monitored and relevant staff will be notified when dust management is required;
- Stockpiles will be managed in an appropriate manner (such as covering stockpiles and installing sediment traps around base of stockpiles) to prevent dust, erosion and sediment runoff;
- Sweeping of hard surfaces to capture and dispose of dust and debris appropriately; and
- Sandblasting will take place utilizing appropriate shielding mechanisms.

15 NOISE IMPACT ASSESSMENT

15.1 Introduction

This section presents the assessment of the environmental impacts on receptors resulting from noise generated during the lifetime of the proposed RTIP project in light of applicable criteria, existing noise levels in the area and model based predictions.

Existing noise levels were defined as a result of a noise baseline survey carried out by CH2M HILL at the RTIP site, at its boundaries and at the nearest areas of interest (inhabited areas and mixed use areas including contractor camps) between 4th and 13th November 2010. The noise baseline survey (methodology, results and conclusions) is described in Section 7- Noise Baseline Conditions.

15.2 Literature Review

The document "RTIP-Jubail EIA Noise Report" supplied by KBR, was used as the primary document to assess the noise impact from RTIP on the property line and community. This document provides the results of the Noise Modelling for the operation phase of RTIP. To estimate construction noise levels for each phase of construction, data from: 'Power Plant Construction Noise Guide', Empire State Electric Energy Research Corporation, New York, Report No. 3321, J.D. Barnes, L.N. Miller and E.W. Wood (eds.), prepared by Bolt, Beranek and Newman, Cambridge, Massachusetts, May 1977, was used (Beranek, 1977).

To estimate the noise impact generated as a result of the traffic increase associated to the project, the documents "RTIP Traffic Study Construction Report (KBR, 2010a)" and "RTIP Traffic Study Operation Report (KBR, 2010b)" was referenced.

15.3 Noise Impact Assessment

15.3.1. Overview

Noise will be generated by RTIP during construction, commissioning, normal and emergency operations of the project. Decommissioning of the plant would also result in generation of noise from the site into adjoining areas.

Potential noise impacts from activities during each of these phases are assessed in this section using the noise criteria set in Section 11 – Impact Assessment Criteria (Tables 11-6 and 11-7).

The assessment of impact from noise is summarised and tabulated in Section 20 – Summary of Impacts (Table 20-1), the magnitude and significance of which for each impact are also stated below at the end of each subsection (in bold italic). Next to each magnitude/significance statement and for ease of reference, each issue is identified by a unique number which is repeated in Table 20-1 and subsequently in Tables 21-1 (Summary of Potential Mitigation Measures) and 22-1 (Summary of Potential Monitoring Measures), where applicable.

15.3.2. Construction

Project noise levels will vary daily during the construction period, depending upon the construction schedule and activities. Details of the numbers and type of construction equipment that will be used and the phasing of construction activities are not available at the time of preparing this document. Such details will be determined by the appointed contractors, though it is expected that 200 trucks on average, will be in operation during the site preparation activities and they will be operating 12 hours a day, 6 days a week for 10 months.

Typical operational noise levels for construction equipment expected to be used are shown in Table 3-10 in section 3.4 of the Project Description.

Construction would include: clearing and grubbing before the site preparation start and excavation (including trenching for water pipelines and sanitary sewer lines); demolition of existing structures (ditches, unfinished culverts...; backfilling & compaction; removal of surplus soil; pouring concrete; erecting steel; installing the plant equipment and performing site cleanup and removal of temporary areas and reinstatement of the original conditions. Minimal demolition is expected and the noise levels are expected to be similar to those of construction (equipment operation and earth movement). There will be no site preparation at the port facilities.

Although details of project construction activities are not known at this time, noise levels due to construction of the main RTIP site have been estimated by referring to source data available from 'Power Plant Construction Noise Guide', Empire State Electric Energy Research Corporation, New York, Report No. 3321, USEPA, and Edison Electric Institute. Predicted construction noise levels for each phase of construction comply with the noise limits specified by Royal Commission Environmental Regulations for corresponding occupied areas. The predicted noise levels are from the construction equipment alone and do not include the existing background noise.

The location of the noise sensitive receptors is depicted in Figure 7-1 (see section 7).

- Jubail prison, located at approximately 3.8 km east of the RTIP site;
- Jubail Old Town, at approximately 13 km north-east of the RTIP site;
- Jubail Community Area, located at approximately 17 km north of the RTIP site; and
- Mixed Use Area located at approximately 1.5 km SE of the RTIP Site. Includes the Mega Coat Factory, agricultural activity and construction areas with associated contractor camps.

Construction activities associated to the port installations are expected to be of smaller magnitude. However, adopting a conservative noise levels at the closest residential areas in Jubail Old Town and JIC Community Area, located at approximately 7 km and 8 km respectively, have been made taking as a basis the same noise emission levels as per construction in the main site. Noise levels due to construction activities associated with port installations are below the noise limits specified by RCER.

As discussed above, the construction activities considered continuous will generate relatively low noise levels and should be able to continue around the clock without exceeding the maximum suggested noise levels at the nearest noise sensitive locations. Magnitude would be low (see Section 11- Impact assessment Criteria).

There will be an increase in noise level associated to the traffic that will take place for personnel transport between the temporary camps (EPC Contractor's Camps and Project Management team Camp-PMT Camp) and the construction areas, as well as an increase in vehicles using the main roads leading to the site during the construction period.

- Vehicles that will be involved in construction are described in Section 3.5.1. According to that it is concluded that Personnel transport between the camps and the main site and the EPC and Owner PMT areas (to be located SW of the main site): According to the traffic study, the best option to access the site from the construction camp will be using a new bridge that will cross Highway 85 (Dammam/Abu-Hadriyah Expressway) and a new road that will take the traffic to the North of the site. Though generated traffic is significant, no sensitive receptors are located at less than 1 km, and therefore it is not expected that sensitive receptors would be affected by a noise increase. The time required to get all the buses to the site is less than 2 hours.

- Personnel transport between the camps and King Fahad Industrial Port (KFIP): Once exiting the Jubail II complex, the route will follow Jiddah Street, which after crossing road 613 goes close to the Jubail residential area, and will then follow Expressway No1 to the KFIP, also close to the residential area. Both Jiddah Street and Expressway No1 are important roads that carry traffic associated with Jubail Industrial City and the Ports, and therefore, noise increases due to transport to the port wouldn't be expected to be significantly perceived by the Jubail Old Town population. It must be noted, however, that the total time to get all the buses to the port would be less than an hour, so the noise increase would be expected to be noticeable but for a short period of time.

There is no information on the traffic increase expected associated with the transport of raw materials and goods during the construction phase. It is likely, though that a combination of sea shipment, truck transports and airfreight will be used. As described in section 3.5.1., the present status of design is not advanced enough to predict the split between these modes of transport and the tonnages involved, although the use of airfreight will probably be limited to materials of high value, high urgency or with a short shelf life.

Though King Abdulaziz Port (Dammam) might be used, the main seaports to be used are expected to be JCP and KFIP. Materials will then be transported by truck to the site, although truck movements will be suspended during peak traffic hours (2 hours between 6:00 am to 8:00 am and 2 hours between 4.00 pm and 6:00 pm (timings to be confirmed).

The main routes to be used are not defined, but it is expected that it would include the section of Jiddah Street and Expressway No1 that run close to Jubail Old Town.

Though the frequency of the trucks is not available, an estimation based on the tonnage of materials to be shipped for construction has been made: approximately 357 truck movements per day are expected.

Therefore it is considered that inhabitants of the Jubail residential area could be exposed to noise increases associated to the transport of raw material and goods from the JCP and KFIP to the RTIP site, and of personnel between the construction camps and the KFIP.

In order to minimize disturbance, construction traffic in or near the Jubail residential area during night time hours should be minimized.

The following general measures may be implemented in order to minimise effects of construction noise:

- Select inherently quiet equipment wherever possible; RTIP will use low noise design construction equipment typical for a world-scale facility of this magnitude;
- Ensure machinery is properly maintained, particularly engine exhaust silencers;
- Ensure that all rotary driven construction equipment has appropriate noise suppression devices installed, and is well maintained;
- Machinery should be turned off when not in use (not left idling);
- Where practicable, make use of screening afforded by spoil stockpiles for high noise activities;
- The construction site will be staffed with on-site mechanics to properly maintain the construction equipment and noise suppression devices;
- While source attenuation should be the priority, construction personnel will be required to wear hearing protection when necessary in the construction site. Ear plugs and earmuffs are considered as proper personnel hearing protection devices; and
- It is expected that the selected contractors would be required to adhere to good working practices so as to minimise noise impacts on both the health and welfare of the onsite workers, and the general environment.

Impact from Construction Noise Increase at Receptors (refer to Issue N1) – Low Magnitude, Low Significance

Impact from Construction Traffic Noise Increase (refer to Issue N2) – Medium Magnitude, Medium Significance

15.3.3. Commissioning

The highest noise levels would be expected during the commissioning of the plant, when it will be necessary to ensure that the pipework is clear of scale and construction debris. The usual method of cleaning is to pass steam at a high flow rate through the line, which is eventually discharged directly to the atmosphere. High-pressure steam blows could produce high noise levels; therefore temporary portable vent silencers will be used to control noise from steam blows to manageable levels both at in-plant and at identified receptors.

The amount of noise attenuation achieved will depend upon the steam flow rate, pressure, and location of the steam blow. Actual steam blow noise levels for any specific steam blow and receptor location will vary, depending upon the factors identified above. These events will be of short duration and will not occur under normal operation and are usually confined to daylight hours.

Low pressure continuous steam blowing will be used where practical. This method maintains relatively low pressures and continuous flowing stream of steam to achieve steady state blowing conditions. This steam blowing approach is safer, relatively quieter due to low pressure drops, and less abusive on the system than high pressure blowing.

High-pressure blows will be restricted to day time periods, when possible. According to World Bank Noise Guidelines (World Bank, 2007a), day-time hours are 7:00 am to 10:00 pm.

There is also the possibility that flaring will be required during some of the commissioning period. This can potentially be a noisy operation. No details are available at this time to evaluate the noise impact. The noise level would be expected to be less than that of steam blows. However, the duration would likely be longer.

Noise associated to other activities or traffic during this phase is not considered to be significant.

Emergency conditions during commissioning are discussed in Section 15.3.5.

Impact from Noise (refer to Issue N3) – Steam Blows and Flaring – High Magnitude, Medium Significance

15.3.4. Operation

Under the normal operations of a petrochemicals plant, noise will be emitted from operating components of the plant (e.g., turbines, compressors, generators, pumps, transformers, air coolers, furnaces, packages, ejectors, process piping, compressor piping). Normally, the plant will be in continuous operation and overall noise levels would be expected to be similar throughout the day and night. Potentially, the most critical period with respect to adverse public reaction would be at night, and this is reflected in the regulatory standards, which have lower limits for night time in residential areas (see Section 11 – Impact Assessment Criteria [Table 11-8]).

KBR's proprietary Plant Noise Modelling System (PNMS) combined with commercial SoundPlan noise-prediction software was used for the development of the plant noise models and the prediction of in-plant and surrounding environmental sound pressure levels near the RTIP site. The SoundPlan software predicts the noise levels at the receivers after considering various attenuation effects (e.g. distance, ground, atmospheric, etc) and screening effects due to buildings, tanks, etc. This model implements the methods in ISO Standard 9613[1] which has a prediction accuracy of ± 3 dB(A) for long term average noise levels at distances up to 1 kilometre. PNMS follows the prediction methodology defined by EEMUA[2] and CONCAWE[3] as referred to in the KBR report (KBR, 2011).

Equipment and piping noise level estimates were based on KBR's verified field experience for similar design/capacity equipment and vendor data where appropriate. The key to the accuracy of any model is the accuracy of the initial sound power levels used to represent each source. The noise sources included were:

- Pumps and drivers;
- Compressors and drivers;
- Expanders/Eductors/Agitators;
- Compressor suction/discharge/recycle piping;
- Air coolers;
- Generators and drivers;
- Fired heaters/Boiler walls;
- Fan and Blowers. Blower ducting where appropriate; and
- Solid handling equipment.

The noise contours from RTIP have been predicted and mapped over the RTIP site and the surrounding areas as shown in Figure 15-1 and Figure 15-2. The predicted noise contours represent the noise levels from the plant with essentially all continuous equipment operating.

Plant operations will result in continuous audible noise within the site perimeter. Appropriate noise control measures, consistent with KBR's previous project experience working with noise limits similar to RCER will be applied for the project. The predicted RTIP property line noise levels are less than the L_{eq} - 70 dBA (or L_{10} – 75 dBA) limits required for consistency with the Royal Commission property line limit of L_{10} – 75 dBA. The predicted noise levels at port facility property line are in compliance with the RCER property line noise limits. KBR's previous project experience for similar facilities has shown that there is typically a 5dBA differential between the L_{10} at a receptor and the corresponding equivalent continuous noise level (L_{eq}), i.e., L_{10} noise level of 75dBA is equivalent to a L_{eq} of 70dBA. .

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[1] ISO 9613-1 (1993) "Acoustic – Attenuation of sound during propagation outdoors-Part1: Calculation of the absorption of sound by the atmosphere". ISO 9613-2 (1996) "Acoustics Attenuation of sound during propagation outdoors Part 2: General Method of Calculation".

[2] Engineering Equipment & Materials Users Association: "Guide to the Use of Noise Procedure Specification", 1985

[3] CONCAWE Report 4.81 "The Propagation of Noise from Petroleum and Petrochemical Complexes to Neighboring Communities", 1981

Table 15-1 shows the predicted noise levels at sensitive receptors and their locations are indicated in Figure 15-2:

Table 15-1 Operation Noise Levels from RTIP, Jubail II, Saudi Arabia

Sensitive Receptors	**Noise Level (dBA L_{eq})**			
	RCER Noise limit	Baseline noise level	RTIP Predicted noise level	Combined (Baseline + Predicted) Noise level
L1: Eastern corner of site, near the adjacent BeeA'h waste facility	70	50	60	60
L2: Close to north eastern boundary of the RTIP site, between the construction area of the electric substation and the contractor camp.	70	50	64	64
L3: Close to the south western corner of the RTIP Site	70	51	65	65
L4: Towards northwestern corner of the site, close to one of the main roads running through the site from	70	51	60	61
L5: Towards western boundary of the RTIP site	70	44	63	63
L6: Within a farm adjacent to Mega Coat Factory	60	50	45	51
L7: Access road to Jubail Prison, about 200m from the prison gate.	60	47	37	47

Sources:
CH2M HILL calculations based on RTIP-Jubail EIA Noise Report (KBR, 2011)Notes:
RCER limits are L10 noise limits, Leq noise limits are typically 5 dB below L10 noise levels

The predicted noise levels at the nearest sensitive receptors comply with all relevant regulations (see Section 11 – Impact Assessment Criteria [Table 11-8]).

Therefore, at the nearest offsite industrial, mixed areas and residential locations, plant noise levels would be below applicable international and local noise criteria limits and, more importantly, should not result in any discernible increases in noise levels at the nearest inhabited areas. The survey measurements indicate existing noise levels (L_{Eq}) around the RTIP property line are in the range of 44-50 dB (A) depending on the proximity to the roads where the highest noise levels were measured.

The ambient noise levels in a farm adjacent to the Mega Coat factory, in the mixed use area was 50 dB(A), and the contribution of the plant at this point would be 45dB (A). Combined levels are expected to be 51 dB(A), and therefore, in compliance with the applicable RCER Noise limit (60 dBA).

The ambient noise level measured close to the Jubail Prison, at a point located near the access road to the prison (about 200m from the prison gate) was 47 dB(A). The contribution of the plant at this point, according to the prediction study, would be 37 dB(A). Given the existing ambient noise levels, this contribution is negligible and should not be noticeable.

Typically, to protect employees' hearing, the plant will meet Occupational Health and Safety standards to confine noise levels on the site to 85 dB(A) at 1 meter from any item of equipment to which personnel would have access. Unless onerous noise control measures are implemented, there will be some areas onsite (designated as "Restricted Areas") where noise levels will exceed 85 dB(A). In these specified work areas the use of appropriate hearing protection is mandatory.

Based on the preceding discussion, normal routine plant operations can be considered to have low to no significant environmental noise impact.

The following noise control abatements are recommended for the RTIP facility based on the plant noise model:

- Installation of Class C acoustic insulation (Specified in ISO 15665) on all compressor suction/ discharge/ recycle piping;
- Installation of vibration isolation pads, such as Fabreeka or equivalent on compressor suction/ discharge pipe supports to reduce the noise transmission to the pipe supports;
- Insulation of noisy control valves, if any, and their downstream piping;
- Areas in plant where sound pressure levels exceed 85dBA need to be designated as "Restricted Areas", and personnel hearing protection is mandatory;

The above recommended noise abatements, together with the recommended "Restricted Areas" form the "Best Practice" noise control design basis, which is in compliance with the noise requirements, and also feasible and practical in the context of plant operation, maintenance and safety considerations.

An increase in noise level would be expected in the port facilities during the loading and unloading activities. Though the frequency of these activities and the ship traffic has not been assessed, due to the location of the installation, in the KFIP, and the distance to sensitive receptors, it is considered that noise impact would be negligible.

A potential increase in traffic noise levels at locations near roadways will occur as a result of the influx of workers that will travel from the residential area (considered to be located at JIC community area) to the KFIP and to the main site.

As shown in Figure 3-14 (Section 3 Project Description), the main routes start/end in the residential area in the Jubail Community Area and one route is the same as that for the construction phase and will go close to residential areas in Jubail Old Town. The traffic increase should be limited to the periods between 6:00 am and 8:00 am, and between 16:00 pm and 18:00 pm.

Outside those periods an increase of traffic associated with process deliveries, transport of limestone and gypsum and other deliveries will take place.

The main traffic increase is expected to be associated with the process deliveries (truck traffic due to the movement of raw materials and product between the Port facilities and RTIP site Packaging Centre). The routes for the process deliveries are shown in Figure 3-15 and will take place between the main site and the KFIP, the JCP and local areas. The routes between the main site and the ports follow Jiddah Street, and Expressway No 1 close to the Jubail Residential area. The route to the local areas is unknown.

Trucks transporting gypsum and limestone are expected to operate 12 hours per day between 8:00 and 22:00 and as the locations of the limestone quarry and gypsum disposal area are currently unknown, neither are the routes.

Additionally, other deliveries to site, including transfer of waste, materials and consumables, cranes, spare parts, equipment, contractor equipment etc., will take place and their routes are unknown.

The additional traffic described above will cause a noise increase that might affect the population of the residential areas close to the routes. Though some of the routes are unknown, the most significant traffic increase routes have been defined and include a section of Jiddah Street, and Expressway No 1 that are close to a residential area (Jubail Old Town). It is expected that the population associated to the buildings located close to those roads would be exposed to a noise increase due to the additional traffic. The impact has been considered of medium magnitude and medium significance.

Routing of the plant traffic should not go through the cities, whenever possible, and heavy vehicle through inhabited areas should be restricted to day periods in order to minimize the impact.

Impact from Operation of the RTIP New Installations (refer to Issue N4) –Low Magnitude, Low Significance.

Impact from Traffic Noise Increase (refer to Issue N2) – Medium Magnitude, Medium Significance.

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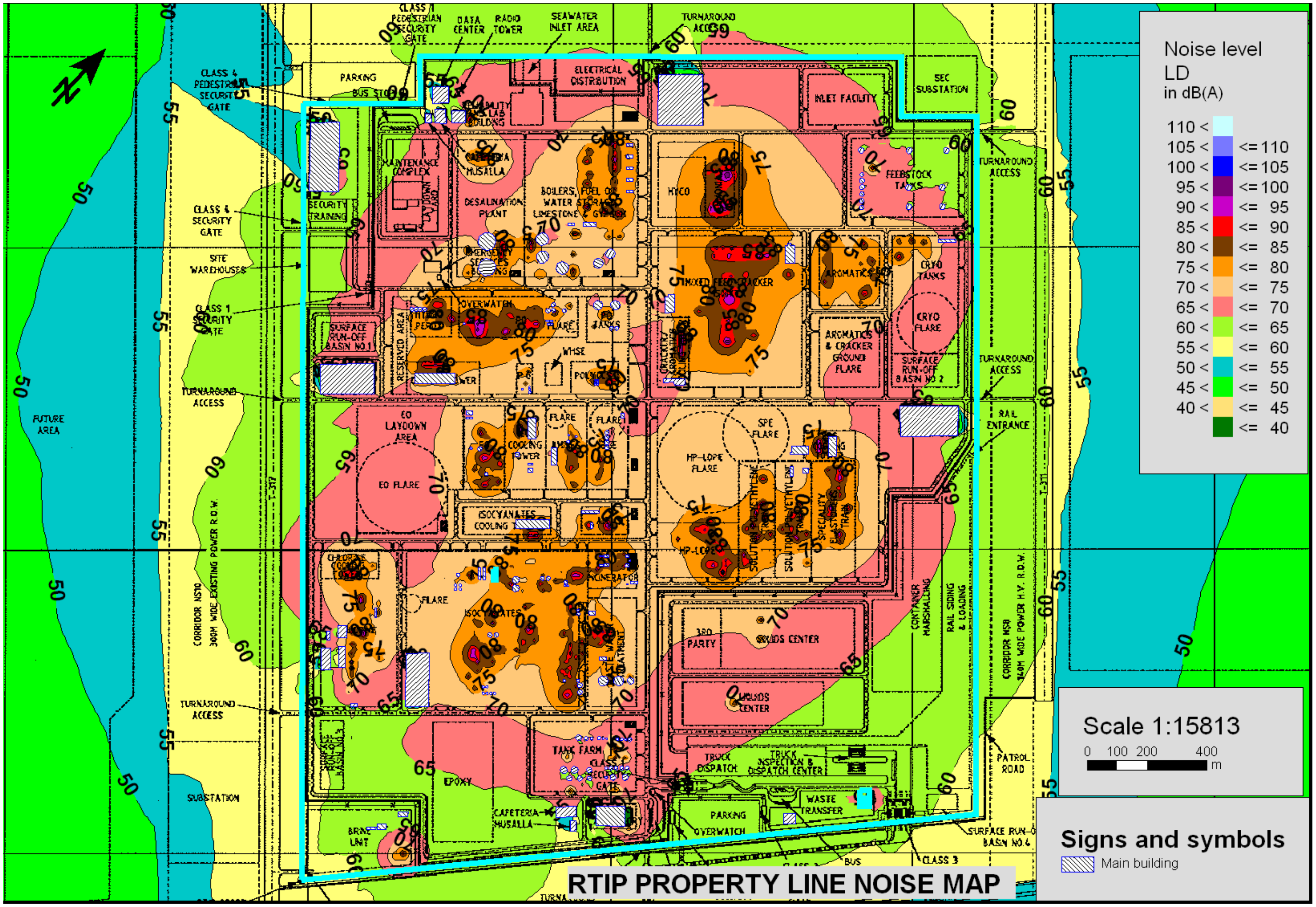

Figure 15-1 Noise Level On-shore Plant - Normal Plant Operations at RTIP Plant

Source: RTIP-Jubail EIA Noise Report (KBR, 2011)

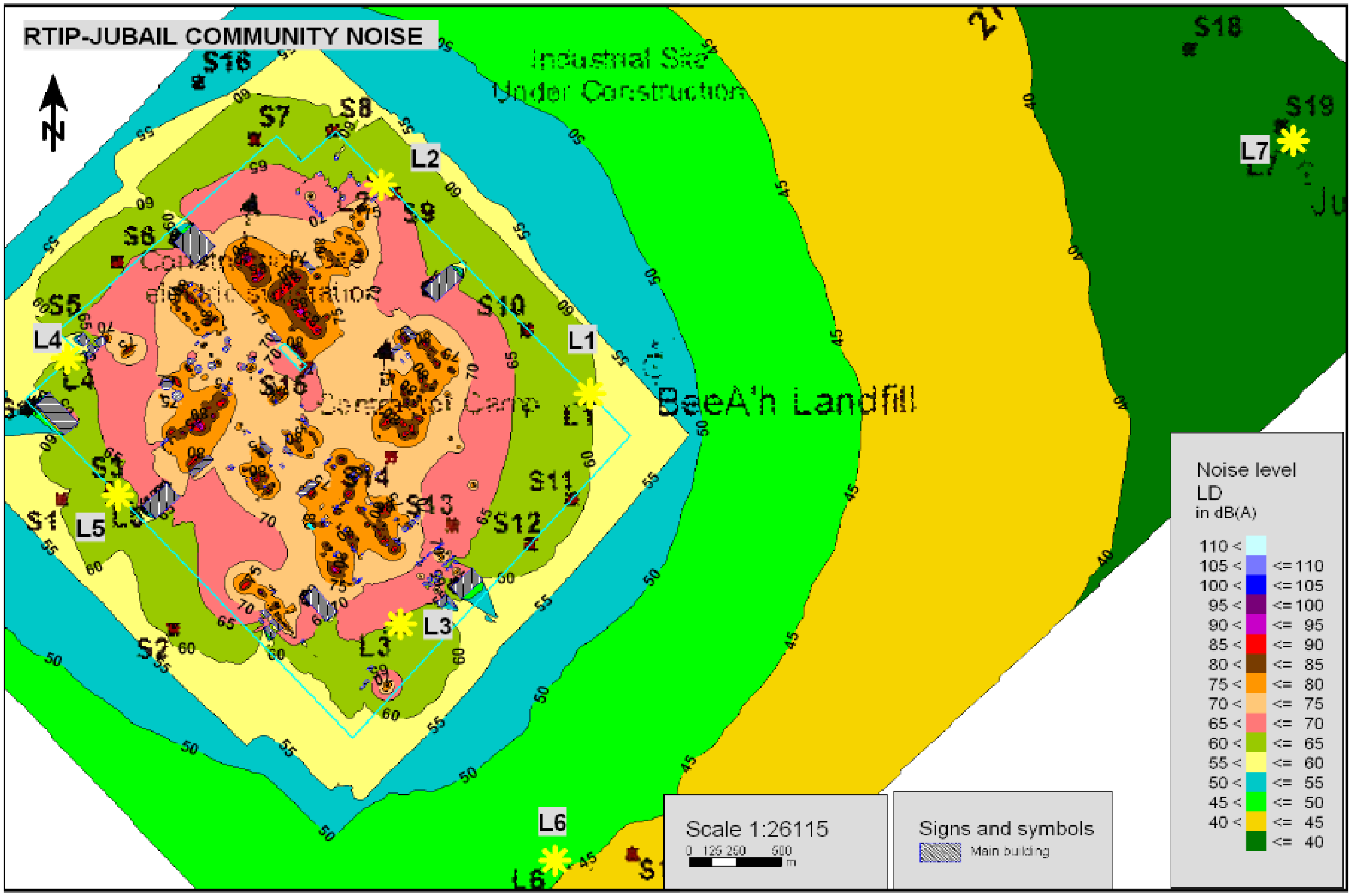

Figure 15-2 Noise Level On-shore Plant - Normal Plant Operations at RTIP Plant and its Surroundings

Source: RTIP-Jubail EIA Noise Report (KBR, 2011)

15.3.5. Emergency Plant Operations

Though not specifically stated, noise limits are considered to apply to the normal operation of the plant. For non-normal (e.g., startup, shutdown) or emergency conditions which would only occur for relatively short periods during commissioning and operation, increase in noise levels would normally be expected.

During emergency conditions, it is inevitable that there will be an increase in noise levels due to steam venting and gas flaring. In the event of an emergency at the plant necessitating the discharge of large quantities of gas via the elevated flares for safety reasons, there would be a significant increase in noise levels from the plant. However, such events would be expected to be infrequent and high gas flow rates would reduce with time as the system is depressurised. No employee will be exposed to more than an absolute maximum noise level of 115dBA in an event of emergency and/or upset conditions. Predicted noise levels are to be checked during detailed engineering for compliance, and actions to protect staff from high noise level exposure should be considered and implemented where necessary in case of non-compliance.

Impact from Noise (refer to Issue N5) – High Magnitude, Low Significance

15.3.6. Decommissioning

At the end of the functional life of the plant, it would be decommissioned. This may relate to the complete site, or more probably, various plants would be upgraded. With respect to noise levels, the highest noise levels would be associated with the removal of the complete plant. No detailed noise predictions have been conducted but there is no reason to consider that the noise level would be any higher than those experienced during the original construction.

Impact from Noise Increase at Receptors (refer to Issue N1) – Low to High Magnitude, Low to Medium Significance

Impact from Traffic Noise Increase (refer to Issue N2) – Medium Magnitude, Medium Significance

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16 WASTE MANAGEMENT

16.1 Introduction

This section presents an evaluation of the potential environmental impacts resulting from wastes generation, storage and management activities during the lifetime of RTIP. Waste management is recognized as an integral and critical component of the EIA. A review of existing waste facilities and management practices in the Eastern Province, the region in which the RTIP site is located, was undertaken as part of the baseline survey to determine the waste disposal options. Wastes generated in the Port Facilities will be sorted on-site and sent to approved solid and hazardous waste handling facilities in Jubail Industrial City (JIC), and as such are considered within this evaluation.

Information relating to the expected waste generation for RTIP has been used to assess potential environmental impacts resulting from waste generation, storage, treatment and disposal during construction, commissioning, routine operation, and facility decommissioning. An evaluation of the potential for release of contaminants was undertaken and cost-effective options identified to reduce, contain or mitigate the adverse effects of these waste streams.

The potential environmental impacts that could result directly from waste management relate to the releases of waste substances, the hazards presented by such releases and the effect that the releases may have on other processes. The principal releases associated with waste management are emissions to air, liquid and solid discharges.

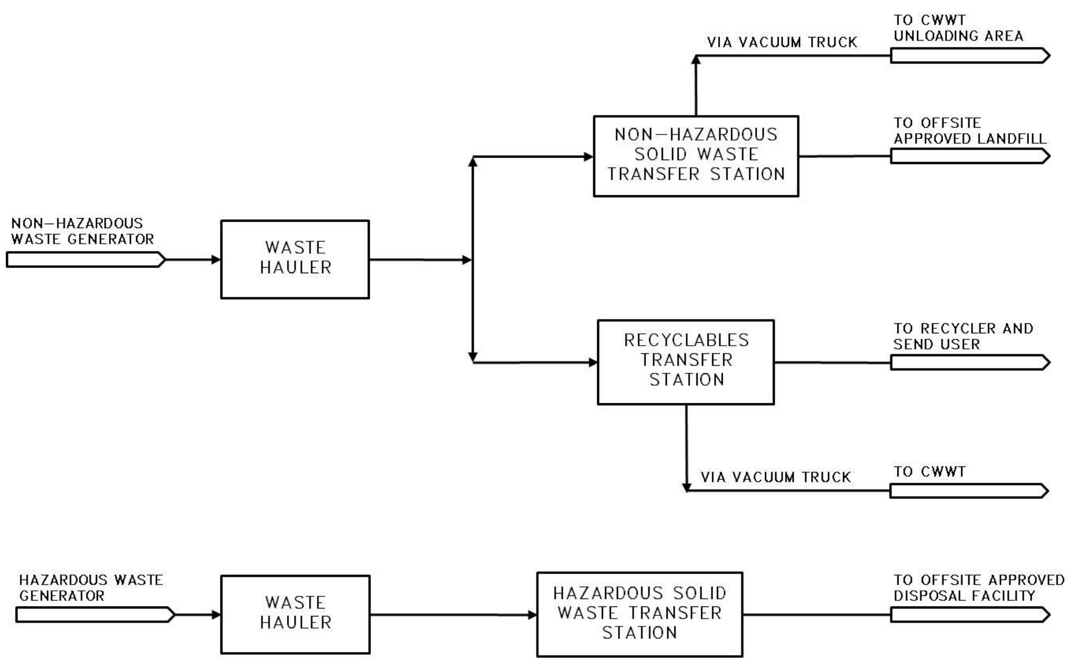

Figure 16-1 Nonhazardous and Hazardous Solid Waste Block Flow Diagram

Source: RTIP – Nonhazardous and Hazardous Solid Waste Handling Basis of Design.

A review of existing solid waste transport, treatment and disposal sites in the Eastern Province, including Jubail Industrial City, the findings of which are described in Section 8-3 - Baseline Investigation, indicate the following:

- The solid waste collection and its transportation at Jubail city is performed by a contractor called *Al-Khudari Establishment*. The vehicles are owned by the Municipality and maintained by the contractor. The containers vary in size from 200 litres to $20m^3$.

- The facilities at the RCJY sanitary landfill include security, a weigh scale house, a diesel filling station, a leachate treatment facility, a maintenance workshop and administrative offices. The sanitary landfill is equipped with a leachate collection system, a leachate neutralization system, and leachate disposal lagoon facilities.

- The National Environmental Preservation Company (BeeA'h) holds an ISO 14001 certificate, and performs hazardous waste management (transportation, treatment and disposal) and environmental testing services. BeeA'h's facilities are contained within a fenced area located adjacent to the RTIP site.

    - The BeeA'h hazardous waste landfill includes Class I and II landfill cells, evaporation ponds, an equalization pond, truck wash, and weigh scale facilities.

    - The Thermal Treatment facility is designed for 20,000-22,000 kta solids, with 30-40% over capacity in the design. Resultant ash is stabilized and confined to a lined chemical landfill.

- The Environment Development Company (EDCO) owns and operates a hazardous waste storage facility which is located in Jubail industrial city, opposite the BeeA'h facility. It performs physical and chemical treatment of wastes, followed by disposal of the residues in Class I and II landfill cells. Treatment is performed in accordance with the standards of the RCJY, PME and USEPA.

The hazards that may occur as a result of the release include the contamination of natural receptors, e.g., the physical environment (i.e., soil and groundwater), the marine environment, the biological environment of the affected area and the atmosphere, and adverse impacts on human heath and safety.

Waste management activities may also contribute to other environmental impacts, albeit indirectly. The storage of wastes on-site (especially if prolonged due to appropriate facilities not being available) may impede operations on-site and thereby increase the risk of other incidents. The transport of wastes off-site will result in additional traffic, the impact of which will be influenced by the condition of vehicles, the routes taken and the containment of the waste.

The assessment of impacts associated with waste generation and management is summarised and tabulated in Section 20 - Summary of Impacts (Table 20-1), the magnitude and significance of which for each impact are also stated below at the end of each subsection (in bold italic). Next to each magnitude/significance statement and for ease of reference, each issue is identified by a unique number which is repeated in Table 20-1 and subsequently in Tables 21-1

(Mitigation Table) and 22-1 (Monitoring Table), where applicable. The background to the potential impacts listed is described in the following sub-sections.

The releases may be controlled or uncontrolled. The latter can be split into "unavoidable" releases (such as small losses during storage or handling) or accidental releases (such as a pipe burst, drum spills, etc.). The type of releases will depend upon the phase of site development and the location of the wastes. The control or management of risks will be more difficult on third party sites, e.g., landfill sites and private incinerators.

It is important to note however, that in addition to the impacts assessed in this section other potential impacts which could arise are those related to the reputation of the operator. Inadequate or negligent management and/or accidental events which result in impacts on the local environment or population could negatively affect the operator's reputation towards consumers, and both private and public institutions, inside and outside of the KSA. Reputational impacts have not been assessed as they are not within the scope of this EIA, nevertheless it is recommended that the operator monitor the potential occurrence on any such impacts and take appropriate measures to mitigate their effects.

16.2 Construction

16.2.1 Overview

Wastes anticipated to be generated during construction include construction materials, broken tools, off specification raw material, packaging and pallets and general trash from temporary workers camps and a range of potentially hazardous liquids. Earthworks associated with the construction site may also produce contaminated soil and rock. The hazardous wastes anticipated include adsorbents used for spill cleanup, lubricants, materials contaminated with hydrocarbons, used and surplus grease, paints, solvents, diesel and adhesives.

The Project will follow the waste management hierarchy of source reduction (or removal), re-use and recycling followed by environmentally responsible disposal. Particular emphasis will be placed on reusing materials and then recycling materials which cannot be reused prior to disposal. All waste shall be handled in accordance with the Royal Commission Environmental Regulations in regards to waste storage, transportation and disposal. The Project will ensure that the 'cradle to grave' approach is followed for all wastes and monitor destination of all wastes.

The EPC contractors will be responsible for the waste management and will be required to comply with the regulations. Further details on temporary storage accumulation areas and ultimate disposal are not available at this stage of the project.

The environmental impact of wastes generated during this phase of the project ranges from low assuming that due care is applied in storage on-site, transportation and appropriate disposal to high should there be any releases of such material in the event of poor storage, transportation and disposal. Potentially affected resources include the soil, groundwater and air quality, especially in the case of accidental spills. Disposal trucks will also generate noise, dust and air emissions, potentially affecting terrestrial biological and human resources. Landfills have the potential to impact the soil and groundwater; however, these impacts would be minimised through the use of an authorised facility subject to the design, construction and operation of the facility meeting good international practice and appropriate environmental controls being established.

16.2.2 Liquid Wastes

16.2.2.1 Non-Hazardous Liquid Wastes

Waste treatment and disposal facilities available in the Jubail Industrial City will be utilized. Non-hazardous liquid wastes will be disposed of in the Marafiq Wastewater Treatment Facility.

Liquid non-hazardous waste (mainly black and grey waters) would be collected through a pipeline network and disposed of in the Marafiq Sanitary Wastewater Treatment Facility (SWTP), which uses Primary and Secondary Treatment Processes. Treated water is filtered and chlorinated for disinfection. According to Marafiq's webpage, some of the treated water from both plants is utilized for irrigation and industrial use. The guidelines for Wastewater and Irrigation water are maintained as per Royal Commission laid down Jubail Management Procedures (JMP) parameters.

On-site storage and off-site disposal: Regular operations of the liquid waste management system (through a pipeline network) are not expected to cause any impacts on-site. Spills from break-offs of the pipeline network will be analysed in section 14.6, Accidental events. Off-site, the Marafiq SWTP and IWTP are expected to cause little negative effects on the natural and social environment if managed adequately. However, specific environmental and quality control methods at the plant are unknown at this stage and the quantities of sanitary wastewater expected to be generated are considerable, so a potential impact of medium magnitude has been identified on soil and the local population (treated water used for irrigation purposes).

Impact from On-site Storage and Off-Site Disposal of Non-Hazardous Liquid Construction Wastes (refer to Issue O15) –Medium Magnitude, Low Significance

16.2.2.2 Hazardous Liquid Wastes

Small quantities of hazardous liquid wastes (e.g. waste oil, waste fuel, chemical wastes) are expected to be generated during the construction phase of the RTIP. These wastes are expected to be stored on-site, and then transported to the recycling company/supplier for its reuse or to appropriate off-site waste disposal facilities. Liquid hazardous wastes have the potential to cause significant impacts on the natural and social environment, but the waste management practices expected to be used minimise the likelihood and the magnitude of these impacts, which will be analysed under unplanned events.

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16.2.3 Solid Wastes

16.2.3.1 Non-Hazardous Solid Wastes

Waste treatment and disposal facilities available in the Jubail Industrial City will be utilized. Non-hazardous solid wastes (municipal and inert) will be disposed of in the Royal Commission sanitary landfill, once a Solid Waste Disposal Permit has been obtained from the Royal Commission Landfill Office.

Since there will be no on-site facilities for waste disposal, all non-hazardous wastes will need to be disposed off-site at managed landfill facilities. This will increase the risk of transport related impacts (air quality and human impact by noise). Other impacts include those to soil and groundwater associated with waste collection, packaging and temporary storage on-site.

Solid non-hazardous waste (of an industrial nature) will be stored temporarily on-site prior to being disposed of in the Royal Commission sanitary landfill.

Off-site, according to published information, the landfill facilities provided by approved contractors present appropriate design measures and include security, a weigh scale house, a diesel filling station, a leachate treatment facility, a maintenance workshop and administrative offices. The sanitary landfill is equipped with a leachate collection system, a leachate neutralization system, and leachate disposal lagoon facilities. However, no information relating to environmental control and monitoring measures currently undertaken in the facility is available. Recyclable waste such as metal, wood, plastics, paper, oil, cardboard, glass or electrical cables will be stored on-site prior to being sent to a recycling company, or will be directly reused.

<u>On-site storage and off-site disposal:</u> the magnitude of the impacts related to on-site storage of non-hazardous waste on human health and the environment is expected to be low in this phase, given the type of the materials involved (solid non hazardous, short term effect). Since it is a regulatory requirement, it is assumed that the on-site storage of such wastes will be undertaken by the EPC Contractors in accordance with Section 5 of Volume I of the Royal Commission Environmental Regulations, so the significance of impacts is expected to be low. However, the uncertainties related to the controls in place for off-site disposal management in addition to the significant quantities of waste expected to be generated increase the potential magnitude of an impact due to off-site disposal. Furthermore, these uncertainties related to off-site disposal management increase the likelihood of potential windblown and subsurface contamination off-site (through rainwater leachate although the low rainfall in KSA will mitigate this impact), which could additionally lead to potential future liabilities. This affects the significance of the impact, which is considered medium.

Impact from On-Site Storage of Non-Hazardous Construction Wastes (refer to Issue O11) – Low Magnitude, Low Significance

Impact from Off-Site Disposal of Non-Hazardous Construction Wastes (refer to Issue O16) – Medium Magnitude, Medium Significance

Mitigation Measures

Prevention and control measures to reduce risks of contamination include:

- Developing a comprehensive waste management plan which complies with internationally accepted industry standards to ensure safe handling, on-site storage, transfer and disposal. Continually monitor and re-evaluate the effectiveness of the plan;

- The Waste Management Plans should encompass all phases of the waste management process under the good industry practice requirements of duty of care and protect the corporate image of the proponents.

- Keeping storage times on RTIP site to the minimum and control access to stored wastes (no longer than 180 days after waste generation, according to RCER);

- Segregating scrap plastic, glass, metal and wood for recycling where possible;

- Undertaking an audit of the waste management facility prior to each phase of the project to ensure that it operated according to regulations and capable of handling the wastes to be generated;

- Following the procedures established in the RCER (2010) for appropriate waste transport and disposal.

16.2.3.2 Hazardous Solid Wastes

The hazardous wastes will be sent for disposal to either BeeA'h or EDCO's waste management facilities located in the Jubail Industrial City. A Hazardous Waste Disposal Permit is required from the Royal Commission Landfill Office before any disposal of such waste can occur.

The quantity of solid hazardous wastes generated during construction is likely to be small, but significant, in comparison with the quantities on non-hazardous solid waste expected to be generated. Solid waste streams mainly relate to empty chemical / paint containers. Storage of generated solid hazardous wastes could result in local environmental impacts, mostly to sub-surface soil and groundwater.

According to the RC Environmental Regulations (RCER), all hazardous wastes generated during construction that cannot be returned to the supplier or recycled in some other way will be stored on-site in appropriately labelled containment facilities. Solid hazardous waste which cannot be recycled will then be transported to either BeeA'h or EDCO's double-lined Class I landfills complete with leachate collection system (approved by the RCJY for the treatment and disposal of solid hazardous waste generated within the Jubail Industrial City), or to an equivalent authorised facility. The EDCO facilities have waste storage facilities for storing liquid, containerised, highly corrosive or reactive wastes whilst awaiting treatment but in the provision of the temporary storage of such wastes, it is assumed that the EPC Contractors will store wastes on-site in accordance with Section 5 of Volume I of the Royal Commission Environmental Regulations. Further to this, unlike BeeA'h's facilities, EDCO's possess no incinerator for solid and liquid hazardous wastes at present as it is currently under construction. This could therefore potentially limit EDCO's capacity to treat and dispose of certain types of hazardous waste such as medical wastes.

On-site storage: the magnitude of the impact related to on-site storage of hazardous waste on human health and the environment is expected to be medium for hazardous waste, given the materials involved (hazardous, long term effect, low quantity), and the mobility of solid waste. Since it is a regulatory requirement, it is assumed that the on-site storage of such wastes will be undertaken by the EPC Contractors in accordance with Section 5 of Volume I of the Royal Commission Environmental Regulations, so the significance of impacts is expected to be low. In addition, it is expected that due to the close proximity of the facilities handling the wastes to the project site, the storage period for liquid hazardous wastes on-site will be aligned with both safety and efficiency considerations. As such, the significance of the impact is considered low for solid wastes and low for liquid wastes.

Impact from On-site Storage of Solid Hazardous Construction Wastes (refer to Issue O13) – Medium Magnitude, Low Significance

Impact from On-site Storage of Liquid Hazardous Construction Wastes (refer to Issue O14) – Medium Magnitude, Low Significance

Off-site disposal: the magnitude of the impact related to off-site disposal of hazardous waste on human health and the environment is expected to be medium, given the materials involved (hazardous, long term effect, low quantity). As is per their website, there is no information available relating to the presence or absence of appropriate environmental control and monitoring measures; nevertheless the disposal management practices and technologies used by EDCO are in accordance with the standards of the RCJY, PME and USEPA. In the case of BeeA'h, their facilities hold an ISO 14001 certification and their services (clients include the RCJY and Saudi Government Ministries) are stated to be provided in accordance with International Conventions. Both the likelihood and the significance of this impact are thus considered to be Low.

Indirect Impact from Off-Site Disposal of Hazardous Construction Wastes (refer to Issue O18) – Medium Magnitude, Low Negative Significance

Transport off-site: during the normal operations of transfer of hazardous construction waste material there is potential for release and potential subsurface soil, surface water and groundwater contamination. The magnitude of the impact related to transport of hazardous waste on human health and the environment is expected to be medium, given the materials involved (hazardous, long term effect, low quantity). According to BeeA'h a key element of their policy is to ensure compliance with all applicable local and international regulations and further to this their services are provided in accordance with the requirements of the appropriate transport authority. If this is the case, the likelihood of occurrence for such an event is low. In addition to this, in providing hazardous waste transportation resources, BeeA'h assumes total liability for all material accepted, which reduces the potential liability associated with the clean-up of receptors. As such, despite the hazardous nature of the waste in question, the low likelihood of occurrence and the absence of any associated remedial liabilities results in the significance of this impact with respect to BeeA'h's services being low for both solid and liquid hazardous wastes. In the case of EDCO however, at present it is unclear that they offer waste collection and transportation as part of their services. As such, if EDCO were selected it would increase uncertainties associated to the transport of hazardous wastes and therefore increase the likelihood of potential contamination occurring, as well as potential future liabilities.

Impact from Hazardous Construction Wastes during Transport Off-site (refer to Issue O19) – Medium Magnitude, Low to Medium Negative Significance

Mitigation Measures

Prevention and control measures to reduce risks of contamination include:

- Developing a comprehensive waste management plan which complies with the internationally accepted industry standards to ensure safe handling, on-site storage, transfer and disposal. Continually monitor and re-evaluate the effectiveness of the plan;

- Providing secondary containment to tanks, to capture any spills and equip tanks with a contents level indicator;

- Keeping storage times at the EPC Contractor base camp to the minimum (no longer than 180 days according to RCER, 2010), and controlling access to stored wastes;

- Providing secure means of transferring wastes safely into and out of the tank to minimise spills. Any shipment of wastes outside of Jubail Industrial City must be previously authorised by the RC. Any shipment of hazardous wastes outside of KSA must conform to the requirements of the Basel Convention;

- Undertaking an audit of the waste management facility prior to each phase of the project to ensure that it is operational, licensed and capable of handling the wastes to be generated;

- Covering trucks where appropriate to prevent wind-blown losses during transport; and

- Following other procedures established in the RCER (2010) for appropriate waste transport and disposal.

16.2.4 Construction Camp Wastes

The construction camp will potentially need to house up to 55,000 persons (at peak). It is estimated that approximately 52 tonnes of solid municipal wastes will be generated daily by a workforce of 55,000. Non-hazardous construction / office or municipal wastes will be disposed of at the Royal Commission sanitary landfill. Transport to the corresponding waste site will be by truck.

It is anticipated that small quantities of hazardous waste materials will be generated at the construction camp from maintenance activities as well as medical waste from the clinic. These wastes will be managed and disposed of following the same procedures as described above in Section 16.2.3.2.

<u>On-site storage and off-site disposal:</u> the magnitude of the impacts on human health and the environment is expected to be low in this phase, given the type of the materials involved. The likelihood of the impact is low for both on-site storage and for off-site disposal, as on-site storage is expected to be undertaken in accordance with Section 5 of Volume I of the Royal Commission Environmental Regulations, and although the quantity of waste produced and transported is expected to be significant, it is expected that the landfill is operated in accordance with the RCJY standards and regulations.

Impact from On-Site Storage of Non-Hazardous Construction Wastes (refer to Issue O12) – Low Magnitude, Low Significance

Impact from Off-Site Disposal of Non-Hazardous Construction Wastes (refer to Issue O17) – Low Magnitude, Low Significance

16.3 Commissioning

16.3.1 Overview

Commissioning will involve initial start up of plant operations and testing of all process equipment, including the various units and tanks, as well as the pipes. The environmental impacts of wastes generated during this phase are anticipated to be minimal given the nature and estimated quantity of materials involved, except in the case of major accidental spills which will be discussed in Section 9.5.6 below.

16.3.2 Liquid Wastes

16.3.2.1 Non-Hazardous Liquid Wastes

During the Commissioning phase, the main non-hazardous liquid waste streams to be produced are expected to be sanitary wastewater (mainly black and grey waters) and hydrotest water. Sanitary wastewater will be collected through a pipeline network and disposed of in the Marafiq Sanitary Wastewater Treatment Facility (SWTP) for Primary and Secondary Treatment. The hydrotest water produced will, depending on quality, be sent to the Marafiq Seawater Cooling Return Header or to the RC Drainage Channel (if in compliance with RCER table 3C) or to Marafiq Industrial Wastewater Treatment Plant (IWTP).

<u>On-site storage and off-site disposal:</u> Regular operations of the liquid waste management system (through pipeline network) are not expected to cause any impacts on-site. Spills from break-offs of the pipeline network will be analysed in section 14.6, Accidental events. Off-site, the Marafiq Wastewater Treatment Plants (SWTP and IWTP) are expected to cause little negative effects on the natural and social environment if managed adequately. However, specific environmental and quality control methods at the plant are unknown at this stage, so a potential impact of low magnitude has been identified on soil, the marine environment and the local population (treated water used for irrigation purposes).

Impact from On-site storage and Off-Site Disposal of Non-Hazardous Liquid Commissioning Wastes (refer to Issue O15) –Low Magnitude, Low Significance

16.3.2.2 Hazardous Liquid Wastes

Considerable quantities of hazardous liquid wastes (e.g. waste oil, waste fuel, chemical wastes) are expected to be generated during the commissioning phase of the RTIP. These wastes are expected to be stored on-site, and then transported to the recycling company/supplier for its reuse, or otherwise it will be transported to BeeA'h's facilities for off-site incineration. Liquid hazardous wastes have the potential to cause significant impacts on the natural and social environment, but the waste management practises expected to be used minimise the likelihood and the magnitude of these impacts, which will be analysed under unplanned events.

16.3.3 Solid Wastes

16.3.3.1 Non-Hazardous Solid Wastes

All non-hazardous wastes generated during the commissioning phase will need to be disposed off-site at managed landfill facilities. In order to facilitate this, the RTIP's Solid Waste Handling Unit (Unit 778) will be commissioned early in the Project, before most of the Process and Utility Units start-up, in order to allow for prior waste segregation and temporary storage. Off-site management at landfills will however increase the risk of transport related impacts (air quality and human impact by noise). Waste storage on-site brings a risk of soil and groundwater impacts in the storage areas, however this risk is reduced by the plans to totally enclose these areas (four walls, a roof and floor) and the installation of a dry sump to collect storm water. It is assumed that non-hazardous industrial waste will be stored on-site at Unit 778 and disposed of in either EDCO or BeeA'h's Class II landfills, or otherwise an equivalent authorised facility.

<u>On-site storage and off-site disposal:</u> The expected quantity of non-hazardous waste generated during this phase will be considerably greater than that of the construction phase. Although the likelihood of the impact arising from the on-site storage or off-site disposal of non-hazardous material generated during the commissioning phase is considered to be low, due to the significant quantities expected, the magnitude of any impact is considered to be medium (Low Magnitude and Low Significance).

Impact from On-Site Storage of Non-Hazardous Commissioning Wastes (refer to Issue O11) – Medium Magnitude, Low Significance

Impact from Off-Site Disposal of Non-Hazardous Commissioning Wastes (refer to Issue O16) –Medium Magnitude, Low Significance

16.3.3.2 Hazardous Solid Wastes

It is anticipated that a significant quantity of hazardous wastes may be produced during the commissioning phase. Hazardous wastes may include waste oil, lubricants, resins, batteries, paints, solvents and oily rags from final construction and modification activities. Solid hazardous waste will be transported to either BeeA'h or EDCO's double-lined Class I landfills after pretreatment or an equivalent authorised facility. Liquid hazardous wastes will be stored on-site, and subsequently transported to the recycling company/supplier for its reuse, or otherwise to BeeA'h's facilities for off-site incineration.

On-site storage: The magnitude of the impact related to on-site storage is expected to be high for hazardous waste, given the materials involved, the quantities expected and the mobility of solid waste. It is assumed that the on-site storage of such wastes will be undertaken in accordance with Section 5 of Volume I of the Royal Commission Environmental Regulations, and it is therefore considered unlikely that this impact will occur. In addition, it is not expected that the storage period for these wastes exceed the medium term due to the close proximity of the facilities handling the wastes to the project site. As such the significance of the impact is considered low for solid wastes and low for liquid wastes.

Impact from On-site Storage of Solid Hazardous Commissioning Wastes (refer to Issue O13) – High Magnitude, Low Significance

Impact from On-site Storage of Liquid Hazardous Commissioning Wastes (refer to Issue O14) –High Magnitude, Low Significance

Off-site disposal: The magnitude of the impact related to off-site disposal of hazardous waste on human health and the environment is expected to be high given the materials involved (hazardous, long term effect, high quantity). The fact that these facilities posses either disposal management and environmental controls, or are under the supervision of the Royal Commission (RC) reduces the likelihood of potential windblown and subsurface contamination. This affects the significance of the impact, which is considered to be low.

Indirect Impact from Off-Site Disposal of Hazardous Commissioning Wastes (refer to Issue O18) – High Magnitude, Low Significance

Transport off-site: The magnitude of the impact related to the transportation of hazardous waste off-site is expected to be high given the materials involved (hazardous, long term effect, high quantity). Considering the contractor's (in the case of BeeA'h) service policy and their willingness to assume any liability associated with the transport and disposal of the wastes, the significance of this impact is considered to be low. However, not all of the facilities considered are known to offer the same waste collection and transport services. Therefore, depending on the facility selected there may be uncertainties associated to the transport of hazardous wastes which would increase the likelihood of potential contamination occurring, as well as potential future liabilities.

Impact from Hazardous Commissioning Wastes during Transport Off-site (refer to Issue O19) –High Magnitude, Low to Medium Negative Significance

Mitigation Measures

See measures described in section 16.2.3.2.

16.3.3.3 Construction Camp & Office Wastes

During the commissioning phase it is expected that the construction camp will be scaled down in size to just accommodate workers remaining on-site. It is assumed that the construction camp will be dismantled during this phase, leading to the generation of inert wastes from the demolition of temporary structures.

The site office and mess facilities will also be in operation at this time and generate a range of non-hazardous wastes which will be disposed off at either EDCO or BeeA'h's Class II landfills, or otherwise an equivalent authorised facility. A small quantity of hazardous wastes, such as batteries, medical waste or IT components may also be produced.

Impact from Construction Camp Wastes (refer to Issue O12 and O17) –Low Magnitude, Low Significance

16.4 Operation

16.4.1 Overview

The operations phase is the period of time when the plant is producing commercially. During this time, a range of process related hazardous and non-hazardous wastes will be produced. Office and mess facilities will also generate non-hazardous wastes and a small quantity of hazardous waste.

The environmental impact of wastes during this phase is anticipated to be low to high, and can be lowered through mitigations measures to ensure that due care is applied in storage on-site, transportation and appropriate disposal. Potentially affected resources will be soil, groundwater, surface water and air quality. Disposal trucks will also generate noise, dust and air emissions, potentially affecting terrestrial, biological and human resources. Landfills have the potential to impact the soil and groundwater, however, such impacts could be minimised if environmental controls such as periodic groundwater sampling are established.

16.4.2 Liquid Wastes

16.4.2.1 Non-Hazardous Liquid Wastes

During the Operations phase, the main non-hazardous liquid waste streams to be produced is expected to be process wastewater. The process wastewater will be directed to the Unit 773 EQ/DQ tank on-site, after which it will be mixed with the cooling tower blow downs and sent to Marafiq Industrial Wastewater Treatment Plant (IWTP) for treatment. Due to the varying degrees of contamination of the mixed wastewater streams, the overall concentration of contaminants in the final stream is reduced as a result of this process. If found to be in compliance with the RCER Table 3B standards, the wastewater will subsequently be directed to the Marafiq IWTP for final treatment before disposal. Any wastewater streams not in compliance will be sent back the Process Unit of origin within RTIP for additional treatment.

Process wastewater streams that meet the RCER Table 3C (direct discharge of variance streams to seawater return) will be sent to the Marafiq Seawater Return header.

Sanitary wastewater will also be produced from the site offices and buildings as well as from the personnel residences in the JIC residential area. This wastewater will be disposed of in the Marafiq Sanitary Wastewater Treatment Facility (SWTP), for Primary and Secondary Treatment. In addition, any flows of storm water, fire water or incident spills in excess of what process unit drainage systems are designed to manage will be collected at Surface Drainage Systems (SDS) and conveyed to Surface Retention Basins (SRBs). This water, if in compliance with RCER table

3C, will go to the RC Drainage Channel, and when not will be sent to the EQ/DQ tank in Unit 773 and mixed with the process wastewater.

On-site storage and off-site disposal: Regular operations of the liquid waste management system (through pipeline network) are not expected to cause any impacts on-site. Spills from any breach in the pipeline network will be analysed in section 14.6, Accidental events. Off-site, the Marafiq SWTP and IWTP are expected to cause little negative effects on the natural and social environment if managed adequately. However, further to specific environmental and quality control methods at the plant being unknown at this stage, the quantities of wastewater to be generated are considerable and so a potential impact of medium magnitude has been identified on soil and the local population (treated water used for irrigation purposes).

Impact from On-site Storage and Off-Site Disposal of Non-Hazardous Liquid Operations Wastes (refer to Issue O15) –Medium Magnitude, Low Significance

16.4.2.2 Hazardous Liquid Wastes

As during construction and commissioning, considerable quantities of hazardous liquid wastes (e.g. waste oil, waste fuel, chemical wastes) are expected to be generated during the operations phase of the RTIP. These wastes are expected to be stored on-site, and then transported to the recycling company/supplier for its reuse, or otherwise it will be transported to BeeA’h’s facilities for off-site incineration. Liquid hazardous wastes have the potential to cause significant impacts on the natural and social environment, but the waste management practises expected to be used minimise the likelihood and the magnitude of these impacts, which will be analysed under unplanned events.

16.4.3 Solid Wastes

16.4.3.1 Non-Hazardous Solid Wastes

Non-Hazardous solid waste will be collected from each RTIP unit and or envelope designated waste collection areas by a waste-collection service provider and transported to a common non-hazardous solid waste transfer station for processing, consolidation, and storage of the waste prior to transport to the approved off-site disposal facility. It is assumed that waste storage in the transfer station will be only on a temporary basis. Gypsum is a byproduct of the Flue Gas Desulfurization (FGD) process in the RTIP Steam Generation Unit (Unit 530) and will be exported off-site for beneficial reuse. In the event that suitable buyers are not available for gypsum reuse/ recycle, then it will be sent off-site for disposal at an approved landfill. Gypsum will not be handled by the RTIP Solid Waste Handling Unit (Unit 778) and will be directly taken off-site from the separate gypsum handling and storage facilities provided within the Steam Generation Unit.

The main non-hazardous solid wastes to be generated during the operations phase are expected to be either compactable or non-compactable and recyclable or non-recyclable. At the specific waste transfer station, overall segregation of these wastes will be done relative to the recyclability of the waste, and will take place within a fully enclosed area with four walls, a floor and roof. Recyclables transfer station may have a perforator and bailer for plastics and metals. Transportation off-site will be performed using an approved company and following the RC guidelines.

On-site, recyclable materials will be received in the waste transfer station and then transferred into the recycling section for either compaction in a baler or bulk storage before being transported by truck to a licensed recycling facility off-site. Non-recyclable non-hazardous solid wastes will be collected, compacted and transferred to the designated off-site Class II landfills operated by BeeA'h or EDCO, or otherwise an equivalent authorised facility. Waste storage on-site brings a risk of soil and groundwater impacts in the storage areas, however this risk is reduced by the plans to totally enclose these areas and the installation of a dry sump to collect storm water.

Off-site, according to published information the landfill facilities present appropriate design measures and include security, a weigh scale house, a diesel filling station, a leachate treatment facility, a maintenance workshop and administrative offices. The sanitary landfill is equipped with a leachate collection system, a leachate neutralization system, and leachate disposal lagoon facilities. In the case of BeeA'h, there are also indications of the presence of environmental controls in the facility.

<u>On-site storage and off-site disposal:</u> The quantity of non-hazardous waste expected to be generated during this phase will be in the same region as for the commissioning phase, and therefore considerably greater than that of the construction phase. As such, the magnitude of this impact is considered to be medium for both on-site storage and off-site disposal. The likelihood of the impact arising from the disposal of non-hazardous material generated during the commissioning phase is however considered to be low for both on-site storage and off-site disposal (Medium Magnitude and Low Significance).

Impact from On-Site Storage of Solid Non-Hazardous Operations Wastes (refer to Issue O11) –Medium Magnitude, Low Significance

Impact from Off-Site Disposal of Solid Non-Hazardous Operations Wastes (refer to Issue O16) –Medium Magnitude, Low Significance

16.4.3.2 Hazardous Solid Wastes

The quantity of hazardous wastes expected to be generated during the operation phase is expected to be in the same region as for the commissioning phase, being mainly spent reactor or catalysts, and ash from the Steam Generation Unit ESP. All catalysts containing precious metals will be returned to the supplier for metals recovery. All those catalysts with no metal recovery value, and other solid hazardous waste will be transported to either the BeeA'h or EDCO's double-lined Class I landfills after pretreatment, or to an equivalent authorised facility. Liquid hazardous wastes will be stored on-site, and subsequently transported to the recycling company/supplier for its reuse, or otherwise to BeeA'h's facilities for off-site incineration.

<u>On-site storage</u>: The magnitude of the impact related to on-site storage is expected to be high for hazardous waste, given the materials involved, the quantities expected and the mobility of solid waste. It is assumed that the on-site storage of such wastes will be undertaken in accordance with Section 5 of Volume I of the Royal Commission Environmental Regulations, and it is thus

considered that it is unlikely any impact will occur. In addition, it is expected that due to the close proximity to the project site of the facilities handling the wastes, the storage period for these wastes on-site will be aligned with both safety and efficiency considerations. As such the significance of the impact is considered low for solid wastes and low for liquid wastes.

Impact from On-site Storage of Solid Hazardous Operations Wastes (refer to Issue O13) – High Magnitude, Low Significance

Impact from On-site Storage of Liquid Hazardous Operations Wastes (refer to Issue O14) – High Magnitude, Low Significance

Off-site disposal: The magnitude of the impact related to the off-site disposal of hazardous waste on human health and the environment is expected to be high given the materials involved (hazardous, long term effect, high quantity). The fact that these facilities posses either disposal management and environmental controls, or are under the supervision of the Royal Commission (RC) reduces the likelihood of potential windblown and subsurface contamination. This affects the significance of the impact, which is considered to be low.

Indirect Impact from Off-Site Disposal of Hazardous Operations Wastes (refer to Issue O18) – High Magnitude, Low Significance

Transport off-site: The magnitude of the impact related to the transportation of hazardous wastes off-site is expected to be high given the materials involved (hazardous, long term effect, high quantity). Considering the contractor's (in the case of BeeA'h) service policy and their willingness to assume any liability associated with the transport and disposal of the wastes, the significance of this impact is considered to be low. However, not all of the facilities considered are known to offer the same waste collection and transport services. Therefore, depending on the facility selected there may be uncertainties associated to the transport of hazardous wastes which would increase the likelihood of potential contamination occurring, as well as potential future liabilities.

Impact from Hazardous Operations Wastes during Transport Off-site (refer to Issue O19) – High Magnitude, Low to Medium Negative Significance

Mitigation Measures

See measures described in section 16.2.3.2.

16.5 Decommissioning

16.5.1 Overview

Decommissioning will involve purging of all equipment, removal of all raw materials and wastes and the possible dismantling and demolition of the complex. The levels of waste generated during the decommissioning phase are similar to the level of waste generated during the construction phase.

16.5.2 Liquid Wastes

16.5.2.1 Non-Hazardous Liquid Wastes

Liquid non-hazardous waste (mainly black and grey waters) would be collected through a pipeline network and disposed of in the Marafiq Sanitary Wastewater Treatment Facility (SWTP), which uses Primary and Secondary Treatment Processes. Treated water is filtered and chlorinated for disinfection. According to Marafiq's webpage, some of the treated water from both plants is utilized for irrigation and industrial use. The guidelines for Wastewater and Irrigation water are maintained as per Royal Commission laid down Jubail Management Procedures (JMP) parameters.

<u>On-site storage and off-site disposal:</u> Regular operations of the liquid waste management system (through pipeline network) are not expected to cause any impacts on-site. Spills from any breach in the pipeline network will be analysed in section 14.6, Accidental events. Off-site, the Marafiq WWTP is expected to cause little negative effects on the natural and social environment if managed adequately. However, specific environmental and quality control methods at the plant are unknown at this stage and the quantities of sanitary wastewater expected to be generated are considerable, so a potential impact of medium magnitude has been identified on soil, marine environment and local population (treated water used for irrigation purposes).

Impact from On-site Storage and Off-Site Disposal of Non-Hazardous Liquid Decommissioning Wastes (refer to Issue O15) –Medium Magnitude, Low Significance

16.5.2.2 Hazardous Liquid Wastes

Small quantities of hazardous liquid wastes (e.g. waste oil, waste fuel, chemical wastes) are expected to be generated during the decommissioning phase of the RTIP. These wastes are expected to be stored on-site, and then transported to the recycling company/supplier for its reuse or incinerated if deemed suitable. Liquid hazardous wastes have the potential to cause significant impacts on the natural and social environment, but the waste management practises expected to be used minimise the likelihood and the magnitude of these impacts, which will be analysed under unplanned events.

16.5.3 Solid Wastes

16.5.3.1 Non Hazardous Solid Wastes

As during the construction phase, in the decommissioning phase non-hazardous solid wastes (municipal and inert) will be disposed of in the Royal Commission sanitary landfill. It is assumed that all on-site facilities will be decommissioned during this phase and as such, there will be no on-site facilities for waste disposal and all non-hazardous wastes will need to be disposed off-site at managed landfill facilities. Conversely, during the decommissioning phase, any solids, liquids and gases that are deemed suitable will be incinerated off-site. This will increase the risk of transport related impacts (air quality and human impact by noise). Other impacts include those to soil and groundwater associated with waste collection, packaging and temporary storage on-site.

Solid non-hazardous waste (of an industrial nature) will be compacted and stored temporarily on-site prior to being disposed of in the Royal Commission sanitary landfill. Resulting debris, and other non-hazardous wastes, will be disposed of in accordance with all applicable / current state laws at the time of decommissioning.

Off-site, according to published information the landfill facilities present appropriate design measures. The sanitary landfill is equipped with a leachate collection system, a leachate neutralization system, and leachate disposal lagoon facilities. No visual or documentary evidence of environmental controls currently undertaken in the facility has been found. Recyclable waste such as metal, wood, plastics, paper, oil, cardboard, glass or electrical cables will be stored on-site prior to being sent to a recycling company, or will be directly reused.

<u>On-site storage and off-site disposal:</u> the magnitude of the impacts related to on-site storage of non-hazardous waste on human health and the environment is expected to be low in this phase, given the type of materials involved (solid non hazardous, short term effect). Since it is a regulatory requirement, it is assumed that the on-site storage of such wastes will be undertaken by in accordance with Section 5 of Volume I of the Royal Commission Environmental Regulations or the equivalent at the time of decommissioning, so the significance of impacts is expected to be low. However, the uncertainties related to the controls in place for off-site disposal management in addition to the significant quantities of waste expected to be generated increase the potential magnitude of an impact due to off-site disposal. Furthermore, these uncertainties related to off-site disposal management increase the likelihood of potential windblown and subsurface contamination off-site (through rainwater leachate), which could additionally lead to potential future liabilities. This affects the significance of the impact, which is considered medium.

Impact from On-Site Storage of Non-Hazardous Decommissioning Wastes (refer to Issue O11) –Low Magnitude, Low Significance

Impact from Off-Site Disposal of Non-Hazardous Decommissioning Wastes (refer to Issue O16) –Medium Magnitude, Medium Significance

<u>Mitigation Measures</u>

See measures described in section 16.2.3.1.

16.5.3.2 Hazardous Solid Wastes

Hazardous wastes generated during decommissioning will include pipe sludge and contaminated components. Used and surplus lubricants and solvents may also arise. It is assumed that hazardous waste will be stored on-site and disposed of at an authorised facility within Jubail Industrial City. Any hazardous waste deemed suitable will be incinerated in Thermal Treatment Units (TTU).

Solid hazardous wastes which are not incinerated will be transported to either BeeA'h or EDCO's double-lined Class I landfills complete with leachate collection system (approved by the RCJY for the treatment and disposal of solid hazardous waste generated within the Jubail Industrial City), or to an equivalent authorised facility. The EDCO facilities have waste storage facilities for storing liquid, containerised, highly corrosive or reactive wastes whilst awaiting treatment but in the provision of the temporary storage of such wastes, it is assumed that the EPC Contractors will store wastes on-site in accordance with Section 5 of Volume I of the Royal Commission Environmental Regulations. Further to this, unlike BeeA'h's facilities, EDCO's possess no incinerator for solid and liquid hazardous wastes and as such, this could potentially limit EDCO's capacity to treat and dispose of certain types of hazardous waste such as medical wastes.

<u>On-site storage</u>: the magnitude of the impact related to on-site storage of hazardous waste on human health and the environment is expected to be medium for hazardous waste, given the materials involved (hazardous, long term effect, low quantity), and the mobility of solid waste. Since it is a regulatory requirement, it is assumed that the on-site storage of such wastes will be undertaken in accordance with Section 5 of Volume I of the Royal Commission Environmental Regulations, so the significance of impacts is expected to be low. In addition, due to the close proximity of the facilities handling the wastes to the project site and that in this phase of the project all wastes deemed suitable will be incinerated, it is expected that the storage period for liquid hazardous wastes on-site will be aligned with both safety and efficiency considerations. As such the significance of the impact is considered low for solid wastes and low for liquid wastes.

Impact from On-site Storage of Solid Hazardous Decommissioning Wastes (refer to Issue O13) –Medium Magnitude, Low Significance

Impact from On-site Storage of Liquid Hazardous Decommissioning Wastes (refer to Issue O14) –Medium Magnitude, Low Significance

<u>Off-site disposal</u>: the magnitude of the impact related to the off-site disposal of hazardous waste on human health and the environment is expected to be medium given the materials involved (hazardous, long term effect, low quantity). As per their website, there is no information available relating to the presence or absence of appropriate environmental control and monitoring measures; nevertheless the disposal management practices used by EDCO are stated to be in accordance with the standards of the RCJY, PME and USEPA. In the case of BeeA'h, their facilities hold an ISO 14001 certification and their services (clients include the RCJY and Saudi Government Ministries) are provided in accordance with International Conventions. Both the likelihood and the significance of this impact are thus considered to be Low

Indirect Impact from Off-Site Disposal of Hazardous Decommissioning Wastes (refer to Issue O18) – Medium Magnitude, Low Negative Significance

<u>Transport off-site</u>: during the normal operations of transfer of hazardous waste material there is potential for release and potential subsurface soil, surface water and groundwater contamination. The magnitude of the impact related to transport of hazardous waste on human

health and the environment is expected to be medium, given the materials involved (hazardous, long term effect, low quantity). According to BeeA'h a key element of their policy is to ensure compliance with all applicable local and international regulations and further to this their services are provided in accordance with the requirements of the appropriate transport authority. If this is the case, the likelihood of occurrence for such an event is low. In addition to this, in providing hazardous waste transportation resources, BeeA'h assumes total liability for all material accepted, which reduces the potential liability associated with the clean-up of receptors. As such, despite the hazardous nature of the waste in question, the low likelihood of occurrence and the absence of any associated remedial liabilities results in the significance of this impact with respect to BeeA'h's services being low for both solid and liquid hazardous wastes. In the case of EDCO however, at present it is unclear that they offer waste collection and transportation as part of their services. As such, if EDCO were selected it would increase uncertainties associated to the transport of hazardous wastes and therefore increase the likelihood of potential contamination occurring, as well as potential future liabilities.

Impact from Hazardous Decommissioning Wastes during Transport Off-site (refer to Issue O19) –Medium Magnitude, Low to Medium Negative Significance

Mitigation Measures

See measures described in section 16.2.3.2.

16.6 Accidental Events

16.6.1 Overview

Accidental releases of waste compounds may give rise to adverse environmental impacts on or off-site during all phases of the project. Significant quantities of liquid wastes may be released on-site by pipe or vessel failure in the process plant or by errors or component failures during storage and/or loading for transport. Other wastes may be released during transport by road vehicles or road accidents.

Accidents are likely to produce the greatest environmental impacts associated with wastes, although these will generally be local to the site and its vicinity given that the registered waste management facilities are nearby. Solid hazardous waste spills would probably have medium impacts, primarily on air if dust were generated but also on groundwater if leachate were produced. Accidents may produce a legacy of contamination for later cleanup either during plant operations or even at the decommissioning stage.

16.6.2 Hazardous Substances

Hazardous substances involved in accidental releases may contaminate the soil, equipment, clothing and buildings, creating a larger volume of hazardous wastes. Accidental releases will need to be cleaned up quickly in accordance with approved emergency response plans. The cleanup of liquid wastes may involve the use of absorbent compounds, further increasing the quantity of hazardous wastes generated. Several of the liquid waste streams contain proportions of volatile compounds that could vaporise once released.

The impacts from the release of liquid wastes could involve contamination of the ambient air, soil and groundwater and the area affected could be larger than the size of the spill. The impact of such releases on the ground surface will be minimised since in addition to providing primary containment, all units and operations will provide and maintain secondary spill containment for process areas, loading, unloading, materials drumming, packaging, storage facilities and areas at risk of primary containment loss.

Solid wastes are likely to be easier to contain, although weather conditions such as high wind and heavy rain may increase the potential for dust or leachate migration respectively. Solid and liquid hazardous wastes can be accidentally released during storage on the RTIP main site or during transport off-site. The drainage system on-site is closed, and pumps at the surface run-off basins will direct flows to appropriate destinations based upon water quality characterization.

The largest accidental release is likely to occur following a fire. The primary source of firewater for firefighting would be fresh water imported from Marafiq which will be stored in the fire water storage tanks.

Surfaces and process plants are paved and equipped with Unit drainage systems. Further to this, Surface Runoff (SRO) which includes fire water deluge flows, storm water flows and incidental spill event flows in excess of what the unit drainage systems are designed to manage, will be managed by the Interconnecting Facilities Surface Drainage System. In all cases, the first flush water (with a volume equivalent to the first 30mm of a single rainfall event, or the first 30 minutes of a fire water deluge event) from the process areas will be treated as contaminated water and will be collected separately in a dedicated unit sump and directed to the EQ/DQ tank in Unit 773. SRO in excess of this first flush is collected and conveyed via ditches directly to the area's Surface Runoff Basins (SRB) for management and control of quality before discharge to the RC Drainage Channel or to the EQ/DQ tank, as appropriate. During its passage through the EQ/DQ tank this stream will be mixed with the other wastewater streams destined for the Marafiq IWTP to reduce the overall concentration of contaminants in the stream.

Impact from Accidental Release of Hazardous Wastes (refer to Issues O20, O21, O22, O23) – Medium to High Magnitude, Medium to High Significance

<u>*Mitigation Measures*</u>

See measures described in section 13.4.3.

16.7 Conclusions

Jubail Industrial City contains various installations able to treat and dispose of industrial and domestic, liquid and solid waste streams. The facility which will manage the RTIP's non-hazardous wastewater will be the Marafiq Wastewater Treatment Facility, which is itself divided into two plants which are the Marafiq Sanitary Wastewater Treatment Plant (SWTP) and the Marafiq Industrial Wastewater Treatment Plant (IWTP). Both of these plants use Primary and Secondary Treatment Processes. With regards to solid waste streams, there are two facilities directly adjacent to the RTIP site, which are able to manage and dispose of both hazardous and non-hazardous wastes. The first of these is operated by the National

Environmental Preservation Company (BeeA'h) and includes hazardous waste landfill with both Class I and II landfill cells, and a Thermal Treatment facility. The second facility is operated by the Environment Development Company (EDCO) and also includes both Class I and II landfill cells, although there is no Thermal Treatment facility at present. In addition to these two facilities there is also the RCJY sanitary landfill which is equipped to handle non-hazardous wastes only.

Wastes will be generated during the construction, commissioning, operation and decommissioning of RTIP. The majority of hazardous wastes will be produced during the commissioning and operational phases of the project, although a significant portion will also be generated during the construction phase. Non-hazardous and inert wastes will be generated during all project phases. Two units will be constructed within the RTIP for the on-site preliminary waste management of solid and liquid waste streams. Wastewater Unit 773 is composed of an EQ/DQ tank and an Emergency Holding tank. During storage, different wastewater streams of varying degrees of contamination will be mixed together to reduce the overall concentration of contaminants. This final wastewater stream will be tested to ensure compliance with RCER table 3B standards, after which it will be redirected to the IWTP plant in the Marafiq facility. In addition to this, a Solid Waste Handling Unit (Unit 778) will also be constructed within the RTIP where waste segregation and temporary storage will be carried out for non-hazardous solid waste and both hazardous solid and liquid waste. The waste will be collected from this Unit to be transported to the designated off-site waste facility where it will be managed and disposed.

The impact of on-site storage and off-site disposal of non-hazardous liquid waste on human health and the environment is expected to be of low significance during all project phases. Non-hazardous liquid waste streams will mainly include sanitary wastewater, process water, surface runoff flows, and hydrotest water, over the course of the four project phases. All sanitary wastewater (mainly made up of grey and black water) generated during the project will be sent to the Marafiq SWTP for treatment, whilst process and hydrotest water will be sent to the IWTP (although in the case of the latter it may be directly discharged into the Marafiq Seawater Cooling Return Header if in compliance with RCER table 3C). Surface runoff will be sent to the RC Drainage Channel when the water quality is in compliance with the RCER table 3C, and when not in compliance will be diverted to the RTIP Unit 773 EQ/DQ tank. Specific environmental and quality control methods at the plant are unknown at this stage and the quantities of sanitary (during construction) and industrial wastewater (during operations) expected to be generated are considerable, so a potential impact of medium magnitude has been identified for soil, marine environment and the local population.

Although on-site storage of non-hazardous solid wastes is expected to be of low significance during all project phases, off-site disposal of these wastes is expected to be of medium significance during the construction and decommissioning phases. Non-hazardous wastes will be segregated and stored at the EPC contractor's camp during the construction phase, and then in the RTIP Solid Waste Handling Unit 778 during the rest of the project phases. Throughout the project, solid waste storage areas will be enclosed within four walls, floor and roof. Off-site disposal will be carried out at the RC sanitary landfill during the construction phase and in either BeeA'h or EDCO's Class II landfills or equivalent licensed facilities during the remaining project phases. Controls in place for off-site disposal management reduce the overall likelihood of potential windblown and subsurface contamination off-site.

The impact of on-site disposal and off-site disposal of hazardous waste on human health and the environment is expected to be of low to medium significance in all project phases, particularly given the materials involved (hazardous, potential long term affect, large quantities). Off-site disposal will be carried out at either BeeA'h or EDCO's Class I landfills during the all project phases. As per their website, there is no documentary evidence of environmental controls being in place at the EDCO facility but nevertheless the disposal management practices used by EDCO are stated to be in accordance with the standards of the RCJY, PME and USEPA. In the case of BeeA'h, their facilities hold an ISO 14001 certification and their services are provided in accordance with International Conventions. The significance of these impacts can be further lowered if appropriate mitigation measures are taken. These include developing a comprehensive waste management plan, or auditing the waste management facility prior to the start of each phase of the project.

Hazardous waste transportation is expected to be of low to medium significance during all project phases. The significance of this impact depends greatly on the facility selected for hazardous waste disposal. BeeA'h for instance state that they aim to ensure compliance with all applicable local and international regulations; that their services are provided in accordance with the requirements of the appropriate transport authority; and that in providing hazardous waste transportation services they also assume total liability for all material accepted. In the case of EDCO however, at present it is unclear whether or not they offer waste collection and transportation as part of their services. Therefore, depending on the facility selected there may be uncertainties associated to the transport of hazardous wastes and which would increase the likelihood of potential contamination occurring, as well as potential future liabilities.

During all phases of the project there is the potential for accidental releases of liquid and solid hazardous wastes both in RTIP and during off-site transportation. The significance of the potential impact resulting from an accidental release is considered medium to high but can be reduced to low if the appropriate mitigation measures are taken and comprehensive and adequate Emergency & Incident Response and Contingency Plans are prepared and implemented.

17 SOCIAL IMPACT ASSESSMENT

17.1 Overview

The implementation of the RTIP project may result in social and health impacts at local, regional, and national levels. The RTIP site is located in Jubail II (an extension of the JIC which serves a major Industrial centre for Saudi Arabia), in the Jubail Governorate of the Eastern Province of Saudi Arabia. The RTIP site is within an area designated as industrial and is located approximately 13 km south west of Jubail old town, and 17 km southwest of the JIC community area. This section provides an assessment of potential impacts during construction, commissioning, operation, and decommissioning phases and is based on current information, including the project description (see Section 3) and social baseline data (see Section 10).

The social baseline included in Section 10 was compiled in order to identify and characterise the receptors that may be impacted by RTIP, and to provide a general understanding of the social and cultural setting for the project. However, limitations in data availability do not permit the development of a thorough local baseline description. For this reason, CH2MHILL has adopted a conservative approach and where local information was not available the worst credible scenario has been considered.

The equator principles and international standards such as the World Bank and IFC Performance standards form the basis for the potential impact assessment.

An archaeological and cultural impact assessment is provided in Section 18 and occupational health is addressed using the operator's health and safety practices and EPC contractor's health and safety standards (see Appendix A EMP). Information regarding impacts related to dust, noise, cultural heritage, and waste management have been addressed and discussed in Section 12-Air Quality & Meteorology, Section 15– Noise Section 18-Archaeological and Cultural Heritage, and Section 16- Waste Management, respectively.

Impacts are summarised and tabulated in Section 20 – Summary of Impacts (Table 20-1 Summary of Environmental and Social Impacts, RTIP, KSA). The magnitude and significance of the impacts are defined according to the criteria presented in Section 11– Impact Assessment Criteria and are also stated at the end of each subsection (in bold italic). Next to each magnitude/significance statement and for ease of reference, each issue is identified by a unique number which is repeated in Table 20-1 and subsequently in Tables 21-1 (Summary of Potential Mitigation Measures for RTIP) and 22-1 (Summary of Potential Monitoring Measures for RTIP), where applicable.

17.2 Construction

Six potential impacts involving social factors have been identified that are either likely or certain to occur due to project construction (including construction of the RTIP Complex, and auxiliary infrastructure such as roads and the expansion of port facilities). The construction phase will require the highest number of employees at one time. It is estimated that up to 55,000 direct and indirect workers will be required during the peak periods of this phase.

Potential sources of impacts during the construction phase include the following:

- Transportation Impacts;
- Employment and Incomes;
- Workers Importation;
- Housing;
- Goods, Services and Infrastructure; and
- Social pathologies.

Impacts associated to the above potential sources are discussed below.

17.2.1 Transportation Impacts

In constructing a project like RTIP, transportation infrastructure use and the resulting traffic can result in diverse impacts to the local social environment. The increase in use and operation of existing infrastructure could impact local citizens and the quality of roadways and roadway conditions (S1). Increased traffic may also increase the potential for traffic accidents (road traffic accidents are discussed in section 17.6.1).

Personnel commuting to the site, as well as equipment and local vendors, will be among the additional and frequent road users during the construction phase. This increase in use could result in disruptions or delays to local citizens/residents of the JIC community area and Jubail (mainly) and other typical user's access to community facilities.

Construction personnel will be transported daily from the camps to the main site by bus. In general, Saudi nationals (about 20%) will not be accommodated within the PMT construction camps so they will mobilize to RTIP from existing adjacent communities. The exception to this rule will be the Saudi nationals that travel from other Saudi Arabian provinces. Moreover, during site preparation activities, approximately 200 trucks on average will be in operation for 12 hours per day, 6 days per week, for 10 months, apart from a number of other items of heavy equipment.

It is expected that the major inconvenience and nuisance from worker transport will be to local road users within JIC. However, it is likely that workers will travel by land to other provinces for tourism or to markets and recreational areas in nearby communities (camps will be located 13 km south west of Jubail old town, and 17 km southwest of the JIC community area), thereby increasing road traffic on weekends.

There will be additional increased traffic should materials need to be brought to or from the site. Supplies will be transported from the nearest capable commercial market or from the nearest port (if by sea) (e.g., JCP, KFIP and Jubail and King Abdulaziz Port, Dammam), depending on the products required. Increases in deliveries of supplies to the areas are expected; as such, an increase in commercial traffic is predicted.

The transportation of raw materials is expected to be predominantly via sea shipment and truck transport. It is estimated that about 3,342,000 MT of raw materials will be required for the construction of the RTIP complex. Although the exact number of trucks and ships required to transport this material is not known, a fair estimation to be used as a reference for the assessment of impacts is based on the following assumptions:

- Half of the material to be transported by ship (1,671,000 MT) requiring local truck movements from the port to the site, and the other half (1,671,000 MT) involving long distance trucks movement;
- With an average truck capacity of 20 MT; about 167,100 truck movements (including local and long distance movements) will be required to transport the material to the project site. Therefore, 334,200 truck movements are estimated will occur to and from the site. On the basis of activities on 6 days per week, approximately 357 daily trucks movements are expected during the construction phase.
- Considering an average ship capacity of 2,000 MT, approximately 1,671 ship movements will occur to and from the ports.

A traffic study for the construction phase of the project was conducted by the project's operators (KBR, 2011). This study includes an analysis of construction and operational traffic associated with the RTIP site and associated port facilities considering the traffic volume around the RTIP complex. The recent expansion of the oil industry resulted in the establishment of an improved road transportation network in Jubail. According to this study, there are two potential routes (two lane roads that are in good condition) for transporting construction personnel to site: existing North-West and South-East road networks from the site. These are, therefore, considered the ones of highest interest for the project and will be considered as those potentially affected by RTIP that may inconvenience local road users and pose an increased safety risk.

An increase in traffic flow (high-moving traffic or slow-moving congestion) or increase on heavy equipment on the road may also contribute to the drop in quality of road surfaces and the increase in maintenance costs. Roads are designed to handle the weights of a number of vehicles for a specific period (the design life). In normal conditions, the areas of contact (where the vehicles' tyres touch the road) are deflected downwards under the weight of the vehicle and as the vehicle moves forward, the deflection corrects itself to its original position. With increased traffic, the time allowed for the deflection correction is not enough and over time, this has the effect of wearing down the road surface.

For ship transport, the project will be using a range of vessels from heavy haul ships that handle 2,000 MT to smaller charter and liner vessels for containers and break bulk. The Jubail area in general represents an important fishing area in the Arabian Gulf, combining traditional and commercial fishing. However, the areas close to the Port including the shipping lanes where the vessel movements will be focussed, are restricted areas and therefore designated as a no-fishing zone. The increase in shipping traffic during the construction phase could cause some disturbance to local fishermen but this is considered a marginal effect (potential economic impact related to this is further discussed in section 17.2.2).

Therefore, nuisance to local road users and RTIP personnel is likely to occur. This impacting activity will occur on a continuous basis and the impact has a high magnitude as the disruption is to occur on a daily basis for an estimated construction period of 40months.

Overall Road Transport Impact on social aspects (refer to Issue S1) – High Magnitude, High (Negative) Significance.

Mitigation Measures

- Develop and implement a traffic management plan (and logistics) for the project in partnership with the RCJY and port authorities, addressing conditions, access management, routing, scheduling, and operational procedures that contribute to traffic hazards as envisaged in the traffic study prepared for the project. Supporting regional road safety programmes and providing input into management of the road work network within the RCJY authorities can further reduce the impact of RTIP;
- Determine the waste and material truck circulation at certain hours to avoid annoyance and congestion;
- Coordinate with RCJY to promote traffic safety in the community. This coordination and outreach should be included in the stakeholder consultation program;
- Disseminate traffic safety information to road users;
- Support RC in the communication with community leaders to inform stakeholders of the impact, schedule, and routing, thereby minimising negative impacts;
- Give preference to local sources for foods and services, in order to minimize offsite traffic and provide positive economic impacts. Integrate into the project design the measures suggested in the traffic study conducted for the operation phase. Some of the recommendations made by this study are listed below:
    - Modifications of the RTIP site south-west and south-east entrances to help optimize the flow of traffic to and from the RTIP site;
    - Establish an additional bus stop at the RTIP north entrance (for 14 buses), the RTIP south entrance (for 9 buses) and at the KFIP (for 1 bus);
    - Staggered or flexible start times for personnel of day shifts.

17.2.2 Employment and Incomes

There are four anticipated impacts resulting from employment and improvement of income involving two target populations, specifically local and international (migrating persons), during construction.

While a majority of workers, particularly during construction, are expected to migrate to the site, this project is likely to also generate employment within the local community (S2). It is estimated that approximately 80% of the total workforce will be global expats (primarily from Southeast Asia, North Africa, the Middle East, US and Europe), and approximately 20% will be locals (Saudi nationals). In other words, during the construction phase about 11,000 new jobs for Saudis will be created as part of the RTIP project. This is expected to be a medium magnitude, positive impact that is likely to occur and directly benefit the community, both in the income generated and the residual spending impact to local vendors. It is expected that this benefit would occur primarily during construction although additional employment would also occur during the operations phase of the project.

It is assumed that a relatively large proportion of income resulting from employment during construction will go to immigrant construction worker populations, whose presence will increase demand for local goods and services. This impact will have a positive effect upon the local economy (S3).

Construction equipment will require both gasoline and diesel fuel and contractors would be expected to secure supplies of fuels and lubricants via local sources.

Local restaurants and convenience stores will likely benefit from temporary increases in demand. At its peak, the construction workforce will reach 55,000 which represents a significant requirement for food supplies and sanitary products. Although some products will be locally grown and manufactured, consumables will also be imported and purchased from local suppliers within the KSA. This influx of workers, which will result in an increase of about 25% in the current population of Jubail, will have a noticeable impact on the availability of goods. This impact is considered certain to occur and to be of medium magnitude. While this impact may increase income to local businesses, it is essential that supply is adequately maintained so that prices remain stable. The influx of a large number of workers into the area may result in an increase in local demand for basic goods and services, which could be exacerbated if the supply chain cannot keep pace with the increase in demand. This may result in an increase in prices for both local residents and workers, though the highest impact could affect local residents as the project and many of the workers may have a higher purchasing power compared to the local residents. Therefore, if demand increases and supply cannot increase fast enough, local residents may be negatively affected by increased prices.

It has been determined that this contribution will result in a positive medium impact. Also, considering that the industrial city will continue growing, the impact may be long term.

Overall Impact on social aspects (refer to Issues S2 and S3) – Medium Magnitude, Medium (Positive) Significance.

As previously discussed, the increase in shipping traffic during the construction phase may marginally impact local fishermen in the Jubail area, but Jubail Port, which is closest to RTIP, and the associated shipping lanes are already designated as a no-fishing zone. Therefore, the RTIP project would not result in losses in catch or directly affect the local fishing economy (S4).

The greatest increase in shipping traffic is expected to occur during the first stage of the construction phase when the major mobilization of equipment would occur (approximately the first 10 months of the construction phase). Therefore, any marginal negative impact on the local fishermen's economy in the Jubail area during the construction phase is estimated to be of short duration.

Overall Impact on social aspects (refer to Issue S4) – Low Magnitude, Low (Negative) Significance. No mitigation required.

Once construction has been completed and the workforce leaves the area, there will be a low magnitude negative impact on income resulting from the reduction in the number of workers (S5). Although the number of employed workers will be reduced significantly, given the expected increases in industrial development within JIC, the infrastructure and businesses established during the RTIP project are expected to continue to provide goods and services to new developments. This will potentially diminish the impact caused during demobilisation, as other JIC projects will require the same or greater levels of service or products, and furthermore the continued development of JIC will bring additional new projects to the area. As such, the significance of this impact has been deemed low.

Overall Impact on social aspects (refer to Issue S5) – Low Magnitude, Low (Negative) Significance.

Recommended Measures

- Coordinate with RCJY to arrange a workshop with the community to inform them about project activities and potential employment opportunities.

Improvements in stakeholder's economic status and income benefit from increasing health services available by the State and population's access to them (S6). The petroleum sector represents a significant percentage (54%) of the KSA's Gross Domestic Product (GDP). The RTIP will contribute to increases in GDP, which in turn will increase the State's capacity to offer a range of health and social services, including education and health care. This is considered a positive impact of low magnitude and regional extent. Impacts related to the potential increase on the demand of health services by workers are discussed in section 17.2.5.

Overall Impact on Health (refer to Issue S6) –Low Magnitude, Low (Positive) Significance.

17.2.3 Worker Migration

The employment of about 55,000 workers will inevitably have associated social impacts. It is estimated that about 80% of the total workforce will be expats (including US, Europeans, Asian, North African, and Middle Eastern). The positive effect has been previously discussed and is related to the increase in income and quality of life. The negative impact (S7) is related to worker's mobilization and migration to KSA. Worker's spouses will be left to care for children and to manage household accounts and responsibilities, where previously they may not have had such responsibility. In addition to the practical household issues, relationship, communication, and emotional issues will result from this period of separation.

Overall Impact on social aspects (refer to Issue S7) – Low Magnitude, Low (Negative) Significance.

Recommendations

- Improve communication systems between workers and families by installing pay telephones at the workers accommodation.

17.2.4 Housing

During the construction phase, workers will be accommodated in base camps that will be constructed near to the RTIP site. In general, Saudi nationals (approximately 20% of the workforce or 11,000 people) will not be accommodated within these construction camps since it is assumed Saudi nationals will live in existing adjacent communities (with the exception of those coming from other provinces). Therefore, the greatest potential for impact would result from Saudi nationals currently living in other areas who migrate to the project area in search of employment which may create a demand for local housing, and result in increased prices for local housing (S8). In a worst case scenario (all Saudi national workers [11,000] in a peak period demanding housing in the JIC community area), would result in a growth rate of 5% of the population during the construction phase (temporary residents). As confirmed by the RCJY

(Letter received by RTIP on the 13th October 2010), the existing community area provides a range of housing types and neighbourhoods with relatively low-density areas. It is designed to accommodate permanent and temporary residents including families and singles. Based on the above, the impact is considered of low magnitude.

Overall Impact on social aspects (refer to Issue S8) – Low Magnitude, Low (Negative) Significance.

17.2.5 Services and Infrastructure

The construction camps will be equipped with the infrastructure and support services necessary to accommodate the workforce, such as water, electricity, air conditioning, laundry, canteens, and medical services, among others. In addition, the workforce will also require other services, such as health services and in some cases also education for their children. Therefore, the increase in expatriate and construction workforce could impact local services and infrastructure throughout the lifetime of the project (particularly peaking during construction) (S9).

The Royal Commission is responsible for the construction and operation of basic infrastructure facilities and public services required by industry and the permanent community. It was confirmed by the RCJY (Letter received by RTIP on the 13th October 2010) that JIC together with other agencies, such as Marafiq, SEC, and various telecom companies and operators, provide the services, utilities, and infrastructure for developments in the industrial city. The infrastructure and utilities provided include potable water generation and distribution, sanitary wastewater treatment and collection, reclaimed water and irrigation, surface water drainage, electrical power, telecommunication and solid waste. JIC also provides educational institutions, health care facilities, and recreational areas (amongst other services) for JIC's residents.

However, the large number of project workers will create additional demands on specific services, for instance the community health care infrastructure because of routine health care needs, work-related accidents, and adverse reactions to environmental conditions. This demand could reduce the local population's access to health care, if resources are not adequately increased during the construction period to meet local needs and those derived from the project workforce. The project could also indirectly cause increases in the demand for medical services by the local population. For example, the local population might require additional treatment for infectious diseases that result from contact with the workforce. Therefore, the demand on health services and infrastructure is considered of medium magnitude.

Despite the potential increase in the demand of services, the existing infrastructure and services provided by JIC are expected to sufficient to respond and be adequate to accommodate the increase in numbers. Any future development including new infrastructure within JIC will absorb any additional increase in demand for future developments in the area. Therefore, potential impacts related to pressure on existing infrastructure is considered of medium magnitude, but unlikely to occur, resulting in an impact of low significance.

Overall Impact on Social Aspects (refer to Issue S9) –Medium Magnitude, Low (Negative) Significance.

17.2.6 Social Pathologies

The social public welfare of surrounding communities will likely be impacted by the RTIP.

The large influx of expatriate male workers into the Project Area has the potential to increase the incidence of communicable disease. The incidence of transmission between the workers and the population of the local communities (S10) must be considered.

Communicable disease refers to an infectious disease that can be transmitted from one individual to another either directly by contact or indirectly by vectors. It must be taken into account that the workplace is considered an important setting for interventions to prevent and control infections. During the construction phase, workers from a number of countries will be employed and housed in a communal setting, where the spread of infectious diseases can occur more rapidly.

During the construction phase, workers will live at construction camps, and food and water will be provided by individual EPC contractors. The quality of food and the hygienic conditions in kitchens and cooking areas play a considerable role in the nutritional health of the workers and in the potential for transmission of communicable diseases. The principle causes of water-transmitted illness could be a decline in hygiene and an impoverished status in terms of quality and quantity of potable water. Accommodation for feeding and housing the workers can have a considerable role in preventing the spread of communicable diseases.

Persons in the local communities might interact with workers if they provide services on site, or when the workers leave the facility for recreation, shopping, religious activities, health care needs not provided on site, and for other reasons. These interactions provide potential pathways for transmission of communicable diseases to the public. It is anticipated that interactions with the community will increase the incidence rates of a variety of commonly occurring infectious ailments and diseases, such as the common cold, influenza, hepatitis, and sexually transmitted diseases (STDs) in the nearby communities. This impact is considered of high magnitude and likely to occur, resulting in an impact of high significance.

Overall Impact on Social Aspects (refer to Issue S10) –High Magnitude, Medium to High (Negative) Significance.

<u>*Mitigation Measures*</u>

- Provide employee counselling, health screening, health and cultural training and awareness, and vaccination programmes.
- Pre-employment physical and inoculation for infectious diseases.
- Awareness and prevention programmes should be developed as well as health policies and procedures. An integrated programme addressing the health and social implications should be developed.
- Management of the workers' accommodation in ways that reduce risky behaviours should be undertaken, including provision of recreational facilities;
- Epidemical diseases at JIC or in the Region were not accessible when the baseline was performed. A health survey campaign to collect data on the most common communicable diseases in the area is recommended. Tracking and monitoring of incidence rates throughout project implementation would provide valuable information for the design of health programs for the RTIP.

- Ensure that the requirement to monitor and screen for communicable diseases is incorporated into the EPC contractor's contract. The operator should enforce and audit against the contract.
- Ongoing commitment to health education and support of local programmes to control the spread of communicable diseases is recommended.

17.3 Testing and Commissioning

Activities to be performed during the commissioning phase involve unit commissioning, pipeline testing, and tank hydrotesting. The number of workers during this phase will be reduced from 55,000 (in a peak period during the construction phase) to approximately 3,600 workers. It is expected that workers during this phase will be accommodated in the same camps used during the construction phase. The duration of this phase is estimated in two and a half years.

The most relevant impacts associated to this phase are related to the following sources:

- Transportation impacts;
- Employment and Incomes;
- Goods, Services and Infrastructure; and
- Social pathologies.

Social and health issues related to these sources discussed under the construction section (section 17.2) are also applicable through the commissioning phase as the nature of the impacts remains the same. However, the potential significance of these impacts is reduced considering the decrease in staff numbers and therefore, in associated traffic levels, and reduced demand for services and infrastructure, amongst other factors. Mitigation measures previously outlined should be retained during this phase.

Overall Impacts on Social Aspects (refer to Issues S1 to S10) – Low to Medium Magnitude, Low to Medium (Negative) Significance.

17.4 Operation

Approximately 3,600 persons will be employed during the operations phase and it is expected that personnel will be accommodated in the JIC community area.

Some of the impacts previously discussed under the construction section (section 17.2) may occur throughout the lifetime of the project though in some cases with a different significance. The operations phase impacts on the social environment around RTIP will be of long term duration and characterised mainly by:

- Transportation impacts,
- Employment and income; and
- Services and Infrastructure.

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17.4.1 Transportation Impacts

While road traffic is expected to diminish after construction is complete (due to the significant decrease in workforce and consequent reduced need for supplies and equipment), there will nevertheless be a net increase in road use compared to the current baseline during operations due to commuting workers, raw material provisions, and waste, and product export. A traffic study for the operation phase of the project was conducted by the project's operators (KBR, 2011).

Personnel transfer vehicles will, where possible, use the roads during the periods when truck traffic is suspended (during peak traffic hours -between 6.00 am to 8.00 am and 4.00 pm to 6.00 pm). However, inconveniences to local road users during the operation phase due to increased traffic are likely to occur. This impact is considered of medium magnitude and long duration.

Overall Impact on social aspects (refer to Issue S1) –Medium Magnitude, Medium (Negative) Significance.

Mitigation Measures

- Refer to measures proposed for the construction phase (Section 17.2.1).
- Integrate into the project design the measures suggested in the traffic study conducted for the operation phase. Some of the recommendations made by this study are listed below:
    - Modifications of the RTIP site south-west and south-east entrances to help optimize the flow of traffic to and from the RTIP site;
    - Establish an additional bus stop at the RTIP north entrance (for 14 buses), the RTIP south entrance (for 9 buses) and at the KFIP (for 1 bus); and
    - Staggered or flexible start times for personnel of day shifts.

17.4.2 Employment and Incomes

A low positive impact resulting from operations will occur through the influx of workers, the creation of new jobs or new contracts (S2), and an increased demand for goods and services in the area (S3).

The overall decline in workforce from commissioning to operation is unlikely to impact local employment as the expatriate workforce is assigned working visas (S2). Once the operational phase begins, surplus workers will be deployed to another project or will return to their native country, and other workers will be hired with high probability of long term jobs. A direct rise in unemployment in the local area is, therefore, not expected.

Unlike the construction and commissioning phase, workers during the operation phase will be accommodated in the JIC community areas. Therefore, workers will spend a greater percentage of their wages locally. This is a new source of income for the local community.

Overall Impact on Socio-Economic Aspect (refer to Issues S2 and S3) – Low to Medium Magnitude, Low to Medium Positive Significance.

17.4.3 Services and Infrastructure

In comparison with the larger RTIP workforce during construction, the workforce during the operations phase is smaller but still significant, with approximately 3,600 workers based locally. The operations workforce will use existing services and infrastructure (S9). However, the increased numbers associated with the RTIP workers and their families represent a small overall growth in the local population. Presuming the maximum 3,600 staff migrate to the area for work who were previously not inhabitants of Jubail and half are married with one child (increasing the number to 7,200), the increase in population in the province is 3.2% (based on a population of 224,430) which is comparable to the overall growth rate in Saudi Arabia of 1.84% in 2009 (CIA, 2010b).

Likewise, the negative impact resulting from the increase in services demand during the operations phase will be of low magnitude. Existing school infrastructure will likely accommodate the increase in project-related student enrolment (expected to be approximately 1,800) and local and regional health infrastructure is expected to be able to accommodate the additional population.

Overall Impact on Social Aspects (refer to Issue S9) – Low Magnitude, Low (Negative) Significance.

Recommendations

- Refer to measures proposed for construction phase (Section 17.2.5).

17.4.4 Social Pathologies

During the operation phase, the workforce will be accommodated in the JIC community area and not at construction camps. Considering the long duration of this phase, workers accommodation will not be as transient as in previous phases, so it is more likely that workers will live with their families instead of in high-density areas. These factors reduce the risk of infectious disease incidence (S10) in comparison to the previous phases (both among workers and from workers to the community). For this phase, magnitude is considered Low.

Overall Impact on Social Aspects (refer to Issue S10) –Low Magnitude, Low (Negative) Significance.

Recommended Measures

- Refer to those proposed for construction phase (Section 17.2.6).

17.5 Decommissioning

The number of workers to be involved during the decommissioning phase is estimated to be in the same order of magnitude as the workforce required during the construction phase (approximately 55,000 at its peak period).

The decommissioning phase impacts on the social environment are considered of short term duration as this phase is estimated to last just 1 or 2 years and the key ones are characterised mainly by:

- Transportation impacts;

- Employment and income; and
- Services and Infrastructure.

Because of the nature of the activities undertaken during the decommissioning phase, impacts previously discussed under the construction section (section 17.2) are expected to also occur during this phase. It must be noted that the significance of potential impacts associated with decommissioning activities is uncertain as the techniques employed could vary over the coming years, especially considering the long duration of the Operation phase (25 years) and the potential changes that could occur in the environmental and social conditions in the project area during this time period (due to natural events or human intervention).

17.5.1 Transportation Impacts

An increase in traffic due to the removal of material to restore land to pre-project conditions is likely to cause inconvenience to the users of the local road network (S1), as discussed for the previous phases (residents of the areas surrounding the RTIP Complex Site, workers of the industrial sites located in the area, residents of Jubail). This impact is expected to be of medium magnitude during the decommissioning phase.

Overall Impact on social aspects (refer to Issue S1) –Medium Magnitude, Medium (Negative) Significance.

Mitigation Measures

- Refer to those proposed for construction phase (Section 17.2.1).

17.5.2 Employment and Incomes

A medium positive impact resulting from decommissioning is likely to occur due to the influx of workers at peak, the creation of new jobs (S2), and an increased demand for goods and services (S3). Although many of these workers will be expected to be immigrants from outside of KSA, their presence will generate the need for local goods and services which will have a positive effect upon the local economy.

Considering the workforce required to perform the activities associated to this phase is expected to be similar to the construction phase, the overall impact upon the local economy is considered positive, as their presence will generate the need for local goods and services which will have a positive effect upon the local economy.

Overall Impact on social aspects (refer to Issues S2 and S3) – Medium Magnitude, Medium (Positive) Significance.

However, the subsequent demobilisation of the workforce will have an impact, as it will result in a decrease in employment and related income (S5). Operations employment will cease and operations staff will need to find alternate sources of income. In addition, once the decommissioning phase is complete and the majority of the decommissioning workforce returns to their home countries, there will be a negative impact on income to both workers and local suppliers.

Nevertheless, as there will be additional projects taking place as well as already established business operating in the area in the future (and operation is expected to occur for 25 years). It is therefore considered that the impact will be of a low magnitude and significance.

Overall Impact on social aspects (refer to Issue S5) – Low Magnitude, Low (Negative) Significance.

<u>*Recommended Measures*</u>

- Refer to the measure proposed for the construction phase (Section 17.2.2).
- An appropriate decommissioning plan should be developed and implemented. The plan should anticipate these social and economic consequences and consider options to minimise adverse health impacts from loss of employment and income.

17.5.3 Services and Infrastructure

The increased demand on services by the project workforce during decommissioning will result in a low negative impact (S9). JIC has thoroughly planned for expansion, proposing and scheduling the construction and operation of a variety of new buildings and facilities with Saudi Aramco in addition to a number of local and international firms. As in other project phases, the existing and planned infrastructures and services should be sufficient to support those demands.

Finally, the reduction in the number of workers following the peak and their use of local suppliers will result in a low negative impact at the decommissioning phase. The decline in consumption through the decommissioning of one project will be temporary and will presumably stabilise once another project commences, assuming that multiple projects do not decommission at the same time. Hence, this impact is of low significance. No mitigation measures are currently recommended for the impacts but it is recommended that this be re-evaluated shortly before decommissioning.

Overall Impact on social aspects (refer to Issue S9) –Low Magnitude, Low (Negative) Significance.

17.6 Accidents and Spills

Accidents and spills could impact health and the economy of certain residents. Upset conditions could potentially pose issues on local communities as gas and smoke clouds can drift over housing areas. These issues are discussed in the Air Quality Section. Mitigation measures are suggested to ensure that communities, schools, hospitals and other facilities are notified when upset conditions occur and what to do in these emergency events.

17.6.1 Road Traffic Accidents (RTAs)

The number of vehicle movements will be increased during all the project phases, especially of heavy vehicles during the construction and decommissioning phases. The movement of equipment and materials, construction workers travelling on weekends, travel by local vendors and the commuting workforce are all expected to increase traffic.

In major construction projects such as RTIP, RTA's could be the major cause of project-related fatalities because of the numbers of vehicles moving about the project site and because of the large volumes of materials typically transported during construction.

The issue of traffic safety is of particular concern, given the high incidence of traffic collisions and injury on KSA roadways and the fact that physical injury and death are the most direct health impacts of motorised transport. RTA's in Saudi Arabia have been recorded as one of the highest rates in the world, and it is has become the largest cause of death in adult males aged 16 to 36 years in KSA (Roadtraffic, 2010).

The potential increase of traffic accidents (S11) is considered to be a likely impact of infrequent occurrence and high magnitude, as physical injury and death are the most direct health impacts of motorised transport.

The number of workers will decrease after construction is complete. Commissioning and operational activities might lead to some increase in traffic as compared with the baseline, but RTAs during the operation phase are expected to be less frequent than during the construction phase. However, during this phase, workers will be housed in nearby community areas; therefore, there will be additional traffic as employees commute to and from communities nearby the facility. Although worker numbers will be lower, efforts to limit RTAs will remain a priority because traffic accidents are likely to continue and can result in fatalities.

During decommissioning, traffic levels will be similar to that expected for construction. For this reason, accident risk is also considered to be equivalent.

Overall Impact on social aspects (refer to Issue S11) – High Magnitude, High (Negative) Significance.

Mitigation Measures

- A structured approach to traffic management and vehicle standards should be specified and safety measures should be implemented. A road transport safety programme for RTIP should be developed and implemented during the lifetime of the project.
- Supporting regional road safety programmes and providing input into management of the road work network can further reduce the impact of the RTIP.
- Coordinating with the local authorities to promote traffic safety and coordinate on transport is recommended. This coordination should be included in the stakeholder consultation program.

17.6.2 Other Accidental Issues: Safety Hazards

The most significant community health and safety hazards associated with the project are expected to occur during the operational phase including the threat from major accidents related to fires and explosions at the facility and potential accidental releases of raw materials or finished products during transportation outside the processing facility (S12).

Should a pollution incident such as a release of product following a ship collision occur then this could have a high negative impact on the local fishery, depending on the location of the spill in relation to the fishing grounds. The probability of such a collision with an associated major release is low but possible; there is a greater likelihood of disturbance to fishermen than direct collision with fishing vessels, as shipping lanes are generally designated and locally known.

The most significant safety hazards are related to the handling and storage of liquid and gaseous substances. Impacts may include significant exposures to workers and, potentially, to surrounding communities, depending on the quantities and types of accidentally released chemicals and the conditions for reactive or catastrophic events, such as fire and explosion.

Overall Impact on Social Aspects (refer to Issue S12) –High Magnitude, Medium to High (Negative) Significance

Mitigation Measures

- Major hazards should be prevented through the implementation of a Process Safety Management Program that includes:
    - Facility wide risk analysis, including a detailed consequence analysis for events with a likelihood above 10^{-6}/year (e.g., HAZOP, HAZID, or QRA);
    - Train employees on operational hazards;
    - Develop and implement procedures for management of change in operations, process hazard analysis, maintenance of mechanical integrity, pre-start review, hot work permits, and other essential aspects of process safety;
    - Develop and implement a Safe Transportation Management System for the transport of raw or processed materials; and
    - Develop and implement procedures for handling and storage of hazardous materials.
- On-site and off-site emergency planning, which should include, at a minimum, the preparation and implementation of an Emergency Management Plan and a Communication Plan prepared with the participation of local authorities and potentially affected communities.

17.7 General recommendations to strengthen relationships with the community

Although identified potential impacts are mainly the result of normal working processes and conditions, it is recommended that RTIP, in collaboration with the RCJY, develop and implement a public awareness campaign that addresses the facility, associated emissions, project progress, and provides public health and safety emergency plans throughout all project phases. It could be beneficial for RTIP to provide a contact person for the community to communicate with and a system for providing responses to community concerns should be developed. Additional recommendations to strengthen the relationship with the community are listed below:

- Include supporting businesses necessary for long-term operations.
- A workshop with the community could be arranged in collaboration with the RCJY, to inform them about project activities and potential employment opportunities.

- In collaboration with the RCJY, develop and deliver a public awareness campaign about the facility, associated emissions, and health and safety emergency plans throughout all project phases. A contact person could be provided for the community to communicate with and a system for providing responses to community concerns could also be developed.

18 ARCHAEOLOGY IMPACT ASSESSMENT

18.1 Overview

This section of the EIA reviews the key archaeological and cultural heritage aspects associated with the RTIP site and surrounding areas potentially impacted during the construction, commissioning, operational and decommissioning phases.

On the basis of our literature review and baseline assessment, there is a very low probability of finding exposed or buried cultural and archaeological resources within or in the vicinity of the project area. As discussed in Section 10.3.3 and 10.4.3 of the Archaeology and Cultural Heritage Baseline Section 10, the RTIP site, which will also encompass a tank farm and loading and unloading facilities at the Jubail King Fahd Industrial Port (KFIP), is largely disturbed and developed for industrial uses, and no archaeological or cultural resources were previously identified in the area. Although the eastern province of KSA and neighbouring areas surrounding JIC II are rich in archaeological and cultural resources, as described earlier in Section 10, the RTIP site literature search, physical site survey, and previous survey and fieldwork investigations made by the Deputy of Antiquities and Museums in JIC II and its vicinity, confirm that it is unlikely that any archaeological and/or cultural resources of significance are present in the project area. If undiscovered archaeological and cultural resources are encountered during construction excavations, these resources can be preserved by developing an "archaeological chance find procedure" for any planned construction work.

The significance of impacts of the proposed RTIP site on the local archaeology and cultural heritage resources, if any, has been assessed as having low or medium significance and applicable mitigation measures are identified below to minimize impacts. Project activities and baseline conditions for archaeological and cultural resources have been considered for the assessment of potential impacts. Potential impacts are discussed below for the construction, commissioning, operation and decommissioning phases of the project at the RTIP site. The assessment of impacts is summarised and tabulated in Section 20 Summary of Impacts (Table 20-1), the magnitude and significance of which for each impact are also stated below at the end of each subsection (in bold italic). Next to each magnitude/significance statement and for ease of reference, each issue is identified by a unique number, which is repeated in Table 20-1 and subsequently in Tables 21-1 (Mitigation Table) and 22-1 (Monitoring Table), where applicable.

18.2 Construction

The construction phase involves site preparation for temporary facilities and the main site. Temporary facilities, such as the lay down, fabrication shops and batching plant areas, and EPC labour and PMT camps, will require grading, compaction and levelling and will have associated vehicle movements. In addition, levelling, earthworks, facility construction, trenching for pipelines, and construction vehicle movement will be required for permanent facilities, such as process infrastructure, personnel facilities, environmental facilities, and port facilities. Activities considered to have a higher potential of causing impacts on archaeological and cultural resources include site levelling, earthworks, facility construction, trenching for pipelines and cables, and vehicles movements.

Section 10.5 Summary of Findings and Early Assessment, confirms that archaeological and/or cultural resources are not likely to be present in the project area based on literature review and our baseline assessment. Although it is highly unlikely that archaeological resources are present at the RTIP site, unknown buried archaeological artefacts could be discovered during construction excavations, which could result in two potential impacts on unidentified archaeological resources. A discovery could either have a potentially negative impact (AC1) if the feature or artefact is mechanically disturbed / degraded during earth movement activities or during vehicle movements. Alternatively, it could have a positive impact (AC2) if it is collected intact, salvaged and made available to the authorities for documentation and preservation.

Impacts resulting from the discovery of an unknown archaeological resource might be potentially significant, should they arise. Because this impact is characterised by a considerable consequence and low probability, and, given that the area to be excavated is not known to be archaeologically significant, the impact is considered to have a medium significance.

Overall Impact on Archaeological Aspect (refer to Issues AC1 and AC2) – Low Magnitude, Low (Negative & Positive) Significance

<u>*Recommendations*</u>

- Develop and implement an "archaeological chance find procedure" before starting construction work that includes a trained supervisor to oversee the excavation phase and provision of a simple discovery action card to workers as part of the site orientation. The "archaeological chance find procedure" should involve an appropriate briefing of workers and a notification system. To ensure awareness of employees and contractors, once developed the procedures will be part of the site induction process.

If a worker discovers archaeological artefacts, work in that area shall be stopped and the EH&S Manager and site representative shall be notified. The competent authority should be informed, so that the artefacts can be investigated and the area released. A potential impact on the cultural heritage has been identified during all project phases including the construction phase is derived from the employment of expatriate workers (AC3). Despite the compound living arrangements (EPC labour and PMT camps), there will inevitably be interaction between persons from diverse cultural backgrounds with the local community resulting in cross-cultural tension, specifically related to differences in dress, behaviour, and tradition. In addition, expatriate workers are likely to make tourist expeditions to cultural heritage and archaeology sites of interest, which could impact archaeological resources if artefacts are found and kept as souvenirs or if they disturb archaeological sites visited.

The influx of expatriate worker of various nationalities into the area may be viewed as a negative result of RTIP Site development and may not be approved by locals, who might reject the influx of foreign worker's lifestyles, particularly those involving unacceptable conduct and improper dress. The planned location of EPC labour and PMT camps is within the JIC II, near the Abu-Hadriyah Expressway and the proposed project area, and interaction between workers and residents of nearby communities could occur when workers use recreational areas and engage in recreational activities. This impact is considered of a medium magnitude. Considering the number of workers to be employed during this phase (about 55,000 workers) the impact is assessed as being of medium magnitude.

Overall Impact on Cultural Heritage (refer to Issues AC3) – Medium Magnitude, Medium Significance.

Mitigation Measures

- Provide training to workers to increase awareness and provide an introduction to local culture and traditions. Similar courses should be developed and delivered to local citizens. This would include disseminating educational and informative materials promoting cross-cultural understanding.

- Regarding the influx of workers during the construction, impacts to the local population should be managed through the stakeholder engagement process (Appendix F).

18.3 Commissioning

Activities to be performed during the commissioning phase are associated with multiple petrochemical process units, pipeline testing, and tank hydrotesting. With the exception of the presence of expatriate workers which is discussed under construction, there are no other identified potential impacts on the archaeological and cultural aspects resulting from commissioning activities (AC4).

Cultural heritage issues previously discussed under the construction section are effectively maintained through the projects lifetime; although the potential of an archaeological find would diminish as works are completed and the related workforce leaves the area.

Overall Impact on Archaeological Aspect (refer to Issues AC4) – Very Low Magnitude, Low Significance.

18.4 Operation

The operation phase activities that could pose impacts on the archaeological and cultural heritage aspects of JIC II and the RTIP site are characterised by:

- Vehicle movements between the supply centres, camps and project site; and

- Expatriate workers making tourist expeditions.

During the operation phase there will be vehicle movements between the supply centres, the camps and the RTIP site (AC5). The possibility of finding and consequently damaging possible archaeological wealth lying on the roads is quite small considering:

- There are no known archaeological sites of interest that exist within RTIP site area and its vicinity;
- The RTIP site was greatly affected by recent human activities, mainly from the surrounding industrial complexes and previous site disturbance; and
- The project is expected to use existing roads as far as possible. If there are new roads constructed by RTIP, any archaeological finds would be likely to be identified during construction and recovered. In the case of existing roads, any damage would have occurred prior to project construction.

The magnitude of this potential impact (if any) is considered to be medium but unlikely and rare, so the impact is considered to be of low significance. Therefore, no mitigation measures are recommended.

Overall Impact on Archaeological Aspect (refer to Issues AC5) – Medium Magnitude, Low Significance.

As mentioned under the construction section, potential impacts on cultural heritage issues derive from the employment of expatriate workers are maintained through the lifetime of the project. It is very likely that expatriate workers will take opportunities to explore the country during their stay in the KSA, particularly to sites of archaeological interest. An impact on archaeological resources could occur if they find archaeological artefacts and keep them as souvenirs or if they disturb archaeological sites visited. Despite the significant reduction in worker numbers during the operation phase there will inevitably be interaction between people from diverse cultural backgrounds with the local community due to the compound living arrangements. Unlike the construction workforce housed in the construction camps, the supervisory staff and permanent operational workers involved in the operational phase will live with their families within JIC residential areas in the closest communities. This could derive cross-cultural tension, specifically related to differences in dress, behaviour, and tradition (AC6). Therefore, this impact has been considered as likely but of low magnitude and medium significance.

Overall Impact on Cultural Heritage (refer to Issues AC6) – Low Magnitude, Medium Significance.

Mitigation Measures

– Refer to mitigation measures suggested for impact AC3.

18.5 Decommissioning

Decommissioning phase involves vehicle movements for the removal of material to restore land to pre-project conditions. These vehicle movements may impact archaeological artefacts found near or on the roads. In addition, the presence of expatriate workers, as discussed in impact AC3, may result in cross-cultural tension and disturbance to archaeological sites of interest and artefacts (AC7). This impact is considered to have the same characteristics as impacts identified for AC5 which were assessed for the operation phase.

Overall Impact on Archaeological Aspect (refer to Issues AC7) – Medium Magnitude, Low (Negative) Significance

Recommendations

– Mitigation measures previously discussed during construction should be retained. Refer to mitigation measures suggested for impacts AC1 and AC2.

– Refer to mitigation measures suggested for impact AC3.

18.6 Accidents & Spills

There are no identified potential impacts on the archaeological or cultural aspects resulting from accidents and spills. All identified potential impacts are the result of normal working processes and conditions. There is a low potential for archaeological resources to be identified and recovered during construction and thereby avoid potential impacts to these resources.

Overall Impact on Archaeological Aspect (refer to Issues AC8) – Low Magnitude, Low (Negative) Significance

Recommendations

– Should spills result in excavation of soil, the chance finds procedure should be applied, as discussed in AC1 and AC2. Those archaeological resources that remain buried and undiscovered would continue to be offered protection by their position under the ground surface therefore impact would likely be low.

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19 CUMULATIVE IMPACTS ASSESSMENT

19.1 Introduction and Overview

As part of the EIA process, it is important to consider cumulative impacts. The objective of this section is to assess the cumulative impacts that are likely to result from the Project on affected environmental and socioeconomic conditions at the RTIP site including other approved and/or planned projects in the region that could reasonably be expected to have a combined effect.

Cumulative impacts refer to the impacts of the project development along with the impacts from other development projects in the area. The impacts of existing permitted facilities operating in the region is reflected in the baseline environmental quality, therefore, cumulative impacts have been assessed considering the impacts from the proposed development along with other future projects in the area.

19.2 Literature Review

A data search was carried out to obtain available information about existing and future proposed projects for the region. The main literature used included the following:

- Royal Commission for Jubail and Yanbu web site 2011, Retrieved March 2011 from http://www.rcjy.gov.sa/en-US/Pages/default.aspx.

19.3 Existing and Future Proposed Projects

Information on existing projects and future and/or planned projects for the region was sourced from the other available EIAs and by web based research.

JIC is one of two major industrial cities in Saudi Arabia and has more than 19 primary and 21 secondary industries in operation, as well as support facilities managed by the Saudi Basic Industries Corporation (SABIC). The development of Jubail II is currently underway and divided into four phases which are to be completed by 2022 at an expected cost of SR 14 billion, financed mainly through international investment. Covering a total area of 84 km^2, Jubail II is located 8 km to the west of the original industrial zone of Jubail I, which already contains a cluster of primary, secondary and support industries, the majority of which are related to petrochemicals.

Table 19-1 below presents details on several future projects or activities that are expected to take place over the coming years. Planned future projects are generally related to oil products processing facilities (including petrochemicals facilities), steel and metal industries, chemical processing facilities, and chlorine products.

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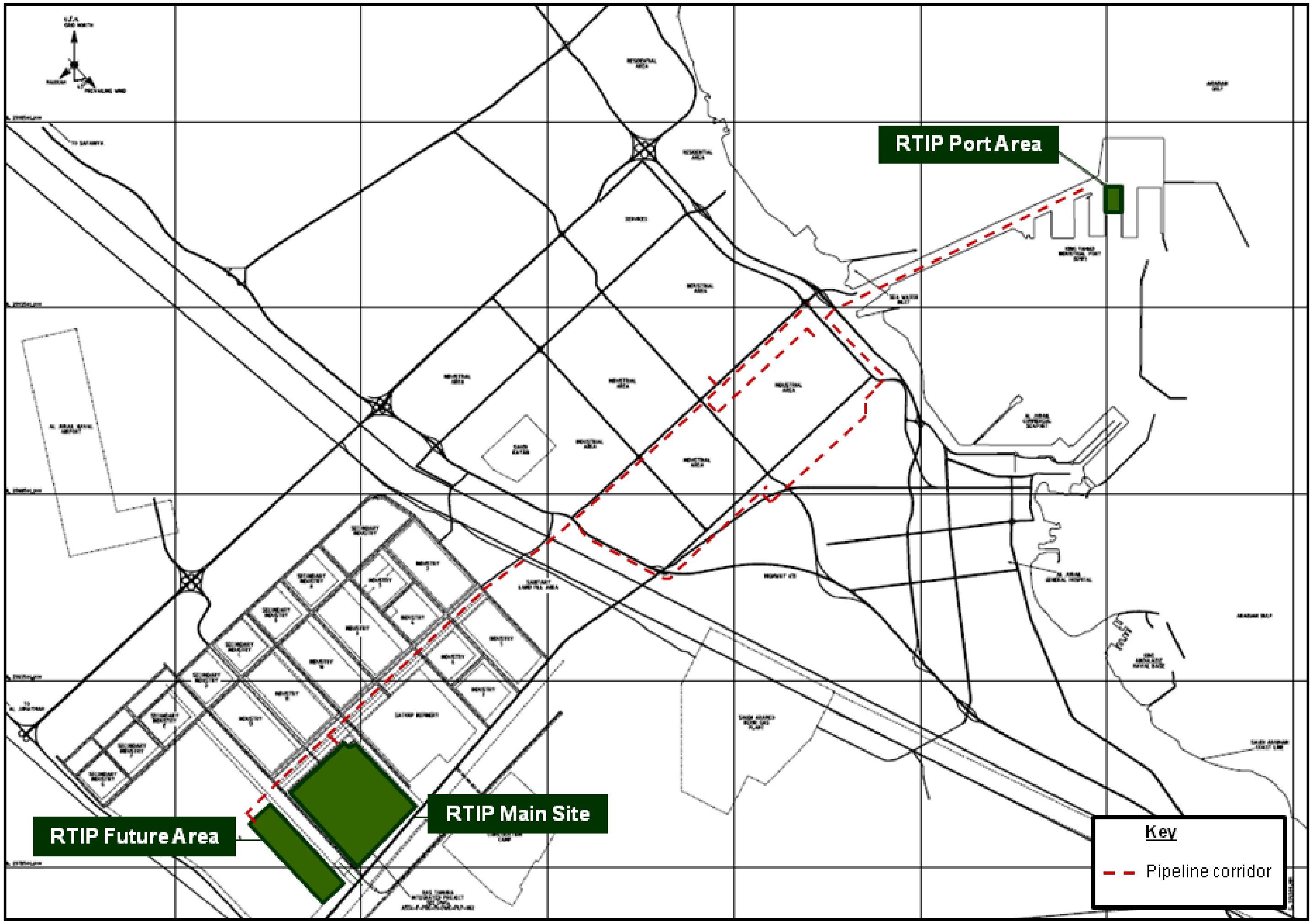
Figure 19-1 RTIP Conceptual Plot Plan, Jubail II, Industrial City of Jubail



Note: This is an schematic drawing based on KBR data provided (CH2MHILL, 2011)

Table 19-1 Future Industrial Projects in the Industrial City of Yanbu (Web search)

Facility	Description	Expected Start-Up Date	Source
SATORP Refinery	A joint venture project between Saudi Aramco and TOTAL to construct a grass roots refinery capable of processing 400,000 Barrels per Stream Day (BPSD) of Arabian heavy crude oil to produce gasoline, diesel, jetfuel, p-xylene, petroleum coke and fuel oil for export and LPG, liquid sulphur, propylene and benzene for domestic consumption or further processing. Date of publication, June 2009.	2013	Environmental and Social Impact Assessment for the Jubail SATORP Export Refinery (Non-Technical Summary), ERM.
IPC Jubail EVA/LDPE Plant	The International Polymers Company (IPC), an affiliate of the Saudi International Petrochemical Company (Sipchem), plans to construct a new plant in Jubail which is to produce vinyl acetate (EVA) and low density polyethylene (LDPE). Its annual production capacity is expected to be in the region of 200,000 tonnes per year. The plant is expected to create 200 jobs and start operation in the second quarter of the year 2013. Date of publication, December 2010.	2013	http://www.icis.com/Articles/2010/12/15/9419584/sipchem-taps-s-koreas-gs-e.html
SABIC, ExxonMobil Saudi Elastomers Facility	SABIC's elastomers and carbon black joint venture (JV) with ExxonMobil (KEMYA Al-Jubail Petrochemical Company) will construct a facility in JIC for the production of rubber, thermoplastic specialty polymers and carbon black for emerging local and international markets in Asia and the Middle East. The project is currently at the FEED stage and the facility is expected to be operational in 2013-2014. Date of publication, March 2011.	2013-2014	http://www.icis.com/Articles/2011/03/01/9439847/sabic-exxonmobil-saudi-elastomers-jv-at-engineering-design-stage.html
PTC Jubail Polysilicon Plant	Polysilicon Technology Company (PTC), a joint venture between Mutajadedah Energy Company (MEC) and KCC Corporation of Korea (KCC), has announced plans to build a polysilicon plant in Jubail. The plant will have an initial production capacity of 3,350 tons of solar grade polysilicon and is expected to start operation in the first quarter of 2014. Date of publication, March 2011.	2014	http://www.saudigazette.com.sa/index.cfm?method=home.regcon&contentID=2011030194863
JANA Epichlorohydrin Plant (Al-Jubail)	Jubail Chemical Industrial Company (JANA), a wholly owned subsidiary of Nama Chemicals, has announced plans for the expansion of their existing epichlorohydrin facility as well as the construction of a new plant at their site in Al-Jubail. Date of publication, March 2011.	Unknown	http://www.nama.com.sa/media-centre/press-releases/nama-chemicals-awards-technical-and-management-contract-to-jacobs-engineering-group-for-its-new-epichlorohydrin-plant-in-al-jubail
IDEA International Soda Ash Plant	IDEA International Company has announced plans for the construction of the first regional Soda Ash and Calcium Chloride plant. It is to be located in Jubail II and the company expects it will produce 500,000 MTA of Soda Ash and Calcium Chloride in Phase one of the project. Date of publication, December 2010.	Unknown	http://www.idea-int.net/news_data.php?id=11

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Table 19-1 Future Industrial Projects in the Industrial City of Yanbu (Web search)

Hadeed Jubail Steel Plant and Rolling Mill	Saudi Basic Industries Corporation's (SABIC) subsidiary Saudi Iron and Steel Company (Hadeed) is to build a new steel plant and rolling mill in Jubail which aims to produce annually one million mt of billets and 500,000 mt of rebar. Production from the new steel plant is expected to start in the second half of 2012. Date of publication, March 2011.	Unknown	http://www.steelorbis.com/steel-news/latest-news/hsbc-finances-hadeeds-new-steel-plant-in-jubail-588796.htm
NCP Petrochemicals Complex (Al-Jubail)	Project to construct a petrochemical complex in the city of Al-Jubail (to the south east of JIC) which includes a 'world-class' olefins cracker, producing 1.2mtpa of ethylene as well as propylene. The project is a joint venture between the Saudi Industrial Investment Group (SIIG), and the Chevron Phillips Chemical Company (CPChem), and the complex is scheduled to become operational by September 2011. Date of publication, 2008.	2011	http://www.worleyparsons.com/Projects/Pages/NCPPetrochemicalComplex.aspx
Saudi Kayan JIC HDPE Plant	Following the completion of construction works for the plant Saudi Kayan commenced trial runs of the HDPE Plant located in JIC at beginning of 2011. The plant is designed to produce 400 KTPA of High Density Polyethylene (HDPE). Date of publication, January 2011.	2011	http://www.saudikayan.com/saudikayan/en/news/23012011.aspx

19.4 Cumulative Impact with Other Projects

The effects from the proposed project, existing projects and other approved and/or planned projects in the region have the potential to interact and cause cumulative environmental impacts.

Considering that sufficient quantitative data were not available at the time of this assessment, a quantitative assessment of cumulative impacts could not be undertaken. Therefore, this assessment is largely qualitative and based on several assumptions. Assumptions are mainly related to future projects in the area (Table 19-1) which are not accounted for in existing baseline environmental data. It is noted that there will inevitably be additional undocumented projects and that all indicated projects in Table 19-1 may not in fact proceed.

The assessment was focused on key primary issues which were defined through references from recent experience with similar projects such as major petrochemical plants, or refineries, and took into account vulnerable receptors that exist in the project area.

Sensitivity of the current environment was factored into the cumulative assessment as cumulative impacts become more significant if the environment is already stressed. As discussed in sections 4 to 18 of this EIA, the local and regional environment is somewhat degraded.

19.4.1 Air Quality

19.4.1.1 Construction & Decommissioning

Cumulative impacts may occur when a project's construction schedule overlaps with other significant construction projects in the region.

It is very likely that the construction phase of the RTIP project will overlap for some time with the construction of the SATORP refinery, located next to the future RTIP site. According to the SATORP EIA (ERM, 2009), the construction phase will start on the first quarter of 2010 with a duration of 42 months.

From Table 19-1, the NCP Petrochemicals Complex (Al-Jubail) and Saudi Kayan JIC HDPE Plant are assumed complete or very near complete, by the time RTIP is under construction. For the other projects in the table, construction schedules are unknown; therefore it is possible for the construction phases to overlap with the RTIP project. Nevertheless, availability of financing, manpower and logistical constraints may prevent simultaneous construction of multiple industries and infrastructure projects.

Possible cumulative air quality impacts may result from the vehicle construction traffic if several projects were under construction in parallel. Without knowing the scheduling of individual projects and additional project details it is not possible to predict the actual concentrations but an area wide modelling study by the RCJY of transport related emissions would help to ensure that air quality impacts were minimised by suitable project phasing, traffic routing and other means. Besides, dust emissions from earth movement and other construction activities carried out at SATORP and RTIP will have a combined impact on the ambient air quality

Cumulative air quality construction impacts are expected to be localised and temporary in nature and within the normal amount of construction activity that occurs daily in these highly industrial areas, therefore, the significance of the impact in relation to the nearest communities is considered low.

An equivalent cumulative impact is expected during the decommissioning phase of the project.

Cumulative Impact (refer to Issue C1) - Low Magnitude, Low Significance

19.4.1.2 Operation & Commissioning

Most of the projects included in Table 19-1 would be expected to generate similar long-term emissions during operation as the RTIP project. Since these projects will be subject to RCJY permitting and emission requirements, it is expected that emissions will be adequately controlled to minimise significant long-term adverse cumulative impacts to air quality. Therefore, no significant immitigable cumulative impacts related to long-term emissions are expected. However, it is recommended that RCJY as the regulator, undertake modelling of emissions from all planned facilities on the basis of the air dispersion modelling studies submitted to them during the permitting process to ensure that cumulative air emission impacts are assessed and suitable mitigation measures assured.

RCJY may also consider undertaking a photochemical modelling study of the airshed to determine whether ozone formation may be an issue in relation to cumulative impacts, this will also assist identification of whether the limiting factor in photochemical pollutant formation is either NO_X or volatile organic compound emissions, and thereby focus regulatory mitigation actions to the limiting factor. Moreover, the current baseline ambient air values for ozone exceed the RCJY ambient air quality standards, pointing that any future development in the area might contribute to this issue. Accordingly, the cumulative impacts of ozone are likely to be of high magnitude and significance.

An equivalent cumulative impact is expected during the commissioning phase of the project.

Cumulative Impact (refer to Issue C2) - High Magnitude, High Significance

19.4.2 Biological Resources

19.4.2.1 Terrestrial Biological Resources

RTIP in combination with other planned projects for the region have the potential to cumulatively impact on terrestrial flora and fauna. Potential negative cumulative impacts include:

- Loss of remnant vegetation;
- General disturbance from construction activities (e.g. dust, noise and lighting); and

- Effects of air emissions on flora and fauna.

Although RTIP adds to the cumulative loss of habitat in the Jubail Industrial City area, given the general industrial and built up nature of the area and the low ecological value of the Project site (as determined by this EIA), it is anticipated that habitat loss as a result of the Project even in combination with other planned projects is going to be of relatively low significance due to the limited ecological biodiversity. The project will utilize the existing port facilities and will require no port site preparation, thereby avoiding the associated impacts to the coastal zone.

If the mitigation measures identified in Section 14 of this EIA are implemented and environmental management measures upheld by the construction contractor, operational personnel and ancillary staff, the potential cumulative impact is considered to be of low significance.

Cumulative Impact (refer to Issue C3) - Low Magnitude, Low Significance

19.4.2.2 Marine Environment

The results of the *Environmental Impact Assessment for the Ras Tanura Integrated Project – Dredging* (KFUPM/RI) undertaken in 2009, 50 km south of Jubail, indicated that the Ras Tanura region is diverse in its marine ecology and lacking in sediment contamination. As discussed in Section 6, Ecology Baseline, this impact assessment assumes the marine environment of Jubail and KFIP are of similar quality to that of the Ras Tanura region. The reliance of the local community fisheries industry upon the region should also be considered as significant in this assessment of cumulative impacts.

Discharges of untreated contaminated surface runoff from RTIP and other Jubail and KFIP facilities could potentially occur during the lifetime of RTIP. Accidental discharges to the ocean via the RC Drainage Channel and the Marafiq Seawater Cooling Return Header could reach the marine environment with a variety of chemical components in concentrations that could be toxic to any of the marine fauna discussed in this impact assessment and the organisms (plants and animals) they rely on for survival.

The cumulative effects of wastewater and surface runoff discharge to the marine environment resulting from the continuous activities of the Marafiq facility, could have an adverse impact on local fisheries and therefore on the health and livelihood of local communities. The impacts can occur in the vicinity of Jubail, or further south along the coast of Saudi Arabia, depending on weather and currents. The Marine Impact Assessment recommends comprehensive wastewater and surface runoff quality monitoring, and treatment, where required, to meet relevant RCER requirements.

The cumulative impact from contaminated wastewater and surface runoff would be of medium magnitude and low to medium significance.

Cumulative Impact (refer to Issue C4) - Medium Magnitude, Low to Medium Significance

The increase in the number of ships that will service the RTIP facility and other planned projects at KFIP will increase the potential for a major chemical or fuel spill directly into the Arabian

Gulf. This could occur through vessel collision near the port or at sea, or via direct release during product loading and unloading.

It is recommended that during the detailed design phase RTIP consults with the Saudi Ports Authority to ensure that emergency response plans and associated staff and equipment are sufficient to cover RTIP activities. In addition to this, RTIP needs to assess its own on-site spill response and develop and implement a Spill Response Plan.

Cumulative Impact (refer to Issue C5) - High Magnitude, High Significance

19.4.3 Noise

19.4.3.1 Construction, Commissioning & Decommissioning

As discussed in Section 15, during construction noise levels will increase as a result of the construction activities in the project sites (main site and port), including vehicle and machinery operations, earth movements, as well as the increased traffic associated to the transport of personnel and goods, raw materials, etc.

Due to the development of Jubail II, which is to be completed by 2022, it's probable that noise generated as a result of the construction activities of the RTIP will have a cumulative effect with the noise to be generated during the development of close-by industries such as those listed in Table 19-1.

There is however limited information on the specific characteristics, locations and timeframes of these new projects. As such, it has been assumed that construction activities (site preparation, earth movements, steel structure erections, etc.) will be similar in all the sites and that the majority of those will be located in Jubail II.

As mentioned in Section 15, the construction activities will generate relatively low noise levels and should be able to continue around the clock without exceeding the maximum suggested noise levels at the nearest noise sensitive locations (residential areas). It is not expected that general activities would pose a significant cumulative effect on the noise to be generated as a result of the development of other industrial sites in the area (magnitude is considered low).

Although an increase in traffic is expected as a result of the development (construction and operation) of other industrial sites in the area, the number of vehicles or the routes that will likely be used are unknown at this stage.

The location of the camps is also unknown at present, however it is expected that most of the developments will require the transport of goods, raw materials, etc. from the port and as such the traffic on the roads between the port and Jubail II will increase. As a result of this it is expected that noise levels at the sensitive receptors located close by will also increase (Jubail Old Town residential area, mainly).

A cumulative impact is therefore expected, as the increase in noise at the residential areas located close to Expressway no. 1 and Jiddah Street, due to the increased traffic associated to the construction of the RTIP sites, will combine with that resulting from the traffic increase caused by the development of other projects in Jubail II. It is expected that traffic will be controlled and that the maximum traffic will depend on the service capacity of the roads, so it is not expected that noise levels at the receptors would exceed more than 5 dBA from the applicable noise standard. Magnitude of the impact has therefore been assessed as medium.

Noise mitigation measures to be implemented are discussed in sections 15 and 21. Additionally and if appropriate, alternative routes and staggered schedules should be considered as well as communication and coordination with other projects to either use or not use the same road networks.

An equivalent cumulative impact is expected during the decommissioning phase of the project, and to a lesser extent, during the commissioning phase as some construction activities will still be taking place in the first half of this phase.

Cumulative Impact from Noise Increase at Receptors (refer to Issue C6) – Low Magnitude, Low Significance

Cumulative Impact from Traffic Noise Increase (refer to Issue C7) – Medium Magnitude, Medium Significance

19.4.3.2 Operation

As discussed in section 15, noise increase during operation of RTIP is expected due to the operation of the new equipment and installations, and due to the traffic associated to the transport of goods, raw material, products and personnel.

There is no available information about the specific processes, nor equipment associated to each of the projects, however, due to the nature of the industries expected to be installed (facilities related to oil products processing; steel and metal; chemical processing) and considering that all new facilities will have to comply with the RCER requirements, it is assumed that noise levels generated will be similar of those predicted for the RTIP plant, and will be under 70 dB(A).

Though certain cumulative impacts are expected, especially in the proximity to the boundaries with other facilities, it is not expected that combined noise levels would pose a significant noise increase in the closest sensitive receptors and mixed used area. Magnitude of the cumulative impact is, therefore, considered low.

With regards to traffic, cumulative impact is expected to be similar to that described for construction, though during operation, part of the traffic for personnel transport will come/go from the JIC community area. For the same reasons as for cumulative noise increase during construction, magnitude of the impact has been assessed as medium.

Noise mitigation measures to implement are those discussed in sections 15 and 21. Additionally and if appropriate, alternative routes and staggered schedules should be considered as well as communication and coordination with other projects to either use or not use the same road networks.

Cumulative Impact from Operation of RTIP New Installations (refer to Issue C8) –Low Magnitude, Low Significance.

Impact from Traffic Noise Increase (refer to Issue C9) – Medium Magnitude, Medium Significance.

19.4.4 Waste Management

According to RCER, no wastes generated within Jubail Industrial City shall be transported outside the boundary of the industrial city for recycle/reuse, recovery or treatment without RCJY and PME approval. At present, generated construction and operational related hazardous and non-hazardous solid and liquid wastes are planned to be disposed of in the Marafiq Wastewater Treatment Facility in the case of non-hazardous liquid waste, and either the Royal Commission Sanitary Landfill, National Environmental Preservation Company (BeeA'h), or the Environment Development Company (EDCO) facilities in the case of all other waste. These waste facilities, given the availability of proximate land have an undetermined but considerable life expectancy.

Although RTIP wastes will be managed within the framework of the Project Waste Management Plan (which includes waste minimisation techniques), waste management facilities have finite capacities. However with regards to landfill facilities, incremental waste that will be generated by the proposed project combined with other projects in Jubail Industrial City is considered negligible compared to the combined capacities and life expectancies of the various facilities available in the area.

With regards to wastewater treatment facilities, the Marafiq WWTP, which is made up of the Industrial Wastewater Treatment Plant (IWTP) and the Sanitary Wastewater Treatment Plant (SWTP), at present has a treatment capacity of 60,000 m^3 per day for industrial wastewater and 72,000 m^3 per day for sanitary wastewater. It is not expected that an excessive portion of this capacity will be used up by the RTIP project during most of the project lifetime as during the operations phase less than 5% of the SWTP's capacity will be used up. However, in the case of the IWTP, figures for normal operation will imply a capacity usage in the region of 45%. This is a very significant portion of the plant's full capacity and could prove highly problematic when considered in combination with other projects in the area. Further to this, with regards to the construction phase which is expected to have a duration of approximately 40 months, the sanitary wastewater to be generated by the project will be considerably greater. It is expected that during this phase approximately 17,700 m3 of sanitary wastewater will be generated on a daily basis, which accounts for almost 25% of the total treatment capacity at the SWTP. This amount may prove excessive when considering the various other industrial projects in the area planned to start construction activities in the next three years. As such, it is recommended that close relations be maintained with the RCJY and Marafiq to ensure that this potential situation is dealt with accordingly and with sufficient lead time.

Nevertheless, any potential implications of this cumulative impact are significantly reduced by plans to expand the treatment capacity of both the IWTP and the SWTP over the course of 2011 (Marafiq, 2006). In the case of the IWTP the plans are to expand the current treatment capacity by a further 55,000 m3 per day (Maree, 2009), and for the SWTP the same expansion is planned however it is to be followed by a further expansion at a later date to double the plants current capacity (Global Water Intelligence, 2009).

Cumulative Impact from Solid and Hazardous Waste Management (refer to Issue C10) - Low Magnitude, Low Significance

Cumulative Impact from Non-Hazardous Liquid Waste Management (refer to Issue C11) - Medium to High Magnitude, Low Significance

Recommended Measures

- Undertake a review prior to the commissioning phase of the Project to determine project infrastructure requirements for wastewater. This will allow existing capacity problems to be identified at an early stage and alternatives to be examined.

19.4.5 Social Aspects

The cumulative social impacts resulting from RTIP and other proposed projects will, if well managed, provide opportunities for the local community with an overall increase in wealth and access to livelihood. The main benefits are associated with improved infrastructure, growth of regional economy, and increased government revenues from oil and gas taxes (in the case of projects related to oil and gas), both of which increase opportunities for local investment and employment. However, there are also other negative impacts related to the RTIP project that if overlapped with other development projects in the area may be exacerbated. A more detailed assessment of potential cumulative social impacts during construction and operation phases is provided below.

19.4.5.1 Construction

During the construction phase about 11,000 new jobs for Saudis will be created as part of the RTIP project with a positive impact on employment and workers' incomes improving their quality of life. The use of third country nationals during construction would also be expected to generate income in deprived areas, due to money being repatriated by the construction workforce, a positive economic impact. In addition local employment and up-skilling/training by skilled non-Saudi workers, particularly during construction, is considered a positive cumulative impact for the community and indirectly, the local economy. Benefits to the regional economy are also expected due to influx of large amount of workers, the numbers of which will result in an increase of about 25% of the current population of Jubail, which increases the demand of goods and services and promotes the growth of regional business and infrastructure.

However, a potential negative impact may occur during demobilization of the construction phase when infrastructure and business established to support project demands would have a reduction in sales going back to regular demands. Considering the expectation on future development projects in the area, construction activities for other projects are expected to start or be in progress at the end of the construction phase of RTIP. This will reduce the probability of the potential negative impact caused during the demobilization of RTIP, as the level of services of product may be retained and workers relocated into future developments, retaining the positive impact initiated by the RTIP project.

Cumulative Impact (refer to Issue C12) – Medium Magnitude, Medium (Positive) Significance

Based on the existing conditions, the potential negative impact related to housing demand due to temporary accommodation of workers during construction has been considered of low significance. However, the significance of the impact may be exacerbated if it is overlapped with housing demands from other projects in the area. This is also the case of a cumulative impact upon the public health care services and related infrastructure. Workers from RTIP and other projects will require access to existing healthcare services during the construction period which may stress the resources available in the current facilities. Injuries and accidents during the construction phase could also increase the need for medical emergency assistance adding additional pressure to the efficiency of this service.

This cumulative impact is also expected over the course of the other project phases, although to a lesser extent as the number of project workers will peak during the construction phase.

Cumulative Impact (refer to Issue C13) – High Magnitude, Medium (Negative) Significance

Mitigation Measures

- Undertake a retrospective review to determine project social infrastructure requirements including health care and accommodation requirements. This will possibly allow existing capacity problems to be identified at an early stage and alternatives to be examined.
- In coordination with the RCJY, monitor social infrastructure requirements envisaged for this project and other future developments in the project area at the time the construction activities of RTIP will be undertaken.

Increased traffic to and from the RTIP site will place pressure on existing infrastructure, create possible inconvenience, increase the risk of physical injury, and nuisance through delays to local movement, and traffic safety hazards. Earth moving activities and general vehicle movements associated with RTIP and other planned/future projects construction and operation activities can have an additive effect with public health and nuisance implications. However, this impact is expected to be of low significance in relation to the local community as the impacts tend to be close to the construction areas.

This cumulative impact is also expected over the course of the decommissioning phase and to lesser extent during the commissioning phase, as there will still be some construction activities taking place during the first half of this phase.

Cumulative Impact (refer to Issue C14) – Medium Magnitude, Low (Negative) Significance

19.4.5.2 Operation

During the operation of RTIP the level heavy machinery use and vehicle movement will be reduced in comparison to the construction phase of the project. The cumulative impacts associated with traffic safety hazards are therefore considered to be low.

19.5 Conclusions

The assessment of cumulative impacts has addressed the cumulative impacts that are likely to result from the Project on all affected environmental and socioeconomic conditions at the RTIP site including other existing, approved and/or planned projects in the region that could reasonably be expected to have a combined effect.

While this assessment has largely been qualitative in nature, identified cumulative impacts will be mitigated by measures described herein or elsewhere in this EIA or are a beneficial cumulative effect.

20 SUMMARY OF IMPACTS

The environmental impact assessment undertaken for the construction, commissioning, operation and decommissioning of the RTIP project is summarised in Table 20-1 for air quality, onshore physical, terrestrial and marine ecology, noise, waste management, social aspects, archaeological and cultural aspects.

Table 20-1 presents the impacts for each phase of the project, considering the frequency, likelihood, extent, duration and magnitude factors of the impact, as defined in Table 11-1 (Terminology Used to Describe Environmental and Social Impacts). The type (positive or negative) and potential significance of each impact are also factored based on Table 11-1.

Finally, a mitigation measure is either required (based on regulatory requirements) or suggested or not needed, based on the impact assessment criteria defined for each environment in Section 11.

Each impact is provided with a unique number for ease of reference between the impact table (Table 20-1) and subsequent mitigation and monitoring tables (Tables 21-1 and 22-1, respectively).

Table 20-1 Summary of Environmental Impact Assessment, RTIP, Jubail II, KSA

Item No.	Impact	Phase				Accident & Spills (1) (Yes/No)	Scope (2) (F, L, E, D, M)	Type (2) (Effect, Action)	Potential Significance (2)	Mitigation Suggested (3) (Yes/No)
		Construc.	Commiss.	Operation	Decomm.					
Air Quality & Meteorology										
A1	Dust emissions during construction activities	X			X	No	F: Frequent L: Likely E: Local D: Medium M: Very High	E: Negative A: Direct	High (close to RTIP) Low (Outside the industrial city)	Yes
A2	Exhaust emissions from vehicle movements.	X			X	No	F: Continuous L: Likely E: Provincial D: Short M: High (close to Industrial city); Low (Outside the industrial city)	E: Negative A: Direct	High (close to the RTIP complex and industrial city) Low (Outside the industrial city)	Yes
A3	NO_X emissions from major combustion sources.		X	X		No	F: Continuous L: Certain E: Local D: Medium M: Low close to RTIP site and very low outside Jubail II	E: Negative A: Direct	Low	Yes

Notes:
(1) Yes = the impact is the result of an accident or upset condition; No = the impact is the result of normal conditions
(2) Definitions for terminology used to describe impacts are given in Section 11.
(3) Mitigation is suggested where significance is "medium" or higher, unless otherwise indicated in the corresponding section of the EIA report

F = Frequency
L = Likelihood
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Abbreviations:
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		Construc.	Commiss.	Operation	Decomm.					
A4	SO_2 emissions from major combustion sources.		X	X		No	F: Continuous L: Certain E: Local D: Medium M: Low	E: Negative A: Direct	Low	Yes
A5	CO emissions from major combustion sources.		X	X		No	F: Continuous L: Certain E: Local D: Medium M: Low	E: Negative A: Direct	Low	No
A6	PM_{10} emissions from RTIP complex		X	X		No	F: Continuous L: Certain E: Local D: Medium M: Very High (due to the high background levels)	E: Negative A: Direct	High (note that contribution of RTIP is well below the RCJY standard but the high baseline makes the priority level high)	Yes (4)

Notes:
(1) Yes = the impact is the result of an accident or upset condition; No = the impact is the result of normal conditions
(2) Definitions for terminology used to describe impacts are given in Section 11.
(3) Mitigation is suggested where significance is "medium" or higher, unless otherwise indicated in the corresponding section of the EIA report
(1) Although mitigation measures are suggested, there is not much the project can do to reduce the existing PM_{10} and $PM_{2.5}$ background levels
(4)

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		Construc.	Commiss.	Operation	Decomm.					
A7	$PM_{2.5}$ emissions from RTIP complex		X	X		No	F: Continuous L: Certain E: Local D: Medium M: Very High (due to the high background levels)	E: Negative A: Direct	High (note that contribution of RTIP is well below the RCJY standard but the high baseline makes the priority level high)	Yes (4)
A8	Benzene emissions from point and fugitive sources		X	X		No	F: Continuous L: Certain E: Provincial D: Medium M: Medium close to RTIP site and low outside the industrial city	E: Negative A: Direct	Medium close to RTIP site and low outside the industrial city	Yes

Notes:
(2) Yes = the impact is the result of an accident or upset condition; No = the impact is the result of normal conditions
(3) Definitions for terminology used to describe impacts are given in Section 11.
(4) Mitigation is suggested where significance is "medium" or higher, unless otherwise indicated in the corresponding section of the EIA report
(5) Although mitigation measures are suggested, there is not much the project can do to reduce the existing PM_{10} and $PM_{2.5}$ background levels

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Table 20-1 Summary of Environmental Impact Assessment, RTIP, Jubail II, KSA

Item No.	Impact	Phase: Construc.	Phase: Commiss.	Phase: Operation	Phase: Decomm.	Accident & Spills (1) (Yes/No)	Scope (2) (F, L, E, D, M)	Type (2) (Effect, Action)	Potential Significance (2)	Mitigation Suggested (3) (Yes/No)
A9	Formaldehyde emissions from point and fugitive sources.		X	X		No	F: Continuous L: Certain E: Local D: Medium M: Low	E: Negative A: Direct	Low	Yes
A10	Toluene emissions from point and fugitive sources.		X	X		No	F: Continuous L: Certain E: Local D: Medium M: Low	E: Negative A: Direct	Low	Yes
A11	Ammonia emissions from point and fugitive sources.		X	X		No	F: Continuous L: Certain E: Local D: Medium M: Low	E: Negative A: Direct	Low	Yes
A12	Chlorine emissions from point and fugitive sources.		X	X		No	F: Continuous L: Certain E: Local D: Medium M: Low	E: Negative A: Direct	Low	Yes

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Item No.	Impact	Phase: Construc.	Phase: Commiss.	Phase: Operation	Phase: Decomm.	Accident & Spills (1) (Yes/No)	Scope (2) (F, L, E, D, M)	Type (2) (Effect, Action)	Potential Significance (2)	Mitigation Suggested (3) (Yes/No)
A13	Xylene emissions from point and fugitive sources.		X	X		No	F: Continuous L: Certain E: Local D: Medium M: Low	E: Negative A: Indirect	Low	Yes
A14	Aniline emissions from point and fugitive sources.		X	X		No	F: Continuous L: Certain E: Local D: Medium M: Low	E: Negative A: Indirect	Low	Yes
A15	Ethylene Oxide emissions from point and fugitive sources.		X	X		No	F: Continuous L: Certain E: Provincial D: Medium E: Local M: Low	E: Negative A: Direct	Low	Yes
A16	Hydrogen Chloride emissions from point and fugitive sources.		X	X		No	F: Continuous L: Certain E: Local D: Medium M: Low	E: Negative A: Indirect	Low	Yes

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Item No.	Impact	Phase: Construc.	Phase: Commiss.	Phase: Operation	Phase: Decomm.	Accident & Spills (1) (Yes/No)	Scope (2) (F, L, E, D, M)	Type (2) (Effect, Action)	Potential Significance (2)	Mitigation Suggested (3) (Yes/No)
A17	Phosgene emissions from point and fugitive sources.		X	X		No	F: Continuous L: Certain E: Local D: Medium M: Low	E: Negative A: Direct	Low	Yes
A18	SO_2 Emissions from Flares during Emergency Scenario and Process Upset		X	X		Yes	F: Infrequent L: Likely E: Local D: Short M: Low	E: Negative A: Direct	Low	Yes
A19	NOx Emissions from Flares during Emergency Scenario and Process Upset		X	X		Yes	F: Infrequent L: Likely E: Local D: Short M: Low	E: Negative A: Direct	Low	Yes
A20	CO Emissions from Flares during Emergency Scenario and Process Upset		X	X		Yes	F: Infrequent L: Likely E: Local D: Short M: Low	E: Negative A: Direct	Low	Yes

Notes:
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		Construc.	Commiss.	Operation	Decomm.					
A21	Benzene Storage Tanks Spills		X	X	X	Yes	F: Rare L: Unlikely E: Provincial D: Short M: High	E: Negative A: Direct	Medium	Yes
A22	Benzene Pipe Rack Failure Spills		X	X	X	Yes	F: Rare L: Unlikely E: Provincial D: Short M: High	E: Negative A: Direct	Medium	Yes
Onshore Physical Environment										
O1	Degradation of soil quality (primarily through shallow soil compaction) due to earth works, facility construction, movement of heavy equipment, construction traffic, building of associated temporary infrastructure and storage of construction materials.	X	X			No	F: Continuous L: Certain E: Local D: Long M: Low	E: Negative A: Direct	Low	No

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		Construc.	Commiss.	Operation	Decomm.					
O2	Alteration of drainage characteristics (including dewatering) and modification of the storm water flow and recharge regime.	X	X	X		No	F: Continuous L: Certain E: Local D: Long M: Medium	E: Negative A: Direct	Low	Yes
O3	Degradation of soil and groundwater quality due to minor accidental releases and spills of hazardous materials during construction	X				Yes	F: Rare L: Likely E: Local D: Short M: Low	E: Negative A: Direct	Low	Yes
O4	Degradation of soil and groundwater quality due to minor accidental releases and spill during occasional maintenance of construction equipment and vehicles	X				Yes	F: Infrequent L: Likely E: Local D: Short M: Low	E: Negative A: Direct	Low	Yes
O5	Degradation of soil and groundwater quality due to minor accidental releases and spills of hazardous materials during commissioning		X			Yes	F: Rare L: Unlikely E: Local D: Short M: Low	E: Negative A: Direct	Low	Yes

Notes:
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		Construc.	Commiss.	Operation	Decomm.					
O6	Degradation of soil and groundwater quality due to accidental releases and spills of hazardous materials during normal operations at the process plants, maintenance of equipment and storage and internal distribution through the utility infrastructure.			X		Yes	F: Infrequent L: Unlikely E: Local D: Medium M: Medium	E: Negative A: Direct	Medium	Yes
O7	Degradation of soil and groundwater quality due to accidental releases and spills during the transportation of raw materials, feed stock and products on or off-site.			X		Yes	F: Infrequent L: Unlikely E: Local D: Short M: Low to medium	E: Negative A: Direct	Low to Medium	Yes
O8	Ex-situ or in-situ remediation of contaminated soil discovered after the demolition of facilities.				X	No	F: Infrequent L: Likely E: Local D: Long M: Low	E: Positive A: Direct	Low	No
O9	Increase of groundwater recharge rates after demolition of facilities				X	No	F: Continuous L: Likely E: Local D: Long M: Low	E: Positive A: Direct	Low	No

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Table 20-1 Summary of Environmental Impact Assessment, RTIP, Jubail II, KSA

Item No.	Impact	Phase: Construc.	Phase: Commiss.	Phase: Operation	Phase: Decomm.	Accident & Spills (1) (Yes/No)	Scope (2) (F, L, E, D, M)	Type (2) (Effect, Action)	Potential Significance (2)	Mitigation Suggested (3) (Yes/No)
O10	General degradation of soil and groundwater quality due to decommissioning activities, traffic and management of inert construction debris				X	No	F: Continuous L: Certain E: Local D: Short M: Low	E: Negative A: Direct	Low	No
O11	Potential for soil contamination resulting from On-Site Storage of Non-Hazardous Solid Waste	X	X	X	X	Yes	F: Continuous L: Unlikely E: Local D: Short M: Low (Construc, Decomm), Medium (Commiss, Operations)	E: Negative A: Direct	Low	Yes
O12	Potential for soil contamination resulting from On-Site Storage of Non-Hazardous Waste from Construction Camp	X	X			Yes	F: Continuous L: Unlikely E: Local D: Short M: Low	E: Negative A: Direct	Low	No
O13	Potential for soil contamination resulting from On-Site Storage of Hazardous Solid Waste	X	X	X	X	Yes	F: Continuous L: Unlikely E: Local D: Short M: Medium (Construc, Decomm), High (Commiss, Operations)	E: Negative A: Direct	Low	Yes

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		Construc.	Commiss.	Operation	Decomm.					
O14	Potential for soil contamination resulting from On-Site Storage of Hazardous Liquid Waste	X	X	X	X	Yes	F: Continuous L: Unlikely E: Local D: Short M: Medium (Construc, Decomm), High (Commiss, Operations)	E: Negative A: Direct	Low	Yes
O15	Potential for soil contamination resulting from Off-Site Disposal of Non-Hazardous Liquid Waste	X	X	X	X	Yes	F: Continuous L: Unlikely E: Local D: Short M: Medium (Construc, Operations, Decomm); Low (Commiss)	E: Negative A: Direct	Low	No
O16	Potential for soil contamination resulting from Off-Site Disposal of Non-Hazardous Solid Waste	X	X	X	X	Yes	F: Frequent L: Unlikely E: Local D: Short M: Medium	E: Negative A: Direct	Medium (Construction, Decommissioning); Low (Commissioning, Operations)	Yes

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		Construc.	Commiss.	Operation	Decomm.					
O17	Potential for soil contamination resulting from Off-Site Disposal of Non-Hazardous Waste from Construction Camp	X	X			Yes	F: Frequent L: Unlikely E: Local D: Short M: Low	E: Negative A: Direct	Low	No
O18	Potential for soil contamination resulting from Off-Site Disposal of Hazardous Waste	X	X	X	X	Yes	F: Infrequent L: Unlikely E: Local D: Medium M: Medium (Construc, Decomm), High (Commiss, Operations)	E: Negative A: Direct	Low	Yes
O19	Potential for subsurface contamination resulting from transport of hazardous wastes off-site	X	X	X	X	Yes	F: Infrequent L: Unlikely E: Local D: Medium M: Medium (Construc, Decomm), High (Commiss, Operations)	E: Negative A: Direct	Low to Medium	Yes

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O20	Accidental release of solid hazardous wastes within the RTIP Complex	X	X	X	X	Yes	F: Rare L: Unlikely E: Local D: Medium M: Medium	E: Negative A: Direct	High	Yes
O21	Accidental release of liquid hazardous wastes within the RTIP Complex	X	X	X	X	Yes	F: Rare L: Unlikely E: Local D: Medium M: High	E: Negative A: Direct	High	Yes
O22	Accidental release of solid hazardous wastes during transport offsite	X	X	X	X	Yes	F: Rare L: Unlikely E: Local D: Medium M: High	E: Negative A: Direct	Medium to High	Yes
O23	Accidental release of liquid hazardous wastes during transport offsite	X	X	X	X	Yes	F: Rare L: Unlikely E: Local D: Medium M: High	E: Negative A: Direct	Medium to High	Yes

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		Construc.	Commiss.	Operation	Decomm.					
Ecology - Terrestrial										
B1	Removal of vegetation and potential foraging sites for nocturnal animals.	X				No	F: Infrequent L: Certain E: Local D: Long M: Medium	E: Negative A: Direct	Low	Yes
B2	Effects of noise on fauna onsite and offsite especially on breeding, wintering and migrant birds offsite (e.g. Sabkhat Al-Fasl Lagoons)	X	X	X	X	No	F: Continuous L: Certain E: Local D: Medium M: Low	E: Negative A: Direct	Low	Yes
B3	Effects of dust and noise from earth moving and vehicle movements, etc. on vegetation and fauna onsite or adjacent to RTIP	X		X	X	No	F: Continuous L: Likely E: Local D: Medium M: Low	E: Negative A: Direct	Low	Yes
B4	Potential effects of light on nocturnal animals	X	X	X		No	F: Continuous L: Likely E: Local D: Medium M: Low	E: Negative A: Direct	Low	No

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		Construc.	Commiss.	Operation	Decomm.					
B5	Potential effects of elevated air pollution on offsite vegetation (protected areas) from major combustion sources.		X	X		No	F: Continuous L: Likely E: Provincial D: Medium M: Medium	E: Negative A: Direct	Low	Yes
B7	Potential effects on vegetation and fauna through accidental release of airborne or waterborne pollutants, hazardous wastes, etc.	X	X	X	X	Yes	F: Infrequent L: Unlikely E: Provincial D: Short M: Low	E: Negative A: Direct	Low	No
Ecology - Marine										
M1	Impact to the marine environment in the area of KFIP from increased vessel movements at KFIP.	X	X	X		Yes	F: Frequent L: Certain E: Local D: Low M: Low	E: Negative A: Direct	Low	Yes

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		Construc.	Commiss.	Operation	Decomm.					
M2	Impact resulting from untreated effluent from batching plant, hydrotest water or surface runoff entering the marine environment, damaging marine ecosystems, and local fisheries industry.	X	X			Yes	F: Rare L: Unlikely E: Local D: Short M: Medium	E: Negative A: Indirect	Low	Yes
M3	Impact from accidental release of construction materials, equipment, or fuel.	X				Yes	F: Rare L: Unlikely E: Local D: Short M: Low	E: Negative A: Direct	Low	No
M4	Impact resulting from untreated contaminated stormwater entering the marine environment, damaging or killing marine organisms, including important species for local fisheries.		X	X	X	Yes	F: Rare L: Unlikely E: Local D: Short M: Medium	E: Negative A: Direct	Low	Yes
M5	Impact resulting from a major fire onsite and contaminated firewater runoff enters the marine environment, damaging or killing marine organisms, including important species for local fisheries.		X	X	X	Yes	F: Rare L: Unlikely E: Regional D: Medium M: Medium	E: Negative A: Direct	Medium	Yes

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M6	Impact from a direct fuel or chemical spill to sea during transportation by a third-party transporter.		X	X		Yes	F: Rare L: Unlikely E: Regional D: Short M:Medium	E: Negative A: Direct	High	Yes
M7	Impact from fuel or chemical spill from trucks, Port Tank Farm, pipelines or jetty topside handling equipment at Port Facilities.			X		Yes	F: Infrequent (tanks)/rare(pipelines) L: Unlikely E: Local D: Short M: High	E: Negative A: Direct	Medium	Yes
M8	Impact to the marine environment resulting from fuel or chemical spills from vessel collision or breach at Port Facilities.		X	X	X	Yes	F: Rare L: Unlikely E: Regional D: Short M:High	E: Negative A: Direct	High	Yes
M9	Impact of regular, small volume fuel or chemical leakage from Port Tank Farm and associated equipment and pipelines at Port Facilities.		X	X	X	Yes	F: Frequent L: Likely E: Regional D: Short M:Medium	E: Negative A: Direct	Medium	Yes

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M10	Impact to marine organisms from noise at Port Facilities.	X	X		X	No	F: Frequent L: Likely E: Local D: Short M:Low	E: Negative A: Direct	Low	Yes
M11	Impact to marine organisms from light at Port Facilities.	X	X	X	X	No	F: Frequent L: Likely E: Local D: Long M:Low	E: Negative A: Direct	Low	No
M12	Impact to marine environment from dust.	X	X	X	X	No	F: Frequent L: Likely E: Local D: Long M:Low	E: Negative A: Direct	Low	Yes
Noise										
N1	Temporary increases in noise levels at the nearest residential receptors and mixed use area (peaking during construction phase).	X			X	No	F: Continuous L: Certain E: Provincial D: Short M: Low	E: Negative A: Direct	Low	Yes

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		Construc.	Commiss.	Operation	Decomm.					
N2	Potential increases in traffic noise levels at locations near roadways.	X		X	X	No	F: Continuous L: Certain E: Provincial D: Short (construction) Medium (operation) M: Medium	E: Negative A: Direct	Medium	Yes
N3	Increased noise at nearest residential receptors and mixed use area due to high-pressure steam blows and flaring.		X			No	F: Infrequent L: Certain E: Provincial D: Short M: High	E: Negative A: Direct	Medium	Yes
N4	Increased noise levels at nearby residential areas and mixed use areas due to operation of the RTIP new installations			X		No	F: Continuous L: Certain E: Provincial D: Medium M: Low	E: Negative A: Direct	Low	Yes
N5	Increased noise levels at nearby residential areas and mixed use areas due to emergency steam venting, gas flaring and other upset conditions.		X	X		Yes	F: Infrequent L: Certain E: Provincial D: Short M: High	E: Negative A: Direct	Low	No

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Socio-Economic										
S1	Increased traffic resulting from worker and equipment/material transport. This impact may cause disruptions in accessing industrial facilities and utilities, residential settlements and leisure to existing infrastructure (peaking during construction)	X	X	X	X	No	F: Continuous L: Likely E: Regional D: Medium M: High (Construc), Medium (Operation, Decomm), Low to Medium (Commiss)	E: Negative A: Direct	Medium to High (Construc), Medium (Operation, Decomm), Low to Medium (Commiss)	Yes
S2	Creation of new jobs. A number of national workers will be required for all the project phases, peaking during construction.	X	X	X	X	No	F: Frequent L: Certain E: National D: Medium (Construc , Operation, Decomm); Short (Commiss) M: Medium (Construc, Decomm); Low to Medium (Commiss, Operation)	E: Positive A: Direct	Medium (Construc, Decomm) Low to Medium (Commiss, Operation)	No

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		Construc.	Commiss.	Operation	Decomm.					
S3	Increased income. Increased demand on services by project workforce and associated service industries, peaking during construction.	X	X	X	X	No	F: Continuous L: Certain E: Regional D: Medium (Construc , Operation, Decomm); Short (Commiss) M: Medium (Construc, Decomm); Low to Medium (Commiss, Operation)	E: Positive A: Direct	Medium (Construc, Decomm), Low to Medium (Commiss, Operation)	No
S4	Loss in catch for local fishermen with direct repercussions on fishing industry's economy due to increased shipping traffic.	X				No	F: Frequent L: Certain E: Regional D: Short M: Low	E: Negative A: Direct	Low	No
S5	Decreased income. Reduction in number of immigrant workers post peak.	X			X	No	F: Infrequent L: Certain E: Regional D: Medium M: Low	E: Negative A: Direct	Low	Yes

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S6	Improvements in stakeholder's economic status and income benefit increasing health services available by the State and population's access to them	X	X	X		No	F: Infrequent L: Likely E: Regional D: Long M: Low to Medium (Commiss, Operation), Low (Construc)	E: Positive A: Direct	Medium (Construc), Low to Medium (Commiss, Operation)	No
S7	Impact of immigrant workers. Foreign workers separated from their families.	X	X	X	X	No	F: Infrequent L: Certain E: International D: Medium (Construction, Operation and Decommissioning); Short (Commissioning) M: Low (	E: Negative A: Direct	Low	Yes
S8	Increase in demand for local housing and prices.	X		X	X	No	F: Infrequent L: Certain E: Regional D: Medium M: Low	E: Negative A: Indirect	Low	No

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		Construc.	Commiss.	Operation	Decomm.					
S9	Increase in demand for local or regional services and infrastructure (peaking during construction). Demand increases on health services and infrastructure by workers could potentially reduce local population's access to health care	X	X	X	X	No	F: Frequent L: Likely E: Regional D: Medium (Construction , Operation and Decommissioning); Short (Commissioning) M: Medium (Construc); Low to Medium (Commiss), Low (Operation, Decomm)	E: Negative A: Indirect	Low	No
S10	Incidence of disease transmission between the workers and the population of the local communities.	X	X	X		No	F: Infrequent L: Likely E: Regional D: Long M: High (Construc); Low to Medium (Commiss), Low (Operation)	E: Negative A: Indirect	Medium to High (Construc), Low to Medium (Commiss) Low (Operation)	Yes

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S11	Potential increase in road traffic accidents	X	X	X	X	Yes	F: Infrequent L: Likely E: Regional D: Medium (Construction , Operation and Decommissioning); Short (Commissioning) M: High	E: Negative A: Direct	High	Yes
S12	Fire and explosion hazards generated by process operations		X	X		Yes	F: Rare L: Unlikely E: Local D: Long M: High	E: Negative A: Direct	Medium to High	Yes
Archaeological and Cultural Heritage										
AC1	Degradation of archaeological wealth which may exist on RTIP area and its vicinity and which is discovered during earth movement activities or vehicle movements.	X				No	F: Rare L: Unlikely E: Local D: Long M: Medium	E: Negative A: Direct	Low	Yes

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AC2	Possibility of finding intact archaeological artefacts during earth movement & ground clearance activities on RTIP Site area.	X				No	F: Rare L: Unlikely E: Local D: Long M: Medium	E: Positive A: Direct	Low (Positive)	Yes (if discovered artefacts remain intact)
AC3	Interaction between persons (expatriate workers) from diverse cultural backgrounds with the local community resulting in cross-cultural tension, specifically related to differences in dress, behaviour, and tradition. In addition, expatriate workers are likely to make tourist expeditions to cultural heritage and archaeology sites, which could impact archaeological resources if artefacts are found and kept as souvenirs or if they disturb archaeological sites visited.	X	X		X	No	F: Infrequent L: Unlikely E: Local D: Long M: Medium	E: Negative A: Direct	Medium	Yes

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Item No.	Impact	Phase: Construc.	Commiss.	Operation	Decomm.	Accident & Spills (1) (Yes/No)	Scope (2) (F, L, E, D, M)	Type (2) (Effect, Action)	Potential Significance (2)	Mitigation Suggested (3) (Yes/No)
AC4	Commissioning phase activities, such as pipeline testing, and tank hydrotesting, impact to archaeological and cultural resources. In addition, the presence of expatriate workers, as discussed in impact AC3, may result in cross-cultural tension and disturbance to archaeological sites of interest and artefacts.		X			No	F: Rare L: Unlikely E: Local D: Long M: Medium	E: Negative A: Direct	Low	No
AC5	Accidental damage during the operation phase to archaeological resources lying on surface during vehicle movements between the supply centres, camps, and project site.			X		No	F: Rare L: Unlikely E: Local D: Long M: Medium	E: Negative A: Direct	Low	No

Notes:
(1) Yes = the impact is the result of an accident or upset condition; No = the impact is the result of normal conditions
(2) Definitions for terminology used to describe impacts are given in Section 4.
(3) Mitigation is suggested where significance is "medium" or higher, unless otherwise indicated in the corresponding section of the EIA report

F = Frequency
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Construc. = Construction
Commiss. = Commissioning
Decomm. = Decommissioning

KSA= Kingdom of Saudi Arabia

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Table 20-1 Summary of Environmental Impact Assessment, RTIP, Jubail II, KSA

Item No.	Impact	Phase: Construc.	Phase: Commiss.	Phase: Operation	Phase: Decomm.	Accident & Spills (1) (Yes/No)	Scope (2) (F, L, E, D, M)	Type (2) (Effect, Action)	Potential Significance (2)	Mitigation Suggested (3) (Yes/No)
AC6	Expatriate workers keeping archaeological resources as souvenirs or disturbing archaeological sites during their tourist expeditions. Expatriate workers living in JIC residential areas could result in cross-cultural tension, specifically related to differences in dress, behaviour, and tradition.			X		No	F: Rare L: Likely E: Local D: Long M: Medium	E: Negative A: Direct	Medium	Yes
AC7	Accidental damage during the decommissioning phase to archaeological resources lying on surface during vehicle movements from the removal of material to restore land to pre-project conditions. Expatriate workers living in JIC residential areas could result in cross-cultural tension, specifically related to differences in dress, behaviour, and tradition. In addition, the presence of expatriate workers, as discussed in impact AC3, may result in the disturbance to archaeological sites of interest and artefacts.				X	Yes	F: Rare L: Unlikely E: Local D: Long M: Medium	E: Negative A: Direct	Low	Yes

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Table 20-1 Summary of Environmental Impact Assessment, RTIP, Jubail II, KSA

Item No.	Impact	Phase				Accident & Spills (1) (Yes/No)	Scope (2) (F, L, E, D, M)	Type (2) (Effect, Action)	Potential Significance (2)	Mitigation Suggested (3) (Yes/No)
		Construc.	Commiss.	Operation	Decomm.					
AC8	Excavation of soil due to accidents and spills, which may result in the discovery of buried archaeological resources.	X	X	X	X	Yes	F: Rare L: Unlikely E: Local D: Long M: Medium	E: Negative A: Direct	Low	Yes
Cumulative Impacts(4)										
C1	Cumulative air quality emissions from earth moving activities (fugitive) and vehicle movements.	X				No	F: Frequent L: Likely E: Provincial D: Short M: Low	E: Negative A: Indirect	Low	No
C2	Cumulative impact from ozone concentrations		X	X		No	F: Continuous L: Unlikely E: Provincial D: Medium M: High	E: Negative A: Indirect	High	No
C3	Cumulative impacts on terrestrial fauna and flora (air emissions, disturbances from construction activities, and loss of remnant vegetation).	X	X	X	X	No	F: Continuous L: Likely E: Provincial D: Long M: Very Low	E: Negative A: Indirect	Low	No

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Table 20-1 Summary of Environmental Impact Assessment, RTIP, Jubail II, KSA

Item No.	Impact	Phase				Accident & Spills (1) (Yes/No)	Scope (2) (F, L, E, D, M)	Type (2) (Effect, Action)	Potential Significance (2)	Mitigation Suggested (3) (Yes/No)
		Construc.	Commiss.	Operation	Decomm.					
C4	Cumulative impact untreated surface runoff discharges to the marine environment	X	X	X	X	No	F: Infrequent L: Unlikely E: Provincial D: Long M: Medium	E: Negative A: Indirect	Medium to Low	No
C5	Cumulative impact of increased vessel movements to service Jubail facilities utilising KFIP	X	X	X	X	Yes	F:Infrequent L: Unlikely E: Regional D: Medium M: High	E: Negative A: Indirect	High	Yes
C6	Cumulative impact of temporary increases in noise levels at the nearest residential receptors and mixed use area (peaking during construction phase) due to construction activities.	X	X		X	No	F: Continuous (in general) L: Certain E: Provincial D: Short M: Low to High	E: Negative A: Direct	Low to Medium	Yes

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(4) For Cumulative Impacts "No mitigation suggested" refers to any mitigation beyond that already proposed to mitigate that impact for RTIP alone

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Table 20-1 Summary of Environmental Impact Assessment, RTIP, Jubail II, KSA

Item No.	Impact	Phase				Accident & Spills (1) (Yes/No)	Scope (2) (F, L, E, D, M)	Type (2) (Effect, Action)	Potential Significance (2)	Mitigation Suggested (3) (Yes/No)
		Construc.	Commiss.	Operation	Decomm.					
C7 & C8	Cumulative impact of noise increase at locations near roadways due to traffic increase.	X	X	X	X	No	F: Continuous L: Certain E: Provincial D: Short (construction) Medium (operation) M: Medium	E: Negative A: Direct	Medium	No
C9	Cumulative impact of increased noise levels at nearby residential areas and mixed use areas due to operation of the RTIP new installations and development of other industrial installations in Jubail II.			X		No	F: Continuous L: Certain E: Provincial D: Medium M: Low	E: Negative A: Direct	Low	No
C10	Cumulative impact of exceeding solid and hazardous waste management facilities' capacities.	X	X	X	X	No	F: Continuous L: Unlikely E: Provincial D: Medium M: Low	E: Negative A: Indirect	Low	No
C11	Cumulative impact of exceeding liquid waste management facilities' capacities.	X	X	X	X	No	F: Continuous L: Unlikely E: Provincial D: Medium M: High	E: Negative A: Indirect	Low	Yes

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Table 20-1 Summary of Environmental Impact Assessment, RTIP, Jubail II, KSA

Item No.	Impact	Phase				Accident & Spills (1) (Yes/No)	Scope (2) (F, L, E, D, M)	Type (2) (Effect, Action)	Potential Significance (2)	Mitigation Suggested (3) (Yes/No)
		Construc.	Commiss.	Operation	Decomm.					
C12	Cumulative impact on regional economy due to demobilization of RTIP construction project and construction activities of future developments	X				No	F: Frequent L: Likely E: Regional D: Medium M: Medium	E: Positive A: Direct	Medium	Yes
C13	Cumulative impact on community's infrastructure (including housing, health care infrastructure, among others).	X				No	F: Frequent L: Likely E: Provincial D: Medium M: High	E: Negative A: Indirect	Medium	Yes
C14	Cumulative impact to public health from increased traffic	X	X	X		No	F: Frequent L: Likely E: Provincial D: Short M: Medium	E: Negative A: Indirect	Low	No

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21 SUMMARY OF MITIGATION

The potential mitigation measures with respect to the environmental impacts resulting from the construction, commissioning, operation and decommissioning of the RTIP project are summarised in Table 21-1 for air quality, onshore physical, biological resources, noise, waste management, marine environment, socio-economic aspects, archaeological and cultural aspects and for impacts on human health. Table 21-1 (overleaf) presents the impacts for each phase of the project entailing mitigation, the potential significance of each impact (from Table 20-1), potential mitigation measures and a potential significance **after** mitigation. Each impact is provided with a unique number for ease of reference between the impact table (Table 20-1), the mitigation table (Table 21-1) and the monitoring table (Table 22-1). The identified mitigation measures are presented in terms of BAT measures to ensure that their adoption is technically and economically feasible.

It should be noted that the project is applying BAT and Good International Industry Practices (GIIP[1]) at the design phase (see BAT Summary in Section 3 Project Description). However, some significant impacts could occur through the development of this project and measures to reduce, minimize or avoid them should be implemented. Table 21-1 includes mitigation measures suggested for those significant impacts. The IFC's General EHS Guidelines (World Bank Group, 2007a) have been used as guidance for the mitigation measures proposed. Furthermore sustainable practices and BAT measures have been recommended and are provided in Section 24 Sustainable Development Assessment.

An Environmental Management Plan (EMP) outline was prepared for this project and is incorporated in Appendix A. The EMP addresses the management of RTIP once the project starts. It will provide a detailed framework of specific management responses to environmental impacts and issues identified during this EIA, all of which are in compliance with recognised environmental management guidelines and other site management plans.

Through the implementation of measures suggested throughout the report and summarised within this section, the significance of negative impacts associated with the project will be minimized, and potential positive impacts will be enhanced.

[1] As defined by the World Bank Group in their EHS Guidelines, 2007:
"Defined as the exercise of professional skill, diligence, prudence and foresight that would be reasonably expected from skilled and experienced professionals engaged in the same type of undertaking under the same or similar circumstances globally. The circumstances that skilled and experienced professionals may find when evaluating the range of pollution prevention and control techniques available to a project may include, but are not limited to, varying levels of environmental degradation and environmental assimilative capacity as well as varying levels of financial and technical feasibility."

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Table 21-1 Summary of Proposed Mitigation Measures, RTIP, Jubail II, KSA

Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
Air Quality & Meteorology				
A1	Dust emissions during construction activities *Phases:* Construction and decommissioning.	High (close to RTIP) Low (Outside the industrial city)	• Covers and water suppression; • Increased moisture content for open material storage piles; • Each EPC contractor to develop and submit a dust control plan, an Air Quality Management Plan and Emissions Monitoring/Testing Plan. • Follow guidance on fugitive sources as per World Bank Group EHS Guidance, p. 8 (2007)	Medium (close to RTIP) Low (Outside the industrial city)
A2	Exhaust emissions from vehicle movements. *Phases:* Construction and decommissioning.	High (close to the RTIP complex and the industrial city); Low (Outside the industrial city)	• Specify use of modern properly maintained vehicles. • Follow guidance on mobile sources – land based as per World Bank Group EHS Guidance, p. 9 (2007)	Medium (close to RTIP complex and inside the industrial city) Low (Outside the industrial city)
A3	NO_X emissions from major combustion sources. *Phases:* Commissioning and operation.	Low	Reduction of process heater NOx emissions by means of: • Use of Low NOx burners (LNBs) for steam boilers and mixed feed cracking unit ethylene furnaces, to minimise the NOx formation via means of enhanced combustion designs such as combustion temperature reduction and reducing oxygen concentration; • Use of Selective Catalytic Reduction (SCR) for steam boilers, thermal treatment units, and Nitric Acid Unit to reduce NOx emissions that have been formed during the combustion process; •	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
Oil Spill Preparedness and Response. IPIECA, 2006
Acronyms:
IPIECA: International Petroleum Industry Environmental Conservation Association

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Table 21-1 Summary of Proposed Mitigation Measures, RTIP, Jubail II, KSA

Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
A4	SO_2 emissions from major combustion sources. *Phases:* Commissioning and operation.	Low	• The project design includes use of Flue Gas Desulphurization (FGD) systems to treat the boiler flue gas as it is a well established technology and has a high SO_2 removal rate (up to 95% removal)	Low
A5	CO emissions from major combustion sources. *Phases:* Commissioning and operation	Low	• The project design includes techniques such as complete combustion via furnace design, monitoring, process control, and maintenance to ensure complete combustion from the boilers; • The project design includes application of design operating temperature of 1100˚C with more than 2 seconds of residence time for Thermal Treatment Units (TTU) at normal operating conditions.	Low
A6	PM_{10} emissions from RTIP complex *Phases:* Commissioning and operation	High (note that contribution of RTIP is well below the RCJY standard but the high baseline makes the priority level high)	• Design includes FGD to treat the boiler flue gas; • Excluding liquid wastes in the TTUs from manufacturing units that contain inorganic chemical constituents that could produce PM; • Gaseous emission control devices used for the TTUs such as water spray quench, HCl water absorber tower, and caustic scrubber also contribute to PM reduction; • During loading/unloading activities and/or during storing of raw materials, the project will apply measures such as closed hanger, shield spraying system etc., to avoid dust emissions from the sources with RC prior approval.	High (1)
A7	$PM_{2.5}$ emissions from RTIP complex *Phases:* Commissioning and operation	High (note that contribution of RTIP is well below the RCJY standard but the high baseline makes the priority level high)		High (1)

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
Oil Spill Preparedness and Response. IPIECA, 2006
Notes:
(1) Although mitigation measures are suggested, the project cannot mitigate the existing PM_{10} and $PM_{2.5}$ background levels
Acronyms:
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Table 21-1 Summary of Proposed Mitigation Measures, RTIP, Jubail II, KSA

Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
A8	Benzene emissions from point and fugitive sources *Phases:* Commissioning and operation	Medium (close to RTIP site) Low (outside the industrial city)	• Loading or discharging of aromatics (or aromatics-rich streams) from road tankers, rail tankers, ships and barges should be provided with a closed vent systems will be connected to a flare system; • All equipment and piping systems should be designed to ensure a high level of containment and to minimise fugitive emissions. This involves seal-less or double/tandem sealed machinery, low loss valve packing, use of spiral wound jointing materials, and minimum use of flange connections. Equipment that handles benzene shall be designed to limit the exposure risk to an acceptable level; • Fugitive emissions from piping and equipment will be mitigated by using LDAR and monitoring program as required by RCER 2010. • Tankage of benzene will be a fixed roof with a flare system.	Medium (close to RTIP site) Low (outside the industrial city)
A9	Formaldehyde emissions from point and fugitive sources *Phases:* Commissioning and operation	Low	• In Formalin Unit (Unit 345) point source emissions (process tail-gas and product tank losses) are controlled by catalytic oxidation. • For fugitive emissions, equipment specifications include high-integrity sealing systems for pumps, compressors, and valves and use of proper types of O-ring and gasket materials for formaldehyde service. • From the Ethylene Oxide Unit, formaldehyde vapors originating from process is sent to the TTU for incineration. • A Leak Detection and Repair (LDAR) Program to monitor and control fugitive emissions will be implemented as required by RCER 2010 • Some of these measures are as recommended by the IFC. No additional mitigation measures were considered feasible.	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
A10	Toluene emissions from point and fugitive sources. *Phases:* Commissioning and operation	Low	• Same as for Impact A9	Low
A11	Ammonia emissions from point and fugitive sources. *Phases:* Commissioning and operation	Low	• For fugitive emissions, equipment specifications include high-integrity sealing systems for pumps, compressors, and valves and use of proper types of O-ring and gasket materials for ammonia service. • A Leak Detection and Repair (LDAR) Program to monitor and control fugitive emissions will be implemented as required by RCER 2010.	Low
A12	Chlorine emissions from point and fugitive sources. *Phases:* Commissioning and operation	Low	• Connection of vent streams from absorber, storage and loading/unloading systems to a recovery system (e.g., condensation, water scrubber) and/or to a vent gas treatment (e.g., thermal/catalytic oxidizer, TTUs); • Minimization of vent streams from storage tanks by backventing on loading/unloading and treating the polluted streams by thermal or catalytic oxidation • For fugitive emissions, equipment specifications include high-integrity sealing systems for pumps, compressors, and valves and use of proper types of O-ring and gasket materials for chlorine service. • A Leak Detection and Repair (LDAR) Program to monitor and control fugitive emissions will be implemented as required by RCER 2010.	Low
A13	Xylene emissions from point and fugitive sources. *Phases:* Commissioning and operation	Low	• Same as for Impact A9	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
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Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
A14	Aniline emissions from point and fugitive sources. *Phases:* Commissioning and operation	Low	• Point source emissions of aniline are controlled by Thermal Treatment in Unit 779 and alternatively Flare. • In regards to fugitives, equipment specifications include high-integrity sealing systems for pumps, compressors, and valves and use of proper types of O-ring and gasket materials for aniline service • A Leak Detection and Repair (LDAR) Program to monitor and control fugitive emissions will be implemented as required by RCER 2010.	Low
A15	Ethylene Oxide emissions from point and fugitive sources. *Phases:* Commissioning and operation	Low	Design features for the Project includes: • Ethylene & Methane are flashed off from the carbonate solution in to minimize HC emission from the CO2 vent to atmosphere. • Pumps with double mechanical seals or seal-less pumps are utilized for the Ethylene Oxide (EO) service. Vents from seal system are captured and sent to waste gas header to TTU. • Ethylene Oxide storage tanks are equipped with a vent recovery collection system to route the EO containing gas back to the process using the vent gas compressor • Minimization of the number of flanged connections, and installation of metal strips around flanges with vent pipes sticking out of the insulation to allow monitoring of Ethylene oxide release • EO detectors are used at potential leak area and building HVAC intake to buildings. Examples : EO storage tanks, transfer pumps as well as HVAC intake to MCC building • A Leak Detection and Repair (LDAR) Program to monitor and control fugitive emissions will be implemented as required by RCER 2010.	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
A16	Hydrogen Chloride emissions from point and fugitive sources. *Phases:* Commissioning and operation	Low	The project design includes equipment and piping systems with a high level of containment to minimise point and fugitive emissions. • In the Isocyanates Units, the point source emissions are controlled primarily by Thermal Treatment in Unit 779 and alternatively by a Mitigation Scrubber System including a Process Scrubber and a backup Emergency Scrubber, both using a strong caustic solution to react/destroy HCL. A backup option when Thermal Treatment is not available is routing scrubber exhaust to Flare. • In regards to fugitives, equipment specifications include seal-less or double/tandem sealed machinery, and minimum use of flange connections. • Process equipment that handles HCL shall be designed to limit the exposure risk. • A Leak Detection and Repair (LDAR) Program to monitor and control fugitive emissions will be implemented as required by RCER 2010.	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
A17	Phosgene emissions from point and fugitive sources. *Phases:* Commissioning and operation	Low	The project design includes equipment and piping systems with a high level of containment to minimise point and fugitive emissions. • Point source emissions are controlled primarily by Thermal Treatment in Unit 779 and alternatively by a Mitigation Scrubber System including a Process Scrubber and a backup Emergency Scrubber, both using a strong caustic solution to react/destroy phosgene. A backup option when Thermal Treatment is not available is routing scrubber exhaust to Flare. • In regards to fugitives, equipment specifications include seal-less or double/tandem sealed machinery, low loss valve packing, use of spiral wound jointing materials, and minimum use of flange connections. • Process equipment that handles phosgene shall be designed to limit the exposure risk and is ultimately backed up by the TDI & PMDI Containment Domes which provide for equipment isolation and conveying significant fugitive emissions to the Emergency Caustic Scrubber for reaction/destruction. • A Leak Detection and Repair (LDAR) Program to monitor and control fugitive emissions will be implemented as required by RCER 2010.	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
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Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
A18	SO_2 Emissions from Flares during Emergency Scenario and Process Upset *Phases:* Commissioning and operation	Low	The RTIP complex design has included the following measures to minimize flare emissions: • Appropriate consideration, through technical evaluation, should be given with respect to flare design to ensure safe operation and minimize impact on the community; • Flares shall be designed for smokeless operation through as much of the operating range as technically feasible; • Flares primary function shall be to manage unplanned events and startup and shutdown of units; • The use of flares as control devices for continuous vent streams is acceptable after other alternatives have been evaluated, considering process safety, cost, etc.. For flares used as control devices, the flares shall be designed and operated such that the combined assist fuel gas and waste stream is in accordance with RCER Table 2B specifications; • Flaring shall be minimized during start-up and shut-downs; • Mitigation measures for A20 are also applicable.	Low
A19	NOx Emissions from Flares during Emergency Scenario and Process Upset *Phases:* Commissioning and operation	Low		Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
A20	CO Emissions from Flares during Emergency Scenario and Process Upset *Phases:* Commissioning and operation	Low	• Mitigation measures for A19 and A20 are also applicable • Cameras shall be used as a means of flame detection/confirmation for flares. In addition, the continuous imaging (digital recording) of all flares with date and time shall be maintained. Cameras shall also be considered for monitoring other critical equipment, remote loading operations, etc. Other measures recommended to minimize flare emissions are as follow: • Minimization of flaring via an overall emissions reduction strategy. The following flare minimization activities are suggested: flares to be designed in accordance with applicable standards, installing a gas recovery system, using high-integrity relief valves, applying advanced process control, and reducing relief gas to flare by management/good housekeeping practices.	Low
A21	Benzene Storage Tanks Spills *Phases:* Commissioning, operation, and decommissioning	Medium	HAZID, HAZOP, etc. assessments will be used throughout the design process. A Spill Prevention and Containment plan needs to be developed and recommendations implemented.	Low to Medium
A22	Benzene Pipe Rack Failure Spills *Phases:* Commissioning, operation, and decommissioning	Medium		

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Table 21-1 Summary of Proposed Mitigation Measures, RTIP, Jubail II, KSA

Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
Onshore Physical Environment				
O2	Alteration of drainage characteristics (including dewatering) and modification of the storm water flow and recharge regime *Phases:* Construction, commissioning, and operation	Low	• Provide a temporary or alternative pathway for stormwater drainage during the construction phase, avoiding the elimination or the temporary closure of the natural run-off pathways. • Careful design and planning of construction is suggested to as the depth to the shallow groundwater ranges from 2 to 12 mBGS. Careful design of the final land elevations could reduce the requirement to dewater and excavate below the water table. • If dewatering is required, then appropriate site specific design and disposal of groundwater is needed. Although the baseline data do not suggest the presence of contaminants in groundwater, sampling and analysis of groundwater is recommended prior to disposal. • Develop and initiate a groundwater monitoring programme to monitor groundwater quality. • Ensure that the drainage system is cleaned from time to time, so it is always able to carry the volume of storm water for which it was designed.	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Table 21-1 Summary of Proposed Mitigation Measures, RTIP, Jubail II, KSA

Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
O3	Degradation of soil and groundwater quality due to minor accidental releases and spills of hazardous materials during construction *Phases:* Construction	Low	• Develop a comprehensive Spill Prevention and Containment Plan (in accordance with RCJY environmental regulations) to ensure safe onsite storage of hazardous materials; handling and containment of accidental spills and releases. The plan shall also address the transfer and disposal of spilled materials as hazardous waste and mitigating measures documented to contain any spills. Continually monitor and re-evaluate the effectiveness of the plan. • Implement procedures indicating the characteristics of the transportation vehicles to be used, trying to minimize as much as possible potential release/spills related to the bad condition of the materials (valves, pumps in the trucks, etc). • Pre-casting of concrete structure will be conducted in paved areas, with a large enough extent and gradient to prevent spillage of concrete or cement onto bare soil. • Keeping the amounts of stored hazardous materials to a minimum and always within controlled areas. • During construction designate an offsite fuel distribution facility that is equipped with spill containment and prevention measures including integrity tested double-wall storage tanks, distribution lines and equipment. If due to project requirements, the re-fuelling of construction vehicles and equipment needs to take place on the RTIP site, a fuel storage and distribution facility with appropriate spill containment and prevention measures should be built as part of the facilities' temporary infrastructure, and an integrity testing programme (which includes integrity tests and volume balance) should be put in place.	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Table 21-1 Summary of Proposed Mitigation Measures, RTIP, Jubail II, KSA

Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
O3 (Cont)	Degradation of soil and groundwater quality due to minor accidental releases and spills of hazardous materials during construction *Phases:* Construction	Low	• Develop and initiate a groundwater monitoring programme to monitor groundwater quality	
O4	Degradation of soil and groundwater quality due to minor accidental releases and spill during occasional maintenance of construction equipment and vehicles *Phases:* Construction	Low	• The RTIP site will have a designated site for the occasional maintenance activities of vehicles and construction equipment. The maintenance area will have a comprehensive spill prevention and containment plan to ensure the safe handling and containment of accidental spills and releases, onsite storage of hazardous materials and the transfer and disposal of spilled materials. Continually monitor and re-evaluate the effectiveness of the plan. • Keep equipment and vehicle maintenance activities onsite to a minimum. Only emergency repairs (such as those needed to stop a spill of hazardous material) should be conducted outside the maintenance area. • Washing of concrete mixers and trucks should only take place in paved or lined areas with appropriate wastewater collection measures. It is recommended that the wastewater generated during washing of concrete mixers and trucks be given sufficient time to allow for the settlement of solids, prior to its treatment and/or disposal. Treatment of the remaining wastewater should take into consideration its pH and dissolved solids load.	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Table 21-1 Summary of Proposed Mitigation Measures, RTIP, Jubail II, KSA

Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
O5	Degradation of soil and groundwater quality due to minor accidental releases and spills of hazardous materials during commissioning *Phases:* Commissioning	Low	• Develop a comprehensive spill prevention and containment plan (in accordance with RCJY regulations) to ensure safe onsite storage of hazardous materials; handling and containment of accidental spills and releases. The comprehensive spill prevention and containment plan shall also address the transfer and disposal of spilled materials as hazardous waste. Continually monitor and re-evaluate the effectiveness of the plan. • Keeping the amounts of stored hazardous materials to the minimum and control access to said materials. • Perform the majority of repairs within the maintenance complex. • Designate an offsite fuel distribution facility that is equipped with spill containment and prevention measures including integrity tested double-wall storage tanks, distribution lines and equipment. If, due to project requirements, any refuelling of construction vehicles and equipment needs to take place on the RTIP site, a fuel storage and distribution facility with appropriate spill containment and prevention measures should be built as part of the facilities' temporary infrastructure and a integrity testing programme (that includes integrity tests and volume balance) should be put in place. Underground storage and distribution equipment should be avoided to the maximum extent possible	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
O6	Degradation of soil and groundwater quality due to accidental releases and spills of hazardous materials and feed stock during normal operations at the process plants, maintenance of equipment and storage and internal distribution through the utility infrastructure. *Phases:* Operation	Medium	• Develop a comprehensive spill prevention and containment plan (in accordance with RCJY regulations) to ensure safe onsite storage of hazardous materials; and handling and containment of accidental spills and releases. The comprehensive spill prevention and containment plan shall also address the transfer and disposal of spilled materials as hazardous waste. Continually monitor and re-evaluate the effectiveness of the plan. • Visual monitoring of the Surface Drainage System. Prompt repair of malfunctioning equipment. Minimize the volumes of SRO stored at SRBs. • Implementation of spill detection systems. • Develop and implement a groundwater monitoring programme to monitor groundwater quality. • Perform the majority of repairs within the maintenance complex.	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
O7	Negative impact due to accidental releases and spills of hazardous materials (including fuel) during the transportation of raw materials, feed stocks and products on or off-site *Phases:* Operation	Low to medium	• Develop a comprehensive spill prevention and containment plan (in accordance with RCER) to ensure safe onsite storage of hazardous materials; handling and containment of accidental spills and releases, and transfer and disposal of spilled materials as hazardous waste. Continually monitor and re-evaluate the effectiveness of the plan. • Integrate spill prevention and containment measures into the transportation plans for third-party vendors.	Low
O11	Potential for soil contamination resulting from On-Site Storage of Non-Hazardous Solid Waste *Phases:* Construction, commissioning, operation, and decommissioning	Low	• Developing a comprehensive waste management plan which complies with internationally accepted industry standards to ensure safe handling, onsite storage, transfer and disposal. Continually monitor and re-evaluate the effectiveness of the plan; • The Waste Management Plans should encompass all phases of the waste management process under the good industry practice requirements of duty of care and protect the corporate image of the proponents. • Keeping storage times on RTIP site to the minimum and control access to stored wastes (no longer than 180 days after waste generation, according to RCER); • Segregating scrap plastic, glass, metal and wood for recycling where possible.	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
O13	Potential for soil contamination resulting from On-Site Storage of Hazardous Solid Waste *Phases:* Construction, commissioning, operation, and decommissioning	Low	• Developing a comprehensive waste management plan which complies with the internationally accepted industry standards to ensure safe handling, onsite storage, transfer and disposal. Continually monitor and re-evaluate the effectiveness of the plan; • Providing secondary containment to tanks, to capture any spills and equip tanks with a contents level indicator; Keeping storage times at the EPC Contractor camp to the minimum, and controlling access to stored wastes; • Providing secure means of transferring wastes safely into and out of the tank to minimise spills. Any shipment of wastes outside of Jubail Industrial City must be previously authorised by the RC. Any shipment of hazardous wastes outside of KSA must conform to the requirements of the Basel Convention; • Undertaking an audit of the waste management facility prior to each phase of the project to ensure that it is operational, licensed and capable of handling the wastes to be generated; • Covering trucks where appropriate to prevent wind-blown losses during transport; • Following other procedures established in the RCER (2010) for appropriate waste transport and disposal.	Low
O14	Potential for soil contamination resulting from On-Site Storage of Hazardous Liquid Waste *Phases:* Construction, commissioning, operation, and decommissioning	Low	• Refer to mitigation measures suggested for item number O13.	Low

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Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
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Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
O16	Potential for soil contamination resulting from Off-Site Disposal of Non-Hazardous Solid Waste *Phases:* Construction, commissioning, operation, and decommissioning	Medium (Construction, Decommissioning); Low (Commissioning, Operations)	• Developing a comprehensive waste management plan which complies with internationally accepted industry standards to ensure safe handling, onsite storage, transfer and disposal. Continually monitor and re-evaluate the effectiveness of the plan; • The Waste Management Plans should encompass all phases of the waste management process under the good industry practice requirements of duty of care and protect the corporate image of the proponents. • Undertaking an audit of the waste management facility prior to each phase of the project to ensure that it operated according to regulations and capable of handling the wastes to be generated; • Following the procedures established in the RCER for appropriate waste transport and disposal.	Low
O18	Potential for soil contamination resulting from Off-Site Disposal of Hazardous Waste *Phases:* Construction, commissioning, operation, and decommissioning	Low	• Developing a comprehensive waste management plan which complies with internationally accepted industry standards to ensure safe handling, onsite storage, transfer and disposal. Continually monitor and re-evaluate the effectiveness of the plan; • The Waste Management Plans should encompass all phases of the waste management process under the good industry practice requirements of duty of care and protect the corporate image of the proponents. • Undertaking an audit of the waste management facility prior to each phase of the project to ensure that it is operational, licensed and capable of handling the wastes to be generated; • Following other procedures established in the RCER (2010) for appropriate waste transport and disposal.	Low

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Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
O19	Potential for subsurface contamination resulting from transport of hazardous wastes off-site *Phases:* Construction, commissioning, operation, and decommissioning	Low to Medium	• Developing a comprehensive waste management plan which complies with internationally accepted industry standards to ensure safe handling, onsite storage, transfer and disposal. Continually monitor and re-evaluate the effectiveness of the plan; • The Waste Management Plans should encompass all phases of the waste management process under the good industry practice requirements of duty of care and protect the corporate image of the proponents. • Providing secure means of transferring wastes safely into and out of the tank to minimise spills. Any shipment of wastes outside of Jubail Industrial City must be previously authorised by the RC. Any shipment of hazardous wastes outside of KSA must conform to the requirements of the Basel Convention; • Covering trucks where appropriate to prevent wind-blown losses during transport; • Following other procedures established in the RCER (2010) for appropriate waste transport and disposal.	Low
O20	Accidental release of solid hazardous wastes within the RTIP Complex *Phases:* Construction, commissioning, operation, and decommissioning	High	• Refer to mitigation measures suggested for item number O6.	Medium/Low

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Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
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Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
O21	Accidental release of liquid hazardous wastes within the RTIP Complex *Phases:* Construction, commissioning, operation, and decommissioning	High	• Refer to mitigation measures suggested for item number O6.	Medium/Low
O22	Accidental release of solid hazardous wastes during transport offsite *Phases:* Construction, commissioning, operation, and decommissioning	Medium to High	• Refer to mitigation measures suggested for item number O7.	Medium/Low
O23	Accidental release of liquid hazardous wastes during transport offsite *Phases:* Construction, commissioning, operation, and decommissioning	Medium to High	• Refer to mitigation measures suggested for item number O7.	Medium/Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
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Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
Terrestrial Ecology				
B1	Removal of vegetation and potential foraging sites for nocturnal animals (habitat loss) ***Phases:*** Construction	Low	• During the construction period, the land based works should to be assessed in relation to the following issues: - The impact on vegetation within the footprint of the RTIP operational site; - The impact on vegetation at locations which are to be used as temporary compounds or storage areas; The effects of construction on other aspects of terrestrial ecology.	Low
B2	Effects of noise on fauna onsite and offsite especially on breeding, wintering and migrant birds offsite (e.g. Sabkhat Al-Fasl Lagoons) *Phases:* Construction	Low	• As per impact B1	Low
B3	Effects of dust and noise from earth moving and vehicle movements, etc. on vegetation and fauna onsite or adjacent to RTIP *Phases:* Construction, commissioning, operation and decommissioning	Low	• The use of modern properly maintained vehicles together with other driving policy measures like minimising off road driving and transporting materials in bulk to minimise trips, should reduce the local impact of emissions on the biological environment from vehicle movement to and from the site during all phases of the project.	Low
B5	Potential effects of elevated air pollution on offsite vegetation (protected areas) from major combustion sources. *Phases:* Commissioning and operation.	Low	• Use of modern properly maintained vehicles should reduce the local impact of emissions on the biological environment from vehicle movement to and from the site during all phases of the project. • Minimise air emissions during commissioning and operation of the RTIP using the BAT approach, which is adopted in the design, to reduce effects of emissions on flora and fauna outside the project site. • Refer to impacts A3 – A7.	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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B6	Potential effects of elevated air pollution on offsite vegetation (protected areas) from major combustion sources. *Phases:* Commissioning and operation.	Low	• Refer to mitigation measures suggested for item numbers A4.	Low
Marine Ecology				
M1	Impact to the marine environment in the area of KFIP from increased vessel movements at KFIP. *Phases:* Construction, commissioning and operation.	Low	RTIP Project Team to work with the Saudi Ports Authority to review and update routing and operating protocols currently in effect at KFIP to ensure that the increase of vessel movements associated to the RTIP activities is adequately managed.	Low
M2, M4, M5	Impact resulting from untreated effluent from batching plant, hydrotest water or surface runoff entering the marine environment, damaging marine ecosystems, and local fisheries industry. *Phases:* Construction, commissioning, operation, and decommissioning	Low to Medium	Waste water monitoring of all sources prior to their discharge to either the Marafiq IWTP, RC Drainage Channel or Marafiq Seawater Cooling Return Header will be undertaken following RCER 2010 and PTO requirements. The following effluents will be monitored in order to ensure compliance with the EPO and RCER applicable limits: • Concrete Batching Plant wastewater prior to discharge to RC Drainage Channel; • Unit 785 –wastewater prior to discharge to the Marafiq Seawater Cooling Return Header; • Surface Runoff Basins sampling prior to discharge to the RC. If water quality does not comply with EPO or RCER 2010 requirements, it will be diverted to Unit 773 for collection and transfer to Marafiq IWTP.	Low

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Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
M6	Direct spill of fuel, raw materials or finished product to marine environment during transport damaging marine ecosystems and local fisheries industry. *Phases:* Commissioning, operation, and decommissioning	High	• RTIP to utilise third-party transport providers that abide by operating procedures that ensure secure containment, appropriate materials management, and adequate equipment and vessel maintenance. In addition transporters must abide by all applicable international codes and guidelines. Third-party emergency and spill response plans must be adequate to accommodate RTIP materials and products. • Decisions regarding preferred transport providers should consider the condition of a transport provider's fleet and equipment, and the appropriateness of their operating and emergency procedures.	Medium
M7, M8, M9	Fuel or chemical spill from trucks, Port Tank Farm, pipelines and jetty topside handling equipment at Port Facilities damaging marine ecosystems and local fisheries industry. Fuel or chemical spill to marine environment from vessel collision or breach at Port Facilities damaging marine ecosystems and local fisheries industry. Marine impact from regular, small volume fuel or chemical leakage from Port Tank Farm and associated equipment and pipelines at Port Facilities. *Phases:* Commissioning, operation, and decommissioning	Medium to High	• RTIP Project Team to work with the Saudi Ports Authority to review and update the Local Anti-Pollution and Port Emergency Plan to ensure capacity for spill response and emergency conditions is adequate for RTIP operations, particularly the shipping, loading, unloading and transportation of raw materials and finished product via truck and pipeline; • RTIP Project team to liaise with the Saudi Ports Authority to assess the adequacy of the existing Spill Response Plan. This plan to be amended and/or expanded to ensure that the existing mutual aid arrangements, established for the response in the event of a spill, are expanded to include RTIP, and that appropriate protection measures are in place for other facilities should a spill occur that could impact Marafiq or other water intake canals. This is to be undertaken in accordance with requirements of World Bank Group, EHS Guidelines (2007) and International Petroleum Industry Environmental Conservation Association (IPIECA) guidelines, 2000 & 2006; • RTIP Project Team to prepare a project specific Spill Contingency Plan. This plan should be implemented in combination with oil response equipment (e.g. spill kits) prior to construction and regularly reviewed and maintained.	Low to Medium

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M10	During construction, frequent noise may result from steelwork erection, offloading of trucks and other vehicles. The highest noise levels would be expected from commissioning of the new plant, pipelines and new equipment. *Phases:* Construction	Low	• The Engineering, Procurement and Construction (EPC) contractor shall ensure that all construction equipment has appropriate noise suppression devices installed, and is maintained appropriately. • On-site mechanics to properly maintain the construction equipment and noise suppression devices	Very Low
M12	Deposition of dust into marine waters damages water quality introduces toxic substances and influences light penetration, damaging marine organisms, including fisheries important to the local fishing industry. *Phases:* Construction, commissioning, operation, and decommissioning	Low	• The Engineering, Procurement and Construction (EPC) contractor shall develop and implement a Sedimentation and Siltation Monitoring Plan for construction activities at Port Facilities; • Water will be sprayed regularly on road surfaces and in material storage areas to prevent dust generation by vehicles; • Stockpiles will be visually monitored and relevant staff will be notified when dust management is required; • Stockpiles will be managed in an appropriate manner (such as covering stockpiles and installing sediment traps around base of stockpiles) to prevent dust, erosion and sediment runoff; • Sweeping of hard surfaces to capture and dispose of dust and debris appropriately; and • Sandblasting will take place utilizing appropriate shielding mechanisms.	Very Low

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Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
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Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
			Noise	
N1	Temporary increases in noise levels at the nearest residential receptors and mixed use area (peaking during construction phase). *Phase*: Construction and decommissioning	Low	• Select inherently quiet equipment wherever possible; RTIP will use low noise design construction equipment typical for a world-scale facility of this magnitude. • Ensure machinery are properly maintained, particularly engine exhaust silencers; • Ensure that all rotary driven construction equipment has appropriate noise suppression devices installed, and is well maintained. • Machinery should be turned off when not in use (not left idling); • Where practicable, make use of screening afforded by spoil stockpiles for high noise activities. • The construction site will be staffed with on-site mechanics to properly maintain the construction equipment and noise suppression devices. • The construction personnel will be required to wear hearing protection when necessary in the construction site. Ear plugs and earmuffs are considered as proper personnel hearing protection devices. • Should any pile driving become necessary it should be restricted to day time hours, which according to the World Bank Noise Guidelines (World Bank, 2007a) comprise the period between 7:00 am to 10:00 pm.	Low
N2	Potential increases in traffic noise levels at locations near roadways. *Phase:* Construction, operation and decommissioning	Medium	• Traffic in or near residential areas, especially during night time hours should be minimized.	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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N3	Increased noise at nearest residential receptors and mixed use area due to high-pressure steam blows and flaring. *Phase:* Commissioning	Medium	• Where practical, limiting high-pressure steam blows to daytime hours. • Temporary portable vent silencers will be used to control the vent noise from these activities to manageable levels. • Low pressure continuous steam blowing will be used where practical. This method maintains relatively low pressures and continuous flowing stream of steam to achieve steady state blowing conditions	Medium
N4	Increased noise levels at nearby residential areas and mixed use areas due to operation of the RTIP new installations. *Phase:* Operation.	Low	• To meet Occupational Health and Safety standards and protect workers' hearing, use of hearing protection devices, warning signage, and work training shall be required in specified work areas. • Installation of Class C acoustic insulation (Specified in ISO 15665) on all compressor suction/ discharge/ recycle piping; • Installation of vibration isolation pads, such as Fabreeka or equivalent on compressor suction/ discharge pipe supports to reduce the noise transmission to the pipe supports; • Insulation of control valves, if any, and their downstream piping; • Areas in plant where sound pressure levels exceed 85dBA need to be designated as "Restricted Areas", and personnel hearing protection is mandatory;	Low

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Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
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Socio-Economic & Cultural Aspects				
S1	Increased traffic resulting from worker and equipment/material transport. This impact may cause disruptions in accessing industrial facilities and utilities, residential settlements and leisure to existing infrastructure (peaking during construction) *Phases:* Construction, commissioning, operation, and decommissioning	High (Construc), Low to Medium (Commiss, Operations, Decomm)	• Develop and implement a traffic management plan (and logistics) for the project in partnership with the RCJY and port authorities, addressing conditions, access management, routing, scheduling, and operational procedures that contribute to traffic hazards as envisaged in the traffic study prepared for the project. Supporting regional road safety programmes and providing input into management of the road work network within the RCJY authorities can further reduce the impact of RTIP. • Determine the waste and material truck circulation at certain hours to avoid annoyance and congestion; • Coordinate with RCJY to promote traffic safety in the community. This coordination and outreach should be included in the stakeholder consultation program. • Disseminate traffic safety information to road users (including instructions on driving in foggy conditions). • Support RC in the communication with community leaders to inform stakeholders of the impact, schedule, and routing, thereby minimising negative impacts. • Give preference to local sources for foods and services, in order to minimize offsite traffic and provide positive economic impacts.	Low to Medium

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Table 21-1 Summary of Proposed Mitigation Measures, RTIP, Jubail II, KSA

Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
S1 (Cont.)	Increased traffic resulting from worker and equipment/material transport. This impact may cause disruptions in accessing industrial facilities and utilities, residential settlements and leisure to existing infrastructure (peaking during construction) *Phases:* Construction, commissioning, operation, and decommissioning		• Integrate into the project design the measures suggested in the traffic study conducted for the operation phase. Some of the recommendations made by this study are listed below: - Modifications of the RTIP site south-west and south-east entrances to help optimize the flow of traffic to and from the RTIP site; - Establish an additional bus stop at the RTIP north entrance (for 14 buses), the RTIP south entrance (for 9 buses) and at the KFIP (for 1 bus). - Staggered or flexible start times for personnel of day shifts.	
S5	Decreased income. Reduction in number of immigrant workers post peak. *Phases:* Construction and decommissioning	Low	• Coordinate with RCJY to arrange a workshop with the community to inform them about project activities and potential employment opportunities. • An appropriate decommissioning plan should be developed and implemented.	Low
S7	Impact of immigrant workers. Foreign workers separated from their families. *Phases:* Construction, commissioning, operation, and decommissioning	Low	• Improve communication systems between workers and families by installing pay telephones at the workers accommodation.	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
Oil Spill Preparedness and Response. IPIECA, 2006
Acronyms:
IPIECA: International Petroleum Industry Environmental Conservation Association

Table 21-1 Summary of Proposed Mitigation Measures, RTIP, Jubail II, KSA

Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
S10	Incidence of disease transmission between the workers and the population of the local communities. *Phases:* Construction, commissioning, operation, and decommissioning	Medium to High (Construc), Low to Medium (Commiss, Operation, Decomm)	• Provide employee counselling, health screening, health and cultural training and awareness, and vaccination programmes. • Pre employment physical and inoculation for contagious diseases • Develop an awareness and prevention programmes and health policies and procedures as well as an integrated programme addressing the health and social implications; • Management of workers' accommodation in ways that reduce risky behaviours, including provision of recreational facilities; • Epidemiological statistics at JIC or in the Region were not accessible when the baseline was performed. A health survey campaign to collect data on the most common communicable diseases in the area is recommended. Tracking and monitoring of incidence rates throughout project implementation would provide valuable information for the design of health programs for RTIP; • Ensure that the requirement to monitor and screen for communicable diseases is incorporated into the EPC contractor's contract. The operator should enforce and audit against the contract; • Ongoing commitment to health education and support of local programmes to control the spread of communicable diseases is recommended. •	Low to Medium

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
Oil Spill Preparedness and Response. IPIECA, 2006
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Table 21-1 Summary of Proposed Mitigation Measures, RTIP, Jubail II, KSA

Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
S11	Potential increase in road traffic accidents *Phases:* Construction, commissioning, operation, and decommissioning	High	• A structured approach to traffic management and vehicle standards should be specified and safety measures should be implemented. A road transport safety programme for the RTIP should be developed and implemented over the lifetime of the project. • Supporting regional road safety programmes and providing input into management of the road work network can further reduce the impact of the RTIP. • Coordinate with the local authorities to promote traffic safety and coordination on transport is recommended. This coordination should be included in the stakeholder consultation program.	Low to Medium

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
Oil Spill Preparedness and Response. IPIECA, 2006
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Table 21-1 Summary of Proposed Mitigation Measures, RTIP, Jubail II, KSA

Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
S12	Fire and explosion hazards generated by process operations *Phases:* Construction, commissioning, operation, and decommissioning	Medium to High	• Major hazards should be prevented through the implementation of a Process Safety Management Program that includes: - Facility wide risk analysis, including a detailed consequence analysis for events with a likelihood above - 10-6/year (e.g., HAZOP, HAZID, or QRA); - Train employees on operational hazards; - Develop and implement procedures for management of change in operations, process hazard analysis, maintenance of mechanical integrity, pre-start review, hot work permits, and other essential aspects of process safety; - Develop and implement a Safe Transportation Management System for the transport of raw or processed materials; and - Develop and implement procedures for handling and storage of hazardous materials. • On-site and off-site emergency planning, which should include, at a minimum, the preparation and implementation of an Emergency Management Plan and a Communication Plan prepared with the participation of local authorities and potentially affected communities. •	Medium

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Table 21-1 Summary of Proposed Mitigation Measures, RTIP, Jubail II, KSA

Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
Archaeological & Cultural Heritage				
AC1	Degradation of archaeological wealth which may exist on RTIP area and its vicinity and which is discovered during earth movement activities or vehicle movements. *Phases:* Construction	Low	• Develop and implement an "archaeological chance find procedure" before starting construction work that includes a trained supervisor to oversee the excavation phase and provision of a simple discovery action card to workers as part of the site orientation. The "archaeological chance find procedure" should involve an appropriate briefing of workers and a notification system. To ensure awareness of employees and contractors, once developed the procedures will be part of the site induction process. • If a worker discovers archaeological artefacts, work in that area shall be stopped and the EH&S Manager and site owner representative shall be notified. The competent authority should be informed, so that the artefacts can be investigated and the area released.	Low
AC2	Possibility of finding intact archaeological artefacts during earth movement & ground clearance activities on RTIP Site area. *Phases:* Construction	Low (Positive)		Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Table 21-1 Summary of Proposed Mitigation Measures, RTIP, Jubail II, KSA

Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
AC3	Interaction between persons (expatriate workers) from diverse cultural backgrounds with the local community resulting in cross-cultural tension, specifically related to differences in dress, behaviour, and tradition. In addition, expatriate workers are likely to make tourist expeditions to cultural heritage and archaeology sites of interest, which could impact archaeological resources if artefacts are found and kept as souvenirs or if they disturb archaeological sites visited. *Phases:* Construction, commissioning, and decommissioning	Medium	• Provide training to workers to increase awareness and provide an introduction to local culture and traditions. This would include disseminating educational and informative materials promoting cross-cultural understanding. • Regarding the influx of workers during the construction, impacts to the local population should be managed through the stakeholder engagement process (Appendix E).	Low
AC4	Commissioning phase activities, such as pipeline testing, and tank hydrotesting, impact to archaeological and cultural resources. In addition, the presence of expatriate workers, as discussed in impact AC3, may result in cross-cultural tension and disturbance to archaeological sites of interest and artefacts. *Phases:* Commissioning	Low	• Refer to mitigation measures suggested for item number AC3.	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Table 21-1 Summary of Proposed Mitigation Measures, RTIP, Jubail II, KSA

Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
AC5	Accidental damage during the operation phase to archaeological resources lying on surface during vehicle movements between the supply centres , camps, and project site. *Phases:* Operation	Low	• Refer to mitigation measures suggested for item numbers AC1, AC2, and AC3.	Low
AC6	Expatriate workers keeping archaeological resources as souvenirs or disturbing archaeological sites during their tourist expeditions. Expatriate workers living in JIC residential areas could result in cross-cultural tension, specifically related to differences in dress, behaviour, and tradition. *Phases:* Construction, commissioning, decommissioning and Operation	Medium	• Refer to mitigation measures suggested for item numbers AC3.	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Table 21-1 Summary of Proposed Mitigation Measures, RTIP, Jubail II, KSA

Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
AC7	Accidental damage during the decommissioning phase to archaeological resources lying on surface during vehicle movements from the removal of material to restore land to pre-project conditions. Expatriate workers living in JIC residential areas could result in cross-cultural tension, specifically related to differences in dress, behaviour, and tradition. In addition, the presence of expatriate workers, as discussed in impact AC3, may result in the disturbance to archaeological sites of interest and artefacts. *Phases:* Decommissioning	Low	• Refer to mitigation measures suggested for item numbers AC1, AC2, and AC3.	Low
AC8	Excavation of soil due to accidents and spills, which may result in the discovery of buried archaeological resources. *Phases:* Decommissioning	Low	• Refer to mitigation measures suggested for item numbers AC1 and AC2.	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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Table 21-1 Summary of Proposed Mitigation Measures, RTIP, Jubail II, KSA

Item No.	Impact	Potential Significance	Potential Mitigation Measure or Recommendation	Significance after Mitigation
Cumulative Impacts				
C11	Cumulative impact of exceeding liquid waste management facilities' capacities.	Low	• Undertake a review prior to the commissioning phase of the Project to determine project infrastructure requirements for wastewater. This will allow existing capacity problems to be identified at an early stage and alternatives to be examined.	Low
C13	Cumulative impact on community health care and housing/accommodation infrastructure.	Low	– Undertake a retrospective review to determine project social infrastructure requirements including health care and accommodation requirements. This will possibly allow existing capacity problems to be identified at an early stage and alternatives to be examined. – In coordination with the RCJY, monitor social infrastructure requirements envisaged for this project and other future developments in the project area at the time the construction activities of RTIP will be undertaken.	Low

Source:
Environmental, Health and Safety Guidelines, Offshore Oil & Gas Development, World Bank Group, 2007
A Guide for Contingency Planning for Oil Spills on Water. IPIECA, 2000.
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22. MONITORING PLAN

Various monitoring procedures are required or suggested for measuring the effectiveness of mitigation and for identifying potential project impacts during construction, commissioning, operation or decommissioning phases of the project. (e.g., impacts to onshore physical environment, air quality, etc.).

Point source or end-of-pipe emission monitoring should be undertaken by RTIP to ensure compliance with the relevant environmental standards (e.g., stack emissions, wastewater discharges, groundwater monitoring, etc.). Certain monitoring items cover several issues and, therefore, not every impact/mitigation has a separate monitoring measure description.

Monitoring measures to minimise environmental impacts resulting from the construction, commissioning, operation and decommissioning of RTIP are presented in Table 22-1 for air quality, onshore physical, biological resources, and for impacts from noise. Table 22-1 presents the impacts of the project entailing a mitigation measure (from Table 21-1) and/or a monitoring measure. Each impact is provided with the same number as the unique issue number used in the impact and mitigation tables (Tables 20-1 and 21-1, respectively) for ease of reference.

During construction and pre-commissioning the EPC contractor will perform the work with his own dedicated personnel. JV staff will take supervisory and assurance roles during the EPC phase of the project. For commissioning, members of the operation team will participate in the activities.

Once commissioned and handed over, "Operations" will run the facilities and associated infrastructure on a day-to-day basis and will be responsible for production, first line maintenance, dealing with hazards and for the control of emergencies.

It is the responsibility of operator and contractors' managers to ensure that work under their control is carried out in a safe and environmentally conscious manner.

The Draft EMP outline incorporated in Appendix A addresses the environmental management of RTIP from the construction phase to the decommissioning phase, including monitoring requirements.

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<table>
<tr><th colspan="3">Table 22-1 Summary of Potential Monitoring Measures for RTIP Site, KSA</th></tr>
<tr><th>Item No.</th><th>Impact</th><th>Monitoring Measure</th></tr>
<tr><th colspan="3">Air Quality & Meteorology</th></tr>
<tr><td>A1</td><td>Dust emissions during construction activities</td><td>Monitoring Measures: Routine visual assessment of dust during initial site preparation work and periodically thereafter, depending on the nature of the work activity.
Timing: Continuous
Responsibility: EPC Contractor</td></tr>
<tr><td>A2</td><td>Exhaust emissions from vehicle movements during construction and decommissioning</td><td>Monitoring Measures: Routine vehicle maintenance and check of vehicle’s inspection records
Timing: Continuous and upon manufacturers indications
Responsibility: EPC Contractor</td></tr>
<tr><td>A3, A4, A5, A6, A7</td><td>NO_X, SO_2, CO, PM_{10}, $PM_{2.5}$ emissions from major combustion sources.</td><td rowspan="2">Monitoring Measures:
1. Stack emission testing to be undertaken in accordance with RCER 2010 requirements.
2. According to the RCER 2010, the following sources should install continuous emissions monitoring systems for the following parameters:
• Combustion Devices >73 MW heat input capacity: Opacity[1], SO_2[1], and NO_x[2]
• Thermal Treatment Unit: CO downstream of combustion zone, Combustion temperature, Waste feed rate, NO_x, SO_2, HCl, PM and Oxygen
• Nitric Acid Plant: NO_x
3. Fugitive Emissions Monitoring Requirements:
LDAR program to be implemented in accordance with the RCER.
All components in VOC or HAP component should be monitored as follows depending on the vapor pressure:
4. Stack emission testing to be undertaken in accordance with RCER 2010 requirements.</td></tr>
<tr><td>A8, A9, A10, A11, A12, A13, A14, A15, A16, A17</td><td>Benzene, Formaldehyde, Toluene, Ammonia, Chlorine, Xylene, Aniline, Ethylene Oxide, Hydrogen Chloride, and Phosgene emissions from point and fugitive sources.</td></tr>
</table>

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Table 22-2 Summary of Potential Monitoring Measures for RTIP Site, KSA

<table>
<tr><th>Item No.</th><th>Impact</th><th>Monitoring Measure</th></tr>
<tr><td>A3, A4, A5, A6, A7</td><td>NO_X, SO_2, CO, PM_{10}, $PM_{2.5}$ emissions from major combustion sources.</td><td rowspan="2">Monitoring Measures:
5. According to the RCER 2010, the following sources should install continuous emissions monitoring systems for the following parameters:
• Combustion Devices >73 MW heat input capacity: Opacity[1], SO_2[1], and NO_x[2]
• Thermal Treatment Unit: CO downstream of combustion zone, Combustion temperature, Waste feed rate, NO_x, SO_2, HCl, PM and Oxygen
• Nitric Acid Plant: NO_x
6. Fugitive Emissions Monitoring Requirements:
LDAR program to be implemented in accordance with the RCER.
All components in VOC or HAP component should be monitored as follows depending on the vapor pressure:
Vapor Pressure @ 20C (psia) > = 0.147, monitoring method: USEPA CFR 40 Part 60 App A Method 21
Vp< 0.147, Physical / Visual Inspection
Vp< 0.04, No inspection required
Timing: As stipulated by RCER.
Responsibility: Project EH&S Lead and JMP EH&S Manager during Project stage; EH&S Lead during the operation stage

Notes:
1. Combustion sources that burn natural gas or hydrogen ONLY shall be exempt from the continuous emission monitoring requirements for opacity and SO_2.</td></tr>
<tr><td>A8, A9, A10, A11, A12, A13, A14, A15, A16, A17</td><td>Benzene, Formaldehyde, Toluene, Ammonia, Chlorine, Xylene, Aniline, Ethylene Oxide, Hydrogen Chloride, and Phosgene emissions from point and fugitive sources.</td></tr>
</table>

Table 22-2 Summary of Potential Monitoring Measures for RTIP Site, KSA

Item No.	Impact	Monitoring Measure
A18, A19, A20	SO_2, NO_x, CO emissions from Flares during Emergency Scenario and Process Upset	2. If the operator of the facility demonstrates during a performance test and subsequent point source monitoring tests that the emissions of NO_x are consistently less than 70% of the applicable standard or less than 43 ng/J for facilities constructed after 1st September 2005, then the source is exempt from the requirement for continuous emission monitoring of NO_x. Demonstration of consistent compliance will require one of the following number consecutive spot sampling tests: • 2 results < 50% standard • 3 results < 60% standard • 4 results < 70% standard • 30 days < 70% standard using portable continuous emission monitor All spot sampling tests shall be separated by at least 3 months and completed within 2 years.
A21	Benzene Storage Tanks Spills	***Monitoring Measures:*** Conduct periodic visual assessments of tanks and pipes racks checking for the presence of leaks. Check that all the measures included in the Spill Response Plan are being implemented and maintain all the associated records. ***Timing:*** Continuous and whenever stated in the Plan. ***Responsibility:*** ***A21*** - EH&S Manager of RTIP. ***A22*** - Project EH&S Lead and JMP EH&S Manager during Project stage; EH&S Lead during the operation stage
A22	Benzene Pipe Rack Failure Spills	

Table 22-2 Summary of Potential Monitoring Measures for RTIP Site, KSA

Item No.	Impact	Monitoring Measure
Onshore Physical Environments (Landforms, Soil, Surface Water & Groundwater)		
O2	Alteration of drainage characteristics (including dewatering) and modification of the storm water flow and recharge regime	***Monitoring Measures:*** Ensure that the drainage system is cleaned from time to time, so it is always able to carry the volume of storm water for which it was designed. Develop and initiate a groundwater monitoring programme to monitor groundwater quality. ***Timing:*** Regular checks, and always after a wind / sand storm or a storm flow. Quarterly for groundwater monitoring Programme. ***Responsibility***: EPC contractor and EH&S Manager of RTIP (construction and commissioning); RTIP Environmental Manager (operation and decommissioning)
O3	Degradation of soil and groundwater quality due to minor accidental releases and spills of hazardous materials during construction	***Monitoring Measures*** Develop and initiate a groundwater monitoring programme to monitor groundwater quality. ***Timing:*** Quarterly. ***Responsibility***: EPC contractor and EH&S Manager of RTIP (construction and commissioning); RTIP Environmental Manager (operation and decommissioning)
O6	Degradation of soil and groundwater quality due to accidental releases and spills of hazardous materials during normal operations at the process plants, maintenance of equipment and storage and internal distribution through the utility infrastructure.	***Monitoring Measures:*** Continuous monitoring of the Facilities Surface Drainage System. Continuous monitoring of spill detection systems. Develop and implement a groundwater monitoring programme to monitor groundwater quality. ***Timing:*** Regular checks, and always after a wind / sand storm or a storm flow. Quarterly for groundwater monitoring Programme. ***Responsibility***: EPC contractor and EH&S Manager of RTIP (construction and commissioning); RTIP Environmental Manager (operation and decommissioning)

Table 22-2 Summary of Potential Monitoring Measures for RTIP Site, KSA

Item No.	Impact	Monitoring Measure
O13, O14, O18, O19, O20, O21, O22 & O23	Potential environmental impacts associated with hazardous wastes generated at RTIP	***Monitoring Measures***: 1. Maintain a catalogue of waste composition and any Material Safety Data Sheets (MSDS). 2. Wastes sent for storage should be accompanied by a waste manifest. 3. Keep waste transfer documents, and follow all procedures established in the RCJY Guidelines for transport and disposal of hazardous wastes. 4. When uncertain, analyse wastes to ascertain concentration of hazardous chemicals in wastes. ***Timing***: 1, 2. Make monthly stock check of wastes in storage. 3. Continually 4. Any necessary analyses should be undertaken on wastes with uncertain composition. ***Responsibility***: EPC Contractor/RTIP EH&S Manager (construction and commissioning); RTIP Environmental Manager (operation and decommissioning).
O11, O12, O13 & O14	Potential environmental impacts associated with the on-site storage of wastes at the RTIP site	***Monitoring Measures***: Perform internal audits to ensure that wastes arising from the RTIP units are compliant with the waste management guides. ***Timing***: One audit per quarter or per phase of the project, whichever is the shorter period. ***Responsibility***: RTIP HSE Manager (construction and commissioning); RTIP Environmental Director (operation and decommissioning).

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Table 22-2 Summary of Potential Monitoring Measures for RTIP Site, KSA

Item No.	Impact	Monitoring Measure
O15, O16, O17, O18 & O19	Potential environmental impacts associated with the transport and disposal of wastes at authorised facilities	***Monitoring Measures***: 1. Audit the waste management facility, and/or waste transportation vehicle to ensure that they are operational, licensed and capable of handling the wastes to be generated; 2. Audit the procedures used for the collection, transport and disposal of wastes to ensure they are in line with industry and regulatory standards; 3. Ensure that the Landfill Operator monitors groundwater around Class I & Class II landfill sites 4. Ensure that the WWTP Operator regularly monitors the quality of treated wastewater and makes regular checks for leaks. ***Timing***: 1, 2. Prior to each phase of the project and once every 5 years during the operation phase. 3, 4. Prior to each phase of the project and once every year during the operation phase. ***Responsibility***: 1,2. RTIP EH&S Manager (construction and commissioning); RTIP Environmental Manager (operation and decommissioning); External audit 3,4. Authorized waste disposal/treatment facility
O20, O21, O22 & O23	Accidental release / spill of waste materials from waste storage areas, onsite transport or during waste collection	***Monitoring Measures***: Regular monitoring of Solid Waste Handling Unit (Unit 778) to ensure appropriate status. Periodical check of containment and segregation, and training to all staff involved in waste management practices. Installation of a network of monitoring wells in accordance with RCER Guidelines, including the implementation of a groundwater monitoring program. ***Timing*** Regular checks of Unit 778 (implement a monitoring program). Checking the material used in the restraint and collection of spills at least once every 3 months. Monitoring of GW wells at least quarterly for visually detecting the presence of free product and groundwater sampling + analysis at least once every year. ***Responsibility***: EPC Contractor/ RTIP EH&S Manager (construction and commissioning); RTIP Environmental Manager (operational and decommissioning)

Table 22-2 Summary of Potential Monitoring Measures for RTIP Site, KSA

Item No.	Impact	Monitoring Measure
Archaeology & Cultural Heritage		
AC1	Degradation of archaeological wealth which may exist on RTIP area and its vicinity and which is discovered during earth movement activities or vehicle movements.	***Monitoring Measures:*** Routine observation by a trained observer for undiscovered archaeological resources during excavations; audits (every three months) during site preparation and excavation activities to verify that all supervisors received training on archaeological chance find procedures; and reporting and monitoring procedures for the discovery of unknown archaeological resources during excavations and earth moving activities, including vehicle movements. s. ***Timing:*** Project Planning / Construction / Commissioning/Decommissioning/Continuous ***Responsibility:*** EPC Contractor/RTIP EH&S Manager
AC2	Possibility of finding intact archaeological artefacts during earth movement & ground clearance activities on RTIP Site area.	
AC7	Accidental damage during the decommissioning phase to archaeological resources lying on surface during vehicle movements from the removal of material to restore land to pre-project conditions. Expatriate workers living in JIC residential areas could result in cross-cultural tension, specifically related to differences in dress, behaviour, and tradition. In addition, the presence of expatriate workers, as discussed in impact AC3, may result in the disturbance to archaeological sites of interest and artefacts.	
AC8	Excavation of soil due to accidents and spills, which may result in the discovery of buried archaeological resources.	

Table 22-2 Summary of Potential Monitoring Measures for RTIP Site, KSA

Item No.	Impact	Monitoring Measure
AC3	Interaction between persons (expatriate workers) from diverse cultural backgrounds with the local community resulting in cross-cultural tension, specifically related to differences in dress, behaviour, and tradition. In addition, expatriate workers are likely to make tourist expeditions to cultural heritage and archaeology sites of interest, which could impact archaeological resources if artefacts are found and kept as souvenirs or if they disturb archaeological sites visited.	***Monitoring Measures:*** Routine audits and reporting of complaints regarding the influx of workers during the construction and impacts to the local population. ***Timing:*** Project Planning / Continuous ***Responsibility:*** RTIP EH&S Manager
Biological Resources		
B5	Potential effects of elevated air pollution on offsite vegetation (protected areas) from major combustion sources.	***Monitoring Measures:*** Refer to impacts A3-A7 ***Timing:*** Refer to impacts A3 – A7 ***Responsibility***: EPC Contractor/RTIP EH&S Manager (commissioning); RTIP Environmental Manager (operation).

Table 22-2 Summary of Potential Monitoring Measures for RTIP Site, KSA

Item No.	Impact	Monitoring Measure
Marine		
M2, M4, M5	Impact resulting from untreated effluent from batching plant, hydrotest water or surface runoff entering the marine environment, damaging marine ecosystems, and local fisheries industry.	***Monitoring Measures:*** Auto-sampling systems (24-hour composite sample) and sample points for all discharges of wastewater at the point of discharges from RTIP will be installed and maintained per EPO and RCER requirements: 1. Concrete Batching Plant wastewater prior to discharge to the RC Drainage Channel. If wastewater is not compliant with the EPO or RCER requirements, wastewater will be collected and transferred to Marafiq IWTP; 2. Unit 785 –wastewater prior to discharge to the Marafiq Seawater Cooling Return Header. If wastewater is not compliant with the EPO or RCER requirements, wastewater will be collected and transferred to Marafiq IWTP; 3. Surface Runoff Basins sampling system prior to discharge to the RC drainage channel. If wastewater is not compliant with the EPO or RCER requirements, wastewater will be collected and transferred to Marafiq IWTP; 4. All RTIP wastewater and surface runoff compliance analysers to be checked and maintained at intervals prescribed by manufacturer to ensure they are in working order, fixed or replaced as required. ***Timing***: During the lifetime of the project ***Responsibility***: EPC Contractor, Project EH&S Lead & JMP EH&S Manager during project stage; EH&S Lead during the operation stage and EH&S Manager of RTIP
M10	During construction, frequent noise may result from steelwork erection, offloading of trucks and other vehicles. The highest noise levels would be expected from commissioning of the new plant, pipelines and new equipment.	***Monitoring Measures:*** Ensure that all construction equipment has appropriate noise suppression devices installed, and is maintained appropriately. ***Timing***: Construction ***Responsibility***: EPC and EH&S Manager of RTIP

Table 22-2 Summary of Potential Monitoring Measures for RTIP Site, KSA

Item No.	Impact	Monitoring Measure
M12	Deposition of dust into marine waters increases turbidity and influences light penetration. In addition, dust particles may increase nutrient levels and introduce toxic substances from vehicle and equipment leaks.	***Monitoring Measures:*** 1. Road dust will be monitored in the jetty area and water applied to roads to minimize dust reaching the marine environment. 2. Stockpiles will be visually monitored and relevant staff will be notified when dust management is required. 3. Ensure sandblasting takes place utilizing appropriate shielding mechanisms ***Timing***: During the lifetime of the project. ***Responsibility***: EPC Contractor and EH&S Manager of RTIP
Noise		
N1, N3 & N4	Noise nuisance during all phases.	***Monitoring Measures***: Monitor noise at site boundaries, confirm noise predictions at local sensitive receptors and document status of compliance with applicable standards. At a minimum, L_{eq} and L_{10} shall be measured and two measurements conducted at each selected monitoring location. ***Timing***: Annually during normal operations, daytime (7:00 to 19:00), evening (19:00-22:00) and night time (22:00 to 07:00). Minimum duration of each measurement shall be 15 minutes. ***Responsibility***: EPC Contractor/RTIP EH&S Manager (construction and commissioning); RTIP Environmental Manager (operation, decommissioning)
Social Aspects		
S1, S11	Increased traffic resulting from worker and equipment/material transport. This impact may cause disruptions in accessing industrial facilities and utilities, residential settlements and leisure to existing infrastructure (peaking during construction)	***Monitoring Measures: Perform a periodic evaluation of traffic issues and k***eep a record of vehicle accidents. Support RCJY in their communications with community leaders to discuss traffic issues during construction. ***Timing***: During the lifetime of the project. ***Responsibility***: EPC Contractor/RTIP EH&S Manager (construction, commissioning); RTIP Environmental Director (operations, decommissioning)

Table 22-2 Summary of Potential Monitoring Measures for RTIP Site, KSA

Item No.	Impact	Monitoring Measure
S5	Decreased income. Reduction in number of immigrant workers post peak.	***Monitoring Measures:*** Conducting focus groups or workshops workers and community in coordination with RCJY to gauge feedback from workers and the community on expectations towards employment opportunities and project duration. ***Timing***: During the lifetime of the project. ***Responsibility****:* RTIP EH&S Manager (construction, commissioning); RTIP Environmental Manager (operations, decommissioning)
S7	Impact of immigrant workers. Foreign workers separated from their families.	***Monitoring Measures:*** Keep a record of the influx of foreign workers. ***Timing***: Annually during the lifetime of the project. ***Responsibility****:* EPC Contractor/RTIP EH&S Manager (construction, commissioning); RTIP Environmental Manager (operations, decommissioning)
S10	Incidence of disease transmission between the workers and the population of the local communities.	***Monitoring Measures:*** Monitoring of incidence rates and prevalence statistics for relevant contagious diseases. ***Timing****:* Frequency of disease testing amongst workers should range from every 6 months to annually depending on the disease being tested and circumstances of the worker. Increases in reported incidents should result in reducing the interval between tests. ***Responsibility****:* EPC Contractor/RTIP EH&S Manager (construction and commissioning); RTIP Environmental Manager (operation and decommissioning). The operator should ensure that the requirement to monitor and screen for communicable diseases is incorporated into the EPC contractor's contract. The operator should enforce and audit against the contract.
S12	Fire and explosion hazards generated by process operations	***Monitoring Measures****:* Perform Audits to evaluate the effectiveness of the EH&S procedures implemented for the RTIP and to take measures where necessary. ***Timing***: As requested by the EH&S plan implemented. ***Responsibility****:* RTIP EH&S Manager (construction, commissioning); RTIP EH&S Lead (operations, decommissioning)

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23 PROJECT JUSTIFICATION AND ANALYSIS OF ALTERNATIVES

23.2 Introduction and Overview

The development of RTIP, an integrated multiple petrochemical process unit project, will provide the Kingdom of Saudi Arabia (KSA) with the expanded capacity to produce petrochemical products, such as ethylene, propylene glycols, benzene, toluene, amines, polyols, and urethane chemicals. The core process units will include a mixed feed stream cracker and an aromatics plant with a chlor-alkali facility to produce chlorine for downstream derivative units. Ethane and naphtha will be used as primary feedstocks.

The overall objective of RTIP is to meet the growing global demand for refined petrochemical products used for automotive, appliance and consumer products, and promote a shift from export-oriented petrochemical production to manufacturing of value-added specialty chemicals.

The alternatives considered for the RTIP include:

- Alternate Project “No-Build” Option;
- Selection of Project Location;
- Selection of Process Technology;
- Wastewater Pre-treatment Alternatives; and
- Waste Management Alternatives.

The details of the selection of process unit technologies, Olefins, Chemicals I, Chemicals II, and Chemicals III, and alternatives to these technologies, are not discussed in detail due to confidential licensing agreements. A brief discussion of wastewater treatment, and solid and hazardous waste management alternatives selected is provided below. This alternative analysis therefore focuses on the alternatives considered but rejected for the No-Build Option and Selection of Project Location.

23.3 Project Demand

The demand for petrochemical products and its end products are increasing from growing markets, such as China, India, and Brazil. Common petrochemical end products include plastic adhesives, fibres, paper, textiles, solvents, cosmetics, pharmaceuticals, coolant, plastics, rubber products etc. The KSA is one of the few countries that have the expansion capacity to produce sufficient petrochemicals to meet growing global demands.

Petrochemical production requires a large quantity of feedstock, primarily ethane and naphtha, to produce ethylene (one of the primary compounds used to produce industrial chemicals and products). Ethane currently accounts for approximately 73 percent of total ethylene production in KSA whereas naphtha accounts for 10 percent (Alpine Capital, 2010). The global demand for ethylene is predicted to reach 153 million metric tons (mmt) by 2015, but by this time actual ethylene production is only estimated to reach 139 mmt, which includes ethylene produced from RTIP (Alpine Capital, 2010). Therefore ethylene supply is predicted to be insufficient to meet global demand.

The price of ethane and naphtha are directly linked to oil and gas prices. Saudi Arabia is the second largest global producer of oil (CIA, 2010), which allows it to provide ethane at lower prices. The KSA provides ethane, a major feedstock for the petroleum and petrochemicals industry, at a price of US $0.75/one million British thermal units (mmbtu), compared to the average global market price of US $6.75/mmbtu (Al Rajhi Capital, 2010). The figure below shows a comparison of global ethane prices. The price of naphtha ranges from US $602 – $753/ton. As a result of rising oil prices and decreased gas prices, KSA is in an advantageous global position for petrochemical processing due to its rich oil reserves and availability of naphtha and ethane as primary feedstocks.

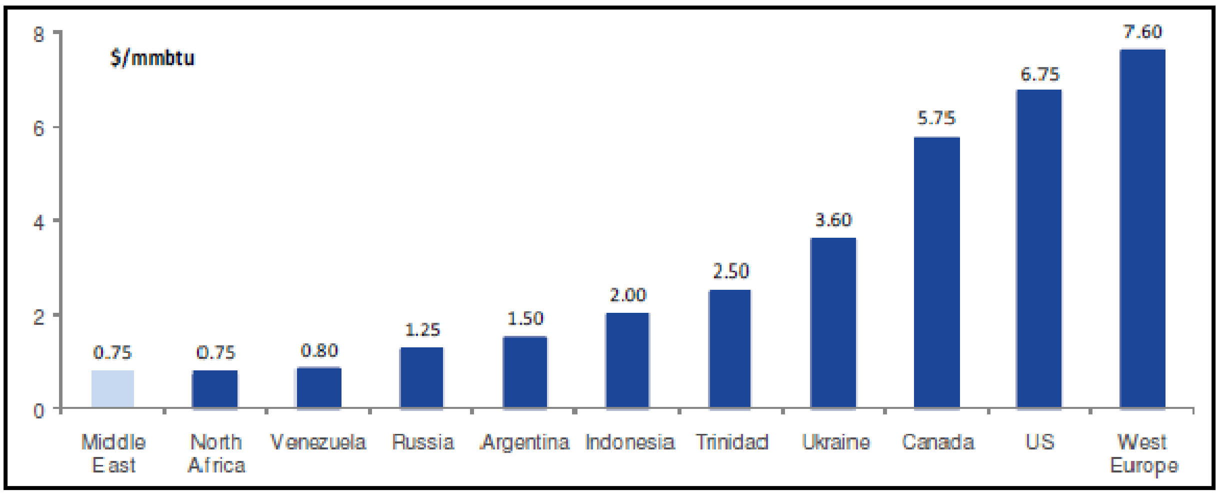

Figure 23-1 Comparison of Ethane Prices Worldwide
Source: Al Rajhi Capital, 2010.

The key factors that have contributed to Saudi Arabia´s position as a competitive petrochemical producer include:

- The world demand for petrochemical products has increased due to the expanding economies in the larger developing countries (India, China, and Brazil) along with the sustained demands of the United States and Europe (Maierbrugger, 2010);
- Saudi Arabia´s geographical location, allows it to strategically access consumer markets;
- Saudi Arabia´s access to low cost feedstock, ethane and naphtha, due to its abundant oil and gas reserves; and
- Saudi Arabia´s available large capacity for petrochemical expansion.

RTIP offers a large scale state-of-the-art facility specifically designed and configured to meet the growing demands for petrochemical products, especially from growing markets; respond to the existing market drivers – low cost petrochemical products; and low cost feedstock (ethane and naphtha) in combination with availability.

23.4 Alternatives

23.4.1 Alternate Project "No-Build" Option

The "No-Build" option would be not to develop the RTIP complex and its units. The option of not proceeding with RTIP would inevitably result in the construction of a similar project or projects elsewhere to meet the market demands and the country´s future growth strategy. The "No-Build" option is likely to have a negative impact on the KSA economy, given that a significant percentage of its national economy is based on the development and export of oil and natural gas resources; and future investments are focused on the expansion of the petrochemicals industry, and increase the predicted shortfall between global supply and demand.

A major market driver for the development of the petrochemical facility is to promote the continued growth of the petrochemical industry in the Gulf region, meet global demand, and increase employment opportunities in the region. The growing demand for petrochemical products, especially from growing economies such as China, India, and Brazil, has led to the need for increased petrochemical processing capacity. KSA is strategically developing its private sector to reduce its dependence on oil exports and increase local employment. This strategic growth plan includes the expansion of the export-oriented petrochemicals industry. KSA has a planned petrochemical capacity expansion of 24 mmt between years 2010 to 2015 (Alpine Capital, 2010).

The proposed RTIP development represents state of the art facility design that will meet the requirements of best available technology (BAT) and best available control technology (BACT) (with some specific exceptions examples of which are discussed), to address potential impacts, and meet local and national regulatory requirements and international standards. Therefore, as detailed in this EIA, if the project follows internationally accepted protocols, local and national laws, as well as applying suggested project-specific mitigation and monitoring measures, the petrochemical facility will be developed with acceptable environmental impacts, contributing significantly to the country's economy with associated social benefits, such as increased employment, while reducing dependency on petrochemical imports.

23.4.2 Selection of Project Location

The main alternatives considered for the RTIP location were developed within an existing industrial city, Jubail, development in the proximity of an existing or planned refinery outside an industrial city or a new Greenfield location remote from existing facilities. These alternatives are discussed below.

23.4.2.1 Jubail

The Royal Commission for Jubail and Yanbu (RCYJ), an autonomous organisation of the Saudi Government, is in charge of the Jubail Industrial City (JIC) administration. Within the KSA, the government policy is focused on concentrating the location of large petrochemical projects in one of two designated industrial cities (principally Jubail and Yanbu although other industrial cities exist). Jubail is located in the eastern portion of the country on the Arabian Gulf coast and Yanbu is located in the western portion of the country along the Red Sea coast. Each of these industrial cities has been designed to provide the infrastructure and services needed for the petrochemical industry and other industries, and for people working in these industries. A strong commitment to environmental protection has been integral to the planning and development of these controlled environments, as reflected in the pollution prevention infrastructure facilities and the environmental regulatory management oversight provided.

JIC is Saudi Arabia's largest industrial centre and is host to over 160 industrial enterprises and home to almost 70,000 full time residents. JIC was developed under the direction of the RCYJ and covers an area of 1,016 square km with designated residential and industrial uses. Approximately 5,500 hectares of the city is dedicated to industrial use. JIC is an established major petrochemical centre with other industrial activities, such as fertiliser plants, an oil refinery, steel works, an industrial port, and the world's largest desalination plant. JIC has a 7% share of the world's gross petrochemical production and accounts for over 7% of the Kingdom's GDP, and it is strategically located to access the major world economies in both the east and west.

In line with KSA policy, RTIP will be located in Jubail II, which is an extension of JIC and one of the two industrial cities designated by the government for industrial development. The city is located on the east coast of the KSA near the town of Al-Jubail. The Jubail expansion ("JIC II") will add a second industrial area to house up to 22 new primary industries, including RTIP. The JIC II development will be accompanied by an expansion of the King Fahd Industrial Port and other supporting infrastructure, utilities and pipelines.

Key factors during the site selection process for RTIP would have included:

- Availability and allocation of large quantities of feedstock, primarily ethane and naphtha;
- Availability of existing infrastructure / common utilities. RCJY has committed to invest $5.8 billion USD in communal infrastructure to support the expansion of JIC II. RCJY, 2010;
- The availability of existing port and harbour facilities;
- KSA policy and environmental protection. RCJY has a track record reflecting its commitment to environmental protection, which is reflected in its achievement of a Environmental Protection Award from a Kuwait-based regional organization, and the United Nations Sasakawa Award for environmental protection;

- Proximity to Dhahran-Jubail Highway and Abu Hadriyah Highway;
- Proximity to JIC, which has existing infrastructure and services available for employees and their families; and
- Site accessibility, availability of local construction workforce, and previous experience in the successful completion of other major industrial developments in JIC.

RTIP incorporates the above factors for site selection and will benefit from being in close proximity to readily available and competitively priced feedstock, as well as to the extensive core infrastructures of JIC, including:

- The King Fahd Industrial Port ("KFIP"), which provides import facilities for the raw materials required by local industries and export facilities for bulk solids (e.g. fertilisers and iron ore), bulk liquids, and LPG products (e.g. ethylene, propylene, butane and ammonia). KFIP has a total of 27 berths of which 19 are fully operational;
- The Jubail Commercial Port ("JCP"), which has 16 berths and facilities for the import and export of commercial and industrial general cargo, containers plus roll-on / roll-off and other bulk cargos;
- Central utilities facilities (third party utilities provision) and other infrastructure, such as electrical power, water desalination plants, seawater cooling network; and wastewater treatment; and
- Established and new pipeline corridors.

23.4.2.2 Greenfield Site

The infrastructure available at JIC II significantly reduces the capital cost investment for RTIP compared to a Greenfield (previously undeveloped land) location. At Jubail, RTIP will also benefit from opportunities for synergies with existing refineries, local industries, utilities and the development of downstream product converters. RTIP will also benefit from infrastructure and resource sharing opportunities with existing refineries, local industries, utilities, and the development of downstream product converters.

Capital cost efficiency is further increased by utilising the experience and facilities available for construction work camp and logistics. After operations commence, RTIP will have access to a well-established network of utility and service providers, and suppliers to ensure that operating costs are optimised.

The project location was selected over a Greenfield location because of its proximity to feedstock resources and infrastructure facilities of JIC and JIC II. As noted above the RCJY maintains and continues to develop the physical and social infrastructure to support industrial development and has committed to investing $5.8 billion in communal infrastructure to support the expansion of JIC II (RCJY, 2010).The site location assigned for RTIP in Jubail II will be used for similar projects if the RTIP is not materialized.

Development at alternative locations, such as Greenfield sites outside the industrial city, would require substantial development of infrastructure to provide captive utility and logistics support to RTIP, such as:

- Water and Wastewater;
- Pipelines, roads, rail and/or marine port; and
- Waste management and disposal facilities.

The above mentioned new infrastructure would represent an increased risk to the environment due to requirement for a larger footprint and increased emissions if additional infrastructure and common utilities, such as power and desalinated water, are required. In addition, labour resources will have to be imported during construction. The development of additional infrastructure incurs additional resource consumption, leading to a larger environmental impact footprint.

23.5 Selection of Process Technology

RTIP will utilize commercially proven advanced technologies licensed from The Dow Chemical Company (Dow) and third parties to produce an extensive and diversified slate of chemicals and plastics that will introduce new value chains and performance products to the Kingdom of Saudi Arabia.

The selection of Dow and its licensed technologies, as the JV partner for Saudi Aramco, was based on:

- Long term support capabilities and cost of ownership;
- Proven operating experience;
- Know-how of integration among the various Process Units;
- Production leadership position in the world;
- Marketing capability; and
- Economics.

Third Party technology licensor selection went through a comprehensive rigorous multi-step process including focus on technical strengths, environmental performance as well as overall long term cost of ownership analysis.

The details of the process unit technologies and alternatives to these technologies are not discussed in detail due to confidential licensing agreements. Process control technologies were selected applying the concept of best available technology (BAT) to address potential impacts, and meet local and national regulatory requirements and international standards.

23.5.1 Wastewater Treatment Alternatives

The main wastewater sources generated from RTIP include:

- Wastewater generated from processes;
- Sanitary wastewater;
- Storm water;
- Fire water or incident spills; and
- Small amounts of hazardous liquid waste, such as waste oil, waste fuel, and chemical wastes.

Sanitary wastewater will also be produced from the site offices and buildings, as well as from the personnel residences in the JIC residential area.

An extensive analysis of various wastewater treatment alternatives was undertaken for this project. The alternatives analyses included at-source reductions (within the proposed production units), design and construction of a centralized pre-treatment facility, and utilization of the existing Jubail Industrial City wastewater treatment infrastructure (Marafiq IWTP and SWTP). After evaluation of the alternatives from an economic and sustainability perspective, it was decided that a combination of various at-source reduction and treatment assets, combined with the existing infrastructure was the appropriate alternative for this project. The use of existing infrastructure lowers the overall environmental footprint for the project, Industrial City and region.

The on-site wastewater treatment plant alternative was not feasible due to the limits of project footprint and the potential variations in wastewater quality. An individual on-site WWTP may involve various single streams, which are more difficult to treat, require a larger project footprint, have longer treatment time requirements, and/or more expensive to treat individually. Whereas, an off-site centralized wastewater treatment facility, such as Marafiq Industrial Wastewater Treatment Plant (IWTP) discussed below, allows various waste streams to be mixed to create one common stream, which is more efficiently treated than single streams generated from individual on-site WWTPs. A typical example is when plant streams are mixed together (COD containing streams and nitrogen containing streams) to make a balanced (COD and nitrogen as the nutrient) feed stream to a centralised biological unit.

RTIP will send wastewater streams that meet the RCER Table 3B pre-treatment standards to the IWTP. Process wastewater streams that meet the RCER Table 3C (Water Quality Standards for Direct Discharge to the Seawater Cooling Return Canal, Variance Streams and Surface Drainage Ditches), will be combined and directed to the Marafiq Seawater Cooling Return Header.

Sanitary wastewater from RTIP will be sent to the Marafiq Sanitary Wastewater Treatment Plant (SWTP). In addition, any flows of storm water, fire water or incident spills in excess

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of what the process unit drainage systems are designed to manage will be collected at Surface Drainage Systems (SDS) and conveyed to Surface Retention Basins (SRBs) for a quality check with appropriate analysis, which will be followed by discharge or treatment. This water, if in compliance with RCER table 3C, will go to the RC Drainage Channel and non-compliant flows will be sent to the RTIP Wastewater Unit 773 for further routing to Marafiq IWTP.

In addition, small quantities of hazardous liquid wastes (e.g. waste oil, waste fuel, chemical wastes) are expected to be generated during the operations phase of RTIP. These wastes will either be stored on site, and then transported to the recycling company/supplier for its reuse, or otherwise transported to Bee´Ah or EDCO´s facilities for offsite incineration.

The storm, process, and sanitary wastewaters, and hazardous liquid wastes for RTIP will be managed to reduce the impact to the surrounding environment.

23.5.2 Solid and Hazardous Waste Management Alternatives

Solid and hazardous waste will be generated during all stages of the Project, including preliminary site preparation, construction, operation and maintenance, and decommissioning. The main non-hazardous solid wastes expected to be generated during the operations phase are:

- Either compactable or non-compactable;
- Recyclable or non-recyclable; and
- Hazardous waste.

Preliminary alternatives considered for processing solid and hazardous waste included:

- On-site management;
- Management by a local accredited contractor; or
- Use of a third-party contractor outside RCJY jurisdiction.

An extensive analysis of various solid waste treatment alternatives was also undertaken for this project. The alternatives analyses included at-source reductions (within the proposed production units), design and construction of dedicated centralized treatment facilities (internal kilns, etc.), and utilization of the existing Jubail Industrial City solid and hazardous waste treatment and disposal infrastructure. After evaluation of the alternatives from an economic and sustainability perspective, it was decided that a combination of various at-source reduction efforts, combined with the existing infrastructure was the appropriate alternative for this project. The use of existing infrastructure lowers the overall environmental footprint for the project, Industrial City and region.

The RCJY guidelines (RCER, 2010) on waste management discourage onsite treatment of waste and encourage the use of accredited facilities within the boundaries of the Jubail Industrial City, such as BeeA'h or EDCO's waste management facilities, which perform physical and chemical treatment of wastes, following disposal in Class I and II landfill cells, and in accordance with the standards of the RCJY, PME and USEPA. RCJY policy requires the use of local accredited waste contractors who are regularly monitored and adhere to industry safety, quality control, and regulatory standards.

Use of a third-party alternative or non-RCJY accredited contractor is contrary to RCJY policy and would require an exception approved by RCJY. This alternative would also increase transportation costs/energy use, because the contractor would not be located locally; and therefore increase the risk of accidents/spills during transportation and potentially take them out of the control of RCJY.

24 SUSTAINABLE DEVELOPMENT ASSESSMENT

24.1 Introduction

A sustainable development assessment (SDA) for the RTIP complex has been performed through an analysis of how the sustainable development principles are integrated into both RTIP's EIA and the project itself.

24.2 General Overview

Sustainable development, as defined by the Brundtland Commission in 1987, is development that "meets the needs of the present without compromising the ability of future generations to meet their own needs (UNECE, 2005)".

Sustainable development does not focus solely on environmental issues. More broadly, sustainable development encompasses three general policy areas: economic, environmental, and social. These areas are recognized as the main pillars of sustainable development by major international organizations such as the World Bank, IMF and OECD. Figure 24-1illustrates the interrelatedness of concepts and, specifically, the confluence of the three main elements of sustainable development.

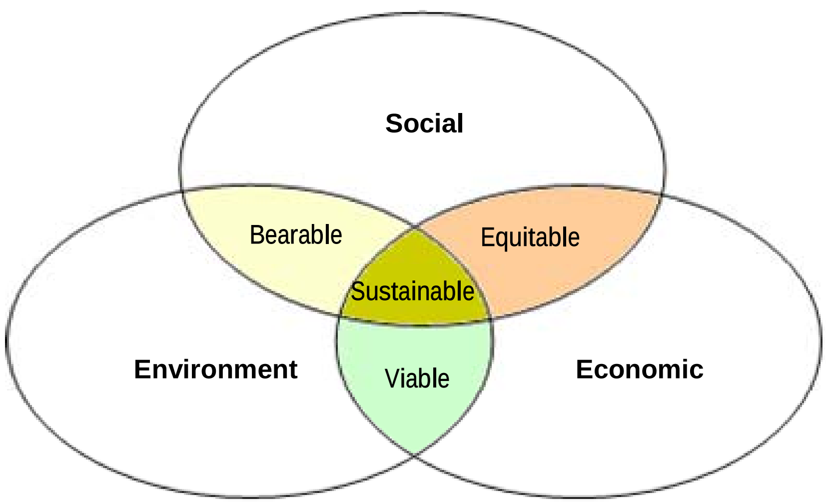

Figure 24-1 Confluence of the Sustainable Development's Elements

Source: Sustainable Development, Wikipedia, the free encyclopaedia, 2009

The United Nations (UN), under Agenda 21, 1992, called on all world Governments to develop and implement national sustainable development strategies (NSDS) (UNCED, 1992). A NSDS can be defined as "a coordinated set of participatory and continuously improving processes of analysis, debate, capacity-strengthening, planning and investment, which integrates the economic, social and environmental objectives of society, seeking tradeoffs where this is not possible" (OECD, 2001). As every country has to determine how to develop and implement strategies for achieving its own sustainable development goals, it is important to stress that it is not the name, but the process and principles content that qualifies a strategy as an NSDS. Figure 24-2 shows a map that tracks progress toward the design and implementation of NSDS worldwide.

Despite the fact that the KSA appears as one of the countries that has not reported information on its NSDS it has submitted reports to the UN regarding its progress on sustainability, and so it can be stated that the KSA is working towards the achievement of Sustainable Development goals. The KSA has identified its future development priorities at the national level within the context and understanding of sustainable development and included them in a national document called "Agenda 21: Kingdom of Saudi Arabia". This document includes programmes and projects to be implemented by the government in the achievement of Sustainable Development. The establishment of the Saudi Environmental Awareness project is a pioneer of its type in cooperation between the government and the private sector (the private sector provides management and finance, while the PME provides the necessary scientific and technical support) (Permanent Mission of Saudi Arabia, 2009).

24.2.1 Sustainable Development as a Policy Concept

Sustainable development is a buzzword found in much environmental and some economics literature these days. In 1987 the UN's Brundtland Commission published a report titled "Our Common Future" which started the process of making sustainable development an important issue on the world stage (WCED, 1987).

The Commission identified a number of "common challenges" facing the earth: Population and human resources, food security, species and ecosystems, energy, industrial development, and urbanization. In addition to these challenges, water sustainability and climate change were also mentioned in the report as related/contributory issues to the main challenges, however these have since been individually acknowledged as serious global problems in their own right. In the context of these challenges they discussed international environmental problems, what successes had been registered in trying to address those problems, the scope and nature of the environmental problems still facing the world community, and the role of the world's economic systems in developing solutions to these problems and providing long-term relief for what they perceived to be the related problems of poverty and underdevelopment.

The Commission then outlined a series of "strategic imperatives," or "critical objectives," inherent in their concept of sustainable development. These included: reviving growth; changing the quality of growth; meeting essential needs for jobs, food, energy, water, and sanitation; ensuring a sustainable level of population; conserving and enhancing the resource base; reorienting technology and managing risk; and merging environment and economics in decision making (WCED, 1987).

The Commission called for a continued economic growth with the growth made more environmentally sensitive in order to raise living standards globally and break the link between poverty and environmental degradation.

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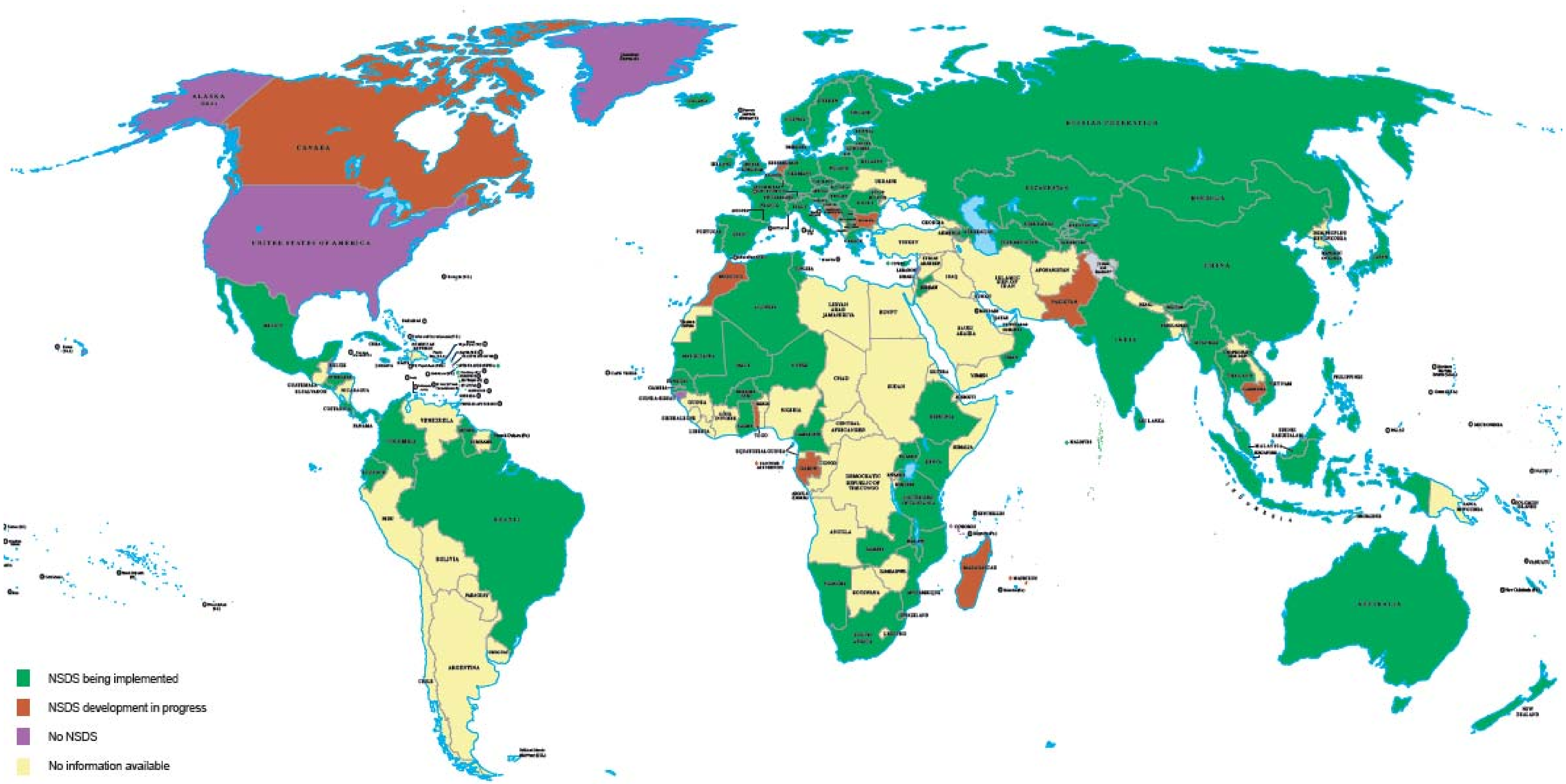

Figure 24-2 National Sustainable Development Strategies: The Global Picture 2010

Source: United Nations Department of Economic And Social Affairs, 2010.

In response to the Commission's sustainable development initiative discussions within the UN and UN's agencies, a number of environmental organizations spread throughout the world which contributed to formulating the ideas that became part of the Brundtland Commission's message. An Earth Summit, the UN Conference on Environment and Development (UNCED), was proposed by the UN and was held in Rio de Janeiro, Brazil in 1992. One hundred and seventy two nations sent representatives, 1,400 non-governmental organizations were in attendance, 8,000 journalists covered the event, and thousands of Brazilians attended one or more sessions (UN, 1992).

The Summit adopted the Rio Declaration that includes 27 principles. These principles provide a framework for the world's diplomats in their efforts to improve both environmental and economic conditions around the world.

After the Earth Summit sustainable development has developed into a policy concept. International organizations such as the International Union for Conservation of Nature (IUCN); the UN; the International Finance Corporation (IFC); the World Bank; and the European Union among others have turned the sustainable development concept into a series of policies.

In September 2000, at the UNs Millennium Summit, world leaders agreed to a set of timebound and measurable goals and targets for combating poverty, hunger, disease, illiteracy, environmental degradation and discrimination against women. Placed at the heart of the global agenda, these are now called the Millennium Development Goals (MDGs). The MDGs provide a framework for the entire UN system to work coherently together towards a common end - the elimination of poverty and sustained development.

Sustainable development should not be considered as a standalone concept but as a framework to address diverse environmental and social aspects. Special initiatives coordinate the IUCN work across individual programmes on specific issues such as climate change; energy, ecosystems and livelihoods; mangroves for the future and conservation for poverty reduction (IUCN, 2009). The 2002 World Summit on Sustainable Development (Johannesburg Summit) recognized the linkage between climate change and sustainable development, which was reinforced by the Delhi Declaration adopted at the 8th Conference of the Parties (COP) in New Delhi in 2002. More recently, in 2007 the UN Commission on Sustainable Development (CSD-15, 2007) also addressed climate change and sustainable development and the Intergovernmental Panel on Climate Change (IPCC) has also covered sustainable development as a cross-cutting issue in its Fourth Assessment report (UNDES, 2007).

The IFC considers multiple dimensions of sustainability in its investments and involve the concept of sustainability into its Policy on Social and Environmental Sustainability (IFC, 2006) which defines IFC's role and responsibility in supporting project performance in partnership with clients.

Other initiatives involving sustainable development have been taken by the World Bank which has focused its work on the achievement of the Millennium Development Goals which provide the World Bank with targets and yardsticks for measuring results (WB, 2009).

The Renewed EU Sustainable Development Strategy was adopted by the European Council in June 2006 (EU, 2006). It is an overarching strategy for all EU policies which deals in an integrated way with economic, environmental and social issues.

24.2.2 Sustainable Development in the Kingdom of Saudi Arabia

The integration of both the environmental and development objectives in the Kingdom of Saudi Arabia is enclosed in the Islamic Sharia principles. These principles direct each individual to conserve and protect natural resources and to be wise and rational in developing the natural environment for his own benefit and that of future generations (Permanent Mission of Saudi Arabia, 2009). Therefore, the concept of sustainable development is reflected in the Islamic view related to the relationship between humans and the natural environment.

The priorities on future development of the KSA in the context of sustainable development have been identified and included in the document "Agenda 21: Kingdom of Saudi Arabia" (Government of Saudi Arabia, 1997).

Through this Agenda, the government of the KSA remarks on the importance of the private sector in the achievement of sustainable development in the country. In fact, companies in the private sector are encouraged to commit to the following; provide environmental impact assessments for their projects; follow existing environmental protection regulations and guidelines with regards to the rational use of natural resources; and limit waste generation by increasing operations efficiency.

One of the major achievements of KSA, at the national level, in this field during the last few years is the attention given to environmental affairs by a number of agencies and organizations in the industrial sector. In particular, to the application of measures pertaining to industrial safety; such agencies and organizations include the Ministry of Petroleum and Mineral Resources, the Ministry of Industry and Electricity, Saudi Aramco, the Royal Commission for Jubail and Yanbu (Licensing Agency of RTIP), and SABIC.

24.2.3 RTIP Sustainable Development Goals and Standards

In addition to the KSA's national standards and guidelines, RTIP's management policy will take into account the specific guidelines and standards established for the project and those set by Project Owners.

RTIP will be in line with the national sustainable development strategy of the KSA through the reduction of emissions and limitations in consumption of natural resources, and through the implementation of measures for the conservation of natural resources.

The sustainable development goals and principles of the Owners (The Dow Chemical Company and Saudi Aramco) will also be considered throughout all the design and execution phases of the project.

24.2.3.1 The Dow Chemical Company Sustainable Development Goals

Dow's vision on overall sustainability is reflected in their Sustainability Goals - a public commitment that they hold themselves fearlessly accountable in the pursuit of solutions to climate change, energy and other pressing world challenges. Sustainable chemistry is Dow’s “cradle to cradle” concept that drives them to use resources more efficiently, to minimize their footprint, provide value to their customers and stakeholders, deliver solutions for customer needs and enhance the quality of life of current and future generations (Dow, 2011).

Following are the Dow sustainability standards and goals:

Local Protection of Human Health and the Environment

- Zero accidents, zero injuries and zero excuses.

Contributing to Community Success

- To be an engaged corporate citizen globally and locally, to help create stronger, safer and sustainable communities.

Sustainable Chemistry

- A lifecycle view of our products, processes, and product uses;
- Using resources extremely efficiently to minimize our footprint;
- Improving the quality of the environment;
- Providing positive value and return for all our stakeholders; and
- Enhancing the quality of life of current and future generations.

Product Safety Leadership

- Have a publicly available Product Safety Assessment for all applicable Dow products by the end of 2015.

Breakthroughs to World Challenges

Achieve at least three breakthroughs that will significantly improve the world’s ability to solve the challenges of:

- Affordable and adequate food supply;
- Decent housing; sustainable water supplies; or
- Improved personal health and safety.

Energy Efficiency and Addressing Climate Change

- Reduce energy intensity 25 percent from 2005 to 2015.

24.2.3.2 Saudi Aramco Corporate Citizenship Strategy

Saudi Aramco's vision is to be an influential leader in creating sustainable social and economic opportunities for the welfare of the Kingdom and in other locations where they do business.

The principles that support Saudi Aramco's corporate citizenship are under the following four pillars:

- *Economy*: Team with Government agencies, academic institutions and suppliers to make strategic investments in entrepreneurship and innovation, build professional and vocational skills, and ensure local job creation;
- *Community*: Support local communities by offering awareness campaigns and volunteer opportunities, along with charitable donations, to promote a prosperous, responsible and inclusive society;
- *Knowledge*: Encourage the Kingdom's transformation into a knowledge hub and innovation leader by empowering individuals through world-class educational opportunities;
- *Environment*: Work to minimize the environmental impact of our operations and promote new strategies to lighten the environmental footprint of petroleum consumption and enhance energy efficiency.

These corporate principles are used by the Saudi Aramco as guiding principles for integrating sustainability as a concept into their business activities.

24.3 Description of the Assessment Methodology

Projects that include industrial processes such as RTIP unavoidably have negative impacts which affect the environment and the community. However, if these are properly managed and mitigated, the project can still contribute to the development of present generations in a sustainable manner, respecting the right of development of future generations. The start of this process is the Sustainable Development Assessment.

There is no single universally applicable methodology for carrying out sustainability assessments. At the project level, the environmental impact assessment (EIA) provides a basis for assessing the level at which the proposed development integrates sustainability principles and identifies the key areas where additional focus is required in relation to sustainability. This is recognized in the Rio Declaration, Principle 17, which specifically calls for EIAs to be undertaken for proposed activities that are likely to have a significant adverse impact on the environment (George, 1999). However, the introduction of EIAs predates the concept of sustainable development and does not necessarily address all of its goals. While a number of EIA goals may be closely related to sustainable development goals, they are not identical. Sustainable development criteria should be specifically included in the assessment.

Therefore, the sustainable development assessment for RTIP has been made in two phases: 1) an assessment of how sustainable development principles have been integrated into the EIA report, and 2) an assessment of the overall sustainability of the project based on the conclusions obtained from the EIA report.

Based on the results of these two phases of the assessment, key areas of the project where additional focus is required in terms of sustainable development have been identified and sustainability recommendations have been proposed.

24.3.1 Methodology for Sustainable Development Assessment of the EIA

The potential of the environmental impact assessment as a sustainability instrument has long been recognized. However, as described above, the criteria used to assess development proposals are not necessarily the appropriate criteria for sustainable development. Therefore the assessment of how sustainable development principles have been integrated into the EIA has been done through a review of the fundamental principles of sustainable development and relating them to the principles used as the basis of this environmental assessment. The intention of the sustainable development assessment is to get a full understanding of the results of the EIA process by identifying any deviation from, or lack of attention toward sustainable development goals. This will facilitate the interpretation of the results when doing the sustainability assessment of the project.

Table 24-1 includes the criteria derived from the fundamental principles of sustainable development (intergenerational[1] and intragenerational equity[2]) that were used to perform the sustainability assessment of the EIA.

Table 24-1 Sustainable Development Criteria

Principle	Criteria	Definition
Intragenerational Equity	Intragenerational Equity	Identify all impacts that may be significant to all social groups affected and ensure that any necessary mitigation is satisfactory for all of them
	Public Information	Results of the EIA, and indeed the whole of the environmental assessment, are published and readily available to the public
	Public Participation	Opportunity for the public to comment on the proposed development. Consideration of their comments taken into account before final decisions made
	Equity for Minorities	Provision has been made for the interests of minority groups (e.g. disadvantaged)
	Transboundary Impacts	Consideration of international and global impacts and any affected parties consulted before final decisions are made

[1] ***Intergenerational equity*** is the principle of equity between people alive today and future generations. The implication is that unsustainable production and consumption by today's society will degrade the ecological, social, and economic basis for tomorrow's society, whereas sustainability involves ensuring that future generations will have the means to achieve a quality of life equal to or better than today's (ISSD, 1997).

[2] ***Intragenerational equity*** is the principle of equity between different groups of people alive today. Similarly to intergenerational equity, intragenerational equity implies that consumption and production in one community should not undermine the ecological, social, and economic basis for other communities to maintain or improve their quality of life (ISDD, 1997).

Table 24-1 Sustainable Development Criteria

Principle	Criteria	Definition
Intergenerational Equity	Critical Ecosystems Factors	Identify any potentially critical ecosystem factors that may be affected
	Irreversibility of damage	Assess the risk of serious or irreversible damage arising from any impact on them
	Strong Sustainability-Conservation principle	Serious or irreversible impacts fully mitigated, in kind, so that there will be zero adverse residual impact
	Weak Sustainability-Analysis of Residual Impacts	Residual impacts assessed and risks evaluated. In case of compensation, specific groups or individuals adversely affected are satisfied with compensation offered. Natural capital converted into some other form, but with no loss of capital passed on to future generations
	Weak Sustainability – Integration of Environmental, Social, Economic Appraisal.	Integrated assessment, so that environmental factors may be weighed against social and economic ones
Intra- and Inter-generational Equity	Globally Sustainable Development	Assessment of Global Impacts. Impacts that are of international interest must be considered. The impacts of greater concern are Climate change, Loss of Biodiversity, and depletion of natural capital. Other impacts of international interest include human rights.

Source: George, 1999 and 2001, reviewed and adapted to RTIP conditions by CH2MHILL in 2011

The assessment consisted of a qualitative valuation of the level of integration that each of these criteria have had in the EIA process. For this purpose, three different levels have been defined:

- *Low:* No clear evidence of consideration of the criterion in the impact assessment process;
- *Medium:* The criterion was considered in the EIA but was not determined in the significance of impacts; and
- *High:* The criterion was key in the definition of the significance of impacts in the EIA.

Criteria identified with low or medium integration in the EIA has been further discussed and assesses to cover any potential gap of the results of the EIA with regards to sustainability.

24.3.2 Methodology for Sustainable Development Assessment of RTIP

The environmental and social performance of major industrial projects is becoming increasingly important in the light of the global drive towards sustainable development. It was therefore considered of high relevance to perform a sustainable development assessment of RTIP.

The results of the EIA study have been the basis for the sustainability assessment of the project together with the complementary analysis made for those sustainable development criterions identified as having a low to medium integration in the EIA, as per the methodology described in the previous section.

To assess the sustainability of the RTIP project, impacts ranked as significant or highly significant were reviewed based on the fundamentals of sustainable development (intragenerational and intergenerational equity). The purpose of this review is to identify any potential areas of the project where additional focus is required (negative impacts), or any strengths which could be further bolstered to enhance their beneficial effects (positive impacts) for the project, in terms of sustainability. This would then allow for appropriate recommended measures to be proposed, along with suitable and relevant priority levels for their implementation. This methodology was used to make a broad, qualitative assessment of the sustainability of the proposed project.

The following matrix was used to classify in terms of spatial scales and time horizons those significant/highly significant impacts identified during the EIA process for the physical, biological, and social environment, related to project activities. Positive impacts will also be reflected in this matrix, as sustainable development will also be focused on the enhancement of project benefits in relation to sustainability.

Table 24-2 Sustainable Development Criteria

High Interest for Intragenerational Equity		High Interest for Intergenerational Equity	

INTRAGENERATIONAL/ INTERGENERATIONAL

Millennia					
Centuries					
Decades					
Years					
Months					
Days					
	Local Within 2 km of site boundary	Provincial Within Jubail Industrial City	Regional Outside Jubail Industrial City but < 100 km away	National Within KSA	International Outside KSA

Source: CH2MHILL, 2011

Depending on the scale and time horizon of the impact, it would have a major effect either on intragenerational or on intergenerational equity. It is important to highlight that intragenerational equity is considered a necessary condition for development while intergenerational equity is considered a necessary condition for sustainability.

24.4 Sustainable Development Assessment of the EIA

This EIA report has been conducted in accordance with the Equator Principles and the IFC's Performance Standards (see checklist of compliance in Section 1 Introduction), within the cultural constraints of a facility being developed in the KSA.

IFC launched a review and update process of the Sustainability Framework, which includes the Policy and Performance Standards on Social and Environmental Sustainability, on September,

2009. The third and final phase of IFC's consultation process for the Sustainability Framework Review and Update ended on March 4 of 2011. Though the updated policy and standards are not expected to come into effect until 2012, these were considered throughout the EIA process.

It should be noted, that this EIA was generally conducted using the more stringent applicable parameters between local, national, and international standards. For the purpose of the EIA, it has been presumed that meeting the most stringent parameters satisfies the principle of intragenerational equity when applied globally. This considers that, whatever is the level of equity represented by these parameters, their agreement is the best that can currently be achieved between the interested parties.

Table 24-3 presents the sustainable development assessment of this EIA following the methodology described in section 24.3.1. This assessment intends to identify any potential gaps that the EIA has as a sustainability assessment tool of RTIP, so that it can be filled in this section providing the appropriate context for the interpretation of the results of the EIA during the sustainability assessment of the Project.

Based on the results of the sustainable development assessment of the project EIA, presented in table below, the main area where additional focus is considered necessary (criteria with a low level of integration) is related to Stakeholder Engagement (public information and participation). This aspect is therefore analysed further in this section and given special consideration during the sustainability assessment of the project.

Secondary areas needing additional attention are those with a medium level of integration and include; the limitations of the social impact assessment, and resulting limitations in the integrated assessment of environmental, social and economic factors and associated mitigation measures largely owing to the indirect nature of engagement with the local population. There were also inherent limitations in the analysis of global impacts (e.g. climate change, loss of biodiversity, depletion of water reserves).

It must be noted that some of the aspects mentioned above are also related to the lack of direct public participation during the preparation of the EIA. With regards to the integrated assessment, this has been addressed through an analysis of the sustainability of the project, focusing on the relationship between the impacts and their potential for affecting the equilibrium between the three main pillars of sustainable development. Section 24.5.2 provides further analysis of global impacts.

Table 24-3 Sustainable Development Assessment of the EIA

	Criteria	Comment	Assessment Level Of Integration
Intragenerational Equity	Intragenerational Equity	This EIA is based on three key elements: the environmental and social baseline of the influenced area of the project; the description of related project activities during all project phases; and the legal framework established for the project (including all applicable local/national standards, as well as international standards and guidelines of best practices). The environmental and social baseline provided information about any potential receptor that could potentially be affected by project activities. The description of project activities provided the information related to the potential adverse effects that the project may pose on existing receptors. The legal framework provided the standards against which the impacts identified must be compared to determine the acceptability or not of the impact according to recognized standards. Sections 12 to 18 include the identification and assessment of potential impacts on air quality, onshore physical environment, biological resources (including marine environment), noise, waste management, social aspects (including health and safety aspects) and archaeology and cultural heritage. Section 19 includes the identification and assessment of potential cumulative impacts. Mitigation measures to get low or tolerable residual impacts have been suggested.	HIGH
	Public Information	The approval process of EIAs in the Jubail Industrial City involves public consultation indirectly via the Royal Commission. Though direct public dissemination of information is recommended by the IFC and Equator Principles it is not considered culturally implementable in the KSA and is not part of this EIA (see Appendix F Stakeholder Engagement). Therefore, results of the EIA are not expected to be directly subjected to the views of the public, unless international lenders or Export Credit Agencies release the EIA for public comment.	LOW
	Public Participation	See comment above.	LOW
	Equity for Minorities	No minority groups were identified to be present in the project's area of influence.	N/A
	Transboundary Impacts	The spatial extent of impacts was considered during the assessment of the significance of potential impacts. The extent criterion considers the area of influence of each impact: as local, provincial, regional, national, and international.	HIGH

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Table 24-3 Sustainable Development Assessment of the EIA

	Criteria	Comment	Assessment Level Of Integration
Intergenerational Equity	Critical Ecosystems Factors	Specific criteria for the assessment of ecological impacts have been applied (see Section 11.3.4. Criteria for Assessment of Biological Resources). Critical ecosystems factors were integrated and considered when the magnitude and significance of impacts were assessed.	HIGH
	Irreversibility of damage	The irreversibility of damage is directly related with the duration in time of potential impacts and the recovery of the affected medium once the impacting activity is stopped. The duration is one of the criteria considered during the assessment of the significance of potential impacts.	HIGH
	Strong Sustainability-Conservation principle	Though measures proposed in this EIA has been focused on prevention, when prevention is not feasible, measures for minimization and mitigation of impacts have been suggested. Strong sustainability (conservation) has not been applied in this EIA but the weak sustainability principle (analysis of residual impacts) has.	N/A
	Weak Sustainability-Analysis of Residual Impacts	The methodology followed in this EIA includes the assessment of potential residual impacts after implementation of mitigation measures. This procedure promotes the appropriate allocation of mitigation measures to ensure all possible feasible and cost-effective measures have been proposed to reduce potential residual risks. In case of high residual impacts, the methodology followed indicates that offsets or other compensatory measures should be considered. However, this does not directly consider the level of satisfaction of affected groups.	MEDIUM
	Weak Sustainability – Integration of Environmental, Social, Economic Appraisal	This EIA also included a Social Impact Assessment in which potential impacts on population wellbeing is assessed. The social impact assessment also evaluates potential indirect impacts on population due to degradation of the environment. However, though an integrated assessment is conducted, this is primarily an environmental impact assessment with no direct public engagement and it has not been possible to clearly weigh environmental factors against social and economic ones.	MEDIUM

Table 24-3 Sustainable Development Assessment of the EIA

	Criteria	Comment	Assessment Level Of Integration
Intra- and Inter-generational Equity	Globally Sustainable Development	Impacts of global interest have been considered during the specific assessment undertaken for each of the potentially affected receptors identified for the project. GHG are discussed in the air quality impact assessment (see Section 12), and loss of biodiversity is assessed in Section 14. Human rights involve a range of rights that define an individual's quality of life and which can so often be threatened. In the context of the RTIP, potential human rights impacts of the project have been implicitly integrated into the social impact assessment. People whose rights may be impacted, as well as other interested stakeholders, have been considered as part of the assessment and as potential receptors. However, the assessment of these impacts has been focused from necessity on a local and national context more than in a global context. Therefore any value judgment on the relative values of environmental and social or economic factors related to these impacts has not been made globally.	MEDIUM

Source: George, 1999 and 2001 and reviewed and adapted to RTIP conditions by CH2MHILL in 2011

Abbreviations: N/A. Not Applicable

24.5 Sustainable Development Assessment of RTIP

The integration of sustainable development elements within petrochemical projects, such as RTIP, gains importance after reviewing the role of the oil industry in the country's economic data and in national development plans. Saudi Arabia possesses around 20% (approximately 264.6 billion bbl) of the world's proven petroleum reserves, ranks as the largest exporter of petroleum, and plays a leading role in the Organization of Petroleum Exporting Countries (OPEC). The petroleum sector represents a significant percentage (over 45%) of the country's Gross Domestic Product (GDP) and 90% of the country's export earnings (CIA, 2011).

To assess the sustainability of RTIP, the confluence of the three elements of sustainable development, social, environmental and economic, were analyzed throughout the project's lifecycle (design, construction and operation).

The sustainability concept has been addressed in RTIP from the early stage "the design phase", which has reduced the adverse impact of the project on the environment and community. The project location is situated within an existing industrial area, and is not adjacent to any residential areas, thereby minimizing impacts to potential human receptors, as well as avoiding damage to community resources while integrating the facility within the region's development plan.

The site selection of the complex, as undertaken by the Royal Commission Urban Planning Department, is an example of how key factors involving sustainability were taken into consideration. As discussed in the analysis of alternatives section (Section 23), the proximity of transport links and the availability of existing infrastructure/common utilities were some of the main issues pertinent to site selection of the project. Through this first analysis the project reduced its environmental footprint and emissions by the use of existing infrastructure instead of constructing new facilities to supply the complex's needs.

This EIA and associated studies such as the BAT analysis, air dispersion modelling and noise study have been performed during the design phase. These studies are considered feasibility studies that evaluate the effects of the project in an environmental, social, and economic environment. Predictions of potential significant impacts on both social and environmental components help to establish appropriate mitigation and enhancement measures at an early stage of the project. Throughout the consideration of environmental and social aspects in feasibility studies, the project is integrating some principles of sustainable development.

Another key factor taken into account during the design phase and which is considered to be aligned with good sustainable development practices is the implementation of Best Available Technologies (BAT) in the different units process. The RTIP design seeks to develop a facility that provides responsible performance and also results in friendly environmental and social performance. Several measures have been proposed to demonstrate a commitment to sustainable design development. For instance, an analysis of BAT has been developed for affected steam boilers (point combustion sources) in the proposed RTIP in order to minimise the emissions of the pollutants these sources generate (e.g. NO_x, SO_x, and PM10). In order to minimise NO_x emissions for example, a total of five primary measures (aimed at reducing emissions at source or during combustion) and two secondary measures (aimed at controlling emissions to air, water and soil) were considered. The efficiency of these measures was compared in terms of how effectively they reduce NO_x emissions as well as in terms of their effect on the overall efficiency of the boilers. Finally, based on the results of this comparison and on the availability of these measures amongst the project suppliers, a final decision was made with regards to NO_x emissions reduction, this process resulted in the selection of low NO_x burners which will reduce the amount of NO_x produced during combustion in the boilers, in combination with the use of Selective Catalytic Reduction (SCR) to treat the flue gas generated as the most effective technology at reducing NO_x emissions.

In essence BAT balances the costs to the operator against benefits to the environment and therefore to society. The application of BAT will responsibly control significant potential impacts to the environment during the operation phase. The most relevant BATs included in the units' process design of the RTIP are discussed in Section 3 Project Description.

The primary feedstocks to the Project are ethane and naphtha which will be supplied by other Saudi Arabian oil and gas companies (Ras Tanura Refinery or Jubail Area Refinery, and Ju'aymah Gas Plant). Processing hydrocarbon products in the same country where it is extracted implies that incomes from both upstream and downstream activities will be kept within the country, thus increasing its Gross Domestic Product. It also implies the creation of indirect and direct employment, benefits for the local economy through network suppliers, and the economic contribution that the Operator makes to the region through tax payments. Downstream operations provide more job opportunities than upstream due to higher value-added components.

Despite the economic and social benefits that the project will bring to the country, it is important to go further in this analysis and evaluate the negative implications of these benefits, especially on the environment, the community, and on potential global impacts for both present and future generations.

Following the methodology described in 24.3.2, impacts ranked with medium/high significance in the environmental impact assessment process have been categorized in the matrix below (see Table 24-4). As per the stated methodology, all the impacts identified in this EIA which possess a significance of medium or higher will be classified in terms of their temporal and spatial extent. The temporal scale ranges from days to millennia and it is important to note that this scale refers not to the duration of the activity causing the impact, but rather the duration of the impact itself and its effects on the receptor in question. The spatial scale defines the potential area affected by said impact and ranges from local to international extents. As a result, this preliminary categorisation of impacts provides a basis for determining the influence of the project on both intergenerational (i.e. contemporary and future generations) and intragenerational (i.e. contemporary generations only) equity. This matrix has been used as the basis for the sustainability assessment of the project.

As such, the overall interpretation of this matrix and its results are dependent on where inside the matrix the majority of the impacts have been placed. Based on the definition of Sustainable Development, development will be sustainable when it is undertaken in a

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manner which does not hinder the development of other generations, particularly future ones. Thus, the larger the extension of a negative impact the more intragenerational equity suffers, and the greater the duration of a negative impact the more intergenerational equity suffers. Oppositely, the larger the extension of a positive impact the more intragenerational equity benefits, and the greater the duration of a positive impact the more intergenerational equity benefits. In terms of the matrix (Table 24-4), this therefore implies that if the majority of the identified negative impacts are found to be in upper right hand corner of the matrix, the project is less sustainable, whilst if the majority of the negative impacts are found to be in the lower left hand corner of the matrix, the project will be more sustainable in the long run (and vice versa for positive impacts). This has been represented below in Figure 24-3.

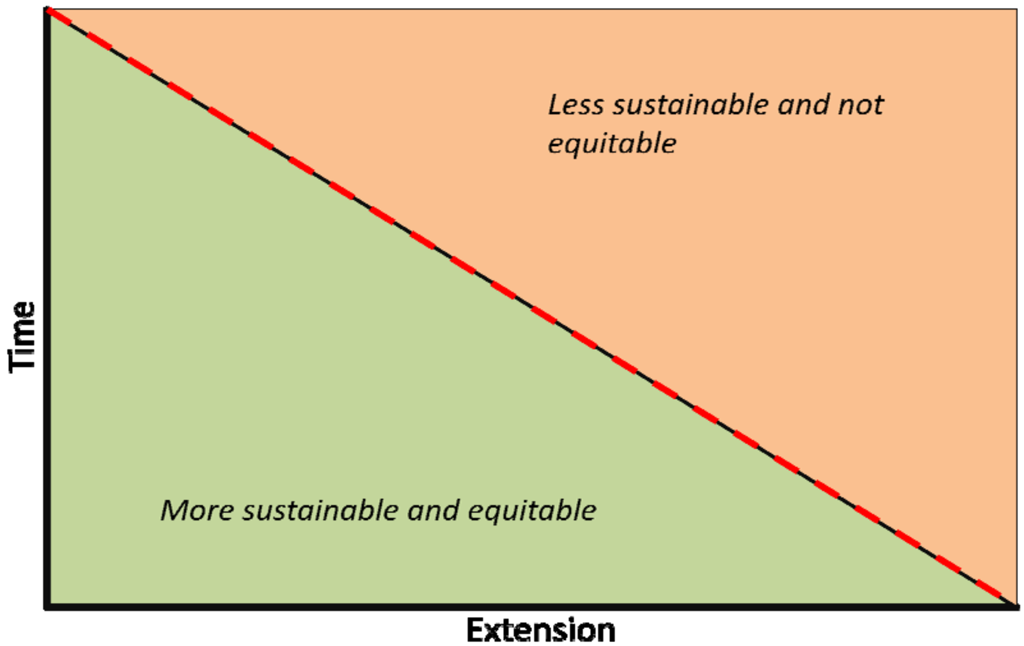

Figure 24-3 Explanatory figure for the interpretation of Matrix of Intergenerational and Intragenerational Impacts

Source: CH2M HILL, 2011.

It is acknowledged that compliance with some international conventions, such as direct stakeholder engagement as promulgated by the IFC, is not feasible at this stage and that in some respects compliance will be a long term objective for the project. However, these deviations are reflected already in the categorization of impacts and their significance as per the criteria established in Section 11 for the environmental impact assessment.

It must be noted that this analysis is based on the assumption that the RTIP project will be operated according to the design available to date. Any improvement on its design with regards to resource consumption, environmental footprint, and energy efficiency will favour the sustainability of the project.

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Table 24-4 Matrix of Intragenerational and Intergenerational Impacts of RTIP

INTRAGENERATIONAL / INTERGENERATIONAL	Local Within 2 km of site boundary	Provincial Within Jubail Industrial City	Regional Outside Jubail Industrial City but < 100 km away	National Within KSA	International Outside KSA
Millennia					
Centuries					
Decades	A3, A6, A7, A9: NOx, PM10, PM2.5, Benzene emissions O2: Alteration Drainage AC3: Cross cultural tensions workers/community N2: Increases in traffic noise levels at locations near roadways S12: Increase in explosions/fire hazards	C2: Increase in ozone concentrations (cumulative) C8: Noise increase near roadways due to traffic increase (cumulative) C13: Impact on local infrastructure (cumulative)	S1: Increased traffic impact on infrastructure, community S3: Increased income/demand services S6: Improvement in stakeholders status & income /increase health services S11: Increase in traffic accidents.	S2: Creation of new jobs	
Years	O2: Alteration Drainage O6, O7: Soil/groundwater quality spills O21, O23: Soil/subsurface contamination waste disposal O24, O25, O26, O27: Accidental release of waste A1, A2, A3, A6, A7, A9: Dust, exhaust, NOx, PM10, PM2.5, Benzene emissions	N2, N3: Traffic noise, construction noise, High-pressure steams C7: Noise increase near roadways due to traffic increase (cumulative)	M5: marine impact from contaminated firewater runoff entering marine environment S10: Increased incidence of disease transmission. C12: Impact on regional economy due to demobilization of RTIP construction (cumulative)	S2: Creation of new jobs	
Months	M7: marine impact from fuel/chemical spills from Port Facilities by third parties.	A22, A23: Benzene emissions from Spills	M6, M8, M9: marine impact from fuel/chemical spills to sea during transport by third parties; from collisions/breaches; and cumulative impacts from regular leaks at Port Facilities. C5: Increase in fuel/chemical spills to sea from increased shipping traffic (cumulative)		
Days	N3: Increases in noise levels at receptors (high-pressure steam blows up & flaring)				

EXTENSION

High Interest for Intragenerational Equity (yellow) High Interest for Intra and Intergenerational Equity (pink) *Positive Impacts*, *Negative Impacts*

Source: CH2MHILL, 2011

Although short term impacts are relevant for biological and physical processes (e.g. soil biology or sudden point-source pollution, or noise generation), the sustainability assessment considering future generations is focused on longer time periods. Thus, these short-term processes would have a higher interest for present generations but lower interest for sustainability in comparison to those that require a longer period for their recovery and which may compromise the availability of resources for future generations. In this way impacts related to project activities (those summarized in chapter 20 Summary of Impacts) have been classified in accordance with their relevance to both future generations (sustainability) and present generations (development).

The matrix above indicates that according to the EIA results, the project will have significant impacts at all spatial levels of high intragenerational interest. According to this matrix, there are also potential significant negative impacts which remain throughout time affecting not only present generations but also future generations and therefore are considered of high intergenerational interest. However, it is envisaged that due to the nature of the impacting activities and the specific conditions of the project area (see detailed assessment on sections 12 to 18), the influence of these intergenerational impacts is predominantly at local, provincial and regional level.

Applying the equity principles globally may be regarded as the most important test for sustainable development. Sustainable development is primarily a global issue, and therefore the spatial influence is a significant criterion to be considered when prioritizing measures in terms of sustainability. It must be noted that measures to prevent, minimize, or mitigate impacts included in the matrix above are proposed and summarized in Section 21. Throughout the implementation of the proposed measures, negative impacts are expected to be properly managed and controlled, and positive impacts enhanced to maximise the benefit of the project for the community. The increase in economic resources, through local procurement and increased employment, can help to make the local community stronger and more sustainable.

According to the EIA and as reflected in the matrix, the impacts having the greatest area of influence are those related to social aspects. The involvement of foreign workers in the project, as well as indirect impacts on the community due to execution of project activities (e.g. increased traffic, impact on fishermen) are the major social aspects to be considered for RTIP. However, if well managed, these impacts can be prevented/mitigated and concerned citizens can be compensated with other direct benefits from the project such as the creation of new jobs or improvement of stakeholder status and incomes. One aspect to be highlighted is the minimal disturbance that the project is envisaged to have on the nearest residents, which is basically due to the nature of the area (industrial park) and the distance from the project site to populated areas (more than 13 km).

The EIA also identified indirect third party impacts on the marine environment resulting from potential spills at the Port Facilities for which it is expected that the areas affected will have a significant extension. The main reason for the sizeable extensions of marine impacts is the rapid rate of propagation of the contaminants considered, when in water. All these impacts would likely originate from accidental events such as spills, fires or collisions, and with the exception of small scale leaks and spills during transportation; it is considered that these events will be rare in their frequency of occurrence. It is important to note however that irrespective of the risks posed by these accidental events, the location and workings of RTIP's entire value chain imply a relatively sustainable option as the close proximity of the complex to its sources for feed stocks as well as points of export, means that the risks associated with these accidental events are significantly reduced as a result of shorter transportation distances. Nevertheless, these impacts can be mitigated via the creation and implementation of conscientious and holistic plans/procedures to ensure adequate preparations are made for these types of events. It is also recommended that drills be carried out on a regular basis to ensure workers are familiar with emergency procedures, and that all these measures be made applicable to third parties involved in the project, wherever possible.

Other impacts identified with potentially large extensions (although to a lesser extent than social and marine impacts) were those associated with air quality and noise. With regards to air quality it is considered that any significant impacts would mainly originate from an accidental event, such as for example, an uncontrolled release of benzene. These impacts, as is the case with the marine impacts discussed above, due to their accidental nature are hard to prevent, but can be effectively mitigated if adequate measures are implemented.

The significance of these impacts can be reduced if appropriate measures are applied in a timely manner. In fact, sometimes impacts can be avoided altogether by means of implementing preventive measures at early stages of the project. Once potentially significant negative impacts have been reduced or avoided, these projects often become beneficial for the community, favouring the country's development.

The residual impact of noise from high pressure steam blows; increased traffic and the associated increase in accidents; increased incidence of disease transmission; potential for transfer of non-compliant wastewater; and various other impacts associated to different accidental events (waste spills, fire and explosion hazards, and spills to the marine environment during transport or at the KFIP) are all expected to remain of medium or medium-low significance despite the mitigation measures proposed. For this reason, RTIP should pay special attention to these activities and ensure that all practicable, feasible and cost-effective mitigation is implemented. Section 24.6 includes recommended measures that can improve the performance of the project in terms of sustainable development.

The following subsections provide a further analysis of the inter-relation between RTIP and key global concerns.

24.5.1 RTIP and Stakeholder Engagement

It is well understood that environmental issues are best handled with the participation of stakeholders, at the relevant level, and this is the essence of what Principle 10 of the Rio Declaration promotes. This principle requires the publication of the EIA report to receive the views of the public that should be considered further by decision-makers of the proposed development. Public participation in decision-making caters to intergenerational as well as intragenerational equity which are fundamental to sustainable development.

The RTIP complex will be located in the Jubail Industrial City, which is one of the two cities specifically developed by the KSA government to exploit the hydrocarbon resources of the Kingdom sustaining the development of the country but minimizing adverse impacts on the environment. Because of the nature of this city, it is recognized that the primary stakeholder for RTIP is the RCJY (local government).

In the KSA the consultation process is traditionally via meetings with local governments and ministries, rather than a public or community consultation. As part of this EIA, a stakeholder engagement plan for RTIP, aligned to current practices in the Country, has been prepared. However, due to cultural constraints, the plan prepared does not meet the requirements of international guidance for public participation.

Sustaining positive relations with the local community is of fundamental importance to long-term project viability and will provide a good foundation for future project activities. The balancing of project needs with community needs and concerns covers a number of potential social, cultural and health impacts.

In order to integrate the spirit of sustainable development into the project and to ensure that the project promotes equity, it is highly recommended that compliance with international standards in the public participation process be set as a long term objective for this plan.

24.5.2 RTIP and Global Impacts

When assessing a project in terms of sustainable development, the principles of intergenerational and intragenerational equity must be reviewed across all sectors affected by the development. This includes the global population and environment, if the project has adverse impacts or cumulative effects at a global level. The following subsections provide a discussion about the potential effect of RTIP on well known global impacts.

24.5.2.1 RTIP and Climate Change

It is increasingly recognized that climate change is a fundamental sustainable development challenge. This challenge has emerged in recent years as it has been acknowledged that climate change impacts impede economic and social well-being and development efforts. This has raised appreciation for the fact that climate change holds a strong relevance to sustainable development and is not just an environmental problem.

Climate change is linked with other environmental factors that are key to combating it, but are also simultaneously influenced by its adverse effects. Examples of these are ecosystem services and integrated water resource management (IWRM) and their role in climate change mitigation as well as adaptation. Ecosystem services are natural resources and processes such as crop pollination, clean drinking water, maintenance of soil fertility and waste decomposition which are fundamental to human well-being and can also act as a significant global carbon stock. IWRM, for instance, increases the capacity of water management systems to address changes in the level and variability of water availability caused by climate change impacts such as droughts, floods and changed precipitation patterns.

The fact that sustainable development involves both intra- and intergenerational equity considerations, further underscores the relevance of addressing climate change in development projects. International funding institutions, such as IFC, promotes this and clearly recognizes the importance of the private sector's role in the reduction of greenhouse gas (GHG) emissions as well as in adaptation to climate change impacts. Given the very long time span over which greenhouse gases remain in the atmosphere, most benefits from current mitigation actions will accrue to future generations, whereas avoiding mitigation will magnify the negative effects of climate change, as well as the need for future generations to implement adaptation measures.

Section 2 Regulatory Framework of the project lists those international conventions and standards signed by the KSA that relate to climate change and that are also recognized as a framework for the development of this project. Section 12 Air Quality Impact Assessment also includes an analysis of GHG and the potential contribution of the project to climate change. The results of this assessment indicate that a total of 4,240,703 MT of CO_2 equivalent GHG will be emitted every year as a result of RTIP operations. This compared to the International Energy Agency's estimate for the KSA's total CO_2 emissions in 2008 (778.4 MMT/year) (IEA, 2010), equates to a 0.5% increase in emissions as a result of the RTIP project, although it seems probable that some of this increase will be offset by reductions associated with the closure of older less economically viable process units located elsewhere. Despite the efforts made by project's owners on the implementation of Best Available Techniques in their process units increasing the energy efficiency and reducing air emissions from their operational units, this is still a significant CO_2 equivalent emission. Further to this, as per the IFC's Performance Standard 3 relevant to Pollution Prevention and Abatement, the project owners have also placed a strong emphasis on both the control of GHG emissions (by means of quantification through an inventory) as well as on reduction (numerous measures are currently being considered and/or investigated for future implementation), thus further demonstrating a commitment to minimizing project emissions.

Based on the quantification of GHG emissions, RTIP needs to make continuous efforts to improve the project's performance with regards to these emissions. However, as previously stated, climate change cannot be considered as a standalone environmental issue due to the strong interdependencies existing between it and other environmental issues. Therefore the performance of the project with regards to other environmental factors such as biodiversity, energy and water use, and the depletion of natural resources will also be of relevance for climate change.

24.5.2.2 RTIP and Loss of Biodiversity

Biodiversity is the basic resource for food and employment, and it is vital for population survival. Ecosystem services do not exist separately to business or the economy, economies are dependent on functioning ecosystems and therefore the loss of biodiversity also endangers the global economy to a multiple degree. The degradation and disappearance of biodiversity and ecosystem services accelerate climate change and threaten long-term business and market viability in developing countries.

As stated in Section 2, the KSA has endorsed the UN Convention on Biological Diversity which is the first global agreement on the conservation and sustainable use of biological diversity. Reversing the loss of biodiversity and promotion of biodiversity conservation are actually part of the targets of the UN Millennium Development Goals (MDGs), which have been integrated by KSA into its own national strategies.

Aligned with KSA environmental policies and standards, RTIP will be built in the Jubail Industrial City (JIC), which is a purpose-built sustainable industrial city on the eastern coast of KSA that was nominated and won the Sasakawa Environmental Prize in 1988 (the most prestigious international prize honouring environmental achievement contribution to the protection of the environment and promotion of sustainable development), which is annually granted by the UNEP (Government of Saudi Arabia, 1997). This city has been designed to support industrial developments in the country and minimizing their potentially adverse effects through a high degree of land use planning, facilities planning and overall environmental protection.

Potential impacts on ecological systems due to RTIP related activities have been assessed in detail in Section 14. The results indicate that the net impact of the project on ecological services due to cumulative loss of habitat is minor due to the low value of habitats potentially impacted by project activities. The ecological value of the potential impacted habitats has been established following international standards and critical ecosystems criteria. This evidences the high degree of land use planning of the city.

The closest area of ecological interest to the project site is the Sabkhat Al-Fasl Lagoons (listed as an Important Bird Area (IBA) for its important breeding and migrant populations of waterfowls) which is located more than 10 km away from the main site (area of most construction intensity). This separation distance helps to mitigate potential disturbance to wildlife, thereby lessening any potential impact.

Though direct impact from the project on biodiversity is considered minimum, unsustainable practices along the supply chain might drive the degradation and potential disappearance of ecosystem services. Efforts should be made to monitor, influence and improve the supply chains' sustainability of RTIP.

24.5.2.3 RTIP and Depletion of Water Resources as a Natural Capital

Natural capital refers to all formations of the Earth's biosphere that provide us with ecosystem goods and services imperative for survival and well-being such as land, air, water, living organisms, etc. (International Institute for Sustainable Development, 2011). Furthermore, it is the basis for all human economic activity.

Water, as a natural capital, is a vital natural resource for both present and future generations, and it is also a basic resource for the economy. The economic importance of water is reflected in the role that water resources play in the development of any economic activity. Water is recognised in KSA as a precious resource and one which must be protected.

As described in Section 9 Social Baseline, the main economic activity in KSA is mining and oil and gas, and at a regional level the main economic activities in the Eastern province are oil and gas activities, agriculture, and fishing. All of these economic activities require water for their development. Without access to water resources these activities would not be possible or economically feasible.

In the case of RTIP, the highest consumption of water will occur during the operation phase (5,440 m^3/hour, out of which 4,676 m^3/hour is cooling water make-up). Water will be supplied by Marafiq, a private water and power utility company that provides essential utility services to industrial, commercial and residential customers in the industrial cities of Jubail and Yanbu. The Marafiq water facilities comprise of a sea water cooling facility (which is not be used for RTIP) and potable water facilities (desalination plant and reverse osmosis treatment) (Marafiq, 2010).

Desalination of seawater or brackish groundwater for water supply is increasingly being considered or adopted around the world in areas where demand has been increasing beyond sustainable supply and where water sources are fragile. The use of desalted water reduces the potential for depletion of water resources. However, there are other environmental issues to be considered with regards to desalination plants and it is the high energy use and consequent high greenhouse gas emissions.

The water quantities required for the operation of the RTIP complex will be highly significant, highlighting the importance of maximising water conservation and water use efficiency during project activities which would consequently reduce potential impacts due to the energy consumption of desalination plants.

24.5.2.4 RTIP and Human Rights

It is well understood that the primary duty for protecting human rights is from the state. However, companies also have a responsibility for identifying adverse risks and impacts of their actions, and by avoiding or addressing these as appropriate.

Human rights issues involve the human rights risks facing a company in its line of business, the location of its operations, and the nature of its supply chains and local partnerships and also the sphere of influence of the company's operations beyond its workforce and the potential for the company to affect the human rights status of host communities and countries (International Finance Corporation, 2007).

Human rights involve a range of rights that define an individual's quality of life which can so often be threatened. In the context of RTIP, potential human rights impacts of the project have been implicitly integrated into the social impact assessment. Therefore, people whose rights may be impacted, as well as other interested stakeholders have been considered as part of the assessment and as potential receptors.

Following are listed the key items of RTIP with regards to human rights:

- *Identification and management of potential adverse risks related to RTIP's line of business*. This has been one of the main purposes of this EIA. Risks have been identified and appropriate measures to mitigate them have been suggested.
- *Employment opportunities:* The increased employment opportunities from project activities (both direct and indirect) have been identified for social impacts associated with worker's rights. Areas of interest include the terms of employment (including remuneration, working hours and conditions) for staff directly employed by the project and the staff of first tier and lower tier subcontractors. In addition, an influx of non-citizen, foreign workers is expected to be proportional to the labour demand of each phase. It should be noted that there are cultural constraints for the project, with regards

to equity on employment opportunities for women. This is not considered a discrepancy of the project in relation to human rights but a deviation for it to be in compliance with national laws and cultural traditions.

- *Fair Salaries:* Wages set by individual contracts will vary depending on the type of work performed; wages for foreign workers are set through bilateral agreements. The wage for citizen workers will be established according to the job performed and following Saudi labour law.
- *Work schedules:* During the construction and commissioning activities, the daily work schedule will be proposed by the construction Contractor and will comply with Saudi Arabian Government regulations.

Ensuring that human rights continue to be protected is essential throughout all project phases. RTIP can contribute to protecting the rights of individuals – whether employees or workers, members of communities or customers – through the effective planning, implementation, and ongoing management of the project. To ensure this, it is recommended that RTIP develops and implements a procedure for identification, assessment and implementation of appropriate management responses to potential infringements on human rights, in order to strengthen the company's contribution to human rights protection.

24.6 Sustainability Recommendations

Sustainable management begins with individual industries minimizing the use and waste of raw materials and maximizing reuse and recycling.

Based on the assessment conducted in sections 24.4 and 24.5, the key areas of focus of the project in terms of sustainability, and therefore the ones for which measures are suggested with high priority, are:

- Community (Public participation);
- Water consumption; and
- GHG and energy efficiency

Recommended sustainability practices for RTIP are summarized Table 24-5. The aim of the proposed measures is to make the most advantage of natural resources while minimizing potential impacts. These measures should be considered as recommended measures complementary of measures suggested in Section 21 to enhance the sustainable performance of RTIP.

Table 24-5 Sustainability Practices Applicable to RTIP

Issue	Practices Recommended
Community *Priority Level: High*	- Develop a comprehensive stakeholder engagement plan in compliance with international standards as a long term project objective given that it is not viable from a cultural perspective to undertake this in the short term. This plan should consider, amongst other items, Stakeholder Analysis and Engagement Planning, External Communications, Dissemination of Information, Consultation, and the development of a Grievance Mechanism. - Design a Social Investment (SI)[3] programme through which external stakeholders could be benefited. The seven steps to consider before starting any SI programmes (IPIECA, 2008) are: o Step 1: Start planning early o Step 2: Understand the context o Step 3: Determine SI objectives and links to the business case o Step 4: Determine the operating principles that provide the overarching 'lens' through which SI decisions will be reviewed o Step 5: Link SI strategy to SI objectives! o Step 6: Align SI priorities with the oil and gas project development timeline o Step 7: Obtain early buy-in from the government and local communities - Develop a programme of training courses for the nearest communities focused on the skills necessary for developing the project activities. In order to maximise the benefits of this investment both for the community and for RTIP, the courses should focus on activities necessary for the operations phase, as it is the longest phase of the project. Invest in training development of specialised roles (e.g. to become a HSE representative), to help the community members become more competitive in the market.
Water Consumption *Priority Level: High*	- Adopt measures that avoid or reduce water usage so that the project's water consumption does not have significant adverse impacts on others. Minimize water consumption as much as possible, by training the workers in personal minimization and recycling practices (such as not allowing the water to flow whilst not in use, not throwing water away but where possible storing in drums for re-use, etc.); - Minimize water consumption related to construction activities; - Investigate additional opportunities for reusing water in operations during detailed design; - Assess additional technically and financially feasible water conservation measures within the project's operations.
GHG and Energy efficiency *Priority Level: High*	- Develop commissioning plan early in the project, issue with scope, initiate 'commissioning' communication at initiation of work scope (not at completion), schedule into overall work plan, and discuss/update at monthly meetings. Properly commissioned equipment has proven to improve life cycle costs for the operator by reducing maintenance, increasing equipment life, and reducing operating costs through energy efficiency - Adopt an energy management system as part of the EMS with the aim of increasing the complex energy efficiency, including annual reporting on energy efficiency improvement plans, an energy consumption reduction plan and participation in benchmarking activities - Analyse opportunities to integrate renewable energy options on building systems—heating, ventilating, and air-conditioning (HVAC) systems; lighting; and electrical technologies that support and must be integrated with the passive design in an efficient and appropriate manner.

[3] "*Social investment (SI) programmes are defined here as the voluntary contributions companies make to the communities and broader societies where they operate, with the objective of mutually benefiting external stakeholders, typically through the transfer of skills or resources, and the company*", IPECA, 2008.

Table 24-5 Sustainability Practices Applicable to RTIP

Issue	Practices Recommended
Biodiversity Conservation – Supply chain *Priority Level: Low*	- When there is the potential for natural and/or critical habitats to be significantly adversely impacted by the project's primary suppliers, the operator should give preference to purchasing from suppliers that can demonstrate that they are not significantly adversely impacting these areas.
Natural Resources *Priority Level: Low*	- Incorporate site disturbance and erosion control measures prior to rough grading. Management of the land protects adjoining community resources, minimizes impacts to the environment, and can prevent delays and additional costs for remedial actions later in the project work cycle. - Utilize electronic media and web based collaboration tool for the distribution of bid documents, and for the communication, documentation, and review of construction documentation throughout the project's duration. Save energy, cost, and resources (trees) normally expended in the transportation and reproduction of bid documents, proposal documents, contractor submittals, and other construction documentation. - Develop a procedure for continual improvement in consumption of energy, water, as well as other resources and material inputs, with a focus on areas that are considered core business activities. Such measures will integrate the principles of cleaner production into product design and production processes with the objective of conserving raw materials, energy, and water. Where benchmarking data are available, a comparison of efficiency can be made.
Wastes *Priority Level: Low*	- Implement a site recycling / waste management program to maximize reclaim/salvage of site materials. Divert a percentage of construction waste from landfill that can be recycled. The amount will be dependent upon the vendors' "materials" segregation process, which can be tracked from loading tickets. This too will present the EPC and operator as 'good corporate citizens' to the community, and will lower waste disposal fees. - Obtain chain of custody documentation of the final destination of hazardous wastes. If the waste management company does not comply with international standards, reduce waste sent to disposal sites and consider alternative disposal options, including the possibility of developing project own recovery and disposal facilities at the project site. - Industries should be encouraged to interact with each other; the waste stream of one industry provides a potential raw material for another. For example, composted sewage sludge can be used as fertiliser, and metals and salt can be extracted from the concentrated brine discharged by desalination plants.
Continuous Improvement *Priority Level: Low*	- Prepare and utilize a Sustainable Construction Log to capture efforts made during the life of the project to publicize and reward participants. Subsequent projects can utilize for 'lessons learned', documentation exists to substantiate benefits, data can be utilized to quantify impacts, and improve operator market position through leadership.
Sources: *CH2MHILL, 2011*	

24.7 Conclusions

A sustainable development assessment (SDA) for the RTIP complex has been performed through an analysis of how the sustainable development principles are integrated into both RTIP's EIA and the project itself.

The assessment of the three elements (environment, social, and economic aspects) reflects not only the way in which sustainable development principles are integrated within this EIA but also that project activities can be performed in a bearable, equitable and viable manner.

In addition to the KSA's national standards and guidelines, the RTIP design and management policy will incorporate the principles of sustainable development as laid down in Our Common Future (WCED, 1987).

The results of the EIA study have been the basis for the sustainability assessment of the project, though it has been complemented by an analysis of the deviation of this study with regards to sustainable development principles (intragenerational and intergenerational equity).

Based on the sustainability assessment of the EIA, the main area where additional focus is required with regards to sustainable development (largely due to cultural norms in the Kingdom) is related to Stakeholder Engagement (public information and participation). Additionally, further areas identified include the limitations of the social impact assessment, and resulting limitations in the integrated assessment of environmental, social and economic factors and associated mitigation measures largely owing to the indirect nature of engagement with the local population. There were also inherent limitations in the analysis of global impacts such as climate change (GHG emissions and therefore climate change were discussed in Section 12, but no comprehensive analysis of global impacts or implications was carried out as this was beyond the scope of the EIA), loss of biodiversity, or the depletion of water reserves.

To assess the sustainability of the RTIP, the confluence of the three elements of sustainable development throughout the project's lifecycle (design, construction and operation) were analyzed.

The sustainability concept has been addressed in RTIP from the early stage "the design phase", which has reduced the adverse impact of the project on the environment and community. Some examples of this are:

- Project location (industrial area remote from residential areas);
- Site location (proximity of existing infrastructure and common utilities);
- Feasibility studies involving environmental criteria (EIA, BAT analysis, air dispersion modelling, noise study, process hazards analysis); and
- Concept design (processing hydrocarbon products in the same country where it is extracted implies incomes from both upstream and downstream activities).

The project will create indirect and direct employment, benefits for the local economy through network suppliers, and the economic contribution that the Operator makes to the region through tax payments. Despite the economic and social benefits that the project will bring to the country, there are negative impacts that were evaluated to understand the implications of achieving these benefits, especially concerning the environment, the community, and on potential global impacts for both present and future generations.

As per Table 24-4, the results of the sustainability assessment of the RTIP project reveal insights into the overall impacts the project will have on local, national and international populations, and the duration of those impacts. One revealing finding is the lack of any impacts for which the effects are expected to exceed a decadal timeframe. It is however important to note in this case that climate change (a process with a duration which is thought to greatly exceed decades), no comprehensive analysis was undertaken of the potential impacts that could arise from the project's GHG emissions as this is generally outside the scope of an EIA. This is the same case as with impacts of an international extent, with the main impact identified being the use of foreign workers during the construction phase. Further to this, it was found that impacts on the physical environment (including air quality and the acoustic environment) were generally found to cover smaller extensions (local – provincial) and have durations ranging from years to decades. Impacts on the marine environment were found to range between a local and regional extent and to have a duration of from months to years. Finally, the impacts which were found to be most relevant to sustainability considerations were the impacts on society, as they covered the maximum extensions as well as lasting for decades.

The key areas where additional project focus is required identified by this assessment, in terms of sustainability, and the high priority ones for which measures are suggested which are:

- Community (direct public participation as a long term objective);
- Water consumption; and
- GHG and energy efficiency.

Recommended sustainability practices have been suggested for RTIP with the aim of making the most advantage of natural resources while minimizing potential impacts. These measures are provided as complementary measures for those suggested in Section 21 to enhance the sustainable performance of RTIP.

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26 GLOSSARY, ABBREVIATIONS & ACRONYMS

26.1. Glossary

Abiotic: Non-living, physical factors in the environment.

Acoustic Doppler Current Profiler: Sonar recorder for wave currents and velocities.

ANOVA: Statistical test of the evenness of groups of data.

Anthropogenic: Effects, processes or materials derived from human impacts or activities.

Benthic organisms: Organisms inhabiting the benthic zone – the lowest ecological zone at the lowest level of a body of water.

Biodiversity: the number, variety, and genetic variation of different organisms found within a specified geographic region

Biotic: Living aspects in the environment.

Biotope: area of uniform environmental conditions providing a living place for a specific assemblage of plants and animals. Biotope is almost synonymous with the term habitat, but while the subject of a habitat is a species or a population, the subject of a biotope is a biological community.

Chlorophyll-a: Green pigment in plants. In terms of water quality, chlorophyll-a is a measure of phytoplankton biomass in a body of water; low levels generally indicate good water quality conditions.

Diurnal: Daily.

Electrical Conductivity: The ability of a material, e.g. water, to conduct electricity. It is typically used as a measure of the dissolved salt content of water.

FOB (Free on Board): Common price term used in international trade. The seller is responsible for the cost of goods is to the point of loading it onto the ship or aircraft. The risk of loss of or damage to the goods is transferred from the seller to the buyer when the goods have been so delivered

Gas chromatograph: Analysis instrument for separating chemicals.

GDP (Gross Domestic Product): The total market value of all final goods and services produced in a country in a given year, equal to total consumer, investment and government spending, plus the value of exports, minus the value of imports.

Habitat: the area or natural environment in which an organism or population normally lives. A habitat is made up of physical factors such as soil, moisture, range of temperature, and availability of light as well as biotic factors such as the availability of food and the presence of predators. A habitat is not necessarily a geographic area for a parasitic organism it is the body of its host or even a cell within the host's body.

Halophytic (vegetation): any plant, especially a seed plant, which is able to grow in habitats excessively rich in salts, such as salt marshes, sea coasts, and saline or alkaline semideserts and steppes. These plants have special physiological adaptations that enable them to absorb water from soils and from seawater, which have solute concentrations that halophibics could not tolerate. Some halophytes are actually succulent, with a high water-storage capacity.

Intergenerational Equity: Equity applied across different generations. The idea behind not reducing the ability of future generations to meet their needs is that, although future generations might gain from economic progress, those gains might be more than offset by environmental deterioration.

Intragenerational Equity: Equity applied across communities and nations within one generation.

Mangrove: a tropical evergreen tree or shrub with intertwining aerial roots that forms dense thickets along coasts [older mangrow (changed through influence of grove), from Portuguese mangue]

pH: Measure of the acidity or alkalinity of a solution.

Phenols: A toxic chemical of limited solubility in water.

Photosynthetically Active Radiation: The range of light that organisms that photosynthesise are able to use in the process of photosynthesis.

Phytoplankton: Typically microscopic photosynthetic organisms drifting in the water column of oceans.

Polychlorinated biphenyl: A toxic chemical of low solubility in water typically used as coolants and insulating fluids.

Polycyclic aromatic hydrocarbons: A toxic chemical of low solubility in water, typically occurring in tar, oil and coal deposits.

Sabkha: saline sedimentary deposits with different surface features according to salt content and their nature. The sabkha is a closed depression with internal draining (i.e., a depression area with no natural drainage) where crystallised salt concentrates on the surface (or depressions where salts accumulate). Sabkhas are generally flat depressions with salts of different chemical compositions

Salinity: Salt content of a body of water.

Saltmarsh: low-lying wet land that is frequently flooded with saltwater

Sessile: Attached or established – in the marine environment: organisms with limited ability to move.

Total Petroleum Hydrocarbons: Chemical originating from crude oil that is toxic to marine organisms.

Zooplankton: Typically microscopic heterotrophic organisms drifting in the water column of oceans.

26.2. Abbreviations & Acronyms

ug/g	Milligrams per gram
μg/kg	Microgram Per Kilogram
μg/L	Microgram Per Litre
$\mu g/m^3$	Microgram Per Cubic Metre
3QTR	Third Quarter
AAQL	Ambient Air Quality Limits
AAQS	Ambient Air Quality Standards
AC	Archaeological and Cultural
ACGIH	American Conference of Governmental and Industrial Hygienists
A.D.	Anno Domini
ADCP	Acoustic Doppler Current Profiler
AEWA	African-Eurasian Waterbird Agreement
AIDS	Acquired Immunodeficiency Syndrome
ALOHA	Areal Locations of Hazardous Atmospheres
am	Ante Meridiem
Am^3/hr	Actual m^3 per hour
ANOVA	Analysis of Variance
ANSI	American National Institute
AQG	Air Quality Guideline
AQL	Air Quality Limit
AQMS	Air Quality Monitoring Station
AQS	Air Quality Standards
As	Arsenic
ASHTO	American Association Of State Highway And Transportation Officials
Ba	Barium

BACT	Best Available Control Technology
BASF	BASF, The Chemical Company
BAT	Best Available Techniques
BATNEEC	Best Available Technology Not Entailing Excessive Cost
bbl	Barrel
B.C.	Before Christ
BDL	Below Detection Limit
BDO	Butanediol
BGE	Butyl Glycol Ethers
BIF	Boilers and Industrials Furnaces
BOD	Biological Oxygen Demand
BOD	Basis of Design
BPD	Barrel Per Day
$Btu/ft^3/hr$	British thermal unit per cubic foot per hour
°C	Degree Celsius
CA	Chlor-Alkali
CBD	Convention on Biological Diversity
Cd	Cadmium
CDSI	Central Department of Statistics & Information. Ministry of Economy and Planning.
CEMS	Continuous Emission Monitoring Systems
CFCs	Chlorofluorocarbons
CFR	United States Code of Federal Register
CH_4	Methane
Chl-a.	Chlorophyll-a
CIA	Central Intelligence Agency (US)
CITES	Convention On International Trade In Endangered Species Of Wild Fauna And Flora
Cl	Chloride
cm	Cubic Meters
cm	Centimeter
cm/s	Centimeters per second
CMY	Container Storage and Marshalling Yard
CO	Carbon Monoxide
CO_2	Carbon Dioxide

CO_3	Carbonate
COD	Chemical Oxygen Demand
COP	Conference of the Parties
Cr	Chromium
CSD	Commission on Sustainable Development
Cu	Copper
dB	Decibel
dB(A)	A-Weighted decibel
DEQ	Louisiana Department of Environmental Quality
DIV	Dutch Intervention Value
DNT	Dinitrotoluene
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DOW	Dow Chemical Company
DRE	Destruction Removal Efficiency
DRO	Diesel Range Organics
EA	Each
EA	Ethyleneamines
EC	European Commission
ECC	Environmental Consent To Construct
ECD	Environmental Commission Department
EDCO	Environment Development Company
EEC	European Economic Community
EEMUA	Engineering Equipment & Materials Users Association: “Guide to the Use of Noise Procedure Specification”, 1985
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EMEA	Europe, the Middle East, and Africa
EMP	Environmental Management Plan
EMS	Environmental Management System
EO	Ethylene Oxide
EOA	Ethanolamines
EQ	Equalization
EPA	Environmental Protection Agency

EPC	Engineering, Procurement & Construction
EPFI	Equator Principles Financial Institution
EPO	Environment Permit To Operate
ERL	Effects Range Low
ERM	Effects Range Medium
ES	Environmental Standards
ESA	Environmental Site Assessment
ESI	Environmental Sensitivity Index
ESP	Electrostatic Precipitation
EU	European Union
EU BREF	European IPPC Bureau´s reference documents on Best Available Techniques
F	Frequency
FAO	Food and Agriculture Organization of the United Nations
FGD	Wet Flue Gas Desulfurisation
FOB	Free on Board
g/L	Grams per litre
GAOCMAO	Gulf Area Oil Companies Mutual Aid Organisation
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIIP	Good International Industrial Practice
GPS	Global Positioning System
GRO	Gasoline Range Organics
GSD	General Statistics Department
GTC	GTC Technology
h	Hour
ha	Hectare
Hg	Mercury
HAP	Hazardous Air Pollutants
HCU	Hydrogen Chloride Conversion
HDPE	High Density Polyethylene
HFCs	Hydrofluorocarbons
HFO	Heavy Fuel Oil

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HIV	Human Immunodeficiency Virus
HOC	Halogenated Organic Compounds
HVAC	Heating, ventilating, and air-conditioning systems
hrs	Hours
H_2S	Hydrogen Sulphide
H_2O_2	Hydrogen Peroxide
HSE	Health, Safety & Environment
HSES	Health Safety Environment And Security
i	Hydraulic Gradient
IBA	Important Bird Area
IBC	Intermediate Bulk Containers
IEA	International Energy Agency
IEEM	The Institute of Ecology & Environmental Management
IEMA	Institute of Environmental Management and Assessment
IFC	International Finance Corporation
IG	Industrial Gases
IGF	Induced Gas Flotation
IISD	International Institute for Sustainable Development
IMF	International Monetary Fund
ind.	Individuals
IPCC	Intergovernmental Panel on Climate Change
IPIECA	International Petroleum Industry Environmental Conservation Association
IPPC	Integrated Pollution Prevention & Control
ISBL	In Side Battery Limit
ISD	Industrial Security Department
ISQG	Canadian Interim Marine Sediment Quality Guideline
ISO	International Organization for Standardization
ISU	Internet Services Unit
IT	Information Technology
IUCN	International Union For Conservation Of Nature & Natural Resources
IWPP	Independent Water And Power Project
IWRM	Integrated Water Resource Management

IWTP	Industrial Wastewater Treatment Plant
JCP	Jubail Commercial Port
JIC	Jubail Industrial City
JIC II	Jubail Industrial City II
JMP	Jubail Management Procedures
JV	Joint Venture
K	Hydraulic Conductivity
kg	kilogrammes
km	Kilometre
Km/h	Kilometre per hour
kta	Kilo ton per annum
KACST	King Abdul Aziz City For Science And Technology
KFIP	King Fahd Industrial Port
KFUPM	King Fahd University of Petroleum and Minerals
KSA	Kingdom Of Saudi Arabia
KTPA	Kilo-Tonnes Per Annum
L_{eq}	Equivalent Noise Level
L_{min}	Minimum Noise Level
L_{max}	Maximum Noise Level
L_n	Percentile Noise Level
LDC	Less Developed Countries
LDPE	Low-Density Polyethylene
LEL	Lower Explosive Limit
LMDL	Laboratory Method of Detection Limit
LPG	Liquefied Petroleum Gas
LVOC	Large Volume petroleum-based Organic Chemicals
m	Metres
m^3/day	Cubic Metres Per Day
m/s	Metre Per Second
M	Magnitude
MA	Million Years
max	Maximum
mBGS	Metres Below Ground Surface
MBPSD	Million barrels per stream day

MCE	Ministerial Committee on Environment
MDGs	Millennium Development Goals
MEED	Middle East Economic Digest
MEPA	Meteorology and Environmental Protection Administration
METEOR	Most Effective Technology for Ethylene Oxide Reaction
MFC	Mixed Feed Cracker Unit
mg	milligram
mg/dscm	milligrams per dry standard cubic meter
mg/kg	Milligram Per Kilogram
mg/l	Milligram Per Litre
mg/m^3	Milligram Per Cubic Metre
MLSS	Mixed Liquor Suspended Solids
mm	Millimetre
MMBTU	Million British thermal units
mmgd	million gallon per day
MMSCFD	Million standard cubic feet per day
MMT	Million metric tons
MMTPA	Million Metric Tonne Per Annum
Mn	Manganese
MNB	Mononitrobenzene
MOH	Ministry Of Health
MOP	Meeting of Parties
MPN	Most Probable Number
m/s	Metre per second
MS	Microsoft
MSDS	Material Safety Data Sheets
MSW	Municipal Solid Waste
MT	Metric Ton
MT/hr	Metric Tonnes per hour
MW	Monitoring Well
N	Nitrogen
N	North
N_2O	Nitrous Oxide
NA or N/A	Not Applicable or Not Available

NAAQS	US EPA National Ambient Air Quality Standards
NaCl	Sodium Chloride
NCWCD	National Commission For Wildlife Conservation And Development
NGO	Non-Governmental Organization
NH_3	Nitrogen Ammonia
Ni	Nickel
NIOSH	National Institute for Occupational Safety and Health
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
NOAA	National Oceanic and Atmospheric Administration
NSDS	National Sustainable Development Strategy
NTU	Nephalometric Turbidity Unit
NW	Northwest
NWS	National Weather Service
O_2	Oxygen
O_3	Ozone
oC	Degrees Celsius
ODS	Ozone Depleting Substances
OECD	Organization for Economic Co-operation and Development
OEO	Osaimi Engineering Office
OHAP	Organic Hazardous Air Pollutant
OHSAS	Occupational Health and Safety Management Systems
OPEC	Organization Of The Petroleum Exporting Countries
OSBL	Outside Battery Limits
OSHA	Occupational Safety and Health Administration
OW	Observation Well
PACD	Plan Of Action To Combat Desertification
PAD	Paved Area Drainage
PAH	Polycyclic-Aromatic Hydrocarbons
PAOC	Potential Area of Concern
PAP	Permit Application Package
PAR	Photosynthetically Active Radiation
Pb	Lead
PCB	Polychlorinated Biphenyl

PD	Project Description
PDD	Power Distribution Department
PERSGA	Preservation Of The Environment Of The Red Sea And The Gulf Of Aden
PEMREF	Petromin-Mobil Yanbu Refinery Company Ltd
PE	Polyethylene
PEL	Probable Effects Level
PELs	Permissible Exposure Limits
PFCs	Perfluorocarbons
PG	Propylene Glycols
pm	Post Meridiem
PM	Particulate Matter
$PM_{2.5}$	Particulate matter with a diameter of 2.5 micrometers or less
PM10	Particulate matter with a diameter of 10 micrometers or less
PMDI	Polymeric Methylene Diphenyl Di-isocyanate
PMC	Project Management Contractor
PME	Presidency of Meteorology and The Environment (Ex- MEPA: Meteorology And Environmental Protection Administration)
PMT	Project Management Team Accommodation
PNMS	Plant Noise Modelling System
PO	Propylene Oxide
PPE	Personal Protective Equipment
ppm	Parts Per Million
PSD	Prevention Of Significant Deterioration
psu	Practical salinity units
PSV	Pressure Safety Value
QA/QC	Quality Assurance / Quality Control
RC	Royal Commission
RCER	Royal Commission On Environmental Regulations
RCJY	Royal Commission Of Jubail And Yanbu
RGME	Rashid Geotechnical & Material Engineers
ROPME	Regional Organisation For The Protection Of The Marine Environment
RRC	Regulatory Control and Compliance
RTA	Road Traffic Accident
ROG	Reactive Organic Gas

S	South
SA	Saudi Aramco
SABIC	Saudi Basic Industries Corporation
Sal.	Salinity
SAMA	Saudi Arabian Monetary Agency
SAMIRAD	Saudi Arabia Market Information Resource and Directory
SAPTACO	Saudi Public Transport Company
SCC	Saudi Cement Company
SCECO	Saudi Consolidated Electricity Company
SCT	Supreme Commission For Tourism
SDA	Sustainable Development Assessment
SDS	Surface Drainage Systems
SD&L	Site Development and Logistics
SE	Standard Error
SEC	Saudi Electricity Company
SEW	Saudi Environmental Works LTd
SF_6	Sulphur Hexafluoride
SI	Social Investment
SO_2	Sulphur Dioxide
SO_4	Sulphate
SOLAS	International Convention For Safety Of Life At Sea
SPD	Sustainable Product Development
SRB	Surface Retention Basin
SRBs	Surface Runoff Basins
SRO	Surface Runoff
STD	Sexually Transmitted Disease
SWTP	Sanitary Wastewater Treatment Plant
TCEQ	Texas Commission On Environmental Quality
TCLP	Toxicity Characteristics Leachate Procedure
TDA	Toluene Diamine
TDI	Toluene Di-isocyanate
TDS	Total Dissolved Solids
Temp.	Temperature
TH	Total Hydrogen

THC	Total Hydrocarbons
Ti	Titanium
TI&D	Truck Inspection and Dispatch
TLV	Threshold Limit Value
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
TTU	Thermal Treatment Unit
TWA	Time Weighted Average
UAE	United Arab Emirates
UEL	Upper Explosive Limit
UER	Umm Er Radhuma Aquifer
UK	United Kingdom
um/s/m2	Micrometers per second per square meter
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference On Environment & Development
UNCLOS	United Nations Convention On The Law Of The Sea
UNDES	United Nations Department of Economic and Social affairs
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific And Cultural Organisation
UNFAO	United Nations Food & Agricultural Organisation
UNFCCC	United Nations Framework Convention On Climate Change
US	United States
USDoS	United States Department of State
USEPA	United States Environmental Protection Agency
UST	Underground Storage Tanks
UTM	Universal Transverse Mercator
VOC	Volatile Organic Compounds
WAS	Waste Activated Sludge
WB	World Bank
WC	World Commission

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WCED	World Commission on Environment and Development
WGS 84	World Geodetic System 1984
WHO	World Health Organization
WSSD	World Summit On Sustainable Development
wt	weight
WTP	Waste Treatment Plant
WMP	Waste Management Plan
WWT	Waste Water Treatment
WWTP	Wastewater Treatment Plant
Zn	Zinc
Φ	Porosity

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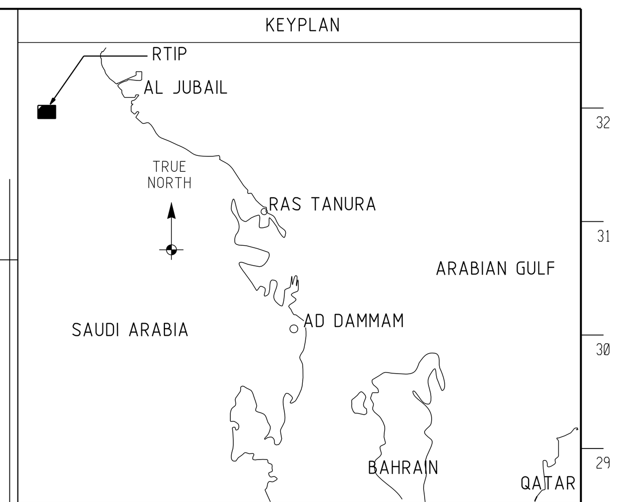
KEYPLAN



ASSUMPTIONS

1. POWER, SEAWATER & PIPELINES WILL ENTER THE SITE FROM THE CORRIDOR NORTH OF SITE.
2. PREVAILING WIND IS FROM PLANT NORTH.
3. THERE ARE NO SURROUNDING FACILITIES AFFECTING THE SITE LOCATION.
4. RAIL LINK COMES FROM THE NORTH AND ENTERS THE SITE FROM THE CORRIDOR TO THE EAST OF SITE.

AREAS/UNITS UNDER DEVELOPMENT

1. OVERALL SIZE OF THE FOLLOWING UNITS/AREAS NEEDS TO BE CONFIRMED.
   A) DELETED.
   B) SEAWATER INLET.
   C) WASTE WATER TREATMENT.
   D) ELECTRICAL DISTRIBUTION.
   E) AROMATICS.
   F) DELETED .
   G) DELETED.
   H) INDUSTRIAL GASES
2. DELETED.
3. DELETED.
4. DELETED.
5. LPP 12.2 STUDIES ARE TO BE COMPLETED.
6. DELETED
7. DELETED
8. DELETED.
9. SECURITY REQUIREMENTS TO BE AGREED.
10. DELETED.
11. EMERGENCY EGRESS AND MUSTER AREAS TO BE DEVELOPED.

LEGEND

REMOTE DISTRIBUTION SUBSTATION
ELECTRICAL SWITCHING STATION
ENVELOPE BOUNDARY
FENCE LINE

REFERENCE DRAWINGS

DRAWING NUMBER	DESCRIPTION
A554-F-PRG-PI-DWG-PLP-001	RTIP OVERALL PLOT PLAN
A554-F-PRG-PI-DWG-PLP-003	RTIP PORT FACILITIES CONCEPTUAL PLOT PLAN
A554-F-PRG-PI-DWG-PLP-010	RTIP OVERALL PLOT PLAN FOR CONTRACTOR SCOPE OF WORK
A554-F-PRG-PI-DWG-PLP-012	RTIP SITE PLAN - NORTH WEST
A554-F-PRG-PI-DWG-PLP-013	RTIP SITE PLAN - CENTER WEST
A554-F-PRG-PI-DWG-PLP-014	RTIP SITE PLAN - SOUTH WEST
A554-F-PRG-PI-DWG-PLP-016	RTIP SITE PLAN - NORTH EAST
A554-F-PRG-PI-DWG-PLP-017	RTIP SITE PLAN - CENTER EAST
A554-F-PRG-PI-DWG-PLP-018	RTIP SITE PLAN - SOUTH EAST
A554-F-PRG-PI-DWG-PLP-024	RTIP MAIN OSBL PIPERACK PLAN
A554-F-PRG-PI-DWG-PLP-025	RTIP MAIN OSBL STREET/ AVENUE NAMING PLAN
A554-F-700-PI-DWG-POB-001	RTIP SITE PLAN - KEY PLAN

APPROVED FOR DESIGN

REV	DATE	DISCIPLINE	SIGNATURE
		PIPING	
		PROJECT	
		PROCESS	
		COMMISSIONING	
		SAFETY	
		CONSTRUCTION	

CONTRACT NO. 39807 — DOC CLASS 2
FW DSN 22416 — FW REV JA1

NOTES:
1. THE LOCAL COORDINATE SYSTEM SHALL BE BASED UPON THE MADINAT AL-JUBAIL AL-SANIYAH PLAN GRID, ALSO REFERRED TO AS ROYAL COMMISSION COORDINATES AND DATUM GRID (RCCDG).
2. ALL COORDINATES AND ELEVATIONS ARE IN METERS, ELEVATIONS ARE BASED ON ROYAL COMMISSION DATUM (RCD) PLUS 100.000.
   EXAMPLE: ROYAL COMMISSION EL.+13.200 = RTIP PLANT EL.+113.200.
3. RTIP SITE COORDINATES E.50980.000, N.40913.870, EL.113.200 ARE EQUIVALENT TO THE UTM COORDINATES, E.349399.536, N.2978535.873, EL.TBC.
4. DRAWING;- 202-030-20UC-CE-002 REV 2, HAS BEEN USED FOR COORDINATES, CORRIDOR AND PLOT DIMENSION INFORMATION.
5. AS PER THE LATEST SEC REQUIREMENTS ALL PROCESS PLANTS ARE NOW CLASS 1 AND REMAINING UNITS ARE CLASS 3 AND 4.

REV. MARK	REVISION	BY	CHK	APP	DATE
J	ISSUED FOR DESIGN (FW REV JA1)	RRD	RD	JW	17/12/10
H	REISSUED FOR COMMENT (FW REV J03)	STK	RD	BG	16/09/10
G	ISSUED FOR COMMENT (FW REV 02) (SITE HAS BEEN RELOCATED TO AL JUBAIL INDUSTRIAL AREA)	RG	RD	JW	02/07/10
F	COMMENCEMENT OF FEED	RG	RD	JW	10/08/09
E	IFD - ISSUED FOR FEED (A554-RFV-PRG-010) (BY KBR)	PG	JS	JW	2/20/09

		DATE
DESIGNED	C. SHACKELL	
DRAWN	R. DE GUZMAN	
CHECKED	R. DONNISON	
APPROVED	J. WELCH	
PROJ. ENGR.	W. KELMAN	
PROJ.MGR.		

Ras Tanura
INTEGRATED PROJECT

CONTAINS CONFIDENTIAL INFORMATION OF BOTH DOW AND SAUDI ARAMCO

TITLE:
RAS TANURA INTEGRATED PROJECT
CONCEPTUAL PLOT PLAN

PROJECT NO. A554 — SCALE 1 : 7500
DRAWING NO. A554-F-PRG-PI-DWG-PLP-002 — SHEET NO. — REV J

BORDER A0 - 841X1189

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FIGURE 5-2
RTIP BOREHOLE AND MONITORING WELL LOCATIONS

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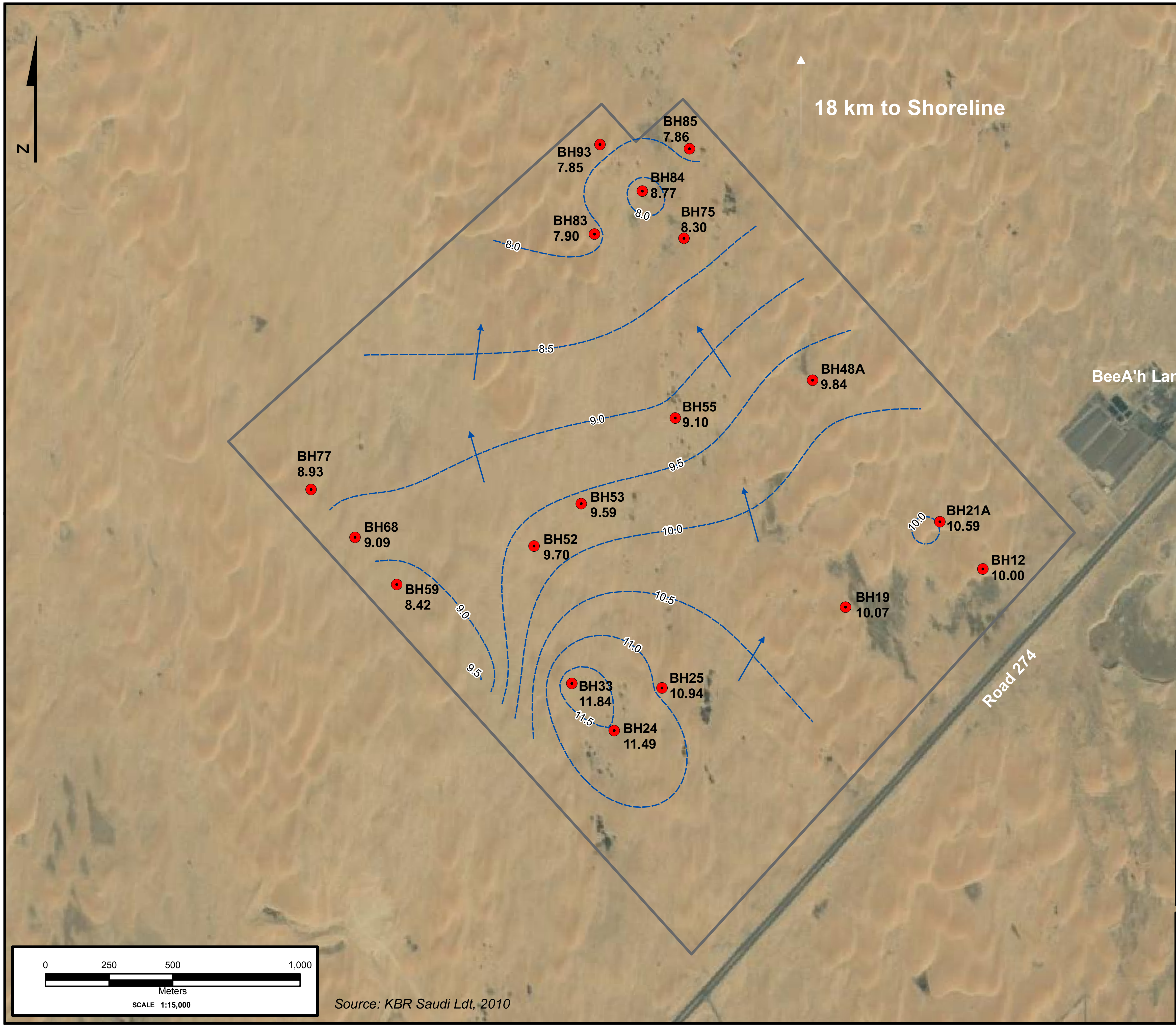

FIGURE 5-4

RTIP GROUNDWATER ELEVATION AND FLOW DIRECTION

(October 2010)

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APPENDIX B

DATA FOR VEGETATION QUADRATS

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Appendix B Data for Vegetation Quadrants

Notes:
Full details of the recording method and categories used are given in the ecological baseline chapter. Locations of quadrats are shown in Figure 6.4. All quadrats measured 10 x 10m.

'Grass' refers to perennial tussock grasses, most of which is presumed to be *Panicum turgidum* or *Pennisetum divisum*. '*Salsola*' may also include *Haloxylon salicornicum*.

QUADRAT 1

Date: 4/11/2010 **Easting (UTM):** 39R 0350131 **Northing (UTM):** 2980416

General notes for the vegetation stand:

Habitat and vegetation: Young and small grasses on a level ground of sandy soil. **Human impact:** Some rubbish present at the sides of the area. **Signs of grazing:** None.

Quadrat data:

Substrate: .... Sandy
Degree of soil compaction:.. Loose
Topography:.. Nearly flat
Perennial cover: 10–15%
Height: 20–30cm
Dominant species: .... grasses, young (30 clumps)

Photo 1: Centre of Quadrat 1 Facing East

QUADRAT 2

Date: 4/11/2010 **Easting (UTM):** 39R 0350387 **Northing (UTM):** 2979530

General notes for the vegetation stand:

Habitat and vegetation: Sandy mounds formed around grasses and *Salsola* forming mounds spaced about 3m apart, 1–2m in diameter, with a height of 80cm. The quadrat is about 40 metres away from the highway. **Human impact:** Car tracks and rubbish present. **Signs of grazing:** None.

Quadrat data:

Substrate: .... Sandy
Degree of soil compaction: .... Loose
Topography: .... Undulating
Perennial cover: 10–15%
Height: 70–80cm
Dominant species: .... grasses (*Panicum*) (10 clumps)
Co-dominant species: .... *Salsola* (3 clumps)

Photo 2: Centre of Quadrat 2

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Photo 3: A General View from Quadrat 2 Southeastwards towards the Highway

QUADRAT 3

Date: 4/11/2010 **Easting (UTM):** 39R 0349473 **Northing (UTM):** 2979610

General notes for the vegetation stand:

Habitat and vegetation: The quadrat is situated on relatively low land in relation to the surroundings, *Salsola* clumps on dunes with about 25% cover; there are about ten palm trees to the east of the quadrat. There are no large mounds compared to quadrat 2 area. **Human impact:** Many car tracks present, more than 20 spent bullets present, indicating there may have been hunting activities practiced in the area at some time. **Signs of grazing:** Grazed by goats, droppings present.

Quadrat data:

Substrate:.. Sandy
Degree of soil compaction:.. Loose
Topography:... Somewhat undulating
Perennial cover:.. 20–25%
Height:... 30–40cm
Dominant species:... *Salsola* (11 clumps)

Photo 4: Quadrat 3, facing towards southeast; the Centre of the Quadrat is to the Right of the Photo.

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QUADRAT 4

Date: 4/11/2010 **Easting (UTM):** 39R 0349484 **Northing (UTM):** 2979728

General notes for the vegetation stand:

Habitat and vegetation: This area is severely grazed and the overall condition of the vegetation is deteriorating. Grass is dominant, four clumps of 40cm diameter present and only one clump of *Salsola*. **Human impact:** Car tracks present. **Signs of grazing:** To the east of the quadrat there is a large bush of severely grazed *Lycium shawii* about 2.5 metres in height and 2.5 m width. This shows that the area is heavily grazed.

Quadrat data:

Substrate: .... Sandy
Degree of soil compaction: .... Loose
Topography: .... Undulating
Perennial cover: 10%
Height: 30–40cm
Dominant species: .... grasses (*Panicum*) 4 clumps
Co-dominant species: .... *Salsola* (1 clump)

Photo 5: Centre of Quadrat 4

Photo 6: Severely Grazed Lycium shawii Bush, to the Right of Quadrat 4

QUADRAT 5

Date: 4/11/2010 **Easting (UTM):** 39R 0349551 **Northing (UTM):** 2979714

General notes for the vegetation stand:

Habitat and vegetation: Sandy mounds formed around *Salsola* with a diameter of 1m and a spacing of about 3–4m. **Human impact:** Car tracks present, rubbish present. **Signs of grazing:** Goat droppings seen.

Quadrat data:

Substrate: .... Sandy
Degree of soil compaction: .... Loose
Topography: .... Gently undulating
Perennial cover: 15–20%
Height: 20–30cm
Dominant species: .... *Salsola* (7 clumps)

Photo 7: General view of Quadrat 5 area

QUADRAT 6

Date: 4/11/2010 **Easting (UTM):** 39R 0350377 **Northing (UTM):** 2979511

General notes for the vegetation stand:

Habitat and vegetation: The area is an extension of quadrat No.1 area with young and small grasses on a level ground of sandy soil, with a spacing of 1m. **Human impact:** Rubbish present. **Signs of grazing:** None.

Quadrat data:

Substrate: .... Sandy
Degree of soil compaction:.. Loose
Topography:.. Nearly flat
Perennial cover: 30–40%
Height: 10–20cm
Dominant species: .... grasses, small (50 clumps)

Photo 8: General view towards the Northeast from the Centre of Quadrat 6

QUADRAT 7

Date: 5/11/2010 **Easting (UTM):** 39R 0348856 **Northing (UTM):** 2979298

General notes for the vegetation stand:

Habitat and vegetation: Sandy mounds formed around vegetation, with a size of 1–2m and a spacing of 4–5m. **Human impact:** Car tracks present, rubbish present. **Signs of grazing:** Goat droppings present.

Quadrat data:

Substrate: .... Sandy
Degree of soil compaction: .... Loose
Topography: .... Undulating
Perennial cover: 5–10%
Height: 40–50cm
Dominant species: .... *Salsola* (5 clumps)

Photo 9: Entering the RTIP Site from the Southwestern Border to Quadrat 7

Photo 10: Centre of Quadrat 7

QUADRAT 8

Date: 5/11/2010 **Easting (UTM):** 39R 0349039 **Northing (UTM):** 2979313

General notes for the vegetation stand:

Habitat and vegetation: Palm trees dominate the quadrat site, average height of palm is about 3.5m and *Lycium* c.80cm. Spacing is around 3–4m. Signs of reptile presence seen. **Human impact:** Car tracks present. **Signs of grazing:** Goat droppings present.

Quadrat data:

Substrate: .... Sandy
Degree of soil compaction: .... Loose
Topography: .... Undulating
Perennial cover: 10–15%
Height: 20–30cm
Dominant species: .... *Phoenix dactylifera* (4)
Co-dominant species: .... grasses (3 clumps)
.... *Salsola* (3 clumps)
.... *Lycium shawii* (1)

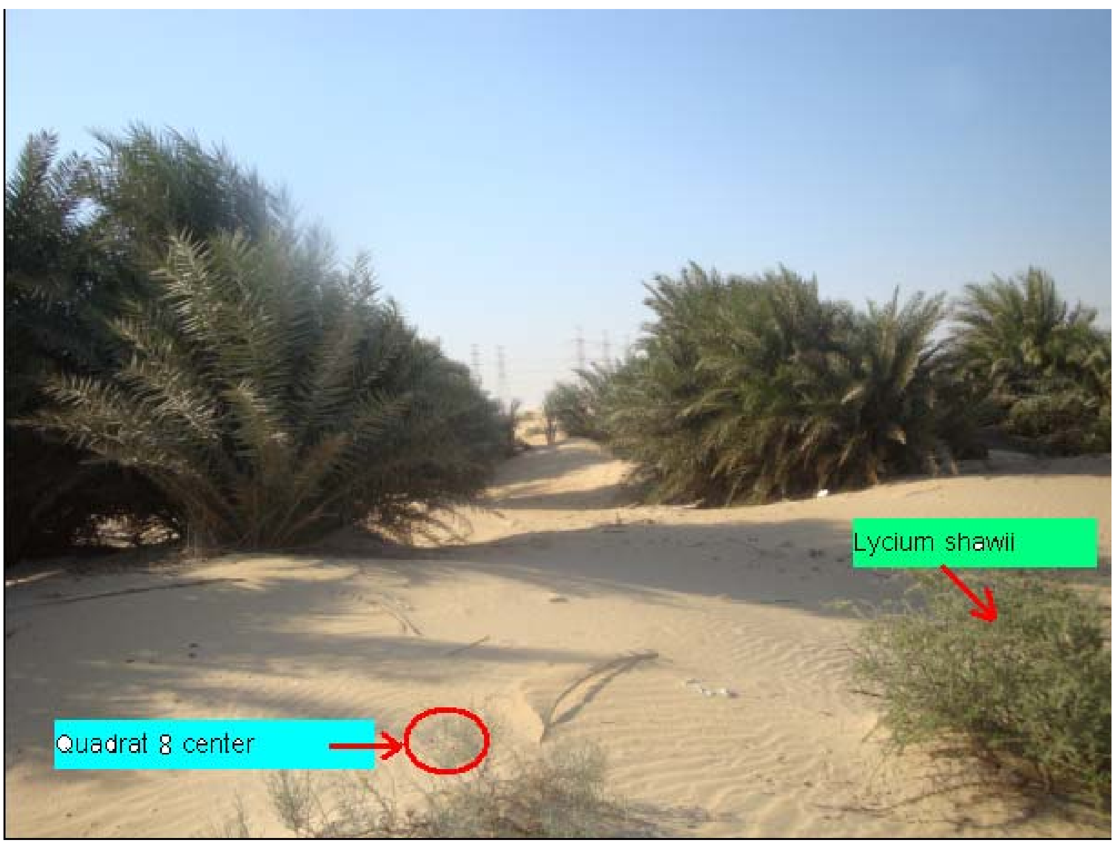

Photo 11: View northwest from Quadrat 8

Photo 12: General View of the Site, Westwards from Quadrat 8

QUADRAT 9

Date: 5/11/2010 **Easting (UTM):** 39R 0349067 **Northing (UTM):** 2979347

General notes for the vegetation stand:

Habitat and vegetation: Sandy mounds formed around grasses with a size of 30–40cm and spacing of 2–3m. **Human impact:** Car tracks present, rubbish present. **Signs of grazing:** Yes.

Quadrat data:

Substrate:..Sandy
Degree of soil compaction:...Loose
Topography:..Gently sloping toward the west
Perennial cover:..15–20%
Height:..40–50cm
Dominant species:..grasses (13 clumps)
Co-dominant species:..*Salsola* (3 clumps)

Photo 13: Quadrat 9, View Westwards

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QUADRAT 10

Date: 5/11/2010 **Easting (UTM):** 39R 0349033 **Northing (UTM):** 2979584

General notes for the vegetation stand:
Habitat and vegetation: Sandy mounds formed around vegetation with a spacing of 2–3m. **Human impact:** Car tracks present. **Signs of grazing:** Goat droppings present.

Quadrat data:
Substrate: .... Sandy
Degree of soil compaction: .... Loose
Topography: .... Sloping towards the west
Perennial cover: 15–20%
Height: 30–40cm
Dominant species: .... grasses (15 clumps)
Co-dominant species: .... *Salsola* (3 clumps)

Photo 14: Centre of Quadrat 10

QUADRAT 11

Date: 5/11/2010 **Easting (UTM):** 39R 0348994 **Northing (UTM):** 2979736

General notes for the vegetation stand:
Habitat and vegetation: Sandy mounds formed around *Salsola*, with a spacing of 2–3m. **Human impact:** Car tracks present, rubbish present. **Signs of grazing:** Goat droppings present.

Quadrat data:
Substrate: .... Sandy
Degree of soil compaction:.. Loose
Topography:... Undulating
Perennial cover: 10–15%
Height: 30–40cm
Dominant species: .... *Salsola* (11 clumps)

Photo 15: Centre of Quadrat 11

QUADRAT 12

Date: 5/11/2010 **Easting (UTM):** 39R 0349008 **Northing (UTM):** 2979885

General notes for the vegetation stand:

Habitat and vegetation: Sandy mounds formed around *Salsola* vegetation with a spacing of 3–4m. The vegetation has started to deteriorate. **Human impact:** Car tracks present. **Signs of grazing:** Goat droppings present.

Quadrat data:

Substrate: .... Sandy
Degree of soil compaction: .... Loose
Topography: .... Undulating
Perennial cover: 10–15%
Height: 30–40cm
Dominant species: .... *Salsola* (8 clumps)

Photo 16: Quadrat 12, General View

QUADRAT 13

Date: 5/11/2010 **Easting (UTM):** 39R 0348996 **Northing (UTM):** 2980031

General notes for the vegetation stand:

Habitat and vegetation: Sandy mounds formed around *Salsola* with a spacing of 2–4m. Vegetation deterioration in percentage cover towards the east was obvious. **Human impact:** Car tracks present, rubbish present. **Signs of grazing:** Goat droppings present.

Quadrat data:

Substrate: .... Sandy
Degree of soil compaction: .... Loose
Topography: .... Undulating
Perennial cover: 5–10%
Height: 20–30cm
Dominant species: .... *Salsola* (13 clumps)

Photo 17: Centre of Quadrat 13

QUADRAT 14

Date: 5/11/2010 **Easting (UTM):** 39R 0348990 **Northing (UTM):** 2980162

General notes for the vegetation stand:
Habitat and vegetation: Sandy mounds formed around *Salsola* with a spacing of 2–4m. **Human impact:** Car tracks present. **Signs of grazing:** Goat droppings present.

Quadrat data:
Substrate: .... Sandy
Degree of soil compaction: .... Loose
Topography: .... Sloping towards the east
Perennial cover: 10–15%
Height: 20–30cm
Dominant species: .... *Salsola* (10 clumps)

Photo 18: Quadrat 14, General View

QUADRAT 15

Date: 5/11/2010 **Easting (UTM):** 39R 0349204 **Northing (UTM):** 2980046

General notes for the vegetation stand:

Habitat and vegetation: Sandy mounds formed around vegetation with a spacing of 2–1m. There is a pond to the east of the centre of the quadrat, this represents the lowest part of the whole area. **Human impact:** Car tracks present, rubbish present. **Signs of grazing:** not noted.

Quadrat data:

Substrate:.. Sandy
Degree of soil compaction:... Loose
Topography:... Undulating
Perennial cover:.. 10–15%
Height:.. 20–30cm
Dominant species:... grasses (13 clumps)
Co-dominant species:... *Salsola* (2 clumps)

Photo 19: Centre of Quadrat 15

Photo 20: General View from Quadrat 15 Eastwards

Photo 21: Quadrat 15, General View

Photo 22: The Pond near Quadrat 15

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APPENDIX C

NOISE

APPENDIX C.1. LONG TERM NOISE MONITORING RESULTS

The following tables summarize the L_{eq} hourly, L_{eq} (24h), L_{eq} (72h), and the LA_{Max} for each long term noise monitoring locations.

Long Term Noise Levels Hourly Measurements, Location1			
Date	**Start Time**	**dB (A) L_{eq}**	**dB (A) LA_{Max}**
04/11/2010	15:00	50	75
04/11/2010	16:00	48	57
04/11/2010	17:00	48	62
04/11/2010	18:00	54	88
04/11/2010	19:00	48	61
04/11/2010	20:00	47	52
04/11/2010	21:00	53	87
04/11/2010	22:00	46	52
04/11/2010	23:00	46	50
05/11/2010	00:00	46	71
05/11/2010	01:00	44	54
05/11/2010	02:00	44	58
05/11/2010	03:00	45	53
05/11/2010	04:00	43	50
05/11/2010	05:00	45	58
05/11/2010	06:00	50	90
05/11/2010	07:00	52	67
05/11/2010	08:00	52	69
05/11/2010	09:00	48	71
05/11/2010	10:00	53	84
05/11/2010	11:00	50	85
05/11/2010	12:00	50	72
05/11/2010	13:00	50	72
05/11/2010	14:00	49	71
Leq (24 h): 49dB(A)			
05/11/2010	15:00	48	83
05/11/2010	16:00	57	83
05/11/2010	17:00	47	84
05/11/2010	18:00	46	72
05/11/2010	19:00	55	94
05/11/2010	20:00	48	69
05/11/2010	21:00	48	59
05/11/2010	22:00	52	93
05/11/2010	23:00	46	55
06/11/2010	00:00	46	56

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Long Term Noise Levels Hourly Measurements, Location1			
Date	**Start Time**	**dB (A) L_{eq}**	**dB (A) LA_{Max}**
06/11/2010	01:00	45	53
06/11/2010	02:00	43	60
06/11/2010	03:00	41	47
06/11/2010	04:00	40	45
06/11/2010	05:00	42	63
06/11/2010	06:00	55	98
06/11/2010	07:00	52	73
06/11/2010	08:00	53	85
06/11/2010	09:00	49	65
06/11/2010	10:00	47	76
06/11/2010	11:00	48	72
06/11/2010	12:00	46	66
06/11/2010	13:00	45	81
06/11/2010	14:00	45	58
Leq (24 h): 50 dB(A)			
06/11/2010	15:00	47	73
06/11/2010	16:00	47	79
06/11/2010	17:00	47	70
06/11/2010	18:00	50	82
06/11/2010	19:00	46	54
06/11/2010	20:00	48	66
06/11/2010	21:00	47	79
06/11/2010	22:00	46	59
06/11/2010	23:00	44	55
07/11/2010	00:00	45	56
07/11/2010	01:00	46	60
07/11/2010	02:00	46	59
07/11/2010	03:00	45	57
07/11/2010	04:00	45	57
07/11/2010	05:00	47	55
07/11/2010	06:00	53	88
07/11/2010	07:00	56	81
07/11/2010	08:00	54	69
07/11/2010	09:00	51	62
07/11/2010	10:00	46	76
07/11/2010	11:00	45	60
07/11/2010	12:00	44	76
07/11/2010	13:00	48	74
Leq (23 h): 49 dB(A)			
Overall Leq: 50 dB(A)			

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Long Term Noise Levels Hourly Measurements, Location1

Date	Start Time	dB (A) L_{eq}	dB (A) LA_{Max}

Notes:
Coordinates (WGS 1984 UTM Zone 39N):
X: 350683 Y: 2980431

Source:
CH2M HILL based on field measurements performed between November 4th and 7th 2010

Long Term Noise Levels Hourly Measurements, Location2			
Date	**Start Time**	**dB (A) L_{eq}**	**dB (A) LA_{Max}**
05/11/2010	9:00	49	65
05/11/2010	10:00	49	63
05/11/2010	11:00	48	60
05/11/2010	12:00	47	58
05/11/2010	13:00	47	58
05/11/2010	14:00	48	58
05/11/2010	15:00	48	64
05/11/2010	16:00	42	62
05/11/2010	17:00	43	64
05/11/2010	18:00	45	60
05/11/2010	19:00	46	51
05/11/2010	20:00	46	57
05/11/2010	21:00	46	57
05/11/2010	22:00	46	50
05/11/2010	23:00	45	52
06/11/2010	0:00	44	53
06/11/2010	1:00	44	51
06/11/2010	2:00	44	52
06/11/2010	3:00	44	52
06/11/2010	4:00	44	49
06/11/2010	5:00	48	72
06/11/2010	6:00	52	69
06/11/2010	7:00	53	73
06/11/2010	8:00	52	75
Leq (24 h): 48 dB(A)			
06/11/2010	9:00	52	70
06/11/2010	10:00	53	71
06/11/2010	11:00	51	74
06/11/2010	12:00	49	68
06/11/2010	13:00	51	65
06/11/2010	14:00	52	72
06/11/2010	15:00	53	70
06/11/2010	16:00	54	76
06/11/2010	17:00	52	71
06/11/2010	18:00	51	61
06/11/2010	19:00	49	59
06/11/2010	20:00	48	70
06/11/2010	21:00	48	54
06/11/2010	22:00	47	58
06/11/2010	23:00	44	49

Long Term Noise Levels Hourly Measurements, Location2			
Date	**Start Time**	**dB (A) L_{eq}**	**dB (A) LA_{Max}**
07/11/2010	0:00	44	50
07/11/2010	1:00	45	51
07/11/2010	2:00	45	51
07/11/2010	3:00	45	52
07/11/2010	4:00	45	49
07/11/2010	5:00	47	67
07/11/2010	6:00	53	61
07/11/2010	7:00	55	75
07/11/2010	8:00	52	73
Leq (24 h): 51 dB(A)			
07/11/2010	9:00	52	72
07/11/2010	10:00	52	77
07/11/2010	11:00	50	76
07/11/2010	12:00	50	77
07/11/2010	13:00	51	71
07/11/2010	14:00	51	72
07/11/2010	15:00	53	75
07/11/2010	16:00	54	72
07/11/2010	17:00	51	73
07/11/2010	18:00	51	60
07/11/2010	19:00	49	59
07/11/2010	20:00	46	53
07/11/2010	21:00	46	60
07/11/2010	22:00	45	51
07/11/2010	23:00	43	49
08/11/2010	0:00	43	47
08/11/2010	1:00	43	48
08/11/2010	2:00	43	48
08/11/2010	3:00	44	49
08/11/2010	4:00	46	54
08/11/2010	5:00	47	66
08/11/2010	6:00	52	71
08/11/2010	7:00	54	73
08/11/2010	8:00	51	69
Leq (24 h): 50 dB(A)			
Overall Leq : 50 dB(A)			
Notes: *Coordinates (WGS 1984 UTM Zone 39N):* *X:* 349583 *Y:* 2981605 *Source:* *CH2M HILL based on field measurements performed between*			

Long Term Noise Levels Hourly Measurements, Location2			
Date	**Start Time**	**dB (A) L_{eq}**	**dB (A) LA_{Max}**
November 5th and 8th 2010			

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Long Term Noise Levels Hourly Measurements, Location 3			
Date	**Start Time**	**dB (A) L_{eq}**	**dB LA_{Max}**
04/11/2010	16:00	52	75
04/11/2010	17:00	53	73
04/11/2010	18:00	51	71
04/11/2010	19:00	52	82
04/11/2010	20:00	51	62
04/11/2010	21:00	51	70
04/11/2010	22:00	50	68
04/11/2010	23:00	49	77
05/11/2010	0:00	45	62
05/11/2010	1:00	45	72
05/11/2010	2:00	44	55
05/11/2010	3:00	43	56
05/11/2010	4:00	43	60
05/11/2010	5:00	45	57
05/11/2010	6:00	49	68
05/11/2010	7:00	54	85
05/11/2010	8:00	53	66
05/11/2010	9:00	51	79
05/11/2010	10:00	51	88
05/11/2010	11:00	53	83
05/11/2010	12:00	56	76
05/11/2010	13:00	55	73
05/11/2010	14:00	54	69
05/11/2010	15:00	53	71
Leq (24 h): 52 dB(A)			
05/11/2010	16:00	51	71
05/11/2010	17:00	49	77
05/11/2010	18:00	47	60
05/11/2010	19:00	49	63
05/11/2010	20:00	48	64
05/11/2010	21:00	48	73
05/11/2010	22:00	48	74
05/11/2010	23:00	45	65
06/11/2010	0:00	46	77
06/11/2010	1:00	45	75
06/11/2010	2:00	43	53
06/11/2010	3:00	42	49
06/11/2010	4:00	43	54
06/11/2010	5:00	44	62
06/11/2010	6:00	47	58

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Long Term Noise Levels Hourly Measurements, Location 3			
Date	**Start Time**	**dB (A) L_{eq}**	**dB LA_{Max}**
06/11/2010	7:00	55	78
06/11/2010	8:00	56	80
06/11/2010	9:00	57	77
06/11/2010	10:00	53	73
06/11/2010	11:00	51	75
06/11/2010	12:00	45	62
06/11/2010	13:00	48	66
06/11/2010	14:00	50	73
06/11/2010	15:00	51	66
Leq (24 h): 50 dB(A)			
06/11/2010	16:00	53	79
06/11/2010	17:00	51	65
06/11/2010	18:00	50	62
06/11/2010	19:00	51	57
06/11/2010	20:00	52	63
06/11/2010	21:00	49	58
06/11/2010	22:00	49	62
06/11/2010	23:00	46	60
07/11/2010	0:00	46	59
07/11/2010	1:00	46	58
07/11/2010	2:00	46	53
07/11/2010	3:00	46	59
07/11/2010	4:00	45	57
07/11/2010	5:00	49	55
07/11/2010	6:00	51	63
07/11/2010	7:00	55	71
07/11/2010	8:00	58	78
07/11/2010	9:00	54	70
07/11/2010	10:00	52	73
07/11/2010	11:00	50	74
07/11/2010	12:00	44	55
07/11/2010	13:00	46	64
07/11/2010	14:00	50	69
07/11/2010	15:00	48	61
Leq (24 h): 51 dB(A)			
Overall Leq: 51 dB(A)			
Notes: *Coordinates (WGS 1984 UTM Zone 39N):* *X: 350089 Y: 2979613* *Source:* *CH2M HILL based on field measurements performed between*			

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Long Term Noise Levels Hourly Measurements, Location 3			
Date	**Start Time**	**dB (A) L_{eq}**	**dB LA_{Max}**
November 4th and 7th 2010			

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Long Term Noise Levels Hourly Measurements, Location 4			
Date	**Start Time**	**dB (A) L_{eq}**	**dB (A) LA_{Max}**
07/11/2010	15:00	45	66
07/11/2010	16:00	46	76
07/11/2010	17:00	47	67
07/11/2010	18:00	46	58
07/11/2010	19:00	50	57
07/11/2010	20:00	48	73
07/11/2010	21:00	48	82
07/11/2010	22:00	46	58
07/11/2010	23:00	44	49
07/11/2010	0:00	47	81
07/11/2010	1:00	44	58
07/11/2010	2:00	44	51
08/11/2010	3:00	45	52
08/11/2010	4:00	44	51
08/11/2010	5:00	45	79
08/11/2010	6:00	46	54
08/11/2010	7:00	52	74
08/11/2010	8:00	53	72
08/11/2010	9:00	51	67
08/11/2010	10:00	49	69
08/11/2010	11:00	47	80
08/11/2010	12:00	45	69
08/11/2010	13:00	61	100
08/11/2010	14:00	48	67
Leq (24 h):50 dB(A)			
08/11/2010	15:00	48	75
08/11/2010	16:00	50	63
08/11/2010	17:00	54	92
08/11/2010	18:00	42	76
08/11/2010	19:00	42	58
08/11/2010	20:00	47	78
08/11/2010	21:00	43	50
08/11/2010	22:00	42	47
08/11/2010	23:00	45	78
08/11/2010	0:00	45	53
08/11/2010	1:00	45	58
08/11/2010	2:00	45	62
09/11/2010	3:00	38	51
09/11/2010	4:00	43	54
09/11/2010	5:00	45	52

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Long Term Noise Levels Hourly Measurements, Location 4

Date	Start Time	dB (A) L_{eq}	dB (A) LA_{Max}
09/11/2010	6:00	49	76
09/11/2010	7:00	53	79
09/11/2010	8:00	54	72
09/11/2010	9:00	51	62
09/11/2010	10:00	45	66
09/11/2010	11:00	45	75
09/11/2010	12:00	45	84
09/11/2010	13:00	43	59
09/11/2010	14:00	42	59
Leq (24 h): 48 dB(A)			
09/11/2010	15:00	47	83
09/11/2010	16:00	48	64
09/11/2010	17:00	46	63
09/11/2010	18:00	44	69
09/11/2010	19:00	45	55
09/11/2010	20:00	50	78
09/11/2010	21:00	53	80
09/11/2010	22:00	50	89
09/11/2010	23:00	47	53
09/11/2010	0:00	48	57
09/11/2010	1:00	47	57
09/11/2010	2:00	47	54
10/11/2010	3:00	47	55
10/11/2010	4:00	47	54
10/11/2010	5:00	48	54
10/11/2010	6:00	50	86
10/11/2010	7:00	51	78
10/11/2010	8:00	61	87
10/11/2010	9:00	59	92
10/11/2010	10:00	58	90
10/11/2010	11:00	58	88
10/11/2010	12:00	49	84
10/11/2010	13:00	54	80
10/11/2010	14:00	53	82
Leq (24 h):53 dB(A)			
Overall Leq: 51 dB(A)			

Notes:
Coordinates (WGS 1984 UTM Zone 39N):
X: 347780 Y: 2980817

Source:
CH2M HILL based on field measurements performed between

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Long Term Noise Levels Hourly Measurements, Location 4			
Date	**Start Time**	**dB (A) L_{eq}**	**dB (A) LA_{Max}**
November 7th and 10th 2010			

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Long Term Noise Levels Hourly Measurements, Location 5			
Date	**Start Time**	**dB (A) Leq**	**dB (A) LA Max**
08/11/2010	16:00	40	55
08/11/2010	17:00	37	51
08/11/2010	18:00	39	53
08/11/2010	19:00	41	55
08/11/2010	20:00	40	46
08/11/2010	21:00	40	50
08/11/2010	22:00	41	54
08/11/2010	23:00	42	55
09/11/2010	0:00	42	60
09/11/2010	1:00	40	56
09/11/2010	2:00	35	44
09/11/2010	3:00	41	50
09/11/2010	4:00	42	48
09/11/2010	5:00	45	53
09/11/2010	6:00	49	60
09/11/2010	7:00	51	62
09/11/2010	8:00	48	72
09/11/2010	9:00	43	65
09/11/2010	10:00	43	72
09/11/2010	11:00	37	55
09/11/2010	12:00	45	68
09/11/2010	13:00	38	61
09/11/2010	14:00	41	56
09/11/2010	15:00	44	66
Leq (24 h):44 dB(A)			
09/11/2010	16:00	43	59
09/11/2010	17:00	42	60
09/11/2010	18:00	43	54
09/11/2010	19:00	43	49
09/11/2010	20:00	42	58
09/11/2010	21:00	42	65
09/11/2010	22:00	45	56
09/11/2010	23:00	42	57
10/11/2010	0:00	43	51
10/11/2010	1:00	42	49
10/11/2010	2:00	44	50
10/11/2010	3:00	42	50
10/11/2010	4:00	44	50
10/11/2010	5:00	45	59
10/11/2010	6:00	49	68

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Long Term Noise Levels Hourly Measurements, Location 5			
Date	**Start Time**	**dB (A) Leq**	**dB (A) LA Max**
10/11/2010	7:00	49	71
10/11/2010	8:00	46	56
10/11/2010	9:00	40	60
10/11/2010	10:00	43	61
10/11/2010	11:00	40	62
10/11/2010	12:00	41	62
10/11/2010	13:00	41	64
10/11/2010	14:00	42	66
10/11/2010	15:00	42	59
Leq (24 h):44 dB(A)			
11/11/2010	16:00	43	63
11/11/2010	17:00	39	49
11/11/2010	18:00	38	49
11/11/2010	19:00	39	47
11/11/2010	20:00	40	47
11/11/2010	21:00	41	51
11/11/2010	22:00	41	47
11/11/2010	23:00	41	48
12/11/2010	0:00	42	49
12/11/2010	1:00	40	53
12/11/2010	2:00	41	48
12/11/2010	3:00	39	47
12/11/2010	4:00	40	46
12/11/2010	5:00	42	48
12/11/2010	6:00	47	65
12/11/2010	7:00	50	72
12/11/2010	8:00	48	75
12/11/2010	9:00	49	67
12/11/2010	10:00	50	69
12/11/2010	11:00	44	66
12/11/2010	12:00	38	55
12/11/2010	13:00	41	58
12/11/2010	14:00	37	52
12/11/2010	15:00	36	47
Leq (24 h): 44 dB(A)			
Overall Leq: 44dB(A)			
Notes: *Coordinates (WGS 1984 UTM Zone 39N):* *X: 348128 Y: 2979859* *Source:* *CH2M HILL based on field measurements performed between*			

Long Term Noise Levels Hourly Measurements, Location 5			
Date	**Start Time**	**dB (A) Leq**	**dB (A) LA Max**
November 8th and 12th 2010			

Long Term Noise Levels Hourly Measurements, Location 6			
Date	**Start Time**	**dB (A) L_{eq}**	**dB (A) LA_{Max}**
08/11/2010	9:00	46	56
08/11/2010	10:00	44	57
08/11/2010	11:00	52	74
08/11/2010	12:00	62	96
08/11/2010	13:00	52	70
08/11/2010	14:00	51	57
08/11/2010	15:00	50	68
08/11/2010	16:00	50	76
08/11/2010	17:00	50	65
08/11/2010	18:00	49	62
08/11/2010	19:00	47	60
08/11/2010	20:00	46	55
08/11/2010	21:00	45	60
08/11/2010	22:00	45	53
08/11/2010	23:00	46	55
09/11/2010	0:00	45	57
09/11/2010	1:00	45	59
09/11/2010	2:00	44	58
09/11/2010	3:00	45	58
09/11/2010	4:00	48	57
09/11/2010	5:00	51	58
09/11/2010	6:00	54	61
09/11/2010	7:00	55	65
09/11/2010	8:00	53	62
Leq (24 h): 52 dB(A)			
09/11/2010	9:00	48	66
09/11/2010	10:00	45	55
09/11/2010	11:00	45	63
09/11/2010	12:00	45	54
09/11/2010	13:00	45	60
09/11/2010	14:00	46	58
09/11/2010	15:00	45	61
09/11/2010	16:00	46	70
09/11/2010	17:00	46	60
09/11/2010	18:00	45	56
09/11/2010	19:00	42	48
09/11/2010	20:00	43	48
09/11/2010	21:00	43	50
09/11/2010	22:00	44	49
09/11/2010	23:00	44	51

Long Term Noise Levels Hourly Measurements, Location 6			
Date	**Start Time**	**dB (A) L_{eq}**	**dB (A) LA_{Max}**
10/11/2010	0:00	43	50
10/11/2010	1:00	43	51
10/11/2010	2:00	45	58
10/11/2010	3:00	48	55
10/11/2010	4:00	50	57
10/11/2010	5:00	52	60
10/11/2010	6:00	51	60
10/11/2010	7:00	53	67
10/11/2010	8:00	50	57
Leq (24 h): 47 dB(A)			
10/11/2010	9:00	45	59
10/11/2010	10:00	45	59
10/11/2010	11:00	45	60
10/11/2010	12:00	45	64
10/11/2010	13:00	44	55
10/11/2010	14:00	49	89
10/11/2010	15:00	45	81
10/11/2010	16:00	46	57
10/11/2010	17:00	48	55
10/11/2010	18:00	47	55
10/11/2010	19:00	46	56
10/11/2010	20:00	45	54
10/11/2010	21:00	46	57
10/11/2010	22:00	45	51
10/11/2010	23:00	46	55
11/11/2010	0:00	46	52
11/11/2010	1:00	44	51
11/11/2010	2:00	48	59
11/11/2010	3:00	50	61
11/11/2010	4:00	50	66
11/11/2010	5:00	54	62
11/11/2010	6:00	56	65
11/11/2010	7:00	56	88
11/11/2010	8:00	51	65
Leq (24 h): 49 dB(A)			
Overall Leq : 50 dB(A)			
Notes: Coordinates (WGS 1984 UTM Zone 39N): X: 350639 Y: 2980720 *Source:* CH2M HILL based on field measurements performed between			

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Long Term Noise Levels Hourly Measurements, Location 6

Date	Start Time	dB (A) L_{eq}	dB (A) LA_{Max}
November 8th and 11th 2010			

Long Term Noise Levels Hourly Measurements, Location 7

Date	Start Time	dB (A) L_{eq}	dB (A) LA $_{Max}$
10/11/2010	17:00	44	60
10/11/2010	18:00	41	55
10/11/2010	19:00	42	63
10/11/2010	20:00	43	54
10/11/2010	21:00	43	57
10/11/2010	22:00	43	68
10/11/2010	23:00	47	83
11/11/2010	0:00	47	57
11/11/2010	1:00	46	56
11/11/2010	2:00	47	59
11/11/2010	3:00	47	56
11/11/2010	4:00	48	57
11/11/2010	5:00	52	64
11/11/2010	6:00	54	79
11/11/2010	7:00	54	80
11/11/2010	8:00	52	67
11/11/2010	9:00	49	77
11/11/2010	10:00	47	73
11/11/2010	11:00	46	66
11/11/2010	12:00	46	71
11/11/2010	13:00	45	79
11/11/2010	14:00	44	64
11/11/2010	15:00	45	75
11/11/2010	16:00	47	73
Leq (24 h):48 dB(A)			
11/11/2010	17:00	44	59
11/11/2010	18:00	48	89
11/11/2010	19:00	43	55
11/11/2010	20:00	45	73
11/11/2010	21:00	44	52
11/11/2010	22:00	45	58
11/11/2010	23:00	45	56
12/11/2010	0:00	45	58
12/11/2010	1:00	44	60
12/11/2010	2:00	46	81
12/11/2010	3:00	45	61
12/11/2010	4:00	45	54
12/11/2010	5:00	47	70
12/11/2010	6:00	50	62
12/11/2010	7:00	51	66

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Long Term Noise Levels Hourly Measurements, Location 7			
Date	**Start Time**	**dB (A) L_{eq}**	**dB (A) LA $_{Max}$**
12/11/2010	8:00	48	60
12/11/2010	9:00	43	58
12/11/2010	10:00	40	58
12/11/2010	11:00	38	58
12/11/2010	12:00	39	62
12/11/2010	13:00	39	70
12/11/2010	14:00	39	57
12/11/2010	15:00	40	60
12/11/2010	16:00	45	69
Leq (24 h): 45 dB(A)			
12/11/2010	17:00	42	75
12/11/2010	18:00	41	55
12/11/2010	19:00	43	68
12/11/2010	20:00	42	60
12/11/2010	21:00	43	58
12/11/2010	22:00	43	57
12/11/2010	23:00	43	57
13/11/2010	0:00	44	55
13/11/2010	1:00	47	73
13/11/2010	2:00	44	53
13/11/2010	3:00	44	52
13/11/2010	4:00	46	78
13/11/2010	5:00	49	73
13/11/2010	6:00	52	60
13/11/2010	7:00	53	62
13/11/2010	8:00	51	83
13/11/2010	9:00	48	74
13/11/2010	10:00	46	67
13/11/2010	11:00	43	63
13/11/2010	12:00	47	78
13/11/2010	13:00	43	72
13/11/2010	14:00	43	77
13/11/2010	15:00	44	77
13/11/2010	16:00	45	61
Leq (24 h): 47 dB(A)			
Overall Leq: 47 dB(A)			
Notes: Coordinates (WGS 1984 UTM Zone 39N): X: 354441 Y: 2981801 *Source:* CH2M HILL based on field measurements performed between			

Long Term Noise Levels Hourly Measurements, Location 7			
Date	**Start Time**	**dB (A) L_{eq}**	**dB (A) LA_{Max}**
November 10th and 13th 2010			

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APPENDIX C.2. SHORT TERM NOISE MONITORING RESULTS

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Table 1 Short Term Noise Level Measurements

Time	Location	WP	1/3 octave bands Hz (dB)																															Leq dBA
			12.5	16	20	25	31	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1k	1.25k	1.6k	2k	2.5k	3.15k	4k	5k	6.3k	8k	10k	12.5k	16k	
9:40	1	WP16	75	72	68	65	65	60	59	58	56	56	51	50	46	43	42	39	37	33	32	28	24	21	19	18	16	16	14	13	13	13	13	15	45
10:02	2	WP17	66	65	62	60	59	56	57	54	54	52	48	46	44	41	35	32	29	26	24	23	22	21	19	17	17	15	13	12	13	13	13	15	42
10:28	3	WP18	64	62	60	58	57	58	60	61	57	55	54	55	56	56	56	54	52	51	49	48	46	45	43	41	39	37	35	33	31	30	28	23	58
10:47	4	WP22	68	65	63	59	56	52	48	45	45	43	37	35	32	30	29	29	27	24	19	17	15	13	11	10	10	10	10	10	10	11	12	15	34
11:08	5	WP23	69	67	64	62	59	55	51	47	46	41	37	35	33	31	29	27	26	23	20	17	16	15	13	12	11	10	10	10	11	11	12	15	34
11:29	6	WP26	71	69	66	64	61	57	53	49	46	43	39	36	34	33	31	31	30	26	22	20	20	21	19	17	16	13	12	12	12	12	13	15	36
11:50	7	WP27	65	62	59	56	52	49	47	45	42	39	34	33	32	29	27	29	27	25	20	18	16	16	15	14	13	12	12	12	12	12	13	15	33
12:09	8	WP29	70	68	66	64	61	59	55	53	49	46	42	40	38	35	32	31	29	28	27	24	24	25	24	22	20	19	17	16	17	16	16	16	39
12:24	9	WP32	73	71	68	66	64	61	58	53	48	45	42	39	43	37	31	29	27	26	26	25	27	27	27	23	17	14	13	12	13	13	14	16	40
12:41	10	WP33	74	72	69	67	64	61	57	53	51	46	43	42	40	39	37	36	36	35	33	30	26	25	25	24	22	17	15	14	14	15	15	17	42
13:29	11	WP34	73	72	70	68	66	64	63	60	63	57	54	53	52	49	48	46	43	41	39	37	33	31	29	26	23	21	18	16	15	14	14	15	51
13:46	12	WP35	73	71	69	67	65	62	60	59	58	58	55	53	52	49	49	47	44	43	40	39	36	34	31	28	24	20	15	13	13	14	14	16	51
14:07	13	WP37	75	74	72	71	69	67	64	60	56	54	50	47	45	42	40	38	36	34	32	30	28	26	24	22	20	19	19	15	15	16	16	18	45
14:20	14	WP38	74	72	70	68	66	63	59	55	53	50	44	43	40	37	35	35	31	28	27	26	24	21	19	16	14	13	13	12	13	13	14	15	41
14:37	15	WP39	76	74	72	70	68	65	61	56	53	50	45	43	39	36	35	38	32	29	26	26	25	24	22	20	19	18	17	16	16	16	15	17	42
14:54	16	WP40	75	73	70	68	64	60	56	52	49	45	42	39	37	35	32	30	28	26	25	21	20	18	17	16	15	13	13	12	13	13	14	15	38
15:19	17	WP41	50	49	48	48	51	51	48	49	48	47	42	39	40	37	34	31	29	29	27	26	25	23	22	20	22	19	16	15	15	15	15	16	39
15:53	18	WP42	65	63	61	59	58	59	54	55	53	49	48	46	45	46	45	45	45	46	47	48	47	45	43	40	35	31	28	25	23	23	21	18	55
16:07	19	WP43	64	62	61	59	57	54	53	55	49	46	46	43	42	42	42	41	39	38	38	36	35	34	32	30	26	24	21	19	17	17	16	16	47

Notes:

(1) *Run time: 10 minutes*

Source:

CH2M HILL based on measurements taken during the field visit carried out on 12th of November 2010

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APPENDIX C.3. CALIBRATION CERTIFICATES

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Certificate of Calibration

Cirrus Research plc
dedicated to noise measurement

Equipment Details

Instrument Manufacturer	Cirrus Research plc
Instrument Type	Sound Level Meter
Model Number	CR:811C
Serial Number	D20548FD

Calibration Procedure

The instrument detailed above has been calibrated to the published test and calibration data as detailed in the instrument handbook, using the techniques recommended in the latest revisions of the International Standards IEC 61672-1:2002, IEC 60651:1979, IEC 60804:2001, IEC 61260:1995, IEC 60942:1997, IEC 61252:1993, ANSI S1.4-1983, ANSI S1.11-1986 and ANSI S1.43-1997 where applicable.

Sound Level Meters: All Calibration procedures were carried out by substituting the microphone capsule with a suitable electrical signal, apart from the final acoustic calibration.

Calibration Traceability

The equipment detailed above was calibrated against the calibration laboratory standards held by Cirrus Research plc. Which are traceable to the appropriate International Standards.

The Cirrus Research plc calibration laboratory standards are:

Microphone Type	B&K4180	Serial Number	1893453	Calibration Ref.	S 5770
Pistonphone Type	B&K4220	Serial Number	613843	Calibration Ref.	S 5845

Calibrated by T. A. Goodcil

Calibration Date 25 August 2010

Calibration Certificate Number 179847

This Calibration Certificate is valid for 12 months from the date above.

Cirrus Research plc, Acoustic House, Bridlington Road, Hunmanby, North Yorkshire, YO14 0PH
Telephone: +44 (0) 1723 891655 Fax: +44 (0) 1723 891742
Email: sales@cirrusresearch.co.uk

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Certificate of Calibration

Cirrus Research plc
dedicated to noise measurement

Equipment Details

Instrument Manufacturer	Cirrus Research plc
Instrument Type	Acoustic Calibrator
Model Number	CR:515
Serial Number	51446

Calibration Procedure

The acoustic calibrator detailed above has been calibrated to the published data as described in the operating manual. The procedures and techniques used to follow the recommendations of the IEC standard Electroacoustics – Sound Calibrators IEC 60942:2003, IEC 60942:1997, BS EN 60942:1998 and BS EN 60942:2003 where applicable.. The calibrator's main output is 94.00 dB (1 Pa) and this was set within the 0.01 dB resolution of the test system, i.e. one hundredth of a decibel. Numbers in {parenthesis} refer to the paragraph in IEC 60942.

Calibration Traceability

The calibrator above was calibrated against the calibration laboratory standards held by Cirrus Research plc. These are traceable to International Standards {A.0.6}. The standards are:

Microphone Type	B&K4180	Serial Number	1893453	Calibration Ref.	S 5770
Pistonphone Type	B&K4220	Serial Number	613843	Calibration Ref.	S 5845

Calibration Climate Conditions

The climatic test conditions were all maintained within the permitted limits of IEC 60942:1997.

Temperature	{B.3.2}	Permitted band 15°C to 25°C
Humidity	{B.3.2}	Permitted band 30% to 90% RH
Static Pressure	{B.3.2}	Permitted band 85 kPa to 105 kPa
Ambient Noise Level	{B.3.3.6}	Max permitted level 64 dB(Z)

Measurement Results

The figures below are the Calibration Laboratory test limits for this model calibrator and have a smaller tolerance than those permitted in IEC 60942.

94 dB Output	94.01	dB	Permitted band 93.95 to 94.05 dB
Frequency	1000	Hz	Permitted band 990 to 1010 Hz

Uncertainty

With an uncertainty coefficient of k=2, i.e. a 95% confidence level, the uncertainty of each measure is

94 dB Output	± 0.13 dB	104 dB Output	± 0.14 dB
Frequency	± 0.1 Hz	Level Stability	± 0.04 dB

Calibrated by T. A. Goodill

Calibration Date 25 August 2010

Calibration Certificate Number 179848

This Calibration Certificate is valid for 12 months from the date above.

Cirrus Research plc, Acoustic House, Bridlington Road, Hunmanby, North Yorkshire, YO14 0PH
Telephone: +44 (0) 1723 891655 Fax: +44 (0) 1723 891742
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ENAC
CALIBRACIÓN
Nº 50/LC003

CERTIFICADO DE CALIBRACIÓN

Certificate of Calibration

Número 12991-A
Number

Brüel & Kjaer Ibérica, S.A.
Teide, 5 • 28703 San Sebastián de los Reyes (Madrid)
Tel.: 91 659 08 20 • Fax: 91 659 08 24
bruelkjaer@bkes.com

LABORATORIO DE CALIBRACIÓN

INSTRUMENTO *Instrument*	SONOMETRO
FABRICANTE *Manufacturer*	BRÜEL & KJAER
MODELO *Model*	2250-L
NÚMERO DE SERIE *Serial Number*	2580001
PETICIONARIO *Customer*	**BRÜEL & KJÆR IBERICA, S. A.** **TEIDE, 5 – 28703 SAN SEBASTIAN DE LOR REYES (MADRID)**
FECHA DE ENTRADA *Date of Reception*	18-may-2010
FECHA DE CALIBRACIÓN *Date of Calibration*	18-may-2010

Signatario/s Autorizado/s
Authorised Signatory/ies

JOSE Mª ALVAREZ
JEFE DE LABORATORIO

BRUEL & KJAER CALIBRACION
Teide, 5
Bruel & Kjaer
Iberica S.A.
28700 S.S. Reyes

Fecha de Emisión
Date of issue

18-may-2010

Este certificado se expide de acuerdo con las condiciones de la acreditación concedida por ENAC, que ha comprobado las capacidades de medida del laboratorio y su trazabilidad a patrones nacionales e internacionales.
Este certificado no podrá ser reproducido parcialmente sin la aprobación por escrito del laboratorio que lo emite y de ENAC.
This certificate is issued in accordance with the conditions of accreditation granted by ENAC, which has assessed the measurement capability of the laboratory and its Traceability to national and international standards.
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Brüel & Kjær

Brüel & Kjær Ibérica, S.A.
Teide, 5 - 28703 San Sebastián de los Reyes (MADRID)
Tel. 91 659 08 20 Fax 91 659 08 24 bruelkjaer@bkes.com

ENAC
CALIBRACIÓN
Nº 50/LC003

CERTIFICADO DE CALIBRACIÓN

Calibración de:

Equipo:	**Brüel & Kjær 2250-L**	**Clase 1**	Nº de Serie:	2580001
Micrófono:	**Brüel & Kjær 4950**		Nº de Serie:	2575844

Cliente:

BRÜEL & KJÆR IBERICA, S. A.
TEIDE, 5 – 28703 SAN SEBASTIAN DE LOR REYES (MADRID)

Fecha de entrada: 18-may-2010

Condiciones de calibración:

Temperatura:	22	°C
Humedad relativa:	35	% RH
Presión Atmosférica:	947	hPa

Procedimiento:

El presente instrumento ha sido calibrado de acuerdo con el Procedimiento PE/B&K-C/04 elaborado a partir de las normas UNE-EN 60651 : 1996 modificada por la UNE-EN 60651/A1 : 1997 y UNE-EN 60804 : 2002, en ensayos eléctricos. Los ensayos acústicos se han elaborado de acuerdo con el BS-7580 : Part 1 : 1997. Normas obsoletas.

Incertidumbres y Resultados:

Incertidumbre Acústica: ± 0.24 dB. (31.5 Hz $\leq$ U $\leq$ 1 kHz.)
: ± 0.30 dB. (1 kHz < U $\leq$ 4 kHz)
: ± 0.40 dB. (4 kHz < U $\leq$ 8 kHz)
: ± 0.50 dB. (8 kHz < U $\leq$ 12.5 kHz)

La incertidumbre expandida de medida se ha obtenido multiplicando la incertidumbre típica de medición por el factor de cobertura k=2 que, para una distribución normal, corresponde a una probabilidad de cobertura de aproximadamente el 95%. La incertidumbre típica de medida se ha determinado conforme al documento EA-4/02.

Fecha de calibración: 18-may-2010

Fecha de edición: 18-may-2010

BRUEL & KJAER CALIBRACION
Teide, 5
Bruel & Kjaer
Iberica S.A.
28700 S.S. Reyes

Miguel Fernández
Técnico de calibración

José Mª Alvarez
Jefe de Laboratorio

Nota: Los resultados contenidos en el presente certificado se refieren al momento y condiciones en que se realizaron las mediciones.

Inscrita en el Registro Mercantil de Barcelona: Hoja 27079, Folio 132, Tomo 2558, Libro 1941, Sección 2ª, Inscripción 1ª N.I.F. A-08349649.

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Lista de los tests realizados durante la calibración:

Un signo " - " a la derecha del test significa que el instrumento en esa prueba está fuera de especificaciones.

Nombre del test	Subtest
Ruido	A
Ruido	C
Ruido	Lin
Respuesta en Frecuencia	A
Respuesta en Frecuencia	C
Respuesta en Frecuencia	Lin
Linealidad	SPL 10dB 31.5 Hz
Linealidad	SPL 10dB 1000 Hz
Linealidad	SPL 10dB 8000 Hz
Linealidad	SPL 1dB 31.5 Hz
Linealidad	SPL 1dB 1000 Hz
Linealidad	SPL 1dB 8000 Hz
Linealidad	Leq
Linealidad	SEL
Detector RMS	CF 3
Detector RMS	CF 5
Detector RMS	CF 10
Constantes de Tiempo	Difference in Indication
Constantes de Tiempo	Single Burst FAST
Constantes de Tiempo	Single Burst SLOW
Constantes de Tiempo	Single Burst IMPULSE
Constantes de Tiempo	Repetitive Burst
Constantes de Tiempo	Peak
Tiempo de Promediado	
Rango de Impulsos	
Sobrecarga	SPL
Sobrecarga	SEL
Leidas en cond. de ref.	
Respuesta Acústica	A
Respuesta Acústica	Lin

Equipos de calibración:

Tipo	Fabricante	Modelo	No. serie	Próxima calib.	Trazable a
Voltmeter	Wavetek	1281	25628-9	15-jun-2011	ENAC
Generator	Brüel & Kjær	1051	1641756	20-may-2010	B&K
Burst Generator	Brüel & Kjær	5918	1556607	14-jun-2010	B&K
Calibrator	Brüel & Kjær	4226	1672930	22-abr-2012	DANAK

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B 20 RUIDO INTERNO

La prueba de ruido interno se realiza en la escala mas sensible del sonómetro, sustituyendo el micrófono por una impedancia equivalente.

Nivel de Ruido: Se calcula hallando la media de 10 medidas en dB, tomadas de la salida DC del equipo, o tomando la lectura directamente del indicador.

Nivel de ruido en frecuencia A dB
13.3

Nivel de ruido en frecuencia C dB
14.0

Nivel de ruido en Lin dB
19.2

B 10 PONDERACIONES FRECUENCIALES

La respuesta en frecuencia de las redes de ponderaciones se ha verificado eléctricamente con ref. de 1000 Hz. El ensayo se ha realizado con una señal de "curva inv.". La entrada al sonómetro se ha aumentado en el mismo valor que la atenuación nominal de cada ponderación.

El nivel de ensayo es F.D.E. -36 dB en el rango de ref.

Frecuencia : Frecuencia de entrada senoidal en Hz.
Nivel de entrad : Nivel de entrada senoidal en dB/uV
Nivel esperado : Nivel esperado del sonómetro
Nivel leido : Nivel leido del sonómetro
Tolerancia : UNE -EN 60651: 4.4, 6.1, 9.1, 9.2.2

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B 10 continued...

Ponderación Frecuencial A

Frecuencia	Nivel de Entrada	Nivel Esperado	Nivel Leido	Tolerancia Pos.	Tolerancia Neg.	Des.
Hz	dB	dB	dB	dB	dB	dB
1000.0	100.0	100.0	100.0			
31.6	139.4	100.0	100.0	1.5	1.5	0.0
39.8	134.6	100.0	100.0	1.5	1.5	0.0
50.1	130.2	100.0	100.0	1.5	1.5	0.0
63.1	126.2	100.0	100.0	1.5	1.5	0.0
79.4	122.5	100.0	100.0	1.5	1.5	0.0
100.0	119.1	100.0	100.0	1.0	1.0	0.0
125.9	116.1	100.0	100.0	1.0	1.0	0.0
158.5	113.4	100.0	100.1	1.0	1.0	0.1
199.5	110.9	100.0	100.0	1.0	1.0	0.0
251.2	108.6	100.0	100.0	1.0	1.0	0.0
316.2	106.6	100.0	100.0	1.0	1.0	0.0
398.1	104.8	100.0	100.0	1.0	1.0	0.0
501.2	103.2	100.0	100.0	1.0	1.0	0.0
631.0	101.9	100.0	100.0	1.0	1.0	0.0
794.3	100.8	100.0	100.0	1.0	1.0	0.0
1258.9	99.4	100.0	100.0	1.0	1.0	0.0
1584.9	99.0	100.0	100.0	1.0	1.0	0.0
1995.3	98.8	100.0	100.0	1.0	1.0	0.0
2511.9	98.7	100.0	100.0	1.0	1.0	0.0
3162.3	98.8	100.0	100.0	1.0	1.0	0.0
3981.1	99.0	100.0	100.0	2.0	2.0	0.0
5011.9	99.5	100.0	100.0	1.5	1.5	0.0
6309.6	100.1	100.0	100.0	1.5	2.0	0.0
7943.3	101.1	100.0	100.0	1.5	3.0	0.0
10000.0	102.5	100.0	100.0	2.0	4.0	0.0
12589.3	104.3	100.0	100.0	3.0	6.0	0.0
15848.9	106.6	100.0	100.0	3.0		0.0

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B 10 continued...

Ponderación Frecuencial C

Frecuencia Hz	Nivel de Entrada dB	Nivel Esperado dB	Nivel Leido dB	Tolerancia Pos. dB	Tolerancia Neg. dB	Des. dB
1000.0	100.0	100.0	100.0			
31.6	103.0	100.0	100.0	1.5	1.5	0.0
39.8	102.0	100.0	100.0	1.5	1.5	0.0
50.1	101.3	100.0	100.0	1.5	1.5	0.0
63.1	100.8	100.0	100.0	1.5	1.5	0.0
79.4	100.5	100.0	100.0	1.5	1.5	0.0
100.0	100.3	100.0	100.0	1.0	1.0	0.0
125.9	100.2	100.0	100.0	1.0	1.0	0.0
158.5	100.1	100.0	100.0	1.0	1.0	0.0
199.5	100.0	100.0	100.0	1.0	1.0	0.0
251.2	100.0	100.0	100.0	1.0	1.0	0.0
316.2	100.0	100.0	100.0	1.0	1.0	0.0
398.1	100.0	100.0	100.0	1.0	1.0	0.0
501.2	100.0	100.0	100.0	1.0	1.0	0.0
631.0	100.0	100.0	100.0	1.0	1.0	0.0
794.3	100.0	100.0	100.0	1.0	1.0	0.0
1258.9	100.0	100.0	100.0	1.0	1.0	0.0
1584.9	100.1	100.0	100.0	1.0	1.0	0.0
1995.3	100.2	100.0	100.0	1.0	1.0	0.0
2511.9	100.3	100.0	100.0	1.0	1.0	0.0
3162.3	100.5	100.0	100.0	1.0	1.0	0.0
3981.1	100.8	100.0	100.0	2.0	2.0	0.0
5011.9	101.3	100.0	100.0	1.5	1.5	0.0
6309.6	102.0	100.0	100.0	1.5	2.0	0.0
7943.3	103.0	100.0	100.0	1.5	3.0	0.0
10000.0	104.4	100.0	100.0	2.0	4.0	0.0
12589.3	106.2	100.0	99.9	3.0	6.0	-0.1
15848.9	108.5	100.0	100.0	3.0		0.0

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B 10 continued...

Ponderación Frecuencial Lin.

Frecuencia Hz	Nivel de Entrada dB	Nivel Esperado dB	Nivel Leido dB			Des. dB
1000.0	100.0	100.0	100.0			
31.6	100.0	100.0	100.0	1.5	1.5	0.0
39.8	100.0	100.0	100.0	1.5	1.5	0.0
50.1	100.0	100.0	100.0	1.5	1.5	0.0
63.1	100.0	100.0	100.0	1.5	1.5	0.0
79.4	100.0	100.0	100.0	1.5	1.5	0.0
100.0	100.0	100.0	100.0	1.0	1.0	0.0
125.9	100.0	100.0	100.0	1.0	1.0	0.0
158.5	100.0	100.0	100.0	1.0	1.0	0.0
199.5	100.0	100.0	100.0	1.0	1.0	0.0
251.2	100.0	100.0	100.0	1.0	1.0	0.0
316.2	100.0	100.0	100.0	1.0	1.0	0.0
398.1	100.0	100.0	100.0	1.0	1.0	0.0
501.2	100.0	100.0	100.0	1.0	1.0	0.0
631.0	100.0	100.0	100.0	1.0	1.0	0.0
794.3	100.0	100.0	100.0	1.0	1.0	0.0
1258.9	100.0	100.0	100.0	1.0	1.0	0.0
1584.9	100.0	100.0	100.0	1.0	1.0	0.0
1995.3	100.0	100.0	100.0	1.0	1.0	0.0
2511.9	100.0	100.0	100.0	1.0	1.0	0.0
3162.3	100.0	100.0	100.0	1.0	1.0	0.0
3981.1	100.0	100.0	100.0	2.0	2.0	0.0
5011.9	100.0	100.0	100.0	1.5	1.5	0.0
6309.6	100.0	100.0	100.0	1.5	2.0	0.0
7943.3	100.0	100.0	100.0	1.5	3.0	0.0
10000.0	100.0	100.0	100.0	2.0	4.0	0.0
12589.3	100.0	100.0	100.0	3.0	6.0	0.0
15848.9	100.0	100.0	100.0	3.0		0.0

B 9 INDICADOR (LINEALIDAD)

Se ha ensayado la linealidad diferencial y global del sonómetro.
La linealidad diferencial y global se ensaya desde el límite inferior hasta el límite superior del rango de referencia, en pasos de 10 dB y de 1 dB.
La linealidad global se ensaya en relación con los 94 dB de referencia.

Tolerancias UNE - EN 60651: 7.9, 7.10

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B 9 continued...

Tipo de sonómetro	*0*	*1*	*2*	*3*
	+/-	*+/-*	*+/-*	*+/-*
Linealidad global	*0.4*	*0.7*	*1.0*	*1.5 dB*
Linealidad diferencial				
en pasos de 10 dB	*0.4*	*0.4*	*0.6*	*1.0 dB*
en pasos de 1 dB	*0.2*	*0.2*	*0.3*	*0.3 dB*

Señal de ensayo : Senoidal

Nivel de entrada : Nivel de señal de entrada en dB/uV
Rel. Esperado : Nivel esperado en ensayo de lin. global.
Dif. Esperada : Nivel esperado en ensayo de lin. dif.
Nivel leido : Lectura en sonómetro.
Desviación : Diferencia entre nivel esperado y leido.
Tolerancia : UNE - EN 60651: 7.9, 7.10

N.P.S. pasos de 10 dB

Frecuencia de ensayo 31,5 Hz.

Nivel de	*Nivel esperado*		*Nivel*	*Desviac.*	
Entrada	*Rel.*	*Dif.*	*Leido*	*Rel.*	*Dif.*
dB	*dB*	*dB*	*dB*	*dB*	*dB*
94.0			*94.0*		
44.0	*44.0*		*44.0*	*0.0*	
52.0	*52.0*	*52.0*	*52.0*	*0.0*	*0.0*
62.0	*62.0*	*62.0*	*61.9*	*-0.1*	*-0.1*
72.0	*72.0*	*71.9*	*71.9*	*-0.1*	*0.0*
82.0	*82.0*	*81.9*	*81.9*	*-0.1*	*0.0*
92.0	*92.0*	*91.9*	*92.0*	*0.0*	*0.1*
102.0	*102.0*	*102.0*	*102.0*	*0.0*	*0.0*
112.0	*112.0*	*112.0*	*112.0*	*0.0*	*0.0*
122.0	*122.0*	*122.0*	*122.0*	*0.0*	*0.0*
132.0	*132.0*	*132.0*	*132.0*	*0.0*	*0.0*
140.0	*140.0*	*140.0*	*139.9*	*-0.1*	*-0.1*

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B 9 continued...

N.P.S. pasos de 10 dB

Frecuencia de ensayo 1000 Hz.

Nivel de Entrada dB	Nivel esperado Rel. dB	Nivel esperado Dif. dB	Nivel Leido dB	Desviac. Rel. dB	Desviac. Dif. dB
94.0			94.0		
35.0	35.0		35.0	0.0	
43.0	43.0	43.0	43.0	0.0	0.0
53.0	53.0	53.0	53.0	0.0	0.0
63.0	63.0	63.0	63.0	0.0	0.0
73.0	73.0	73.0	73.0	0.0	0.0
83.0	83.0	83.0	83.0	0.0	0.0
93.0	93.0	93.0	93.0	0.0	0.0
103.0	103.0	103.0	103.0	0.0	0.0
113.0	113.0	113.0	113.0	0.0	0.0
123.0	123.0	123.0	123.0	0.0	0.0
133.0	133.0	133.0	133.0	0.0	0.0
140.0	140.0	140.0	140.1	0.1	0.1

N.P.S. pasos de 10 dB

Frecuencia de ensayo 8000 Hz.

Nivel de Entrada dB	Nivel Esperado Rel. dB	Nivel Esperado Dif. dB	Nivel Leido dB	Desviac. Rel. dB	Desviac. Dif. dB
95.1			93.9		
36.1	34.9		34.9	0.0	
44.1	42.9	42.9	43.0	0.1	0.1
54.1	52.9	53.0	53.0	0.1	0.0
64.1	62.9	63.0	62.9	0.0	-0.1
74.1	72.9	72.9	72.9	0.0	0.0
84.1	82.9	82.9	82.9	0.0	0.0
94.1	92.9	92.9	92.9	0.0	0.0
104.1	102.9	102.9	102.9	0.0	0.0
114.1	112.9	112.9	112.9	0.0	0.0
124.1	122.9	122.9	123.0	0.1	0.1
134.1	132.9	133.0	133.2	0.3	0.2
141.1	139.9	140.2	140.1	0.2	-0.1

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B 9 continued...

N.P.S. pasos de 1 dB

Frecuencia de ensayo 31,5 Hz.

Nivel de Entrada dB	Nivel esperado Rel. dB	Nivel esperado Dif. dB	Nivel Leido dB	Desviac. Rel. dB	Desviac. Dif. dB
94.0			94.0		
44.0	44.0		44.0	0.0	
45.0	45.0	45.0	45.0	0.0	0.0
46.0	46.0	46.0	46.0	0.0	0.0
47.0	47.0	47.0	47.0	0.0	0.0
48.0	48.0	48.0	48.0	0.0	0.0
49.0	49.0	49.0	49.0	0.0	0.0
50.0	50.0	50.0	50.0	0.0	0.0
51.0	51.0	51.0	51.0	0.0	0.0
52.0	52.0	52.0	52.0	0.0	0.0
53.0	53.0	53.0	53.0	0.0	0.0
54.0	54.0	54.0	54.0	0.0	0.0
55.0	55.0	55.0	54.9	-0.1	-0.1
56.0	56.0	55.9	55.9	-0.1	0.0
57.0	57.0	56.9	56.9	-0.1	0.0
58.0	58.0	57.9	57.9	-0.1	0.0
59.0	59.0	58.9	58.9	-0.1	0.0
60.0	60.0	59.9	59.9	-0.1	0.0
61.0	61.0	60.9	60.9	-0.1	0.0
62.0	62.0	61.9	61.9	-0.1	0.0
63.0	63.0	62.9	62.9	-0.1	0.0
64.0	64.0	63.9	63.9	-0.1	0.0
65.0	65.0	64.9	64.9	-0.1	0.0
66.0	66.0	65.9	65.9	-0.1	0.0
67.0	67.0	66.9	66.9	-0.1	0.0
68.0	68.0	67.9	67.9	-0.1	0.0
69.0	69.0	68.9	68.9	-0.1	0.0
70.0	70.0	69.9	69.9	-0.1	0.0
71.0	71.0	70.9	70.9	-0.1	0.0
72.0	72.0	71.9	71.9	-0.1	0.0
73.0	73.0	72.9	72.9	-0.1	0.0
74.0	74.0	73.9	73.9	-0.1	0.0
75.0	75.0	74.9	74.9	-0.1	0.0
76.0	76.0	75.9	75.9	-0.1	0.0
77.0	77.0	76.9	76.9	-0.1	0.0
78.0	78.0	77.9	77.9	-0.1	0.0
79.0	79.0	78.9	78.9	-0.1	0.0
80.0	80.0	79.9	79.9	-0.1	0.0
81.0	81.0	80.9	80.9	-0.1	0.0
82.0	82.0	81.9	81.9	-0.1	0.0
83.0	83.0	82.9	82.9	-0.1	0.0
84.0	84.0	83.9	83.9	-0.1	0.0
85.0	85.0	84.9	84.9	-0.1	0.0
86.0	86.0	85.9	85.9	-0.1	0.0
87.0	87.0	86.9	86.9	-0.1	0.0

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B 9 continued...

88.0	88.0	87.9	88.0	0.0	0.1
89.0	89.0	89.0	89.0	0.0	0.0
90.0	90.0	90.0	90.0	0.0	0.0
91.0	91.0	91.0	91.0	0.0	0.0
92.0	92.0	92.0	92.0	0.0	0.0
93.0	93.0	93.0	93.0	0.0	0.0
94.0	94.0	94.0	94.0	0.0	0.0
95.0	95.0	95.0	95.0	0.0	0.0
96.0	96.0	96.0	96.0	0.0	0.0
97.0	97.0	97.0	97.0	0.0	0.0
98.0	98.0	98.0	98.0	0.0	0.0
99.0	99.0	99.0	99.0	0.0	0.0
100.0	100.0	100.0	100.0	0.0	0.0
101.0	101.0	101.0	101.0	0.0	0.0
102.0	102.0	102.0	102.0	0.0	0.0
103.0	103.0	103.0	103.0	0.0	0.0
104.0	104.0	104.0	104.0	0.0	0.0
105.0	105.0	105.0	105.0	0.0	0.0
106.0	106.0	106.0	106.0	0.0	0.0
107.0	107.0	107.0	107.0	0.0	0.0
108.0	108.0	108.0	108.0	0.0	0.0
109.0	109.0	109.0	109.0	0.0	0.0
110.0	110.0	110.0	110.0	0.0	0.0
111.0	111.0	111.0	111.0	0.0	0.0
112.0	112.0	112.0	112.0	0.0	0.0
113.0	113.0	113.0	113.0	0.0	0.0
114.0	114.0	114.0	114.0	0.0	0.0
115.0	115.0	115.0	115.0	0.0	0.0
116.0	116.0	116.0	116.0	0.0	0.0
117.0	117.0	117.0	117.0	0.0	0.0
118.0	118.0	118.0	118.0	0.0	0.0
119.0	119.0	119.0	119.0	0.0	0.0
120.0	120.0	120.0	120.0	0.0	0.0
121.0	121.0	121.0	121.0	0.0	0.0
122.0	122.0	122.0	122.0	0.0	0.0
123.0	123.0	123.0	123.0	0.0	0.0
124.0	124.0	124.0	124.0	0.0	0.0
125.0	125.0	125.0	125.0	0.0	0.0
126.0	126.0	126.0	126.0	0.0	0.0
127.0	127.0	127.0	127.0	0.0	0.0
128.0	128.0	128.0	128.0	0.0	0.0
129.0	129.0	129.0	129.0	0.0	0.0
130.0	130.0	130.0	130.0	0.0	0.0
131.0	131.0	131.0	131.0	0.0	0.0
132.0	132.0	132.0	132.0	0.0	0.0
133.0	133.0	133.0	133.0	0.0	0.0
134.0	134.0	134.0	134.0	0.0	0.0
135.0	135.0	135.0	134.9	-0.1	-0.1

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B 9 continued...

136.0	136.0	135.9	135.9	-0.1	0.0
137.0	137.0	136.9	136.9	-0.1	0.0
138.0	138.0	137.9	137.9	-0.1	0.0
139.0	139.0	138.9	138.9	-0.1	0.0
140.0	140.0	139.9	139.9	-0.1	0.0

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B 9 continued...

N.P.S. pasos de 1 dB

Frecuencia de ensayo 1000 Hz.

Nivel de Entrada dB	Nivel esperado Rel. dB	Nivel esperado Dif. dB	Nivel Leido dB	Desviac. Rel. dB	Desviac. Dif. dB
94.0			94.0		
35.0	35.0		35.0	0.0	
36.0	36.0	36.0	36.0	0.0	0.0
37.0	37.0	37.0	37.0	0.0	0.0
38.0	38.0	38.0	38.0	0.0	0.0
39.0	39.0	39.0	39.0	0.0	0.0
40.0	40.0	40.0	40.1	0.1	0.1
41.0	41.0	41.1	41.0	0.0	-0.1
42.0	42.0	42.0	42.0	0.0	0.0
43.0	43.0	43.0	43.0	0.0	0.0
44.0	44.0	44.0	44.0	0.0	0.0
45.0	45.0	45.0	45.0	0.0	0.0
46.0	46.0	46.0	46.0	0.0	0.0
47.0	47.0	47.0	47.0	0.0	0.0
48.0	48.0	48.0	48.0	0.0	0.0
49.0	49.0	49.0	49.0	0.0	0.0
50.0	50.0	50.0	50.0	0.0	0.0
51.0	51.0	51.0	51.0	0.0	0.0
52.0	52.0	52.0	52.0	0.0	0.0
53.0	53.0	53.0	53.0	0.0	0.0
54.0	54.0	54.0	54.0	0.0	0.0
55.0	55.0	55.0	55.0	0.0	0.0
56.0	56.0	56.0	56.0	0.0	0.0
57.0	57.0	57.0	57.0	0.0	0.0
58.0	58.0	58.0	58.0	0.0	0.0
59.0	59.0	59.0	59.0	0.0	0.0
60.0	60.0	60.0	60.0	0.0	0.0
61.0	61.0	61.0	61.0	0.0	0.0
62.0	62.0	62.0	62.0	0.0	0.0
63.0	63.0	63.0	63.0	0.0	0.0
64.0	64.0	64.0	64.0	0.0	0.0
65.0	65.0	65.0	65.0	0.0	0.0
66.0	66.0	66.0	66.0	0.0	0.0
67.0	67.0	67.0	67.0	0.0	0.0
68.0	68.0	68.0	68.0	0.0	0.0
69.0	69.0	69.0	69.0	0.0	0.0
70.0	70.0	70.0	70.0	0.0	0.0
71.0	71.0	71.0	71.0	0.0	0.0
72.0	72.0	72.0	72.0	0.0	0.0
73.0	73.0	73.0	73.0	0.0	0.0
74.0	74.0	74.0	74.0	0.0	0.0
75.0	75.0	75.0	75.0	0.0	0.0
76.0	76.0	76.0	76.0	0.0	0.0
77.0	77.0	77.0	77.0	0.0	0.0
78.0	78.0	78.0	78.0	0.0	0.0

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B 9 continued...

79.0	79.0	79.0	79.0	0.0	0.0
80.0	80.0	80.0	80.0	0.0	0.0
81.0	81.0	81.0	81.0	0.0	0.0
82.0	82.0	82.0	82.0	0.0	0.0
83.0	83.0	83.0	83.0	0.0	0.0
84.0	84.0	84.0	84.0	0.0	0.0
85.0	85.0	85.0	85.0	0.0	0.0
86.0	86.0	86.0	86.0	0.0	0.0
87.0	87.0	87.0	87.0	0.0	0.0
88.0	88.0	88.0	88.0	0.0	0.0
89.0	89.0	89.0	89.0	0.0	0.0
90.0	90.0	90.0	90.0	0.0	0.0
91.0	91.0	91.0	91.0	0.0	0.0
92.0	92.0	92.0	92.0	0.0	0.0
93.0	93.0	93.0	93.0	0.0	0.0
94.0	94.0	94.0	94.0	0.0	0.0
95.0	95.0	95.0	95.0	0.0	0.0
96.0	96.0	96.0	96.0	0.0	0.0
97.0	97.0	97.0	97.0	0.0	0.0
98.0	98.0	98.0	98.0	0.0	0.0
99.0	99.0	99.0	99.0	0.0	0.0
100.0	100.0	100.0	100.0	0.0	0.0
101.0	101.0	101.0	101.0	0.0	0.0
102.0	102.0	102.0	102.0	0.0	0.0
103.0	103.0	103.0	103.0	0.0	0.0
104.0	104.0	104.0	104.0	0.0	0.0
105.0	105.0	105.0	105.0	0.0	0.0
106.0	106.0	106.0	106.0	0.0	0.0
107.0	107.0	107.0	107.0	0.0	0.0
108.0	108.0	108.0	108.0	0.0	0.0
109.0	109.0	109.0	109.0	0.0	0.0
110.0	110.0	110.0	110.0	0.0	0.0
111.0	111.0	111.0	111.0	0.0	0.0
112.0	112.0	112.0	112.0	0.0	0.0
113.0	113.0	113.0	113.0	0.0	0.0
114.0	114.0	114.0	114.0	0.0	0.0
115.0	115.0	115.0	115.0	0.0	0.0
116.0	116.0	116.0	116.0	0.0	0.0
117.0	117.0	117.0	117.0	0.0	0.0
118.0	118.0	118.0	118.0	0.0	0.0
119.0	119.0	119.0	119.0	0.0	0.0
120.0	120.0	120.0	120.0	0.0	0.0
121.0	121.0	121.0	121.0	0.0	0.0
122.0	122.0	122.0	122.0	0.0	0.0
123.0	123.0	123.0	123.0	0.0	0.0
124.0	124.0	124.0	124.0	0.0	0.0
125.0	125.0	125.0	125.0	0.0	0.0
126.0	126.0	126.0	126.0	0.0	0.0
127.0	127.0	127.0	127.0	0.0	0.0
128.0	128.0	128.0	128.0	0.0	0.0
129.0	129.0	129.0	129.0	0.0	0.0

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B 9 continued...

130.0	130.0	130.0	130.0	0.0	0.0
131.0	131.0	131.0	131.0	0.0	0.0
132.0	132.0	132.0	132.0	0.0	0.0
133.0	133.0	133.0	133.0	0.0	0.0
134.0	134.0	134.0	134.0	0.0	0.0
135.0	135.0	135.0	135.2	0.2	0.2
136.0	136.0	136.2	136.2	0.2	0.0
137.0	137.0	137.2	137.2	0.2	0.0
138.0	138.0	138.2	138.1	0.1	-0.1
139.0	139.0	139.1	139.2	0.2	0.1
140.0	140.0	140.2	140.1	0.1	-0.1

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B 9 continued...

N.P.S. pasos de 1 dB

Frecuencia de ensayo 8000 Hz.

Nivel de Entrada dB	Nivel esperado Rel. dB	Dif. dB	Nivel Leido dB	Desviac. Rel. dB	Dif. dB
95.1			93.9		
36.1	34.9		34.9	0.0	
37.1	35.9	35.9	35.9	0.0	0.0
38.1	36.9	36.9	36.9	0.0	0.0
39.1	37.9	37.9	37.9	0.0	0.0
40.1	38.9	38.9	39.0	0.1	0.1
41.1	39.9	40.0	40.0	0.1	0.0
42.1	40.9	41.0	41.0	0.1	0.0
43.1	41.9	42.0	42.0	0.1	0.0
44.1	42.9	43.0	43.0	0.1	0.0
45.1	43.9	44.0	44.0	0.1	0.0
46.1	44.9	45.0	45.0	0.1	0.0
47.1	45.9	46.0	46.0	0.1	0.0
48.1	46.9	47.0	47.0	0.1	0.0
49.1	47.9	48.0	48.0	0.1	0.0
50.1	48.9	49.0	49.0	0.1	0.0
51.1	49.9	50.0	50.0	0.1	0.0
52.1	50.9	51.0	51.0	0.1	0.0
53.1	51.9	52.0	52.0	0.1	0.0
54.1	52.9	53.0	53.0	0.1	0.0
55.1	53.9	54.0	54.0	0.1	0.0
56.1	54.9	55.0	54.9	0.0	-0.1
57.1	55.9	55.9	55.9	0.0	0.0
58.1	56.9	56.9	56.9	0.0	0.0
59.1	57.9	57.9	57.9	0.0	0.0
60.1	58.9	58.9	58.9	0.0	0.0
61.1	59.9	59.9	59.9	0.0	0.0
62.1	60.9	60.9	60.9	0.0	0.0
63.1	61.9	61.9	61.9	0.0	0.0
64.1	62.9	62.9	62.9	0.0	0.0
65.1	63.9	63.9	63.9	0.0	0.0
66.1	64.9	64.9	64.9	0.0	0.0
67.1	65.9	65.9	65.9	0.0	0.0
68.1	66.9	66.9	66.9	0.0	0.0
69.1	67.9	67.9	67.9	0.0	0.0
70.1	68.9	68.9	68.9	0.0	0.0
71.1	69.9	69.9	69.9	0.0	0.0
72.1	70.9	70.9	70.9	0.0	0.0
73.1	71.9	71.9	71.9	0.0	0.0
74.1	72.9	72.9	72.9	0.0	0.0
75.1	73.9	73.9	73.9	0.0	0.0
76.1	74.9	74.9	74.9	0.0	0.0
77.1	75.9	75.9	75.9	0.0	0.0
78.1	76.9	76.9	76.9	0.0	0.0
79.1	77.9	77.9	77.9	0.0	0.0

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B 9 continued...

80.1	78.9	78.9	78.9	0.0	0.0
81.1	79.9	79.9	79.9	0.0	0.0
82.1	80.9	80.9	80.9	0.0	0.0
83.1	81.9	81.9	81.9	0.0	0.0
84.1	82.9	82.9	82.9	0.0	0.0
85.1	83.9	83.9	83.9	0.0	0.0
86.1	84.9	84.9	84.9	0.0	0.0
87.1	85.9	85.9	85.9	0.0	0.0
88.1	86.9	86.9	86.9	0.0	0.0
89.1	87.9	87.9	87.9	0.0	0.0
90.1	88.9	88.9	88.9	0.0	0.0
91.1	89.9	89.9	89.9	0.0	0.0
92.1	90.9	90.9	90.9	0.0	0.0
93.1	91.9	91.9	91.9	0.0	0.0
94.1	92.9	92.9	92.9	0.0	0.0
95.1	93.9	93.9	93.9	0.0	0.0
96.1	94.9	94.9	94.9	0.0	0.0
97.1	95.9	95.9	95.9	0.0	0.0
98.1	96.9	96.9	97.0	0.1	0.1
99.1	97.9	98.0	97.9	0.0	-0.1
100.1	98.9	98.9	98.9	0.0	0.0
101.1	99.9	99.9	99.9	0.0	0.0
102.1	100.9	100.9	100.9	0.0	0.0
103.1	101.9	101.9	101.9	0.0	0.0
104.1	102.9	102.9	102.9	0.0	0.0
105.1	103.9	103.9	103.9	0.0	0.0
106.1	104.9	104.9	104.9	0.0	0.0
107.1	105.9	105.9	105.9	0.0	0.0
108.1	106.9	106.9	106.9	0.0	0.0
109.1	107.9	107.9	107.9	0.0	0.0
110.1	108.9	108.9	108.9	0.0	0.0
111.1	109.9	109.9	109.9	0.0	0.0
112.1	110.9	110.9	110.9	0.0	0.0
113.1	111.9	111.9	111.9	0.0	0.0
114.1	112.9	112.9	112.9	0.0	0.0
115.1	113.9	113.9	113.9	0.0	0.0
116.1	114.9	114.9	114.9	0.0	0.0
117.1	115.9	115.9	116.0	0.1	0.1
118.1	116.9	117.0	117.0	0.1	0.0
119.1	117.9	118.0	118.0	0.1	0.0
120.1	118.9	119.0	119.0	0.1	0.0
121.1	119.9	120.0	120.0	0.1	0.0
122.1	120.9	121.0	121.0	0.1	0.0
123.1	121.9	122.0	122.0	0.1	0.0
124.1	122.9	123.0	123.0	0.1	0.0
125.1	123.9	124.0	124.0	0.1	0.0
126.1	124.9	125.0	125.0	0.1	0.0
127.1	125.9	126.0	126.0	0.1	0.0
128.1	126.9	127.0	127.0	0.1	0.0
129.1	127.9	128.0	128.0	0.1	0.0
130.1	128.9	129.0	129.0	0.1	0.0

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B 9 continued...

131.1	129.9	130.0	130.0	0.1	0.0
132.1	130.9	131.0	131.0	0.1	0.0
133.1	131.9	132.0	132.0	0.1	0.0
134.1	132.9	133.0	133.2	0.3	0.2
135.1	133.9	134.2	134.2	0.3	0.0
136.1	134.9	135.2	135.2	0.3	0.0
137.1	135.9	136.2	136.2	0.3	0.0
138.1	136.9	137.2	137.2	0.3	0.0
139.1	137.9	138.2	138.2	0.3	0.0
140.1	138.9	139.2	139.1	0.2	-0.1
141.1	139.9	140.1	140.1	0.2	0.0

Leq

Frecuencia de ensayo 4000 Hz.

Nivel de Entrada dB	Esperado Rel. dB	Nivel Leido dB	Tolerancia +/- dB	Desviac. Rel. dB
93.0		94.0		
34.0	35.0	34.9	0.7	-0.1
42.0	43.0	43.0	0.7	0.0
52.0	53.0	53.0	0.7	0.0
62.0	63.0	62.9	0.7	-0.1
72.0	73.0	72.9	0.7	-0.1
82.0	83.0	82.9	0.7	-0.1
92.0	93.0	92.9	0.7	-0.1
102.0	103.0	103.0	0.7	0.0
112.0	113.0	113.0	0.7	0.0
122.0	123.0	123.0	0.7	0.0
132.0	133.0	133.0	0.7	0.0
139.0	140.0	140.1	0.7	0.1

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B 9 continued...

SEL

Frecuencia de ensayo 4000 Hz.

Nivel de Entrada dB	Esperado Rel. dB	Nivel Leido dB	Tolerancia +/- dB	Desviac. Rel. dB
93.0		94.0		
53.0	54.0	54.0	0.7	0.0
59.0	60.0	60.0	0.7	0.0
69.0	70.0	70.0	0.7	0.0
79.0	80.0	80.0	0.7	0.0
89.0	90.0	90.0	0.7	0.0
99.0	100.0	99.9	0.7	-0.1
109.0	110.0	110.0	0.7	0.0
119.0	120.0	120.0	0.7	0.0
129.0	130.0	129.9	0.7	-0.1
139.0	140.0	140.1	0.7	0.1

B 6 DETECCION CUADRATICA

Ensayo de exactitud del detector de RMS para señales con varios factores de cresta.

El nivel de referencia inicial para el ensayo es el nivel de fondo de escala -20 dB, en el rango de referencia.

Frecuencia de ensayo : 2000 Hz
Periodo de señales rectangulares : 25 msec

Nivel de entrada : Nivel de entrada senoidal continua.
Nivel de refer. : Lectura del sonómetro con señal de ref.
Nivel esperado : Nivel eficaz calculado con señal de entrada rec.
Nivel leido : Nivel eficaz leido en el sonómetro.
Tolerancia : UNE - EN 60651: 7.5, 9.4.2
Desviación : Diferencia entre el nivel esperado y leido.

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B 6 continued...

Factor de cresta 3 Duración de señal 5,5 msec.

Nivel de Entrada dB	Nivel Ref. dB	Nivel Esperado dB	Nivel Leido dB	Toleranc. +/- dB	Desviac. dB
138.0	138.2	131.7	131.6	0.5	-0.1
128.0	128.0	121.5	121.4	0.5	-0.1
118.0	118.0	111.5	111.5	0.5	0.0
108.0	108.0	101.5	101.5	0.5	0.0
98.0	98.0	91.5	91.5	0.5	0.0
88.0	88.0	81.5	81.5	0.5	0.0
78.0	78.0	71.5	71.5	0.5	0.0
68.0	68.0	61.5	61.5	0.5	0.0
58.0	58.0	51.5	51.5	0.5	0.0

Factor de cresta 5 Duración de señal 2 msec.

Nivel de Entrada dB	Nivel Ref. dB	Nivel Esperado dB	Nivel Leido dB	Toleranc. +/- dB	Desviac. dB
138.0	138.2	127.3	127.2	1.0	-0.1
128.0	128.0	117.1	117.1	1.0	0.0
118.0	118.0	107.1	107.1	1.0	0.0
108.0	108.0	97.1	97.1	1.0	0.0
98.0	98.0	87.1	87.1	1.0	0.0
88.0	88.0	77.1	77.2	1.0	0.1
78.0	78.0	67.1	67.1	1.0	0.0
68.0	68.0	57.1	57.1	1.0	0.0
58.0	58.0	47.1	47.1	1.0	0.0

Factor de cresta 10 Duración de señal 0,5 msec.

Nivel de Entrada dB	Nivel Ref. dB	Nivel Esperado dB	Nivel Leido dB	Toleranc. +/- dB	Desviac. dB
138.0	138.2	121.3	121.2	1.5	-0.1
128.0	128.0	111.1	111.0	1.5	-0.1
118.0	118.0	101.1	101.1	1.5	0.0
108.0	108.0	91.1	91.1	1.5	0.0
98.0	98.0	81.1	81.1	1.5	0.0
88.0	88.0	71.1	71.3	1.5	0.2
78.0	78.0	61.1	61.1	1.5	0.0
68.0	67.9	51.0	51.2	1.5	0.2

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B 7 PONDERACION TEMPORAL

Verificación de las ponderaciones temporales F. S. I. y Pico.

Tolerancias UNE - EN 60651: 4.5, 7.2-7.5, 9.4.1, 9.4.3, 9.4.4
Diferencia en indicación entre F. S. I.
Tipo 0, 1, 2: Max. 0.1 dB
Tipo 3 Max. 0.2 dB
Ensayo de Pico
Max. desviación con impulso de ensayo -2 dB
Ensayo de sobrelectura
Max. sobrelectura Tipo 0 : Fast 0.5 dB
Slow 1.0 dB
Max. sobrelectura Tipo 1,2,3 : Fast 1.1 dB
Slow 1.6 dB

El nivel de la señal rectangular se establece en las tablas como nivel de entrada para los ensayos de F ,S e I.
En el ensayo de F y S se utiliza una señal base a -20 dB.

Duración : 5 msec.
Frecuencia de la señal de ensayo : 2000 Hz.

Nivel de entrada	:	Nivel de entrada senoidal continua.
Nivel de referencía	:	Lectura del sonómetro con entrada sen.
Nivel esperado	:	Nivel esperado del sonómetro.
Nivel Leido	:	Nivel leido del sonómetro.
Tolerancia	:	UNE - EN 60651: 4.5, 7.2-7.5, 9.4.1, 9.4.3, 9.4.4
Desviación	:	Diferencia entre nivel esperado y leido.
Duración	:	Duración de la señal rectangular.
POS / NEG	:	Pulso positivo o negativo.

Diferencia en indicación

Nivel de	Nivel leido			Desviac.	
Entrada	F	S	I	S	I
dB	dB	dB	dB	dB	dB
94.0	94.0				
94.0		94.0		0.0	
94.0			94.0		0.0

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B 7 continued...

Salva única en F , duración de salva 200 msec.

Nivel de Entrada dB	Nivel Ref. dB	Nivel Esperado dB	Nivel Leido dB	Tolerancia + dB	Tolerancia - dB	Desv dB
136.0	136.2	135.2	135.2	1.0	1.0	0.0
116.0	116.0	115.0	115.0	1.0	1.0	0.0
96.0	96.0	95.0	95.0	1.0	1.0	0.0
76.0	76.0	75.0	75.1	1.0	1.0	0.1
56.0	56.0	55.0	55.1	1.0	1.0	0.1

Pulso único S, duración de pulso 500 msec.

Nivel de Entrada dB	Nivel Ref. dB	Nivel Esperado dB	Nivel Leido dB	Tolerancia + dB	Tolerancia - dB	Desv dB
136.0	136.2	132.1	132.2	1.0	1.0	0.1
116.0	116.0	111.9	112.0	1.0	1.0	0.1
96.0	96.0	91.9	92.0	1.0	1.0	0.1
76.0	76.0	71.9	72.0	1.0	1.0	0.1
56.0	56.0	51.9	52.0	1.0	1.0	0.1

Pulso único I, duracion de pulso 20 msec.

Nivel de Entrada dB	Nivel Ref. dB	Nivel Esperado dB	Nivel Leido dB	Tolerancia + dB	Tolerancia - dB	Desv dB
140.0	140.1	136.5	136.4	1.5	1.5	-0.1
120.0	120.0	116.4	116.3	1.5	1.5	-0.1
100.0	100.0	96.4	96.4	1.5	1.5	0.0
80.0	80.0	76.4	76.4	1.5	1.5	0.0
60.0	60.0	56.4	56.3	1.5	1.5	-0.1

Pulso único I, duración de pulso 5 msec.

Nivel de Entrada dB	Nivel Ref. dB	Nivel Esperado dB	Nivel Leido dB	Tolerancia + dB	Tolerancia - dB	Desv dB
140.0	140.1	131.3	131.2	2.0	2.0	-0.1
120.0	120.0	111.2	111.1	2.0	2.0	-0.1
100.0	100.0	91.2	91.2	2.0	2.0	0.0
80.0	80.0	71.2	71.2	2.0	2.0	0.0
60.0	60.0	51.2	51.2	2.0	2.0	0.0

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B 7 continued...

Pulso único I, duración de pulso 2 msec.

Nivel de Entrada dB	Nivel Ref. dB	Nivel Esperado dB	Nivel Leido dB	Tolerancia + dB	Tolerancia - dB	Desv dB
140.0	140.1	127.5	127.5	2.0	2.0	0.0
120.0	120.0	107.4	107.3	2.0	2.0	-0.1
100.0	100.0	87.4	87.3	2.0	2.0	-0.1
80.0	80.0	67.4	67.4	2.0	2.0	0.0
60.0	60.0	47.4	47.3	2.0	2.0	-0.1

Señal continua I, periodo de repetición 10 msec.

Nivel de Entrada dB	Nivel Ref. dB	Nivel Esperado dB	Nivel Leido dB	Tolerancia + dB	Tolerancia - dB	Desv dB
140.0	140.1	137.4	137.3	1.0	1.0	-0.1
120.0	120.0	117.3	117.2	1.0	1.0	-0.1
100.0	100.0	97.3	97.2	1.0	1.0	-0.1
80.0	80.0	77.3	77.3	1.0	1.0	0.0
60.0	60.0	57.3	57.3	1.0	1.0	0.0

Señal continua I, periodo de repetición de 50 msec

Nivel de Entrada dB	Nivel Ref. dB	Nivel Esperado dB	Nivel Leido dB	Tolerancia + dB	Tolerancia - dB	Desv dB
140.0	140.1	132.5	132.5	2.0	2.0	0.0
120.0	120.0	112.4	112.4	2.0	2.0	0.0
100.0	100.0	92.4	92.4	2.0	2.0	0.0
80.0	80.0	72.4	72.4	2.0	2.0	0.0
60.0	60.0	52.4	52.5	2.0	2.0	0.1

Señal continua I, periodo de repetición 500 msec.

Nivel de Entrada dB	Nivel Ref. dB	Nivel Esperado dB	Nivel Leido dB	Tolerancia + dB	Tolerancia - dB	Desv dB
140.0	140.1	131.3	131.3	2.0	2.0	0.0
120.0	120.0	111.2	111.2	2.0	2.0	0.0
100.0	100.0	91.2	91.2	2.0	2.0	0.0
80.0	80.0	71.2	71.2	2.0	2.0	0.0
60.0	60.0	51.2	51.2	2.0	2.0	0.0

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B 7 continued...

Pulso único de onda cuadrada

Duración	Esperado		Leido		Desviac.	
	POS	NEG	POS	NEG	POS	NEG
usec	dB	dB	dB	dB	dB	dB
10000.0	139.8			-0.1	0.1	0.0
10000.0		139.9	0.1		0.2	0.1
100.0	139.7		-0.1	-0.2		-0.1
100.0		139.8	0.0	-0.1	0.1	

C 19 PROMEDIACION TEMPORAL
==========================

Este ensayo compara la lectura del sonómetro para señales de salva continua con las lecturas obtenidas a partir de la secuencia de salva senoidal con el mismo nivel de RMS.

Tolerancias UNE - EN 60804: 4.5, 6.1, 9.3.2.

Factor de duración	Tiempo de repetición	Tiempo de Integración	Tolerancias UNE +/- dB Tipo 0	1	2y3
1/10	10 msec	60 sec	0.5	0.5	1.0
1/100	100	60	0.5	0.5	1.0
1/1000	1 sec	60	0.5	1.0	1.5
1/10000	10	300	1.0	1.0	-
1/100000	100	3000	1.0	-	-

El nivel de ensayo es 20 dB por encima del límite inferior del rango.
Frecuencia básica de la señal de salva: 4000 Hz
Duración de la señal de salva : 1 msec.
Señal de base. : - 80 dB

Tiempo de repetición : Tiempo de repetición de la señal de salva
Esperado : Nivel esperado
Leido : Nivel leido del sonómetro
Desviación : Diferencia entre nivel esperado y leido

Tiempo de repetición	Esperado		Leido		Desviac.	
	Leq	SEL	Leq	SEL	Leq	SEL
msec	dB	dB	dB	dB	dB	dB
			53.0			
10.0	53.0	70.8	52.9	70.7	-0.1	-0.1
100.0	53.0	70.8	52.9	70.7	-0.1	-0.1
1000.0	53.0	70.8	52.9	70.7	-0.1	-0.1
10000.0	53.0	77.8	52.9	77.7	-0.1	-0.1

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C 17 CAMPO DE APTITUD PARA MEDIDA DE IMPULSOS

Se ensaya la respuesta del sonómetro a una salva única de corta duración.
La señal de salva esta superpuesta a la señal base correspondiente en el límite inferior del rango de referencia.

Tolerancias UNE - EN 60804: 6.2, 9.3.4

SLM Tipo	Duración de la salva tonal.			
	1 msec	10 msec	100 msec	1 sec
	+/-	+/-	+/-	+/-
0	1.9	1.4	1.4	1.4 dB
1	2.2	1.7	1.7	1.7 dB
2 y 3	2.5	2.0	2.0	2.0 dB

El nivel de la señal de salva se establece en la primera linea de la tabla como Leq leido.
La señal base es -70 dB para Tipo 0, -60 dB para Tipo 1 y -50 dB para Tipo 2 y 3 relativos a este nivel.
Frecuencia : 4000 Hz
Tiempo de integración : 60 sec

Duracion : Duracion de la salva
Esperado : Nivel calculado
Leido : Lectura del sonómetro
Desviación : Diferencia entre nivel esperado y leido.

Duracion	Esperado		Leido		Desviac.	
	Leq	SEL	Leq	SEL	Leq	SEL
msec	dB	dB	dB	dB	dB	dB
			92.9			
1.0	45.4	63.2	45.4	63.2	0.0	0.0
10.0	55.1	72.9	55.2	73.0	0.1	0.1
100.0	65.1	82.9	65.2	83.0	0.1	0.1
1000.0	75.1	92.9	75.2	93.0	0.1	0.1

B 11 INDICACION DE SOBRECARGA

El indicador de sobrecarga se ha ensayado en los modos NPS y SEL si estan incluidos en el sonómetro.
El ensayo finaliza cuando se produce la indicación de sobrecarga.

Frecuencia de señal de prueba en modo SEL: 4000 Hz.

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B 11 continued...

Frecuencia : Frecuencia de la entrada senoidal.
Nivel de entrada: Nivel de entrada senoidal.
Nivel esperado : Nivel esperado del sonómetro.
Nivel Leido : Nivel leido del sonómetro.
Tolerancia : UNE - EN 60651: 6.5, 9.3.1
UNE - EN 60804: 4.6, 7.1, 7.2, 7.3, 9.3.5
Desviac. : Diferencia entre nivel esperado y leido.

Modo NPS

Frecuencia	Nivel de Entrada	Nivel Esperado	Nivel Leido	Tolerancia	Desv.
Hz	dB	dB	dB	dB	dB
1000.0	135.0		135.2		
800.0	135.8	135.2	135.2	1.0	0.0
630.0	136.9	135.2	135.1	1.0	-0.1
500.0	138.2	135.2	135.1	1.0	-0.1
400.0	139.8	135.2	135.1	1.0	-0.1
315.0	141.6	135.2	135.0		-0.2

Modo SEL

Nivel de Entrada	Nivel Esperado	Nivel Leido	Tolerancia +/-	Desv.
dB	dB	dB	dB	dB
135.0		106.0		
136.0	107.0	107.0	2.2	0.0
137.0	108.0	108.0	2.2	0.0
138.0	109.0	109.0	2.2	0.0
139.0	110.0	110.0	2.2	0.0
140.0	111.0	111.0	2.2	0.0
141.0	112.0	112.0	2.2	0.0
142.0	113.0	112.9		-0.1

A 1 LECTURA EN CONDICIONES DE REF.

El sonómetro se ha ajustado acústicamente a 94 dB y 1000 Hz con un calibrador multifunción modelo 4226 de B&K.

A 2 RESPUESTA EN FRECUENCIA POR ENTRADA ACUSTICA

La respuesta acústica del sonómetro y el micrófono se han ensayado en el rango de frecuencia 31,5 Hz. a 12.5 KHz. con un calibrador acústico multifunción modelo 4226.

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A 2 continued...

El ensayo se ha realizado en ponderaciónes A y Lin.

Frecuencia de referencia: 1KHz.
Nivel de referencia : 94 dB
Tolerancia : UNE - EN 60651: 4.4, 6.1, 9.1, 9.2
9.2.1, 9.2.2

Ponderación frecuencial A

		Nivel		Tolerancia		
Frecuencia	FF-Corr.	Esp.	Leido	Pos.	Neg.	Des
1000.0	0.1		93.8			
31.5	0.0	54.6	54.9	1.5	1.5	0.3
63.0	0.0	67.8	68.0	1.5	1.5	0.2
125.0	0.0	77.9	78.0	1.0	1.0	0.1
250.0	0.0	85.4	85.3	0.9	1.0	-0.1
500.0	0.0	90.8	90.7	0.8	0.9	-0.1
2000.0	0.3	94.9	94.7	0.8	0.7	-0.2
4000.0	1.1	93.9	93.8	0.8	0.8	-0.1
8000.0	3.8	89.1	89.0	1.4	2.8	-0.1
12500.0	7.3	82.4	81.9	2.8	5.8	-0.5

Ponderación frecuencial Lin.

		Nivel		Tolerancia		
Frecuencia	FF-Corr.	Esp.	Leido	Pos.	Neg.	Des
1000.0	0.1		93.8			
31.5	0.0	94.0	94.4	1.5	1.5	0.4
63.0	0.0	94.0	94.2	1.5	1.5	0.2
125.0	0.0	94.0	94.1	1.0	1.0	0.1
250.0	0.0	94.0	94.0	0.9	1.0	0.0
500.0	0.0	94.0	94.0	0.8	0.9	0.0
2000.0	0.3	93.7	93.5	0.8	0.7	-0.2
4000.0	1.1	92.9	92.8	0.8	0.8	-0.1
8000.0	3.8	90.2	90.1	1.4	2.8	-0.1
12500.0	7.3	86.7	86.3	2.8	5.8	-0.4

Sensibilidad del Micrófono: 47.86 mV/Pa.

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ENAC
CALIBRACIÓN
Nº 50/LC003

CERTIFICADO DE CALIBRACIÓN

Certificate of Calibration

Número 13140-A
Number

Brüel & Kjær

Brüel & Kjær Ibérica, S.A.
Teide, 5 • 28703 San Sebastián de los Reyes (Madrid)
Tel.: 91 659 08 20 • Fax: 91 659 08 24
bruelkjaer@bkes.com

LABORATORIO DE CALIBRACIÓN

INSTRUMENTO *Instrument*	SONOMETRO
FABRICANTE *Manufacturer*	BRÜEL & KJAER
MODELO *Model*	2250
NÚMERO DE SERIE *Serial Number*	DEMO 43
PETICIONARIO *Customer*	**BRUEL & KJÆR IBERICA, S. A.** **TEIDE, 5 – 28703 SAN SEBASTIAN DE LOS REYES (MADRID)**
FECHA DE ENTRADA *Date of Reception*	20-oct-2010
FECHA DE CALIBRACIÓN *Date of Calibration*	21-oct-2010

Signatario/s Autorizado/s
Authorised Signatory/ies

JOSE Mª ALVAREZ
JEFE DE LABORATORIO

BRUEL & KJAER CALIBRACION
Teide, 5
Bruel & Kjaer
Iberica S.A.
28700 S.S. Reyes

Fecha de Emisión
Date of issue

21-oct-2010

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Brüel & Kjær

Brüel & Kjær Ibérica, S.A.
Teide, 5 - 28703 San Sebastián de los Reyes (MADRID)
Tel. 91 659 08 20 Fax 91 659 08 24 bruelkjaer@bkes.com

ENAC
CALIBRACIÓN
N° 50/LC003

CERTIFICADO DE CALIBRACIÓN

Cert. N° **13140-A**

Calibración de:

Equipo:	**Brüel & Kjær 2250**	**Clase 1**	N° de Serie:	DEMO 43
Micrófono:	**Brüel & Kjær 4189**		N° de Serie:	2021298

Cliente:

BRUEL & KJÆR IBERICA, S. A.
TEIDE, 5 – 28703 SAN SEBASTIAN DE LOS REYES
MADRID

Fecha de entrada: 21-oct-2010

Condiciones de calibración:

Temperatura:	23	°C
Humedad relativa:	35	% RH
Presión Atmosférica:	945	hPa

Procedimiento:

El presente instrumento ha sido calibrado de acuerdo con el Procedimiento PE/B&K-C/20 elaborado a partir de las normas UNE-EN 60651 : 1996 modificada por la UNE-EN 60651/A1 : 1997 y UNE-EN 60804 : 2002, en ensayos eléctricos. Los ensayos acústicos se han elaborado de acuerdo con el BS-7580 : Part 1 : 1997. Normas obsoletas.

Incertidumbres y Resultados:

Incertidumbre Acústica: ± 0.24 dB. (31.5 Hz $\leq$ U $\leq$ 1 kHz.)
: ± 0.30 dB. (1 kHz $<$ U $\leq$ 4 kHz)
: ± 0.40 dB. (4 kHz $<$ U $\leq$ 8 kHz)
: ± 0.50 dB. (8 kHz $<$ U $\leq$ 12.5 kHz)
Incertidumbre Eléctrica: ± 0.20 dB.

La incertidumbre expandida de medida se ha obtenido multiplicando la incertidumbre típica de medición por el factor de cobertura k=2 que, para una distribución normal, corresponde a una probabilidad de cobertura de aproximadamente el 95%. La incertidumbre típica de medida se ha determinado conforme al documento EA-4/02.

Fecha de calibración: 21-oct-2010

BRUEL & KJAER CALIBRACIÓN
Teide, 5
Bruel & Kjaer Iberica S.A.
28700 S.S. Reyes

Fernando Muñoz
Técnico de calibración

Fecha de edición: 21-oct-2010

José Mª Alvarez
Jefe de Laboratorio

Nota: Los resultados contenidos en el presente certificado se refieren al momento y condiciones en que se realizaron las mediciones.

Inscrita en el Registro Mercantil de Barcelona. Hoja 27078, Folio 132, Tomo 2558, Libro 1941, Sección 2ª, Inscripción 1ª. N.I.F. A-08349649.

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Sumario

CONFIDENTIAL INFORMATION – THIS INFORMATION IS CONFIDENTIAL AND CONTAINS CONFIDENTIAL BUSINESS AND TECHNICAL INFORMATION AND TRADE SECRETS AND SHOULD NOT BE DISCLOSED TO ANY THIRD PARTY ABSENT CONSENT FROM THE DOW CHEMICAL COMPANY AND SAUDI ARABIAN OIL COMPANY

El Sistema está compuesto por los siguientes Patrones

Objeto:	Modelo:	Fabricante:	Identificación:	Fecha de última calibración:	Trazables a:
Generator	Pulse Generator	Brüel & Kjær	2447674		
Voltmeter	DMM34970A	Agilent	US37044999	2010-09-03	ENAC
Calibrator	4226	Brüel & Kjær	1672930	2010-04-22	ENAC - C1003523
AmplifierDivider	3111 Output Module	Brüel & Kjær	2345678		

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Nivel de sensibilidad Acústica Absoluta

La respuesta del sonómetro a una señal de presión acústica sinusoidal a la frecuencia de calibración.

	Coupler Pressure Lc	Mic. Correction C4226	Body Influence Cbi	Expected	Measured	Accept - Limit	Accept + Limit	Deviation
	[dB SPL]	[dB]	[dB]	[dB SPL]	[dB SPL]	[dB]	[dB]	[dB]
Ref. Conditions	93.91	0.10	-0.07	93.88	93.81	-1.0	1.0	-0.07

Respuesta en Frecuencia Acústica con Ponderación "A"

La respuesta del sonómetro a señales sinusoidales de presión acústica en el nivel de calibración a 1 kHz y en otras frecuencias. A partir de este la respuesta de frecuencia en campo libre. La respuesta de frecuencia se calcula para otras frecuencias de 1 kHz respecto a la respuesta a 1 kHz. la respuesta esperada se calcula como el nivel de presión sonora en el calibrador acústico menos las correciones a campo libre. Los resultados se comparan con la ponderación de la frecuencia nominal.

	Coupler Pressure Lc	Mic. Correction C4226	Body Influence Cbi	Expected	Measured	Accept - Limit	Accept + Limit	Deviation
	[dB SPL]	[dB]	[dB]	[dB SPL]	[dB SPL]	[dB]	[dB]	[dB]
1000Hz <Ref>	93.91	0.10	-0.07	93.88	93.81	-1.0	1.0	-0.07
31.623Hz	93.92	0.00	0.00	54.52	54.81	-1.5	1.5	0.29
63.096Hz	93.95	0.00	0.00	67.75	67.87	-1.5	1.5	0.12
125.89Hz	93.95	0.00	0.00	77.85	77.88	-1.0	1.0	0.03
251.19Hz	93.94	0.00	0.07	85.27	85.31	-1.0	1.0	0.04
501.19Hz	93.93	0.00	0.22	90.51	90.67	-1.0	1.0	0.16
1995.3Hz	93.95	0.25	-0.09	94.99	94.71	-1.0	1.0	-0.28
3981.1Hz	93.66	0.90	-0.09	93.85	93.32	-1.0	1.0	-0.53
7943.3Hz	93.23	2.80	-0.08	89.41	88.98	-3.0	1.5	-0.43
12589Hz	92.38	5.45	0.15	82.48	82.62	-6.0	3.0	0.14

Respuesta en Frecuencia Acústica con Ponderación "C"

La respuesta del sonómetro a señales sinusoidales de presión acústica en el nivel de calibración a 1 kHz y en otras frecuencias. A partir de este la respuesta de frecuencia en campo libre. La respuesta de frecuencia se calcula para otras frecuencias de 1 kHz respecto a la respuesta a 1 kHz. la respuesta esperada se calcula como el nivel de presión sonora en el calibrador acústico menos las correciones a campo libre. Los resultados se comparan con la ponderación de la frecuencia nominal.

	Coupler Pressure Lc	Mic. Correction C4226	Body Influence Cbi	Expected	Measured	Accept - Limit	Accept + Limit	Deviation
	[dB SPL]	[dB]	[dB]	[dB SPL]	[dB SPL]	[dB]	[dB]	[dB]
1000Hz <Ref>	93.91	0.10	-0.07	93.88	93.81	-1.0	1.0	-0.07
31.623Hz	93.92	0.00	0.00	90.92	91.07	-1.5	1.5	0.15
63.096Hz	93.95	0.00	0.00	93.15	93.20	-1.5	1.5	0.05
125.89Hz	93.95	0.00	0.00	93.75	93.81	-1.0	1.0	0.06
251.19Hz	93.94	0.00	0.07	93.87	93.94	-1.0	1.0	0.07
501.19Hz	93.93	0.00	0.22	93.71	93.94	-1.0	1.0	0.23
1995.3Hz	93.95	0.25	-0.09	93.59	93.35	-1.0	1.0	-0.24
3981.1Hz	93.66	0.90	-0.09	92.05	91.53	-1.0	1.0	-0.52

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7943.3Hz	93.23	2.80	-0.08	87.51	87.08	-3.0	1.5	-0.43
12589Hz	92.38	5.45	0.15	80.58	80.71	-6.0	3.0	0.13

Respuesta en Frecuencia Acústica con Ponderacion "Z"

La respuesta del sonómetro a señales sinusoidales de presión acústica en el nivel de calibración a 1 kHz y en otras frecuencias. A partir de este la respuesta de frecuencia en campo libre. La respuesta de frecuencia se calcula para otras frecuencias de 1 kHz respecto a la respuesta a 1 kHz. la respuesta esperada se calcula como el nivel de presión sonora en el calibrador acústico menos las correciones a campo libre. Los resultados se comparan con la ponderación de la frecuencia nominal.

	Coupler Pressure Lc [dB SPL]	Mic. Correction C4226 [dB]	Body Influence Cbi [dB]	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
1000Hz <Ref>	93.91	0.10	-0.07	93.88	93.89	-1.0	1.0	0.01
31.623Hz	93.92	0.00	0.00	94.00	94.10	-1.5	1.5	0.10
63.096Hz	93.95	0.00	0.00	94.03	94.05	-1.5	1.5	0.02
125.89Hz	93.95	0.00	0.00	94.03	94.02	-1.0	1.0	-0.01
251.19Hz	93.94	0.00	0.07	93.95	93.97	-1.0	1.0	0.02
501.19Hz	93.93	0.00	0.22	93.79	93.91	-1.0	1.0	0.12
1995.3Hz	93.95	0.25	-0.09	93.87	93.52	-1.0	1.0	-0.35
3981.1Hz	93.66	0.90	-0.09	92.93	92.36	-1.0	1.0	-0.57
7943.3Hz	93.23	2.80	-0.08	90.59	90.10	-3.0	1.5	-0.49
12589Hz	92.38	5.45	0.15	86.86	86.96	-6.0	3.0	0.10

Ruido eléctrico intrinseco con Ponderación "A"

La conexión del adaptador de entrada eléctrica al generador es sustituido por un cortocircuito y la lectura del sonómetro quedara registrada. Se comprueba que la lectura es lo suficientemente baja para indicar que el ruido inherente no afecta a la linealidad del sonómetro.

	Max [dB SPL]	Measured [dB SPL]	Deviation [dB]
Noise	20.00	12.48	-7.52

Ruido eléctrico intrinseco con Ponderación "C"

La conexión del adaptador de entrada eléctrica al generador es sustituido por un cortocircuito y la lectura del sonómetro quedara registrada. Se comprueba que la lectura es lo suficientemente baja para indicar que el ruido inherente no afecta a la linealidad del sonómetro.

	Max [dB SPL]	Measured [dB SPL]	Deviation [dB]
Noise	20.00	12.76	-7.24

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Ruido eléctrico intrinseco con Ponderación "Z"

La conexión del adaptador de entrada eléctrica al generador es sustituido por un cortocircuito y la lectura del sonómetro quedara registrada. Se comprueba que la lectura es lo suficientemente baja para indicar que el ruido inherente no afecta a la linealidad del sonómetro.

	Max [dB SPL]	Measured [dB SPL]	Deviation [dB]
Noise	20.00	18.74	-1.26

Determinación del nivel eléctrico de referencia a 1 kHz.

La respuesta a un nivel de entrada de señal eléctrica que corresponde a la respuesta esperada a un nivel de presión acústica de 94 dB. Todas las señales eléctricas se establecen en relación con este valor.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref.	94.00	93.30	-2.0	2.0	-0.70

Respuesta en frecuencia eléctrica con Ponderación "A"

La respuesta del sonómetro a señales de tensión sinusoidal a 1 kHz y en otras frecuencias. La respuesta de frecuencia se calcula para otras frecuencias respecto a la respuesta a 1 kHz. Los resultados se comparan con la ponderación de la frecuencia nominal.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
1000Hz <Ref>	135.00	135.02	-1.0	1.0	0.02
10Hz	64.62	64.71	-100.0	3.0	0.09
12.58Hz	71.62	71.63	-100.0	3.0	0.01
15.84Hz	78.32	78.28	-100.0	3.0	-0.04
19.95Hz	84.52	84.51	-3.0	3.0	-0.01
25.19Hz	90.32	90.47	-2.0	2.0	0.15
31.623Hz	95.62	95.64	-1.5	1.5	0.02
39.811Hz	100.42	100.43	-1.5	1.5	0.01
50.119Hz	104.82	104.82	-1.5	1.5	0.00
63.096Hz	108.82	108.84	-1.5	1.5	0.02
79.433Hz	112.52	112.53	-1.5	1.5	0.01
100Hz	115.92	115.88	-1.0	1.0	-0.04
125.89Hz	118.92	118.92	-1.0	1.0	0.00
158.49Hz	121.62	121.67	-1.0	1.0	0.05
199.53Hz	124.12	124.15	-1.0	1.0	0.03
251.19Hz	126.42	126.39	-1.0	1.0	-0.03
316.23Hz	128.42	128.41	-1.0	1.0	-0.01
398.11Hz	130.22	130.21	-1.0	1.0	-0.01
501.19Hz	131.82	131.79	-1.0	1.0	-0.03
630.96Hz	133.12	133.12	-1.0	1.0	0.00
794.33Hz	134.22	134.20	-1.0	1.0	-0.02
1258.9Hz	135.62	135.61	-1.0	1.0	-0.01
1584.9Hz	136.02	136.00	-1.0	1.0	-0.02
1995.3Hz	136.22	136.23	-1.0	1.0	0.01
2511.9Hz	136.32	136.30	-1.0	1.0	-0.02

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3162.3Hz	136.22	136.23	-1.0	1.0	0.01
3981.1Hz	136.02	136.01	-1.0	1.0	-0.01
5011.9Hz	135.52	135.59	-1.5	1.5	0.07
6309.6Hz	134.92	134.93	-2.0	1.5	0.01
7943.3Hz	133.92	133.91	-3.0	1.5	-0.01
10000Hz	132.52	132.42	-4.0	2.0	-0.10
12589Hz	130.72	130.25	-6.0	3.0	-0.47
15849Hz	128.42	127.52	-100.0	3.0	-0.90
19953Hz	125.72	126.11	-100.0	3.0	0.39

Respuesta en frecuencia eléctrica con Ponderación "C"

La respuesta del sonómetro a señales de tensión sinusoidal a 1 kHz y en otras frecuencias. La respuesta de frecuencia se calcula para otras frecuencias respecto a la respuesta a 1 kHz. Los resultados se comparan con la ponderación de la frecuencia nominal.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
1000Hz <Ref>	135.00	135.02	-1.0	1.0	0.02
10Hz	120.72	120.64	-100.0	3.0	-0.08
12.58Hz	123.82	123.73	-100.0	3.0	-0.09
15.84Hz	126.52	126.44	-100.0	3.0	-0.08
19.95Hz	128.82	128.73	-3.0	3.0	-0.09
25.19Hz	130.62	130.72	-2.0	2.0	0.10
31.623Hz	132.02	132.07	-1.5	1.5	0.05
39.811Hz	133.02	133.07	-1.5	1.5	0.05
50.119Hz	133.72	133.75	-1.5	1.5	0.03
63.096Hz	134.22	134.22	-1.5	1.5	0.00
79.433Hz	134.52	134.53	-1.5	1.5	0.01
100Hz	134.72	134.73	-1.0	1.0	0.01
125.89Hz	134.82	134.86	-1.0	1.0	0.04
158.49Hz	134.92	134.94	-1.0	1.0	0.02
199.53Hz	135.02	134.99	-1.0	1.0	-0.03
251.19Hz	135.02	135.02	-1.0	1.0	0.00
316.23Hz	135.02	135.04	-1.0	1.0	0.02
398.11Hz	135.02	135.05	-1.0	1.0	0.03
501.19Hz	135.02	135.05	-1.0	1.0	0.03
630.96Hz	135.02	135.05	-1.0	1.0	0.03
794.33Hz	135.02	135.04	-1.0	1.0	0.02
1258.9Hz	135.02	134.99	-1.0	1.0	-0.03
1584.9Hz	134.92	134.94	-1.0	1.0	0.02
1995.3Hz	134.82	134.86	-1.0	1.0	0.04
2511.9Hz	134.72	134.73	-1.0	1.0	0.01
3162.3Hz	134.52	134.53	-1.0	1.0	0.01
3981.1Hz	134.22	134.23	-1.0	1.0	0.01
5011.9Hz	133.72	133.75	-1.5	1.5	0.03
6309.6Hz	133.02	133.05	-2.0	1.5	0.03
7943.3Hz	132.02	132.02	-3.0	1.5	0.00
10000Hz	130.62	130.50	-4.0	2.0	-0.12
12589Hz	128.82	128.33	-6.0	3.0	-0.49
15849Hz	126.52	125.59	-100.0	3.0	-0.93
19953Hz	123.82	124.18	-100.0	3.0	0.36

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Respuesta en frecuencia eléctrica con Ponderación "Z"

La respuesta del sonómetro a señales de tensión sinusoidal a 1 kHz y en otras frecuencias. La respuesta de frecuencia se calcula para otras frecuencias respecto a la respuesta a 1 kHz. Los resultados se comparan con la ponderación de la frecuencia nominal.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
1000Hz <Ref>	135.00	135.02	-1.0	1.0	0.02
10Hz	135.02	134.97	-100.0	3.0	-0.05
12.58Hz	135.02	134.97	-100.0	3.0	-0.05
15.84Hz	135.02	134.98	-100.0	3.0	-0.04
19.95Hz	135.02	134.97	-3.0	3.0	-0.05
25.19Hz	135.02	135.11	-2.0	2.0	0.09
31.623Hz	135.02	135.08	-1.5	1.5	0.06
39.811Hz	135.02	135.06	-1.5	1.5	0.04
50.119Hz	135.02	135.05	-1.5	1.5	0.03
63.096Hz	135.02	135.04	-1.5	1.5	0.02
79.433Hz	135.02	135.03	-1.5	1.5	0.01
100Hz	135.02	135.03	-1.0	1.0	0.01
125.89Hz	135.02	135.03	-1.0	1.0	0.01
158.49Hz	135.02	135.02	-1.0	1.0	0.00
199.53Hz	135.02	135.02	-1.0	1.0	0.00
251.19Hz	135.02	135.02	-1.0	1.0	0.00
316.23Hz	135.02	135.02	-1.0	1.0	0.00
398.11Hz	135.02	135.02	-1.0	1.0	0.00
501.19Hz	135.02	135.02	-1.0	1.0	0.00
630.96Hz	135.02	135.02	-1.0	1.0	0.00
794.33Hz	135.02	135.02	-1.0	1.0	0.00
1258.9Hz	135.02	135.02	-1.0	1.0	0.00
1584.9Hz	135.02	135.03	-1.0	1.0	0.01
1995.3Hz	135.02	135.03	-1.0	1.0	0.01
2511.9Hz	135.02	135.03	-1.0	1.0	0.01
3162.3Hz	135.02	135.04	-1.0	1.0	0.02
3981.1Hz	135.02	135.05	-1.0	1.0	0.03
5011.9Hz	135.02	135.05	-1.5	1.5	0.03
6309.6Hz	135.02	135.05	-2.0	1.5	0.03
7943.3Hz	135.02	135.02	-3.0	1.5	0.00
10000Hz	135.02	134.90	-4.0	2.0	-0.12
12589Hz	135.02	134.57	-6.0	3.0	-0.45
15849Hz	135.02	134.15	-100.0	3.0	-0.87
19953Hz	135.02	135.28	-100.0	3.0	0.26

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Linealidad en pasos de 1 dB a la frecuencia de 31,5 Hz.

La respuesta del sonómetro a señales de amplitud sinusoidal en varios niveles que abarca el rango de referencia, incluyendo un nivel nominal correspondiente a Lref en la frecuencia de medición. A partir de esta respuesta de otros niveles se calcula la respuesta correspondiente a Lref. La respuesta relativa se compara con la respuesta relativa.Para cada nivel entre las respuestas y el nivel anterior se calcula también con el fin de determinar la linealidad diferencial de nivel.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
94 dB	94.00	94.06	-1.0	1.0	0.06
31 dB Rel. Ref.	31.06	31.45	-0.7	0.7	0.39
32 dB Rel. Ref.	32.06	32.41	-0.7	0.7	0.35
32 dB Diff.	32.45	32.41	-0.2	0.2	-0.04
33 dB Rel. Ref.	33.06	33.36	-0.7	0.7	0.30
33 dB Diff.	33.41	33.36	-0.2	0.2	-0.05
34 dB Rel. Ref.	34.06	34.35	-0.7	0.7	0.29
34 dB Diff.	34.36	34.35	-0.2	0.2	-0.01
35 dB Rel. Ref.	35.06	35.31	-0.7	0.7	0.25
35 dB Diff.	35.35	35.31	-0.2	0.2	-0.04
36 dB Rel. Ref.	36.06	36.30	-0.7	0.7	0.24
36 dB Diff.	36.31	36.30	-0.2	0.2	-0.01
37 dB Rel. Ref.	37.06	37.31	-0.7	0.7	0.25
37 dB Diff.	37.30	37.31	-0.2	0.2	0.01
38 dB Rel. Ref.	38.06	38.25	-0.7	0.7	0.19
38 dB Diff.	38.31	38.25	-0.2	0.2	-0.06
39 dB Rel. Ref.	39.06	39.25	-0.7	0.7	0.19
39 dB Diff.	39.25	39.25	-0.2	0.2	0.00
40 dB Rel. Ref.	40.06	40.24	-0.7	0.7	0.18
40 dB Diff.	40.25	40.24	-0.2	0.2	-0.01
41 dB Rel. Ref.	41.06	41.25	-0.7	0.7	0.19
41 dB Diff.	41.24	41.25	-0.2	0.2	0.01
42 dB Rel. Ref.	42.06	42.25	-0.7	0.7	0.19
42 dB Diff.	42.25	42.25	-0.2	0.2	0.00
43 dB Rel. Ref.	43.06	43.17	-0.7	0.7	0.11
43 dB Diff.	43.25	43.17	-0.2	0.2	-0.08
44 dB Rel. Ref.	44.06	44.16	-0.7	0.7	0.10
44 dB Diff.	44.17	44.16	-0.2	0.2	-0.01
45 dB Rel. Ref.	45.06	45.13	-0.7	0.7	0.07
45 dB Diff.	45.16	45.13	-0.2	0.2	-0.03
46 dB Rel. Ref.	46.06	46.14	-0.7	0.7	0.08
46 dB Diff.	46.13	46.14	-0.2	0.2	0.01
47 dB Rel. Ref.	47.06	47.10	-0.7	0.7	0.04
47 dB Diff.	47.14	47.10	-0.2	0.2	-0.04
48 dB Rel. Ref.	48.06	48.11	-0.7	0.7	0.05
48 dB Diff.	48.10	48.11	-0.2	0.2	0.01
49 dB Rel. Ref.	49.06	49.12	-0.7	0.7	0.06
49 dB Diff.	49.11	49.12	-0.2	0.2	0.01
50 dB Rel. Ref.	50.06	50.10	-0.7	0.7	0.04
50 dB Diff.	50.12	50.10	-0.2	0.2	-0.02
51 dB Rel. Ref.	51.06	51.09	-0.7	0.7	0.03
51 dB Diff.	51.10	51.09	-0.2	0.2	-0.01
52 dB Rel. Ref.	52.06	52.09	-0.7	0.7	0.03
52 dB Diff.	52.09	52.09	-0.2	0.2	0.00

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53 dB Rel. Ref.	53.06	53.09	-0.7	0.7	0.03
53 dB Diff.	53.09	53.09	-0.2	0.2	0.00
54 dB Rel. Ref.	54.06	54.09	-0.7	0.7	0.03
54 dB Diff.	54.09	54.09	-0.2	0.2	0.00
55 dB Rel. Ref.	55.06	55.10	-0.7	0.7	0.04
55 dB Diff.	55.09	55.10	-0.2	0.2	0.01
56 dB Rel. Ref.	56.06	56.08	-0.7	0.7	0.02
56 dB Diff.	56.10	56.08	-0.2	0.2	-0.02
57 dB Rel. Ref.	57.06	57.08	-0.7	0.7	0.02
57 dB Diff.	57.08	57.08	-0.2	0.2	0.00
58 dB Rel. Ref.	58.06	58.08	-0.7	0.7	0.02
58 dB Diff.	58.08	58.08	-0.2	0.2	0.00
59 dB Rel. Ref.	59.06	59.08	-0.7	0.7	0.02
59 dB Diff.	59.08	59.08	-0.2	0.2	0.00
60 dB Rel. Ref.	60.06	60.08	-0.7	0.7	0.02
60 dB Diff.	60.08	60.08	-0.2	0.2	0.00
61 dB Rel. Ref.	61.06	61.08	-0.7	0.7	0.02
61 dB Diff.	61.08	61.08	-0.2	0.2	0.00
62 dB Rel. Ref.	62.06	62.07	-0.7	0.7	0.01
62 dB Diff.	62.08	62.07	-0.2	0.2	-0.01
63 dB Rel. Ref.	63.06	63.07	-0.7	0.7	0.01
63 dB Diff.	63.07	63.07	-0.2	0.2	0.00
64 dB Rel. Ref.	64.06	64.07	-0.7	0.7	0.01
64 dB Diff.	64.07	64.07	-0.2	0.2	0.00
65 dB Rel. Ref.	65.06	65.08	-0.7	0.7	0.02
65 dB Diff.	65.07	65.08	-0.2	0.2	0.01
66 dB Rel. Ref.	66.06	66.07	-0.7	0.7	0.01
66 dB Diff.	66.08	66.07	-0.2	0.2	-0.01
67 dB Rel. Ref.	67.06	67.07	-0.7	0.7	0.01
67 dB Diff.	67.07	67.07	-0.2	0.2	0.00
68 dB Rel. Ref.	68.06	68.07	-0.7	0.7	0.01
68 dB Diff.	68.07	68.07	-0.2	0.2	0.00
69 dB Rel. Ref.	69.06	69.07	-0.7	0.7	0.01
69 dB Diff.	69.07	69.07	-0.2	0.2	0.00
70 dB Rel. Ref.	70.06	70.07	-0.7	0.7	0.01
70 dB Diff.	70.07	70.07	-0.2	0.2	0.00
71 dB Rel. Ref.	71.06	71.07	-0.7	0.7	0.01
71 dB Diff.	71.07	71.07	-0.2	0.2	0.00
72 dB Rel. Ref.	72.06	72.07	-0.7	0.7	0.01
72 dB Diff.	72.07	72.07	-0.2	0.2	0.00
73 dB Rel. Ref.	73.06	73.07	-0.7	0.7	0.01
73 dB Diff.	73.07	73.07	-0.2	0.2	0.00
74 dB Rel. Ref.	74.06	74.07	-0.7	0.7	0.01
74 dB Diff.	74.07	74.07	-0.2	0.2	0.00
75 dB Rel. Ref.	75.06	75.07	-0.7	0.7	0.01
75 dB Diff.	75.07	75.07	-0.2	0.2	0.00
76 dB Rel. Ref.	76.06	76.07	-0.7	0.7	0.01
76 dB Diff.	76.07	76.07	-0.2	0.2	0.00
77 dB Rel. Ref.	77.06	77.07	-0.7	0.7	0.01
77 dB Diff.	77.07	77.07	-0.2	0.2	0.00
78 dB Rel. Ref.	78.06	78.08	-0.7	0.7	0.02
78 dB Diff.	78.07	78.08	-0.2	0.2	0.01
79 dB Rel. Ref.	79.06	79.07	-0.7	0.7	0.01
79 dB Diff.	79.08	79.07	-0.2	0.2	-0.01

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80 dB Rel. Ref.	80.06	80.07	-0.7	0.7	0.01
80 dB Diff.	80.07	80.07	-0.2	0.2	0.00
81 dB Rel. Ref.	81.06	81.07	-0.7	0.7	0.01
81 dB Diff.	81.07	81.07	-0.2	0.2	0.00
82 dB Rel. Ref.	82.06	82.07	-0.7	0.7	0.01
82 dB Diff.	82.07	82.07	-0.2	0.2	0.00
83 dB Rel. Ref.	83.06	83.07	-0.7	0.7	0.01
83 dB Diff.	83.07	83.07	-0.2	0.2	0.00
84 dB Rel. Ref.	84.06	84.07	-0.7	0.7	0.01
84 dB Diff.	84.07	84.07	-0.2	0.2	0.00
85 dB Rel. Ref.	85.06	85.07	-0.7	0.7	0.01
85 dB Diff.	85.07	85.07	-0.2	0.2	0.00
86 dB Rel. Ref.	86.06	86.07	-0.7	0.7	0.01
86 dB Diff.	86.07	86.07	-0.2	0.2	0.00
87 dB Rel. Ref.	87.06	87.07	-0.7	0.7	0.01
87 dB Diff.	87.07	87.07	-0.2	0.2	0.00
88 dB Rel. Ref.	88.06	88.07	-0.7	0.7	0.01
88 dB Diff.	88.07	88.07	-0.2	0.2	0.00
89 dB Rel. Ref.	89.06	89.07	-0.7	0.7	0.01
89 dB Diff.	89.07	89.07	-0.2	0.2	0.00
90 dB Rel. Ref.	90.06	90.07	-0.7	0.7	0.01
90 dB Diff.	90.07	90.07	-0.2	0.2	0.00
91 dB Rel. Ref.	91.06	91.07	-0.7	0.7	0.01
91 dB Diff.	91.07	91.07	-0.2	0.2	0.00
92 dB Rel. Ref.	92.06	92.07	-0.7	0.7	0.01
92 dB Diff.	92.07	92.07	-0.2	0.2	0.00
93 dB Rel. Ref.	93.06	93.06	-0.7	0.7	0.00
93 dB Diff.	93.07	93.06	-0.2	0.2	-0.01
95 dB Rel. Ref.	95.06	95.06	-0.7	0.7	0.00
95 dB Diff.	95.06	95.06	-0.4	0.4	0.00
96 dB Rel. Ref.	96.06	96.06	-0.7	0.7	0.00
96 dB Diff.	96.06	96.06	-0.2	0.2	0.00
97 dB Rel. Ref.	97.06	97.06	-0.7	0.7	0.00
97 dB Diff.	97.06	97.06	-0.2	0.2	0.00
98 dB Rel. Ref.	98.06	98.06	-0.7	0.7	0.00
98 dB Diff.	98.06	98.06	-0.2	0.2	0.00
99 dB Rel. Ref.	99.06	99.06	-0.7	0.7	0.00
99 dB Diff.	99.06	99.06	-0.2	0.2	0.00
100 dB Rel. Ref.	100.06	100.06	-0.7	0.7	0.00
100 dB Diff.	100.06	100.06	-0.2	0.2	0.00
101 dB Rel. Ref.	101.06	101.06	-0.7	0.7	0.00
101 dB Diff.	101.06	101.06	-0.2	0.2	0.00
102 dB Rel. Ref.	102.06	102.06	-0.7	0.7	0.00
102 dB Diff.	102.06	102.06	-0.2	0.2	0.00
103 dB Rel. Ref.	103.06	103.07	-0.7	0.7	0.01
103 dB Diff.	103.06	103.07	-0.2	0.2	0.01
104 dB Rel. Ref.	104.06	104.07	-0.7	0.7	0.01
104 dB Diff.	104.07	104.07	-0.2	0.2	0.00
105 dB Rel. Ref.	105.06	105.07	-0.7	0.7	0.01
105 dB Diff.	105.07	105.07	-0.2	0.2	0.00
106 dB Rel. Ref.	106.06	106.07	-0.7	0.7	0.01
106 dB Diff.	106.07	106.07	-0.2	0.2	0.00
107 dB Rel. Ref.	107.06	107.07	-0.7	0.7	0.01
107 dB Diff.	107.07	107.07	-0.2	0.2	0.00

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108 dB Rel. Ref.	108.06	108.07	-0.7	0.7	0.01
108 dB Diff.	108.07	108.07	-0.2	0.2	0.00
109 dB Rel. Ref.	109.06	109.07	-0.7	0.7	0.01
109 dB Diff.	109.07	109.07	-0.2	0.2	0.00
110 dB Rel. Ref.	110.06	110.07	-0.7	0.7	0.01
110 dB Diff.	110.07	110.07	-0.2	0.2	0.00
111 dB Rel. Ref.	111.06	111.07	-0.7	0.7	0.01
111 dB Diff.	111.07	111.07	-0.2	0.2	0.00
112 dB Rel. Ref.	112.06	112.07	-0.7	0.7	0.01
112 dB Diff.	112.07	112.07	-0.2	0.2	0.00
113 dB Rel. Ref.	113.06	113.07	-0.7	0.7	0.01
113 dB Diff.	113.07	113.07	-0.2	0.2	0.00
114 dB Rel. Ref.	114.06	114.07	-0.7	0.7	0.01
114 dB Diff.	114.07	114.07	-0.2	0.2	0.00
115 dB Rel. Ref.	115.06	115.08	-0.7	0.7	0.02
115 dB Diff.	115.07	115.08	-0.2	0.2	0.01
116 dB Rel. Ref.	116.06	116.08	-0.7	0.7	0.02
116 dB Diff.	116.08	116.08	-0.2	0.2	0.00
117 dB Rel. Ref.	117.06	117.08	-0.7	0.7	0.02
117 dB Diff.	117.08	117.08	-0.2	0.2	0.00
118 dB Rel. Ref.	118.06	118.08	-0.7	0.7	0.02
118 dB Diff.	118.08	118.08	-0.2	0.2	0.00
119 dB Rel. Ref.	119.06	119.08	-0.7	0.7	0.02
119 dB Diff.	119.08	119.08	-0.2	0.2	0.00
120 dB Rel. Ref.	120.06	120.08	-0.7	0.7	0.02
120 dB Diff.	120.08	120.08	-0.2	0.2	0.00
121 dB Rel. Ref.	121.06	121.08	-0.7	0.7	0.02
121 dB Diff.	121.08	121.08	-0.2	0.2	0.00
122 dB Rel. Ref.	122.06	122.08	-0.7	0.7	0.02
122 dB Diff.	122.08	122.08	-0.2	0.2	0.00
123 dB Rel. Ref.	123.06	123.08	-0.7	0.7	0.02
123 dB Diff.	123.08	123.08	-0.2	0.2	0.00
124 dB Rel. Ref.	124.06	124.08	-0.7	0.7	0.02
124 dB Diff.	124.08	124.08	-0.2	0.2	0.00
125 dB Rel. Ref.	125.06	125.08	-0.7	0.7	0.02
125 dB Diff.	125.08	125.08	-0.2	0.2	0.00
126 dB Rel. Ref.	126.06	126.08	-0.7	0.7	0.02
126 dB Diff.	126.08	126.08	-0.2	0.2	0.00
127 dB Rel. Ref.	127.06	127.08	-0.7	0.7	0.02
127 dB Diff.	127.08	127.08	-0.2	0.2	0.00
128 dB Rel. Ref.	128.06	128.08	-0.7	0.7	0.02
128 dB Diff.	128.08	128.08	-0.2	0.2	0.00
129 dB Rel. Ref.	129.06	129.08	-0.7	0.7	0.02
129 dB Diff.	129.08	129.08	-0.2	0.2	0.00
130 dB Rel. Ref.	130.06	130.08	-0.7	0.7	0.02
130 dB Diff.	130.08	130.08	-0.2	0.2	0.00
131 dB Rel. Ref.	131.06	131.08	-0.7	0.7	0.02
131 dB Diff.	131.08	131.08	-0.2	0.2	0.00
132 dB Rel. Ref.	132.06	132.08	-0.7	0.7	0.02
132 dB Diff.	132.08	132.08	-0.2	0.2	0.00
133 dB Rel. Ref.	133.06	133.08	-0.7	0.7	0.02
133 dB Diff.	133.08	133.08	-0.2	0.2	0.00
134 dB Rel. Ref.	134.06	134.08	-0.7	0.7	0.02
134 dB Diff.	134.08	134.08	-0.2	0.2	0.00

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135 dB Rel. Ref.	135.06	135.08	-0.7	0.7	0.02
135 dB Diff.	135.08	135.08	-0.2	0.2	0.00
136 dB Rel. Ref.	136.06	136.08	-0.7	0.7	0.02
136 dB Diff.	136.08	136.08	-0.2	0.2	0.00
137 dB Rel. Ref.	137.06	137.08	-0.7	0.7	0.02
137 dB Diff.	137.08	137.08	-0.2	0.2	0.00
138 dB Rel. Ref.	138.06	138.08	-0.7	0.7	0.02
138 dB Diff.	138.08	138.08	-0.2	0.2	0.00
139 dB Rel. Ref.	139.06	139.08	-0.7	0.7	0.02
139 dB Diff.	139.08	139.08	-0.2	0.2	0.00
140 dB Rel. Ref.	140.06	140.08	-0.7	0.7	0.02
140 dB Diff.	140.08	140.08	-0.2	0.2	0.00
140 dB Rel. Ref.	140.06	140.08	-0.7	0.7	0.02
140 dB Diff.	140.08	140.08	-0.2	0.2	0.00

Linealidad en pasos de 1 dB a la frecuencia de 1 kHz.

La respuesta del sonómetro a señales de amplitud sinusoidal en varios niveles que abarca el rango de referencia, incluyendo un nivel nominal correspondiente a Lref en la frecuencia de medición. A partir de esta respuesta de otros niveles se calcula la respuesta correspondiente a Lref. La respuesta relativa se compara con la respuesta relativa.Para cada nivel entre las respuestas y el nivel anterior se calcula también con el fin de determinar la linealidad diferencial de nivel.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
94 dB	94.00	94.00	-1.0	1.0	0.00
25 dB Rel. Ref.	25.00	25.55	-0.7	0.7	0.55
26 dB Rel. Ref.	26.00	26.48	-0.7	0.7	0.48
26 dB Diff.	26.55	26.48	-0.2	0.2	-0.07
27 dB Rel. Ref.	27.00	27.37	-0.7	0.7	0.37
27 dB Diff.	27.48	27.37	-0.2	0.2	-0.11
28 dB Rel. Ref.	28.00	28.22	-0.7	0.7	0.22
28 dB Diff.	28.37	28.22	-0.2	0.2	-0.15
29 dB Rel. Ref.	29.00	29.21	-0.7	0.7	0.21
29 dB Diff.	29.22	29.21	-0.2	0.2	-0.01
30 dB Rel. Ref.	30.00	30.15	-0.7	0.7	0.15
30 dB Diff.	30.21	30.15	-0.2	0.2	-0.06
31 dB Rel. Ref.	31.00	31.12	-0.7	0.7	0.12
31 dB Diff.	31.15	31.12	-0.2	0.2	-0.03
32 dB Rel. Ref.	32.00	32.09	-0.7	0.7	0.09
32 dB Diff.	32.12	32.09	-0.2	0.2	-0.03
33 dB Rel. Ref.	33.00	33.05	-0.7	0.7	0.05
33 dB Diff.	33.09	33.05	-0.2	0.2	-0.04
34 dB Rel. Ref.	34.00	34.06	-0.7	0.7	0.06
34 dB Diff.	34.05	34.06	-0.2	0.2	0.01
35 dB Rel. Ref.	35.00	35.02	-0.7	0.7	0.02
35 dB Diff.	35.06	35.02	-0.2	0.2	-0.04
36 dB Rel. Ref.	36.00	36.02	-0.7	0.7	0.02
36 dB Diff.	36.02	36.02	-0.2	0.2	0.00
37 dB Rel. Ref.	37.00	37.02	-0.7	0.7	0.02
37 dB Diff.	37.02	37.02	-0.2	0.2	0.00
38 dB Rel. Ref.	38.00	38.00	-0.7	0.7	0.00
38 dB Diff.	38.02	38.00	-0.2	0.2	-0.02

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39 dB Rel. Ref.	39.00	39.00	-0.7	0.7	0.00
39 dB Diff.	39.00	39.00	-0.2	0.2	0.00
40 dB Rel. Ref.	40.00	40.00	-0.7	0.7	0.00
40 dB Diff.	40.00	40.00	-0.2	0.2	0.00
41 dB Rel. Ref.	41.00	40.99	-0.7	0.7	-0.01
41 dB Diff.	41.00	40.99	-0.2	0.2	-0.01
42 dB Rel. Ref.	42.00	42.00	-0.7	0.7	0.00
42 dB Diff.	41.99	42.00	-0.2	0.2	0.01
43 dB Rel. Ref.	43.00	43.00	-0.7	0.7	0.00
43 dB Diff.	43.00	43.00	-0.2	0.2	0.00
44 dB Rel. Ref.	44.00	44.00	-0.7	0.7	0.00
44 dB Diff.	44.00	44.00	-0.2	0.2	0.00
45 dB Rel. Ref.	45.00	45.00	-0.7	0.7	0.00
45 dB Diff.	45.00	45.00	-0.2	0.2	0.00
46 dB Rel. Ref.	46.00	46.00	-0.7	0.7	0.00
46 dB Diff.	46.00	46.00	-0.2	0.2	0.00
47 dB Rel. Ref.	47.00	47.00	-0.7	0.7	0.00
47 dB Diff.	47.00	47.00	-0.2	0.2	0.00
48 dB Rel. Ref.	48.00	48.00	-0.7	0.7	0.00
48 dB Diff.	48.00	48.00	-0.2	0.2	0.00
49 dB Rel. Ref.	49.00	49.00	-0.7	0.7	0.00
49 dB Diff.	49.00	49.00	-0.2	0.2	0.00
50 dB Rel. Ref.	50.00	50.00	-0.7	0.7	0.00
50 dB Diff.	50.00	50.00	-0.2	0.2	0.00
51 dB Rel. Ref.	51.00	51.00	-0.7	0.7	0.00
51 dB Diff.	51.00	51.00	-0.2	0.2	0.00
52 dB Rel. Ref.	52.00	51.99	-0.7	0.7	-0.01
52 dB Diff.	52.00	51.99	-0.2	0.2	-0.01
53 dB Rel. Ref.	53.00	52.99	-0.7	0.7	-0.01
53 dB Diff.	52.99	52.99	-0.2	0.2	0.00
54 dB Rel. Ref.	54.00	53.99	-0.7	0.7	-0.01
54 dB Diff.	53.99	53.99	-0.2	0.2	0.00
55 dB Rel. Ref.	55.00	54.99	-0.7	0.7	-0.01
55 dB Diff.	54.99	54.99	-0.2	0.2	0.00
56 dB Rel. Ref.	56.00	55.99	-0.7	0.7	-0.01
56 dB Diff.	55.99	55.99	-0.2	0.2	0.00
57 dB Rel. Ref.	57.00	56.99	-0.7	0.7	-0.01
57 dB Diff.	56.99	56.99	-0.2	0.2	0.00
58 dB Rel. Ref.	58.00	58.00	-0.7	0.7	0.00
58 dB Diff.	57.99	58.00	-0.2	0.2	0.01
59 dB Rel. Ref.	59.00	59.00	-0.7	0.7	0.00
59 dB Diff.	59.00	59.00	-0.2	0.2	0.00
60 dB Rel. Ref.	60.00	60.00	-0.7	0.7	0.00
60 dB Diff.	60.00	60.00	-0.2	0.2	0.00
61 dB Rel. Ref.	61.00	61.00	-0.7	0.7	0.00
61 dB Diff.	61.00	61.00	-0.2	0.2	0.00
62 dB Rel. Ref.	62.00	62.00	-0.7	0.7	0.00
62 dB Diff.	62.00	62.00	-0.2	0.2	0.00
63 dB Rel. Ref.	63.00	63.00	-0.7	0.7	0.00
63 dB Diff.	63.00	63.00	-0.2	0.2	0.00
64 dB Rel. Ref.	64.00	64.00	-0.7	0.7	0.00
64 dB Diff.	64.00	64.00	-0.2	0.2	0.00
65 dB Rel. Ref.	65.00	65.00	-0.7	0.7	0.00
65 dB Diff.	65.00	65.00	-0.2	0.2	0.00

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66 dB Rel. Ref.	66.00	66.00	-0.7	0.7	0.00
66 dB Diff.	66.00	66.00	-0.2	0.2	0.00
67 dB Rel. Ref.	67.00	67.00	-0.7	0.7	0.00
67 dB Diff.	67.00	67.00	-0.2	0.2	0.00
68 dB Rel. Ref.	68.00	68.00	-0.7	0.7	0.00
68 dB Diff.	68.00	68.00	-0.2	0.2	0.00
69 dB Rel. Ref.	69.00	69.00	-0.7	0.7	0.00
69 dB Diff.	69.00	69.00	-0.2	0.2	0.00
70 dB Rel. Ref.	70.00	70.00	-0.7	0.7	0.00
70 dB Diff.	70.00	70.00	-0.2	0.2	0.00
71 dB Rel. Ref.	71.00	71.00	-0.7	0.7	0.00
71 dB Diff.	71.00	71.00	-0.2	0.2	0.00
72 dB Rel. Ref.	72.00	72.00	-0.7	0.7	0.00
72 dB Diff.	72.00	72.00	-0.2	0.2	0.00
73 dB Rel. Ref.	73.00	73.00	-0.7	0.7	0.00
73 dB Diff.	73.00	73.00	-0.2	0.2	0.00
74 dB Rel. Ref.	74.00	74.01	-0.7	0.7	0.01
74 dB Diff.	74.00	74.01	-0.2	0.2	0.01
75 dB Rel. Ref.	75.00	75.01	-0.7	0.7	0.01
75 dB Diff.	75.01	75.01	-0.2	0.2	0.00
76 dB Rel. Ref.	76.00	76.01	-0.7	0.7	0.01
76 dB Diff.	76.01	76.01	-0.2	0.2	0.00
77 dB Rel. Ref.	77.00	77.01	-0.7	0.7	0.01
77 dB Diff.	77.01	77.01	-0.2	0.2	0.00
78 dB Rel. Ref.	78.00	78.01	-0.7	0.7	0.01
78 dB Diff.	78.01	78.01	-0.2	0.2	0.00
79 dB Rel. Ref.	79.00	79.01	-0.7	0.7	0.01
79 dB Diff.	79.01	79.01	-0.2	0.2	0.00
80 dB Rel. Ref.	80.00	80.01	-0.7	0.7	0.01
80 dB Diff.	80.01	80.01	-0.2	0.2	0.00
81 dB Rel. Ref.	81.00	81.01	-0.7	0.7	0.01
81 dB Diff.	81.01	81.01	-0.2	0.2	0.00
82 dB Rel. Ref.	82.00	82.01	-0.7	0.7	0.01
82 dB Diff.	82.01	82.01	-0.2	0.2	0.00
83 dB Rel. Ref.	83.00	83.01	-0.7	0.7	0.01
83 dB Diff.	83.01	83.01	-0.2	0.2	0.00
84 dB Rel. Ref.	84.00	84.01	-0.7	0.7	0.01
84 dB Diff.	84.01	84.01	-0.2	0.2	0.00
85 dB Rel. Ref.	85.00	85.00	-0.7	0.7	0.00
85 dB Diff.	85.01	85.00	-0.2	0.2	-0.01
86 dB Rel. Ref.	86.00	86.00	-0.7	0.7	0.00
86 dB Diff.	86.00	86.00	-0.2	0.2	0.00
87 dB Rel. Ref.	87.00	87.00	-0.7	0.7	0.00
87 dB Diff.	87.00	87.00	-0.2	0.2	0.00
88 dB Rel. Ref.	88.00	88.00	-0.7	0.7	0.00
88 dB Diff.	88.00	88.00	-0.2	0.2	0.00
89 dB Rel. Ref.	89.00	89.00	-0.7	0.7	0.00
89 dB Diff.	89.00	89.00	-0.2	0.2	0.00
90 dB Rel. Ref.	90.00	90.00	-0.7	0.7	0.00
90 dB Diff.	90.00	90.00	-0.2	0.2	0.00
91 dB Rel. Ref.	91.00	91.00	-0.7	0.7	0.00
91 dB Diff.	91.00	91.00	-0.2	0.2	0.00
92 dB Rel. Ref.	92.00	92.00	-0.7	0.7	0.00
92 dB Diff.	92.00	92.00	-0.2	0.2	0.00

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93 dB Rel. Ref.	93.00	93.00	-0.7	0.7	0.00
93 dB Diff.	93.00	93.00	-0.2	0.2	0.00
95 dB Rel. Ref.	95.00	95.00	-0.7	0.7	0.00
95 dB Diff.	95.00	95.00	-0.4	0.4	0.00
96 dB Rel. Ref.	96.00	96.00	-0.7	0.7	0.00
96 dB Diff.	96.00	96.00	-0.2	0.2	0.00
97 dB Rel. Ref.	97.00	97.00	-0.7	0.7	0.00
97 dB Diff.	97.00	97.00	-0.2	0.2	0.00
98 dB Rel. Ref.	98.00	98.00	-0.7	0.7	0.00
98 dB Diff.	98.00	98.00	-0.2	0.2	0.00
99 dB Rel. Ref.	99.00	99.00	-0.7	0.7	0.00
99 dB Diff.	99.00	99.00	-0.2	0.2	0.00
100 dB Rel. Ref.	100.00	100.00	-0.7	0.7	0.00
100 dB Diff.	100.00	100.00	-0.2	0.2	0.00
101 dB Rel. Ref.	101.00	101.00	-0.7	0.7	0.00
101 dB Diff.	101.00	101.00	-0.2	0.2	0.00
102 dB Rel. Ref.	102.00	102.00	-0.7	0.7	0.00
102 dB Diff.	102.00	102.00	-0.2	0.2	0.00
103 dB Rel. Ref.	103.00	103.00	-0.7	0.7	0.00
103 dB Diff.	103.00	103.00	-0.2	0.2	0.00
104 dB Rel. Ref.	104.00	104.00	-0.7	0.7	0.00
104 dB Diff.	104.00	104.00	-0.2	0.2	0.00
105 dB Rel. Ref.	105.00	105.00	-0.7	0.7	0.00
105 dB Diff.	105.00	105.00	-0.2	0.2	0.00
106 dB Rel. Ref.	106.00	106.00	-0.7	0.7	0.00
106 dB Diff.	106.00	106.00	-0.2	0.2	0.00
107 dB Rel. Ref.	107.00	107.01	-0.7	0.7	0.01
107 dB Diff.	107.00	107.01	-0.2	0.2	0.01
108 dB Rel. Ref.	108.00	108.01	-0.7	0.7	0.01
108 dB Diff.	108.01	108.01	-0.2	0.2	0.00
109 dB Rel. Ref.	109.00	109.01	-0.7	0.7	0.01
109 dB Diff.	109.01	109.01	-0.2	0.2	0.00
110 dB Rel. Ref.	110.00	110.01	-0.7	0.7	0.01
110 dB Diff.	110.01	110.01	-0.2	0.2	0.00
111 dB Rel. Ref.	111.00	111.01	-0.7	0.7	0.01
111 dB Diff.	111.01	111.01	-0.2	0.2	0.00
112 dB Rel. Ref.	112.00	112.01	-0.7	0.7	0.01
112 dB Diff.	112.01	112.01	-0.2	0.2	0.00
113 dB Rel. Ref.	113.00	113.01	-0.7	0.7	0.01
113 dB Diff.	113.01	113.01	-0.2	0.2	0.00
114 dB Rel. Ref.	114.00	114.01	-0.7	0.7	0.01
114 dB Diff.	114.01	114.01	-0.2	0.2	0.00
115 dB Rel. Ref.	115.00	115.01	-0.7	0.7	0.01
115 dB Diff.	115.01	115.01	-0.2	0.2	0.00
116 dB Rel. Ref.	116.00	116.01	-0.7	0.7	0.01
116 dB Diff.	116.01	116.01	-0.2	0.2	0.00
117 dB Rel. Ref.	117.00	117.01	-0.7	0.7	0.01
117 dB Diff.	117.01	117.01	-0.2	0.2	0.00
118 dB Rel. Ref.	118.00	118.01	-0.7	0.7	0.01
118 dB Diff.	118.01	118.01	-0.2	0.2	0.00
119 dB Rel. Ref.	119.00	119.02	-0.7	0.7	0.02
119 dB Diff.	119.01	119.02	-0.2	0.2	0.01
120 dB Rel. Ref.	120.00	120.02	-0.7	0.7	0.02
120 dB Diff.	120.02	120.02	-0.2	0.2	0.00

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121 dB Rel. Ref.	121.00	121.02	-0.7	0.7	0.02
121 dB Diff.	121.02	121.02	-0.2	0.2	0.00
122 dB Rel. Ref.	122.00	122.02	-0.7	0.7	0.02
122 dB Diff.	122.02	122.02	-0.2	0.2	0.00
123 dB Rel. Ref.	123.00	123.02	-0.7	0.7	0.02
123 dB Diff.	123.02	123.02	-0.2	0.2	0.00
124 dB Rel. Ref.	124.00	124.02	-0.7	0.7	0.02
124 dB Diff.	124.02	124.02	-0.2	0.2	0.00
125 dB Rel. Ref.	125.00	125.02	-0.7	0.7	0.02
125 dB Diff.	125.02	125.02	-0.2	0.2	0.00
126 dB Rel. Ref.	126.00	126.02	-0.7	0.7	0.02
126 dB Diff.	126.02	126.02	-0.2	0.2	0.00
127 dB Rel. Ref.	127.00	127.02	-0.7	0.7	0.02
127 dB Diff.	127.02	127.02	-0.2	0.2	0.00
128 dB Rel. Ref.	128.00	128.02	-0.7	0.7	0.02
128 dB Diff.	128.02	128.02	-0.2	0.2	0.00
129 dB Rel. Ref.	129.00	129.02	-0.7	0.7	0.02
129 dB Diff.	129.02	129.02	-0.2	0.2	0.00
130 dB Rel. Ref.	130.00	130.20	-0.7	0.7	0.20
130 dB Diff.	130.02	130.20	-0.2	0.2	0.18
131 dB Rel. Ref.	131.00	131.02	-0.7	0.7	0.02
131 dB Diff.	131.20	131.02	-0.2	0.2	-0.18
132 dB Rel. Ref.	132.00	132.02	-0.7	0.7	0.02
132 dB Diff.	132.02	132.02	-0.2	0.2	0.00
133 dB Rel. Ref.	133.00	133.02	-0.7	0.7	0.02
133 dB Diff.	133.02	133.02	-0.2	0.2	0.00
134 dB Rel. Ref.	134.00	134.02	-0.7	0.7	0.02
134 dB Diff.	134.02	134.02	-0.2	0.2	0.00
135 dB Rel. Ref.	135.00	135.02	-0.7	0.7	0.02
135 dB Diff.	135.02	135.02	-0.2	0.2	0.00
136 dB Rel. Ref.	136.00	136.02	-0.7	0.7	0.02
136 dB Diff.	136.02	136.02	-0.2	0.2	0.00
137 dB Rel. Ref.	137.00	137.02	-0.7	0.7	0.02
137 dB Diff.	137.02	137.02	-0.2	0.2	0.00
138 dB Rel. Ref.	138.00	138.02	-0.7	0.7	0.02
138 dB Diff.	138.02	138.02	-0.2	0.2	0.00
139 dB Rel. Ref.	139.00	139.02	-0.7	0.7	0.02
139 dB Diff.	139.02	139.02	-0.2	0.2	0.00
140 dB Rel. Ref.	140.00	140.02	-0.7	0.7	0.02
140 dB Diff.	140.02	140.02	-0.2	0.2	0.00
140 dB Rel. Ref.	140.00	140.02	-0.7	0.7	0.02
140 dB Diff.	140.02	140.02	-0.2	0.2	0.00

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Linealidad en pasos de 1 dB a la frecuencia de 4 kHz.

La respuesta del sonómetro a señales de amplitud sinusoidal en varios niveles que abarca el rango de referencia, incluyendo un nivel nominal correspondiente a Lref en la frecuencia de medición. A partir de esta respuesta de otros niveles se calcula la respuesta correspondiente a Lref. La respuesta relativa se compara con la respuesta relativa.Para cada nivel entre las respuestas y el nivel anterior se calcula también con el fin de determinar la linealidad diferencial de nivel.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
94 dB	94.00	93.99	-1.0	1.0	-0.01
25 dB Rel. Ref.	24.99	25.46	-0.7	0.7	0.47
26 dB Rel. Ref.	25.99	26.45	-0.7	0.7	0.46
26 dB Diff.	26.46	26.45	-0.2	0.2	-0.01
27 dB Rel. Ref.	26.99	27.45	-0.7	0.7	0.46
27 dB Diff.	27.45	27.45	-0.2	0.2	0.00
28 dB Rel. Ref.	27.99	28.42	-0.7	0.7	0.43
28 dB Diff.	28.45	28.42	-0.2	0.2	-0.03
29 dB Rel. Ref.	28.99	29.39	-0.7	0.7	0.40
29 dB Diff.	29.42	29.39	-0.2	0.2	-0.03
30 dB Rel. Ref.	29.99	30.38	-0.7	0.7	0.39
30 dB Diff.	30.39	30.38	-0.2	0.2	-0.01
31 dB Rel. Ref.	30.99	31.32	-0.7	0.7	0.33
31 dB Diff.	31.38	31.32	-0.2	0.2	-0.06
32 dB Rel. Ref.	31.99	32.28	-0.7	0.7	0.29
32 dB Diff.	32.32	32.28	-0.2	0.2	-0.04
33 dB Rel. Ref.	32.99	33.21	-0.7	0.7	0.22
33 dB Diff.	33.28	33.21	-0.2	0.2	-0.07
34 dB Rel. Ref.	33.99	34.18	-0.7	0.7	0.19
34 dB Diff.	34.21	34.18	-0.2	0.2	-0.03
35 dB Rel. Ref.	34.99	35.10	-0.7	0.7	0.11
35 dB Diff.	35.18	35.10	-0.2	0.2	-0.08
36 dB Rel. Ref.	35.99	36.08	-0.7	0.7	0.09
36 dB Diff.	36.10	36.08	-0.2	0.2	-0.02
37 dB Rel. Ref.	36.99	37.07	-0.7	0.7	0.08
37 dB Diff.	37.08	37.07	-0.2	0.2	-0.01
38 dB Rel. Ref.	37.99	38.05	-0.7	0.7	0.06
38 dB Diff.	38.07	38.05	-0.2	0.2	-0.02
39 dB Rel. Ref.	38.99	39.02	-0.7	0.7	0.03
39 dB Diff.	39.05	39.02	-0.2	0.2	-0.03
40 dB Rel. Ref.	39.99	40.04	-0.7	0.7	0.05
40 dB Diff.	40.02	40.04	-0.2	0.2	0.02
41 dB Rel. Ref.	40.99	41.06	-0.7	0.7	0.07
41 dB Diff.	41.04	41.06	-0.2	0.2	0.02
42 dB Rel. Ref.	41.99	42.05	-0.7	0.7	0.06
42 dB Diff.	42.06	42.05	-0.2	0.2	-0.01
43 dB Rel. Ref.	42.99	43.00	-0.7	0.7	0.01
43 dB Diff.	43.05	43.00	-0.2	0.2	-0.05
44 dB Rel. Ref.	43.99	44.07	-0.7	0.7	0.08
44 dB Diff.	44.00	44.07	-0.2	0.2	0.07
45 dB Rel. Ref.	44.99	45.01	-0.7	0.7	0.02
45 dB Diff.	45.07	45.01	-0.2	0.2	-0.06
46 dB Rel. Ref.	45.99	46.00	-0.7	0.7	0.01
46 dB Diff.	46.01	46.00	-0.2	0.2	-0.01

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47 dB Rel. Ref.	46.99	47.02	-0.7	0.7	0.03
47 dB Diff.	47.00	47.02	-0.2	0.2	0.02
48 dB Rel. Ref.	47.99	48.02	-0.7	0.7	0.03
48 dB Diff.	48.02	48.02	-0.2	0.2	0.00
49 dB Rel. Ref.	48.99	48.99	-0.7	0.7	0.00
49 dB Diff.	49.02	48.99	-0.2	0.2	-0.03
50 dB Rel. Ref.	49.99	50.02	-0.7	0.7	0.03
50 dB Diff.	49.99	50.02	-0.2	0.2	0.03
51 dB Rel. Ref.	50.99	51.00	-0.7	0.7	0.01
51 dB Diff.	51.02	51.00	-0.2	0.2	-0.02
52 dB Rel. Ref.	51.99	51.99	-0.7	0.7	0.00
52 dB Diff.	52.00	51.99	-0.2	0.2	-0.01
53 dB Rel. Ref.	52.99	53.00	-0.7	0.7	0.01
53 dB Diff.	52.99	53.00	-0.2	0.2	0.01
54 dB Rel. Ref.	53.99	53.99	-0.7	0.7	0.00
54 dB Diff.	54.00	53.99	-0.2	0.2	-0.01
55 dB Rel. Ref.	54.99	54.99	-0.7	0.7	0.00
55 dB Diff.	54.99	54.99	-0.2	0.2	0.00
56 dB Rel. Ref.	55.99	55.99	-0.7	0.7	0.00
56 dB Diff.	55.99	55.99	-0.2	0.2	0.00
57 dB Rel. Ref.	56.99	56.98	-0.7	0.7	-0.01
57 dB Diff.	56.99	56.98	-0.2	0.2	-0.01
58 dB Rel. Ref.	57.99	57.98	-0.7	0.7	-0.01
58 dB Diff.	57.98	57.98	-0.2	0.2	0.00
59 dB Rel. Ref.	58.99	58.98	-0.7	0.7	-0.01
59 dB Diff.	58.98	58.98	-0.2	0.2	0.00
60 dB Rel. Ref.	59.99	59.99	-0.7	0.7	0.00
60 dB Diff.	59.98	59.99	-0.2	0.2	0.01
61 dB Rel. Ref.	60.99	60.99	-0.7	0.7	0.00
61 dB Diff.	60.99	60.99	-0.2	0.2	0.00
62 dB Rel. Ref.	61.99	62.00	-0.7	0.7	0.01
62 dB Diff.	61.99	62.00	-0.2	0.2	0.01
63 dB Rel. Ref.	62.99	62.99	-0.7	0.7	0.00
63 dB Diff.	63.00	62.99	-0.2	0.2	-0.01
64 dB Rel. Ref.	63.99	63.99	-0.7	0.7	0.00
64 dB Diff.	63.99	63.99	-0.2	0.2	0.00
65 dB Rel. Ref.	64.99	64.99	-0.7	0.7	0.00
65 dB Diff.	64.99	64.99	-0.2	0.2	0.00
66 dB Rel. Ref.	65.99	65.99	-0.7	0.7	0.00
66 dB Diff.	65.99	65.99	-0.2	0.2	0.00
67 dB Rel. Ref.	66.99	66.99	-0.7	0.7	0.00
67 dB Diff.	66.99	66.99	-0.2	0.2	0.00
68 dB Rel. Ref.	67.99	67.99	-0.7	0.7	0.00
68 dB Diff.	67.99	67.99	-0.2	0.2	0.00
69 dB Rel. Ref.	68.99	68.99	-0.7	0.7	0.00
69 dB Diff.	68.99	68.99	-0.2	0.2	0.00
70 dB Rel. Ref.	69.99	69.99	-0.7	0.7	0.00
70 dB Diff.	69.99	69.99	-0.2	0.2	0.00
71 dB Rel. Ref.	70.99	70.99	-0.7	0.7	0.00
71 dB Diff.	70.99	70.99	-0.2	0.2	0.00
72 dB Rel. Ref.	71.99	71.99	-0.7	0.7	0.00
72 dB Diff.	71.99	71.99	-0.2	0.2	0.00
73 dB Rel. Ref.	72.99	73.00	-0.7	0.7	0.01
73 dB Diff.	72.99	73.00	-0.2	0.2	0.01

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74 dB Rel. Ref.	73.99	73.99	-0.7	0.7	0.00
74 dB Diff.	74.00	73.99	-0.2	0.2	-0.01
75 dB Rel. Ref.	74.99	75.00	-0.7	0.7	0.01
75 dB Diff.	74.99	75.00	-0.2	0.2	0.01
76 dB Rel. Ref.	75.99	76.00	-0.7	0.7	0.01
76 dB Diff.	76.00	76.00	-0.2	0.2	0.00
77 dB Rel. Ref.	76.99	76.99	-0.7	0.7	0.00
77 dB Diff.	77.00	76.99	-0.2	0.2	-0.01
78 dB Rel. Ref.	77.99	78.00	-0.7	0.7	0.01
78 dB Diff.	77.99	78.00	-0.2	0.2	0.01
79 dB Rel. Ref.	78.99	79.00	-0.7	0.7	0.01
79 dB Diff.	79.00	79.00	-0.2	0.2	0.00
80 dB Rel. Ref.	79.99	80.00	-0.7	0.7	0.01
80 dB Diff.	80.00	80.00	-0.2	0.2	0.00
81 dB Rel. Ref.	80.99	81.00	-0.7	0.7	0.01
81 dB Diff.	81.00	81.00	-0.2	0.2	0.00
82 dB Rel. Ref.	81.99	82.00	-0.7	0.7	0.01
82 dB Diff.	82.00	82.00	-0.2	0.2	0.00
83 dB Rel. Ref.	82.99	82.99	-0.7	0.7	0.00
83 dB Diff.	83.00	82.99	-0.2	0.2	-0.01
84 dB Rel. Ref.	83.99	84.00	-0.7	0.7	0.01
84 dB Diff.	83.99	84.00	-0.2	0.2	0.01
85 dB Rel. Ref.	84.99	84.99	-0.7	0.7	0.00
85 dB Diff.	85.00	84.99	-0.2	0.2	-0.01
86 dB Rel. Ref.	85.99	85.99	-0.7	0.7	0.00
86 dB Diff.	85.99	85.99	-0.2	0.2	0.00
87 dB Rel. Ref.	86.99	86.99	-0.7	0.7	0.00
87 dB Diff.	86.99	86.99	-0.2	0.2	0.00
88 dB Rel. Ref.	87.99	87.99	-0.7	0.7	0.00
88 dB Diff.	87.99	87.99	-0.2	0.2	0.00
89 dB Rel. Ref.	88.99	88.99	-0.7	0.7	0.00
89 dB Diff.	88.99	88.99	-0.2	0.2	0.00
90 dB Rel. Ref.	89.99	89.99	-0.7	0.7	0.00
90 dB Diff.	89.99	89.99	-0.2	0.2	0.00
91 dB Rel. Ref.	90.99	90.99	-0.7	0.7	0.00
91 dB Diff.	90.99	90.99	-0.2	0.2	0.00
92 dB Rel. Ref.	91.99	91.99	-0.7	0.7	0.00
92 dB Diff.	91.99	91.99	-0.2	0.2	0.00
93 dB Rel. Ref.	92.99	92.99	-0.7	0.7	0.00
93 dB Diff.	92.99	92.99	-0.2	0.2	0.00
95 dB Rel. Ref.	94.99	94.99	-0.7	0.7	0.00
95 dB Diff.	94.99	94.99	-0.4	0.4	0.00
96 dB Rel. Ref.	95.99	95.99	-0.7	0.7	0.00
96 dB Diff.	95.99	95.99	-0.2	0.2	0.00
97 dB Rel. Ref.	96.99	96.99	-0.7	0.7	0.00
97 dB Diff.	96.99	96.99	-0.2	0.2	0.00
98 dB Rel. Ref.	97.99	97.99	-0.7	0.7	0.00
98 dB Diff.	97.99	97.99	-0.2	0.2	0.00
99 dB Rel. Ref.	98.99	98.99	-0.7	0.7	0.00
99 dB Diff.	98.99	98.99	-0.2	0.2	0.00
100 dB Rel. Ref.	99.99	99.99	-0.7	0.7	0.00
100 dB Diff.	99.99	99.99	-0.2	0.2	0.00
101 dB Rel. Ref.	100.99	100.99	-0.7	0.7	0.00
101 dB Diff.	100.99	100.99	-0.2	0.2	0.00

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102 dB Rel. Ref.	101.99	101.99	-0.7	0.7	0.00
102 dB Diff.	101.99	101.99	-0.2	0.2	0.00
103 dB Rel. Ref.	102.99	102.99	-0.7	0.7	0.00
103 dB Diff.	102.99	102.99	-0.2	0.2	0.00
104 dB Rel. Ref.	103.99	103.99	-0.7	0.7	0.00
104 dB Diff.	103.99	103.99	-0.2	0.2	0.00
105 dB Rel. Ref.	104.99	104.99	-0.7	0.7	0.00
105 dB Diff.	104.99	104.99	-0.2	0.2	0.00
106 dB Rel. Ref.	105.99	105.99	-0.7	0.7	0.00
106 dB Diff.	105.99	105.99	-0.2	0.2	0.00
107 dB Rel. Ref.	106.99	106.99	-0.7	0.7	0.00
107 dB Diff.	106.99	106.99	-0.2	0.2	0.00
108 dB Rel. Ref.	107.99	108.00	-0.7	0.7	0.01
108 dB Diff.	107.99	108.00	-0.2	0.2	0.01
109 dB Rel. Ref.	108.99	108.99	-0.7	0.7	0.00
109 dB Diff.	109.00	108.99	-0.2	0.2	-0.01
110 dB Rel. Ref.	109.99	109.99	-0.7	0.7	0.00
110 dB Diff.	109.99	109.99	-0.2	0.2	0.00
111 dB Rel. Ref.	110.99	111.00	-0.7	0.7	0.01
111 dB Diff.	110.99	111.00	-0.2	0.2	0.01
112 dB Rel. Ref.	111.99	112.00	-0.7	0.7	0.01
112 dB Diff.	112.00	112.00	-0.2	0.2	0.00
113 dB Rel. Ref.	112.99	113.00	-0.7	0.7	0.01
113 dB Diff.	113.00	113.00	-0.2	0.2	0.00
114 dB Rel. Ref.	113.99	114.00	-0.7	0.7	0.01
114 dB Diff.	114.00	114.00	-0.2	0.2	0.00
115 dB Rel. Ref.	114.99	115.00	-0.7	0.7	0.01
115 dB Diff.	115.00	115.00	-0.2	0.2	0.00
116 dB Rel. Ref.	115.99	116.00	-0.7	0.7	0.01
116 dB Diff.	116.00	116.00	-0.2	0.2	0.00
117 dB Rel. Ref.	116.99	117.00	-0.7	0.7	0.01
117 dB Diff.	117.00	117.00	-0.2	0.2	0.00
118 dB Rel. Ref.	117.99	118.00	-0.7	0.7	0.01
118 dB Diff.	118.00	118.00	-0.2	0.2	0.00
119 dB Rel. Ref.	118.99	119.00	-0.7	0.7	0.01
119 dB Diff.	119.00	119.00	-0.2	0.2	0.00
120 dB Rel. Ref.	119.99	120.01	-0.7	0.7	0.02
120 dB Diff.	120.00	120.01	-0.2	0.2	0.01
121 dB Rel. Ref.	120.99	121.00	-0.7	0.7	0.01
121 dB Diff.	121.01	121.00	-0.2	0.2	-0.01
122 dB Rel. Ref.	121.99	122.00	-0.7	0.7	0.01
122 dB Diff.	122.00	122.00	-0.2	0.2	0.00
123 dB Rel. Ref.	122.99	123.01	-0.7	0.7	0.02
123 dB Diff.	123.00	123.01	-0.2	0.2	0.01
124 dB Rel. Ref.	123.99	124.00	-0.7	0.7	0.01
124 dB Diff.	124.01	124.00	-0.2	0.2	-0.01
125 dB Rel. Ref.	124.99	125.00	-0.7	0.7	0.01
125 dB Diff.	125.00	125.00	-0.2	0.2	0.00
126 dB Rel. Ref.	125.99	126.01	-0.7	0.7	0.02
126 dB Diff.	126.00	126.01	-0.2	0.2	0.01
127 dB Rel. Ref.	126.99	127.01	-0.7	0.7	0.02
127 dB Diff.	127.01	127.01	-0.2	0.2	0.00
128 dB Rel. Ref.	127.99	128.00	-0.7	0.7	0.01
128 dB Diff.	128.01	128.00	-0.2	0.2	-0.01

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129 dB Rel. Ref.	128.99	129.01	-0.7	0.7	0.02
129 dB Diff.	129.00	129.01	-0.2	0.2	0.01
130 dB Rel. Ref.	129.99	130.01	-0.7	0.7	0.02
130 dB Diff.	130.01	130.01	-0.2	0.2	0.00
131 dB Rel. Ref.	130.99	131.01	-0.7	0.7	0.02
131 dB Diff.	131.01	131.01	-0.2	0.2	0.00
132 dB Rel. Ref.	131.99	132.01	-0.7	0.7	0.02
132 dB Diff.	132.01	132.01	-0.2	0.2	0.00
133 dB Rel. Ref.	132.99	133.01	-0.7	0.7	0.02
133 dB Diff.	133.01	133.01	-0.2	0.2	0.00
134 dB Rel. Ref.	133.99	134.01	-0.7	0.7	0.02
134 dB Diff.	134.01	134.01	-0.2	0.2	0.00
135 dB Rel. Ref.	134.99	135.01	-0.7	0.7	0.02
135 dB Diff.	135.01	135.01	-0.2	0.2	0.00
136 dB Rel. Ref.	135.99	136.01	-0.7	0.7	0.02
136 dB Diff.	136.01	136.01	-0.2	0.2	0.00
137 dB Rel. Ref.	136.99	137.01	-0.7	0.7	0.02
137 dB Diff.	137.01	137.01	-0.2	0.2	0.00
138 dB Rel. Ref.	137.99	138.01	-0.7	0.7	0.02
138 dB Diff.	138.01	138.01	-0.2	0.2	0.00
139 dB Rel. Ref.	138.99	139.01	-0.7	0.7	0.02
139 dB Diff.	139.01	139.01	-0.2	0.2	0.00
140 dB Rel. Ref.	139.99	140.01	-0.7	0.7	0.02
140 dB Diff.	140.01	140.01	-0.2	0.2	0.00
140 dB Rel. Ref.	139.99	140.01	-0.7	0.7	0.02
140 dB Diff.	140.01	140.01	-0.2	0.2	0.00

Linealidad en pasos de 1 dB a la frecuencia de 8 kHz.

La respuesta del sonómetro a señales de amplitud sinusoidal en varios niveles que abarca el rango de referencia, incluyendo un nivel nominal correspondiente a Lref en la frecuencia de medición. A partir de esta respuesta de otros niveles se calcula la respuesta correspondiente a Lref. La respuesta relativa se compara con la respuesta relativa.Para cada nivel entre las respuestas y el nivel anterior se calcula también con el fin de determinar la linealidad diferencial de nivel.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
94 dB	94.00	93.96	-1.0	1.0	-0.04
25 dB Rel. Ref.	24.96	25.52	-0.7	0.7	0.56
26 dB Rel. Ref.	25.96	26.38	-0.7	0.7	0.42
26 dB Diff.	26.52	26.38	-0.2	0.2	-0.14
27 dB Rel. Ref.	26.96	27.31	-0.7	0.7	0.35
27 dB Diff.	27.38	27.31	-0.2	0.2	-0.07
28 dB Rel. Ref.	27.96	28.27	-0.7	0.7	0.31
28 dB Diff.	28.31	28.27	-0.2	0.2	-0.04
29 dB Rel. Ref.	28.96	29.20	-0.7	0.7	0.24
29 dB Diff.	29.27	29.20	-0.2	0.2	-0.07
30 dB Rel. Ref.	29.96	30.15	-0.7	0.7	0.19
30 dB Diff.	30.20	30.15	-0.2	0.2	-0.05
31 dB Rel. Ref.	30.96	31.11	-0.7	0.7	0.15
31 dB Diff.	31.15	31.11	-0.2	0.2	-0.04
32 dB Rel. Ref.	31.96	32.10	-0.7	0.7	0.14
32 dB Diff.	32.11	32.10	-0.2	0.2	-0.01

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33 dB Rel. Ref.	32.96	33.06	-0.7	0.7	0.10
33 dB Diff.	33.10	33.06	-0.2	0.2	-0.04
34 dB Rel. Ref.	33.96	34.04	-0.7	0.7	0.08
34 dB Diff.	34.06	34.04	-0.2	0.2	-0.02
35 dB Rel. Ref.	34.96	35.03	-0.7	0.7	0.07
35 dB Diff.	35.04	35.03	-0.2	0.2	-0.01
36 dB Rel. Ref.	35.96	36.03	-0.7	0.7	0.07
36 dB Diff.	36.03	36.03	-0.2	0.2	0.00
37 dB Rel. Ref.	36.96	37.00	-0.7	0.7	0.04
37 dB Diff.	37.03	37.00	-0.2	0.2	-0.03
38 dB Rel. Ref.	37.96	38.01	-0.7	0.7	0.05
38 dB Diff.	38.00	38.01	-0.2	0.2	0.01
39 dB Rel. Ref.	38.96	39.00	-0.7	0.7	0.04
39 dB Diff.	39.01	39.00	-0.2	0.2	-0.01
40 dB Rel. Ref.	39.96	39.99	-0.7	0.7	0.03
40 dB Diff.	40.00	39.99	-0.2	0.2	-0.01
41 dB Rel. Ref.	40.96	40.99	-0.7	0.7	0.03
41 dB Diff.	40.99	40.99	-0.2	0.2	0.00
42 dB Rel. Ref.	41.96	41.98	-0.7	0.7	0.02
42 dB Diff.	41.99	41.98	-0.2	0.2	-0.01
43 dB Rel. Ref.	42.96	42.98	-0.7	0.7	0.02
43 dB Diff.	42.98	42.98	-0.2	0.2	0.00
44 dB Rel. Ref.	43.96	43.98	-0.7	0.7	0.02
44 dB Diff.	43.98	43.98	-0.2	0.2	0.00
45 dB Rel. Ref.	44.96	44.98	-0.7	0.7	0.02
45 dB Diff.	44.98	44.98	-0.2	0.2	0.00
46 dB Rel. Ref.	45.96	45.97	-0.7	0.7	0.01
46 dB Diff.	45.98	45.97	-0.2	0.2	-0.01
47 dB Rel. Ref.	46.96	46.97	-0.7	0.7	0.01
47 dB Diff.	46.97	46.97	-0.2	0.2	0.00
48 dB Rel. Ref.	47.96	47.97	-0.7	0.7	0.01
48 dB Diff.	47.97	47.97	-0.2	0.2	0.00
49 dB Rel. Ref.	48.96	48.97	-0.7	0.7	0.01
49 dB Diff.	48.97	48.97	-0.2	0.2	0.00
50 dB Rel. Ref.	49.96	49.97	-0.7	0.7	0.01
50 dB Diff.	49.97	49.97	-0.2	0.2	0.00
51 dB Rel. Ref.	50.96	50.97	-0.7	0.7	0.01
51 dB Diff.	50.97	50.97	-0.2	0.2	0.00
52 dB Rel. Ref.	51.96	51.97	-0.7	0.7	0.01
52 dB Diff.	51.97	51.97	-0.2	0.2	0.00
53 dB Rel. Ref.	52.96	52.97	-0.7	0.7	0.01
53 dB Diff.	52.97	52.97	-0.2	0.2	0.00
54 dB Rel. Ref.	53.96	53.96	-0.7	0.7	0.00
54 dB Diff.	53.97	53.96	-0.2	0.2	-0.01
55 dB Rel. Ref.	54.96	54.96	-0.7	0.7	0.00
55 dB Diff.	54.96	54.96	-0.2	0.2	0.00
56 dB Rel. Ref.	55.96	55.96	-0.7	0.7	0.00
56 dB Diff.	55.96	55.96	-0.2	0.2	0.00
57 dB Rel. Ref.	56.96	56.96	-0.7	0.7	0.00
57 dB Diff.	56.96	56.96	-0.2	0.2	0.00
58 dB Rel. Ref.	57.96	57.96	-0.7	0.7	0.00
58 dB Diff.	57.96	57.96	-0.2	0.2	0.00
59 dB Rel. Ref.	58.96	58.96	-0.7	0.7	0.00
59 dB Diff.	58.96	58.96	-0.2	0.2	0.00

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60 dB Rel. Ref.	59.96	59.96	-0.7	0.7	0.00
60 dB Diff.	59.96	59.96	-0.2	0.2	0.00
61 dB Rel. Ref.	60.96	60.96	-0.7	0.7	0.00
61 dB Diff.	60.96	60.96	-0.2	0.2	0.00
62 dB Rel. Ref.	61.96	61.96	-0.7	0.7	0.00
62 dB Diff.	61.96	61.96	-0.2	0.2	0.00
63 dB Rel. Ref.	62.96	62.96	-0.7	0.7	0.00
63 dB Diff.	62.96	62.96	-0.2	0.2	0.00
64 dB Rel. Ref.	63.96	63.96	-0.7	0.7	0.00
64 dB Diff.	63.96	63.96	-0.2	0.2	0.00
65 dB Rel. Ref.	64.96	64.96	-0.7	0.7	0.00
65 dB Diff.	64.96	64.96	-0.2	0.2	0.00
66 dB Rel. Ref.	65.96	65.96	-0.7	0.7	0.00
66 dB Diff.	65.96	65.96	-0.2	0.2	0.00
67 dB Rel. Ref.	66.96	66.97	-0.7	0.7	0.01
67 dB Diff.	66.96	66.97	-0.2	0.2	0.01
68 dB Rel. Ref.	67.96	67.97	-0.7	0.7	0.01
68 dB Diff.	67.97	67.97	-0.2	0.2	0.00
69 dB Rel. Ref.	68.96	68.97	-0.7	0.7	0.01
69 dB Diff.	68.97	68.97	-0.2	0.2	0.00
70 dB Rel. Ref.	69.96	69.97	-0.7	0.7	0.01
70 dB Diff.	69.97	69.97	-0.2	0.2	0.00
71 dB Rel. Ref.	70.96	70.97	-0.7	0.7	0.01
71 dB Diff.	70.97	70.97	-0.2	0.2	0.00
72 dB Rel. Ref.	71.96	71.97	-0.7	0.7	0.01
72 dB Diff.	71.97	71.97	-0.2	0.2	0.00
73 dB Rel. Ref.	72.96	72.97	-0.7	0.7	0.01
73 dB Diff.	72.97	72.97	-0.2	0.2	0.00
74 dB Rel. Ref.	73.96	73.97	-0.7	0.7	0.01
74 dB Diff.	73.97	73.97	-0.2	0.2	0.00
75 dB Rel. Ref.	74.96	74.97	-0.7	0.7	0.01
75 dB Diff.	74.97	74.97	-0.2	0.2	0.00
76 dB Rel. Ref.	75.96	75.97	-0.7	0.7	0.01
76 dB Diff.	75.97	75.97	-0.2	0.2	0.00
77 dB Rel. Ref.	76.96	76.97	-0.7	0.7	0.01
77 dB Diff.	76.97	76.97	-0.2	0.2	0.00
78 dB Rel. Ref.	77.96	77.97	-0.7	0.7	0.01
78 dB Diff.	77.97	77.97	-0.2	0.2	0.00
79 dB Rel. Ref.	78.96	78.97	-0.7	0.7	0.01
79 dB Diff.	78.97	78.97	-0.2	0.2	0.00
80 dB Rel. Ref.	79.96	79.97	-0.7	0.7	0.01
80 dB Diff.	79.97	79.97	-0.2	0.2	0.00
81 dB Rel. Ref.	80.96	80.97	-0.7	0.7	0.01
81 dB Diff.	80.97	80.97	-0.2	0.2	0.00
82 dB Rel. Ref.	81.96	81.97	-0.7	0.7	0.01
82 dB Diff.	81.97	81.97	-0.2	0.2	0.00
83 dB Rel. Ref.	82.96	82.96	-0.7	0.7	0.00
83 dB Diff.	82.97	82.96	-0.2	0.2	-0.01
84 dB Rel. Ref.	83.96	83.96	-0.7	0.7	0.00
84 dB Diff.	83.96	83.96	-0.2	0.2	0.00
85 dB Rel. Ref.	84.96	84.96	-0.7	0.7	0.00
85 dB Diff.	84.96	84.96	-0.2	0.2	0.00
86 dB Rel. Ref.	85.96	85.96	-0.7	0.7	0.00
86 dB Diff.	85.96	85.96	-0.2	0.2	0.00

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87 dB Rel. Ref.	86.96	86.96	-0.7	0.7	0.00
87 dB Diff.	86.96	86.96	-0.2	0.2	0.00
88 dB Rel. Ref.	87.96	87.96	-0.7	0.7	0.00
88 dB Diff.	87.96	87.96	-0.2	0.2	0.00
89 dB Rel. Ref.	88.96	88.96	-0.7	0.7	0.00
89 dB Diff.	88.96	88.96	-0.2	0.2	0.00
90 dB Rel. Ref.	89.96	89.96	-0.7	0.7	0.00
90 dB Diff.	89.96	89.96	-0.2	0.2	0.00
91 dB Rel. Ref.	90.96	90.96	-0.7	0.7	0.00
91 dB Diff.	90.96	90.96	-0.2	0.2	0.00
92 dB Rel. Ref.	91.96	91.96	-0.7	0.7	0.00
92 dB Diff.	91.96	91.96	-0.2	0.2	0.00
93 dB Rel. Ref.	92.96	92.96	-0.7	0.7	0.00
93 dB Diff.	92.96	92.96	-0.2	0.2	0.00
95 dB Rel. Ref.	94.96	94.96	-0.7	0.7	0.00
95 dB Diff.	94.96	94.96	-0.4	0.4	0.00
96 dB Rel. Ref.	95.96	95.96	-0.7	0.7	0.00
96 dB Diff.	95.96	95.96	-0.2	0.2	0.00
97 dB Rel. Ref.	96.96	96.96	-0.7	0.7	0.00
97 dB Diff.	96.96	96.96	-0.2	0.2	0.00
98 dB Rel. Ref.	97.96	97.96	-0.7	0.7	0.00
98 dB Diff.	97.96	97.96	-0.2	0.2	0.00
99 dB Rel. Ref.	98.96	98.96	-0.7	0.7	0.00
99 dB Diff.	98.96	98.96	-0.2	0.2	0.00
100 dB Rel. Ref.	99.96	99.96	-0.7	0.7	0.00
100 dB Diff.	99.96	99.96	-0.2	0.2	0.00
101 dB Rel. Ref.	100.96	100.96	-0.7	0.7	0.00
101 dB Diff.	100.96	100.96	-0.2	0.2	0.00
102 dB Rel. Ref.	101.96	101.96	-0.7	0.7	0.00
102 dB Diff.	101.96	101.96	-0.2	0.2	0.00
103 dB Rel. Ref.	102.96	102.96	-0.7	0.7	0.00
103 dB Diff.	102.96	102.96	-0.2	0.2	0.00
104 dB Rel. Ref.	103.96	103.96	-0.7	0.7	0.00
104 dB Diff.	103.96	103.96	-0.2	0.2	0.00
105 dB Rel. Ref.	104.96	104.97	-0.7	0.7	0.01
105 dB Diff.	104.96	104.97	-0.2	0.2	0.01
106 dB Rel. Ref.	105.96	105.97	-0.7	0.7	0.01
106 dB Diff.	105.97	105.97	-0.2	0.2	0.00
107 dB Rel. Ref.	106.96	106.97	-0.7	0.7	0.01
107 dB Diff.	106.97	106.97	-0.2	0.2	0.00
108 dB Rel. Ref.	107.96	107.97	-0.7	0.7	0.01
108 dB Diff.	107.97	107.97	-0.2	0.2	0.00
109 dB Rel. Ref.	108.96	108.97	-0.7	0.7	0.01
109 dB Diff.	108.97	108.97	-0.2	0.2	0.00
110 dB Rel. Ref.	109.96	109.97	-0.7	0.7	0.01
110 dB Diff.	109.97	109.97	-0.2	0.2	0.00
111 dB Rel. Ref.	110.96	110.98	-0.7	0.7	0.02
111 dB Diff.	110.97	110.98	-0.2	0.2	0.01
112 dB Rel. Ref.	111.96	111.98	-0.7	0.7	0.02
112 dB Diff.	111.98	111.98	-0.2	0.2	0.00
113 dB Rel. Ref.	112.96	112.97	-0.7	0.7	0.01
113 dB Diff.	112.98	112.97	-0.2	0.2	-0.01
114 dB Rel. Ref.	113.96	113.98	-0.7	0.7	0.02
114 dB Diff.	113.97	113.98	-0.2	0.2	0.01

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115 dB Rel. Ref.	114.96	114.98	-0.7	0.7	0.02
115 dB Diff.	114.98	114.98	-0.2	0.2	0.00
116 dB Rel. Ref.	115.96	115.97	-0.7	0.7	0.01
116 dB Diff.	115.98	115.97	-0.2	0.2	-0.01
117 dB Rel. Ref.	116.96	116.98	-0.7	0.7	0.02
117 dB Diff.	116.97	116.98	-0.2	0.2	0.01
118 dB Rel. Ref.	117.96	117.98	-0.7	0.7	0.02
118 dB Diff.	117.98	117.98	-0.2	0.2	0.00
119 dB Rel. Ref.	118.96	118.98	-0.7	0.7	0.02
119 dB Diff.	118.98	118.98	-0.2	0.2	0.00
120 dB Rel. Ref.	119.96	119.98	-0.7	0.7	0.02
120 dB Diff.	119.98	119.98	-0.2	0.2	0.00
121 dB Rel. Ref.	120.96	120.98	-0.7	0.7	0.02
121 dB Diff.	120.98	120.98	-0.2	0.2	0.00
122 dB Rel. Ref.	121.96	121.98	-0.7	0.7	0.02
122 dB Diff.	121.98	121.98	-0.2	0.2	0.00
123 dB Rel. Ref.	122.96	122.98	-0.7	0.7	0.02
123 dB Diff.	122.98	122.98	-0.2	0.2	0.00
124 dB Rel. Ref.	123.96	123.98	-0.7	0.7	0.02
124 dB Diff.	123.98	123.98	-0.2	0.2	0.00
125 dB Rel. Ref.	124.96	124.98	-0.7	0.7	0.02
125 dB Diff.	124.98	124.98	-0.2	0.2	0.00
126 dB Rel. Ref.	125.96	125.98	-0.7	0.7	0.02
126 dB Diff.	125.98	125.98	-0.2	0.2	0.00
127 dB Rel. Ref.	126.96	126.98	-0.7	0.7	0.02
127 dB Diff.	126.98	126.98	-0.2	0.2	0.00
128 dB Rel. Ref.	127.96	127.98	-0.7	0.7	0.02
128 dB Diff.	127.98	127.98	-0.2	0.2	0.00
129 dB Rel. Ref.	128.96	128.98	-0.7	0.7	0.02
129 dB Diff.	128.98	128.98	-0.2	0.2	0.00
130 dB Rel. Ref.	129.96	129.98	-0.7	0.7	0.02
130 dB Diff.	129.98	129.98	-0.2	0.2	0.00
131 dB Rel. Ref.	130.96	130.98	-0.7	0.7	0.02
131 dB Diff.	130.98	130.98	-0.2	0.2	0.00
132 dB Rel. Ref.	131.96	131.98	-0.7	0.7	0.02
132 dB Diff.	131.98	131.98	-0.2	0.2	0.00
133 dB Rel. Ref.	132.96	132.98	-0.7	0.7	0.02
133 dB Diff.	132.98	132.98	-0.2	0.2	0.00
134 dB Rel. Ref.	133.96	133.98	-0.7	0.7	0.02
134 dB Diff.	133.98	133.98	-0.2	0.2	0.00
135 dB Rel. Ref.	134.96	134.98	-0.7	0.7	0.02
135 dB Diff.	134.98	134.98	-0.2	0.2	0.00
136 dB Rel. Ref.	135.96	135.98	-0.7	0.7	0.02
136 dB Diff.	135.98	135.98	-0.2	0.2	0.00
137 dB Rel. Ref.	136.96	136.98	-0.7	0.7	0.02
137 dB Diff.	136.98	136.98	-0.2	0.2	0.00
138 dB Rel. Ref.	137.96	137.98	-0.7	0.7	0.02
138 dB Diff.	137.98	137.98	-0.2	0.2	0.00
139 dB Rel. Ref.	138.96	138.98	-0.7	0.7	0.02
139 dB Diff.	138.98	138.98	-0.2	0.2	0.00
139 dB Rel. Ref.	138.96	138.98	-0.7	0.7	0.02
139 dB Diff.	138.98	138.98	-0.2	0.2	0.00

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Linealidad en pasos de 10 dB a la frecuencia de 31,5 Hz.

La respuesta del sonómetro a señales de amplitud sinusoidal en varios niveles que abarca el rango de referencia, incluyendo un nivel nominal correspondiente a Lref en la frecuencia de medición. A partir de esta respuesta de otros niveles se calcula la respuesta correspondiente a Lref. La respuesta relativa se compara con la respuesta relativa.Para cada nivel entre las respuestas y el nivel anterior se calcula también con el fin de determinar la linealidad diferencial de nivel.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
94 dB	94.00	94.07	-1.0	1.0	0.07
31 dB Rel. Ref.	31.07	31.45	-0.7	0.7	0.38
39 dB Rel. Ref.	39.07	39.35	-0.7	0.7	0.28
39 dB Diff.	39.45	39.35	-0.4	0.4	-0.10
49 dB Rel. Ref.	49.07	49.21	-0.7	0.7	0.14
49 dB Diff.	49.35	49.21	-0.4	0.4	-0.14
59 dB Rel. Ref.	59.07	59.12	-0.7	0.7	0.05
59 dB Diff.	59.21	59.12	-0.4	0.4	-0.09
69 dB Rel. Ref.	69.07	69.07	-0.7	0.7	0.00
69 dB Diff.	69.12	69.07	-0.4	0.4	-0.05
79 dB Rel. Ref.	79.07	79.07	-0.7	0.7	0.00
79 dB Diff.	79.07	79.07	-0.4	0.4	0.00
89 dB Rel. Ref.	89.07	89.06	-0.7	0.7	-0.01
89 dB Diff.	89.07	89.06	-0.4	0.4	-0.01
99 dB Rel. Ref.	99.07	99.06	-0.7	0.7	-0.01
99 dB Diff.	99.06	99.06	-0.4	0.4	0.00
109 dB Rel. Ref.	109.07	109.01	-0.7	0.7	-0.06
109 dB Diff.	109.06	109.01	-0.4	0.4	-0.05
119 dB Rel. Ref.	119.07	119.02	-0.7	0.7	-0.05
119 dB Diff.	119.01	119.02	-0.4	0.4	0.01
129 dB Rel. Ref.	129.07	129.05	-0.7	0.7	-0.02
129 dB Diff.	129.02	129.05	-0.4	0.4	0.03
139 dB Rel. Ref.	139.07	139.08	-0.7	0.7	0.01
139 dB Diff.	139.05	139.08	-0.4	0.4	0.03

Linealidad en pasos de 10 dB a la frecuencia de 1 kHz.

La respuesta del sonómetro a señales de amplitud sinusoidal en varios niveles que abarca el rango de referencia, incluyendo un nivel nominal correspondiente a Lref en la frecuencia de medición. A partir de esta respuesta de otros niveles se calcula la respuesta correspondiente a Lref. La respuesta relativa se compara con la respuesta relativa.Para cada nivel entre las respuestas y el nivel anterior se calcula también con el fin de determinar la linealidad diferencial de nivel.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
94 dB	94.00	94.00	-1.0	1.0	0.00
25 dB Rel. Ref.	25.00	25.45	-0.7	0.7	0.45
33 dB Rel. Ref.	33.00	33.15	-0.7	0.7	0.15
33 dB Diff.	33.45	33.15	-0.4	0.4	-0.30
43 dB Rel. Ref.	43.00	43.05	-0.7	0.7	0.05
43 dB Diff.	43.15	43.05	-0.4	0.4	-0.10
53 dB Rel. Ref.	53.00	52.99	-0.7	0.7	-0.01
53 dB Diff.	53.05	52.99	-0.4	0.4	-0.06

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63 dB Rel. Ref.	63.00	63.00	-0.7	0.7	0.00
63 dB Diff.	62.99	63.00	-0.4	0.4	0.01
73 dB Rel. Ref.	73.00	73.01	-0.7	0.7	0.01
73 dB Diff.	73.00	73.01	-0.4	0.4	0.01
83 dB Rel. Ref.	83.00	83.00	-0.7	0.7	0.00
83 dB Diff.	83.01	83.00	-0.4	0.4	-0.01
93 dB Rel. Ref.	93.00	93.00	-0.7	0.7	0.00
93 dB Diff.	93.00	93.00	-0.4	0.4	0.00
103 dB Rel. Ref.	103.00	103.00	-0.7	0.7	0.00
103 dB Diff.	103.00	103.00	-0.4	0.4	0.00
113 dB Rel. Ref.	113.00	113.01	-0.7	0.7	0.01
113 dB Diff.	113.00	113.01	-0.4	0.4	0.01
123 dB Rel. Ref.	123.00	123.02	-0.7	0.7	0.02
123 dB Diff.	123.01	123.02	-0.4	0.4	0.01
133 dB Rel. Ref.	133.00	133.02	-0.7	0.7	0.02
133 dB Diff.	133.02	133.02	-0.4	0.4	0.00
140 dB Rel. Ref.	140.00	140.02	-0.7	0.7	0.02
140 dB Diff.	140.02	140.02	-0.4	0.4	0.00

Linealidad en pasos de 10 dB a la frecuencia de 4 kHz.

La respuesta del sonómetro a señales de amplitud sinusoidal en varios niveles que abarca el rango de referencia, incluyendo un nivel nominal correspondiente a Lref en la frecuencia de medición. A partir de esta respuesta de otros niveles se calcula la respuesta correspondiente a Lref. La respuesta relativa se compara con la respuesta relativa.Para cada nivel entre las respuestas y el nivel anterior se calcula también con el fin de determinar la linealidad diferencial de nivel.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
94 dB	94.00	93.99	-1.0	1.0	-0.01
25 dB Rel. Ref.	24.99	25.26	-0.7	0.7	0.27
33 dB Rel. Ref.	32.99	33.15	-0.7	0.7	0.16
33 dB Diff.	33.26	33.15	-0.4	0.4	-0.11
43 dB Rel. Ref.	42.99	43.08	-0.7	0.7	0.09
43 dB Diff.	43.15	43.08	-0.4	0.4	-0.07
53 dB Rel. Ref.	52.99	53.00	-0.7	0.7	0.01
53 dB Diff.	53.08	53.00	-0.4	0.4	-0.08
63 dB Rel. Ref.	62.99	63.00	-0.7	0.7	0.01
63 dB Diff.	63.00	63.00	-0.4	0.4	0.00
73 dB Rel. Ref.	72.99	73.00	-0.7	0.7	0.01
73 dB Diff.	73.00	73.00	-0.4	0.4	0.00
83 dB Rel. Ref.	82.99	83.00	-0.7	0.7	0.01
83 dB Diff.	83.00	83.00	-0.4	0.4	0.00
93 dB Rel. Ref.	92.99	93.00	-0.7	0.7	0.01
93 dB Diff.	93.00	93.00	-0.4	0.4	0.00
103 dB Rel. Ref.	102.99	102.99	-0.7	0.7	0.00
103 dB Diff.	103.00	102.99	-0.4	0.4	-0.01
113 dB Rel. Ref.	112.99	113.00	-0.7	0.7	0.01
113 dB Diff.	112.99	113.00	-0.4	0.4	0.01
123 dB Rel. Ref.	122.99	123.01	-0.7	0.7	0.02
123 dB Diff.	123.00	123.01	-0.4	0.4	0.01
133 dB Rel. Ref.	132.99	133.01	-0.7	0.7	0.02
133 dB Diff.	133.01	133.01	-0.4	0.4	0.00

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140 dB Rel. Ref.	139.99	140.01	-0.7	0.7	0.02
140 dB Diff.	140.01	140.01	-0.4	0.4	0.00

Linealidad en pasos de 10 dB a la frecuencia de 8 kHz.

La respuesta del sonómetro a señales de amplitud sinusoidal en varios niveles que abarca el rango de referencia, incluyendo un nivel nominal correspondiente a Lref en la frecuencia de medición. A partir de esta respuesta de otros niveles se calcula la respuesta correspondiente a Lref. La respuesta relativa se compara con la respuesta relativa.Para cada nivel entre las respuestas y el nivel anterior se calcula también con el fin de determinar la linealidad diferencial de nivel.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
94 dB	94.00	93.96	-1.0	1.0	-0.04
25 dB Rel. Ref.	24.96	25.36	-0.7	0.7	0.40
33 dB Rel. Ref.	32.96	33.12	-0.7	0.7	0.16
33 dB Diff.	33.36	33.12	-0.4	0.4	-0.24
43 dB Rel. Ref.	42.96	43.05	-0.7	0.7	0.09
43 dB Diff.	43.12	43.05	-0.4	0.4	-0.07
53 dB Rel. Ref.	52.96	52.97	-0.7	0.7	0.01
53 dB Diff.	53.05	52.97	-0.4	0.4	-0.08
63 dB Rel. Ref.	62.96	62.96	-0.7	0.7	0.00
63 dB Diff.	62.97	62.96	-0.4	0.4	-0.01
73 dB Rel. Ref.	72.96	72.97	-0.7	0.7	0.01
73 dB Diff.	72.96	72.97	-0.4	0.4	0.01
83 dB Rel. Ref.	82.96	82.96	-0.7	0.7	0.00
83 dB Diff.	82.97	82.96	-0.4	0.4	-0.01
93 dB Rel. Ref.	92.96	92.96	-0.7	0.7	0.00
93 dB Diff.	92.96	92.96	-0.4	0.4	0.00
103 dB Rel. Ref.	102.96	102.96	-0.7	0.7	0.00
103 dB Diff.	102.96	102.96	-0.4	0.4	0.00
113 dB Rel. Ref.	112.96	112.96	-0.7	0.7	0.00
113 dB Diff.	112.96	112.96	-0.4	0.4	0.00
123 dB Rel. Ref.	122.96	122.96	-0.7	0.7	0.00
123 dB Diff.	122.96	122.96	-0.4	0.4	0.00
133 dB Rel. Ref.	132.96	132.98	-0.7	0.7	0.02
133 dB Diff.	132.96	132.98	-0.4	0.4	0.02
139 dB Rel. Ref.	138.96	138.98	-0.7	0.7	0.02
139 dB Diff.	138.98	136.98	-0.4	0.4	0.00

Diferencia de indicación en Ponderación Temporal

La respuesta del sonómetro a una señal de 1 kHz constante en tensión a un nivel de referencia. Las diferencias entre las distintas respuestas de ponderación Temporal se calculan y se comparan con las diferencias máximas y minimas permitidas.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. Fast	94.00	94.00	-1.0	1.0	0.00
Meas. Slow	94.00	94.00	-0.1	0.1	0.00
Meas. Impulse	94.00	94.00	-0.1	0.1	0.00

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Respuesta a Salvas simples de 200 ms en Ponderación Temporal "Fast"

La lectura máxima del sonómetro cuando se exponen a salvas tonales de 200 ms de duracion. La respuesta del sonómetro se calcula como la lectura máxima respecto a a una señal constante sinusoidal con la misma frecuencia y tensión de pico equivalente a las salvas tonales. Se ensaya la respuesta del sonómetro a un solo pulso y se compara con la respuesta anterior.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 136 dB	136.00	136.03	-1.0	1.0	0.03
Burst Meas. 136 dB	135.03	135.03	-1.0	1.0	0.00
Ref. 126 dB	126.00	126.03	-1.0	1.0	0.03
Burst Meas. 126 dB	125.03	125.03	-1.0	1.0	0.00
Ref. 116 dB	116.00	116.02	-1.0	1.0	0.02
Burst Meas. 116 dB	115.02	115.03	-1.0	1.0	0.01
Ref. 106 dB	106.00	106.01	-1.0	1.0	0.01
Burst Meas. 106 dB	105.01	105.03	-1.0	1.0	0.02
Ref. 96 dB	96.00	96.01	-1.0	1.0	0.01
Burst Meas. 96 dB	95.01	95.03	-1.0	1.0	0.02
Ref. 86 dB	86.00	86.01	-1.0	1.0	0.01
Burst Meas. 86 dB	85.01	85.03	-1.0	1.0	0.02
Ref. 76 dB	76.00	76.02	-1.0	1.0	0.02
Burst Meas. 76 dB	75.02	75.03	-1.0	1.0	0.01
Ref. 66 dB	66.00	66.01	-1.0	1.0	0.01
Burst Meas. 66 dB	65.01	65.02	-1.0	1.0	0.01
Ref. 56 dB	56.00	56.01	-1.0	1.0	0.01
Burst Meas. 56 dB	55.01	55.03	-1.0	1.0	0.02
Ref. 46 dB	46.00	46.06	-1.0	1.0	0.06
Burst Meas. 46 dB	45.06	45.07	-1.0	1.0	0.01
Ref. 36 dB	36.00	36.24	-1.0	1.0	0.24
Burst Meas. 36 dB	35.24	35.24	-1.0	1.0	0.00

Respuesta a Salvas simples de 500 ms en Ponderación Temporal "Slow"

La lectura máxima del sonómetro cuando se exponen a salvas tonales de 500 ms de duracion. La respuesta del sonómetro se calcula como la lectura máxima respecto a a una señal constante sinusoidal con la misma frecuencia y tensión de pico equivalente a las salvas tonales. Se ensaya la respuesta del sonómetro a un solo pulso y se compara con la respuesta anterior.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 136 dB	136.00	135.98	-1.0	1.0	-0.02
Burst Meas. 136 dB	131.88	131.97	-1.0	1.0	0.09
Ref. 126 dB	126.00	125.98	-1.0	1.0	-0.02
Burst Meas. 126 dB	121.88	121.96	-1.0	1.0	0.08
Ref. 116 dB	116.00	115.97	-1.0	1.0	-0.03
Burst Meas. 116 dB	111.87	111.96	-1.0	1.0	0.09
Ref. 106 dB	106.00	105.96	-1.0	1.0	-0.04
Burst Meas. 106 dB	101.86	101.96	-1.0	1.0	0.10
Ref. 96 dB	96.00	95.96	-1.0	1.0	-0.04

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Burst Meas. 96 dB	91.86	91.96	-1.0	1.0	0.10
Ref. 86 dB	86.00	85.96	-1.0	1.0	-0.04
Burst Meas. 86 dB	81.86	81.96	-1.0	1.0	0.10
Ref. 76 dB	76.00	75.96	-1.0	1.0	-0.04
Burst Meas. 76 dB	71.86	71.96	-1.0	1.0	0.10
Ref. 66 dB	66.00	65.96	-1.0	1.0	-0.04
Burst Meas. 66 dB	61.86	61.96	-1.0	1.0	0.10
Ref. 56 dB	56.00	55.96	-1.0	1.0	-0.04
Burst Meas. 56 dB	51.86	51.96	-1.0	1.0	0.10
Ref. 46 dB	46.00	45.99	-1.0	1.0	-0.01
Burst Meas. 46 dB	41.89	42.02	-1.0	1.0	0.13
Ref. 36 dB	36.00	36.15	-1.0	1.0	0.15
Burst Meas. 36 dB	32.05	32.36	-1.0	1.0	0.31

Respuesta a Salvas simples de 20 ms, en Ponderación Temporal "Imp"

La lectura máxima del sonómetro cuando se exponen a salvas tonales de 20 ms de duracion. La respuesta del sonómetro se calcula como la lectura máxima respecto a a una señal constante sinusoidal con la misma frecuencia y tensión de pico equivalente a las salvas tonales. Se ensaya la respuesta del sonómetro a un solo pulso y se compara con la respuesta anterior.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 140 dB	140.00	140.03	-1.0	1.0	0.03
Burst Meas. 140 dB	136.43	136.33	-1.5	1.5	-0.10
Ref. 130 dB	130.00	130.03	-1.0	1.0	0.03
Burst Meas. 130 dB	126.43	126.32	-1.5	1.5	-0.11
Ref. 120 dB	120.00	120.03	-1.0	1.0	0.03
Burst Meas. 120 dB	116.43	116.33	-1.5	1.5	-0.10
Ref. 110 dB	110.00	110.02	-1.0	1.0	0.02
Burst Meas. 110 dB	106.42	106.39	-1.5	1.5	-0.03
Ref. 100 dB	100.00	100.01	-1.0	1.0	0.01
Burst Meas. 100 dB	96.41	96.36	-1.5	1.5	-0.05
Ref. 90 dB	90.00	90.01	-1.0	1.0	0.01
Burst Meas. 90 dB	86.41	86.38	-1.5	1.5	-0.03
Ref. 80 dB	80.00	80.02	-1.0	1.0	0.02
Burst Meas. 80 dB	76.42	76.37	-1.5	1.5	-0.05
Ref. 70 dB	70.00	70.01	-1.0	1.0	0.01
Burst Meas. 70 dB	66.41	66.36	-1.5	1.5	-0.05
Ref. 60 dB	60.00	60.02	-1.0	1.0	0.02
Burst Meas. 60 dB	56.42	56.36	-1.5	1.5	-0.06
Ref. 50 dB	50.00	50.04	-1.0	1.0	0.04
Burst Meas. 50 dB	46.44	46.38	-1.5	1.5	-0.06
Ref. 40 dB	40.00	40.17	-1.0	1.0	0.17
Burst Meas. 40 dB	36.57	36.47	-1.5	1.5	-0.10

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Respuesta a Salvas simples de 5 ms, en Ponderación Temporal "Imp"

La lectura máxima del sonómetro cuando se exponen a salvas tonales de 5 ms de duracion. La respuesta del sonómetro se calcula como la lectura máxima respecto a a una señal constante sinusoidal con la misma frecuencia y tensión de pico equivalente a las salvas tonales. Se ensaya la respuesta del sonómetro a un solo pulso y se compara con la respuesta anterior.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 140 dB	140.00	140.03	-1.0	1.0	0.03
Burst Meas. 140 dB	131.23	131.14	-2.0	2.0	-0.09
Ref. 130 dB	130.00	130.03	-1.0	1.0	0.03
Burst Meas. 130 dB	121.23	121.20	-2.0	2.0	-0.03
Ref. 120 dB	120.00	120.03	-1.0	1.0	0.03
Burst Meas. 120 dB	111.23	111.18	-2.0	2.0	-0.05
Ref. 110 dB	110.00	110.02	-1.0	1.0	0.02
Burst Meas. 110 dB	101.22	101.25	-2.0	2.0	0.03
Ref. 100 dB	100.00	100.01	-1.0	1.0	0.01
Burst Meas. 100 dB	91.21	91.20	-2.0	2.0	-0.01
Ref. 90 dB	90.00	90.01	-1.0	1.0	0.01
Burst Meas. 90 dB	81.21	81.19	-2.0	2.0	-0.02
Ref. 80 dB	80.00	80.02	-1.0	1.0	0.02
Burst Meas. 80 dB	71.22	71.16	-2.0	2.0	-0.06
Ref. 70 dB	70.00	70.01	-1.0	1.0	0.01
Burst Meas. 70 dB	61.21	61.17	-2.0	2.0	-0.04
Ref. 60 dB	60.00	60.02	-1.0	1.0	0.02
Burst Meas. 60 dB	51.22	51.24	-2.0	2.0	0.02
Ref. 50 dB	50.00	50.04	-1.0	1.0	0.04
Burst Meas. 50 dB	41.24	41.23	-2.0	2.0	-0.01
Ref. 40 dB	40.00	40.15	-1.0	1.0	0.15
Burst Meas. 40 dB	31.35	31.63	-2.0	2.0	0.28

Respuesta a Salvas simples de 2 ms. en Ponderación Temporal "Imp"

La lectura máxima del sonómetro cuando se exponen a salvas tonales de 2 ms de duracion. La respuesta del sonómetro se calcula como la lectura máxima respecto a a una señal constante sinusoidal con la misma frecuencia y tensión de pico equivalente a las salvas tonales. Se ensaya la respuesta del sonómetro a un solo pulso y se compara con la respuesta anterior.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 140 dB	140.00	140.03	-1.0	1.0	0.03
Burst Meas. 140 dB	127.43	127.44	-2.0	2.0	0.01
Ref. 130 dB	130.00	130.03	-1.0	1.0	0.03
Burst Meas. 130 dB	117.43	117.35	-2.0	2.0	-0.08
Ref. 120 dB	120.00	120.03	-1.0	1.0	0.03
Burst Meas. 120 dB	107.43	107.36	-2.0	2.0	-0.07
Ref. 110 dB	110.00	110.02	-1.0	1.0	0.02
Burst Meas. 110 dB	97.42	97.39	-2.0	2.0	-0.03
Ref. 100 dB	100.00	100.01	-1.0	1.0	0.01

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Burst Meas. 100 dB	87.41	87.39	-2.0	2.0	-0.02
Ref. 90 dB	90.00	90.01	-1.0	1.0	0.01
Burst Meas. 90 dB	77.41	77.41	-2.0	2.0	0.00
Ref. 80 dB	80.00	80.02	-1.0	1.0	0.02
Burst Meas. 80 dB	67.42	67.40	-2.0	2.0	-0.02
Ref. 70 dB	70.00	70.01	-1.0	1.0	0.01
Burst Meas. 70 dB	57.41	57.38	-2.0	2.0	-0.03
Ref. 60 dB	60.00	60.02	-1.0	1.0	0.02
Burst Meas. 60 dB	47.42	47.38	-2.0	2.0	-0.04
Ref. 50 dB	50.00	50.04	-1.0	1.0	0.04
Burst Meas. 50 dB	37.44	37.51	-2.0	2.0	0.07

Respuesta a Salvas continuas a 100 Hz.

La respuesta del sonómetro a secuencias repetidas de salvas tonales en ponderación Temporal Impulsiva para diversas frecuencias. El nivel pico de la salva tonal se mantiene constante para todas las señales, y la respuesta del sonómetro se calcula como la lectura máxima respecto a la respuesta de una señal sinusoidal de valor constante de pico igual a las salvas tonales. Las respuestas se comparan con las respuestas anteriores.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 140 dB	140.00	140.03	-1.0	1.0	0.03
Burst Meas. 140 dB	137.33	137.25	-1.0	1.0	-0.08
Ref. 130 dB	130.00	130.03	-1.0	1.0	0.03
Burst Meas. 130 dB	127.33	127.27	-1.0	1.0	-0.06
Ref. 120 dB	120.00	120.03	-1.0	1.0	0.03
Burst Meas. 120 dB	117.33	117.28	-1.0	1.0	-0.05
Ref. 110 dB	110.00	110.02	-1.0	1.0	0.02
Burst Meas. 110 dB	107.32	107.27	-1.0	1.0	-0.05
Ref. 100 dB	100.00	100.01	-1.0	1.0	0.01
Burst Meas. 100 dB	97.31	97.27	-1.0	1.0	-0.04
Ref. 90 dB	90.00	90.01	-1.0	1.0	0.01
Burst Meas. 90 dB	87.31	87.27	-1.0	1.0	-0.04
Ref. 80 dB	80.00	80.02	-1.0	1.0	0.02
Burst Meas. 80 dB	77.32	77.30	-1.0	1.0	-0.02
Ref. 70 dB	70.00	70.01	-1.0	1.0	0.01
Burst Meas. 70 dB	67.31	67.29	-1.0	1.0	-0.02
Ref. 60 dB	60.00	60.02	-1.0	1.0	0.02
Burst Meas. 60 dB	57.32	57.28	-1.0	1.0	-0.04
Ref. 50 dB	50.00	50.04	-1.0	1.0	0.04
Burst Meas. 50 dB	47.34	47.28	-1.0	1.0	-0.06
Ref. 40 dB	40.00	40.14	-1.0	1.0	0.14
Burst Meas. 40 dB	37.44	37.45	-1.0	1.0	0.01

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Respuesta a Salvas continuas de 20 Hz.

La respuesta del sonómetro a secuencias repetidas de salvas tonales en ponderación Temporal Impulsiva para diversas frecuencias. El nivel pico de la salva tonal se mantiene constante para todas las señales, y la respuesta del sonómetro se calcula como la lectura máxima respecto a la respuesta de una señal sinusoidal de valor constante de pico igual a las salvas tonales. Las respuestas se comparan con las respuestas anteriores.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 140 dB	140.00	140.03	-1.0	1.0	0.03
Burst Meas. 140 dB	132.43	132.41	-2.0	2.0	-0.02
Ref. 130 dB	130.00	130.03	-1.0	1.0	0.03
Burst Meas. 130 dB	122.43	122.41	-2.0	2.0	-0.02
Ref. 120 dB	120.00	120.03	-1.0	1.0	0.03
Burst Meas. 120 dB	112.43	112.34	-2.0	2.0	-0.09
Ref. 110 dB	110.00	110.02	-1.0	1.0	0.02
Burst Meas. 110 dB	102.42	102.44	-2.0	2.0	0.02
Ref. 100 dB	100.00	100.01	-1.0	1.0	0.01
Burst Meas. 100 dB	92.41	92.41	-2.0	2.0	0.00
Ref. 90 dB	90.00	90.01	-1.0	1.0	0.01
Burst Meas. 90 dB	82.41	82.41	-2.0	2.0	0.00
Ref. 80 dB	80.00	80.02	-1.0	1.0	0.02
Burst Meas. 80 dB	72.42	72.40	-2.0	2.0	-0.02
Ref. 70 dB	70.00	70.01	-1.0	1.0	0.01
Burst Meas. 70 dB	62.41	62.39	-2.0	2.0	-0.02
Ref. 60 dB	60.00	60.02	-1.0	1.0	0.02
Burst Meas. 60 dB	52.42	52.36	-2.0	2.0	-0.06
Ref. 50 dB	50.00	50.04	-1.0	1.0	0.04
Burst Meas. 50 dB	42.44	42.42	-2.0	2.0	-0.02
Ref. 40 dB	40.00	40.16	-1.0	1.0	0.16
Burst Meas. 40 dB	32.56	32.95	-2.0	2.0	0.39

Respuesta a Salvas continuas de 2 Hz.

La respuesta del sonómetro a secuencias repetidas de salvas tonales en ponderación Temporal Impulsiva para diversas frecuencias. El nivel pico de la salva tonal se mantiene constante para todas las señales, y la respuesta del sonómetro se calcula como la lectura máxima respecto a la respuesta de una señal sinusoidal de valor constante de pico igual a las salvas tonales. Las respuestas se comparan con las respuestas anteriores.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 140 dB	140.00	140.03	-1.0	1.0	0.03
Burst Meas. 140 dB	131.23	131.23	-2.0	2.0	0.00
Ref. 130 dB	130.00	130.03	-1.0	1.0	0.03
Burst Meas. 130 dB	121.23	121.22	-2.0	2.0	-0.01
Ref. 120 dB	120.00	120.03	-1.0	1.0	0.03
Burst Meas. 120 dB	111.23	111.16	-2.0	2.0	-0.07
Ref. 110 dB	110.00	110.02	-1.0	1.0	0.02
Burst Meas. 110 dB	101.22	101.22	-2.0	2.0	0.00
Ref. 100 dB	100.00	100.01	-1.0	1.0	0.01
Burst Meas. 100 dB	91.21	91.16	-2.0	2.0	-0.05

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Ref. 90 dB	90.00	90.01	-1.0	1.0	0.01
Burst Meas. 90 dB	81.21	81.16	-2.0	2.0	-0.05
Ref. 80 dB	80.00	80.02	-1.0	1.0	0.02
Burst Meas. 80 dB	71.22	71.22	-2.0	2.0	0.00
Ref. 70 dB	70.00	70.01	-1.0	1.0	0.01
Burst Meas. 70 dB	61.21	61.17	-2.0	2.0	-0.04
Ref. 60 dB	60.00	60.02	-1.0	1.0	0.02
Burst Meas. 60 dB	51.22	51.17	-2.0	2.0	-0.05
Ref. 50 dB	50.00	50.04	-1.0	1.0	0.04
Burst Meas. 50 dB	41.24	41.32	-2.0	2.0	0.08
Ref. 40 dB	40.00	40.14	-1.0	1.0	0.14
Burst Meas. 40 dB	31.34	31.64	-2.0	2.0	0.30

Ponderación Temporal "Peak"

La indicación del nivel de pico maximo cuando se exponen a pulsos rectangulares de diferente duración. El nivel máximo indicado para un pulso rectangular de corta duración se compara con el nivel máximo indicado para un pulso rectangular de duración de 10 ms. Las mediciones se realizan tanto con pulsos positivos como negativos. El nivel de pico de la señal es de 1 dB por debajo del límite superior del rango de referencia.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. Pos	139.00	140.76	-2.0	2.0	1.76
Meas. Pos	140.76	139.36	-2.0	2.0	-1.40
Ref. Neg	139.00	140.70	-2.0	2.0	1.70
Meas. Neg	140.70	139.36	-2.0	2.0	-1.34

Detección cuadratica. Factor de Cresta CF 3

La respuesta del sonómetro a las secuencias repetidas de salvas tonales. El nivel máximo se mantiene constante para todas las señales y la frecuencia de repetición es de 40 Hz es decir, factores de cresta diferentes.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 138 dB	138.00	137.98	-1.0	1.0	-0.02
Burst Meas. 138 dB	131.48	131.42	-0.5	0.5	-0.06
Ref. 128 dB	128.00	127.97	-1.0	1.0	-0.03
Burst Meas. 128 dB	121.47	121.42	-0.5	0.5	-0.05
Ref. 118 dB	118.00	117.97	-1.0	1.0	-0.03
Burst Meas. 118 dB	111.47	111.42	-0.5	0.5	-0.05
Ref. 108 dB	108.00	107.96	-1.0	1.0	-0.04
Burst Meas. 108 dB	101.46	101.42	-0.5	0.5	-0.04
Ref. 98 dB	98.00	97.96	-1.0	1.0	-0.04
Burst Meas. 98 dB	91.46	91.42	-0.5	0.5	-0.04
Ref. 88 dB	88.00	87.96	-1.0	1.0	-0.04
Burst Meas. 88 dB	81.46	81.42	-0.5	0.5	-0.04
Ref. 78 dB	78.00	77.96	-1.0	1.0	-0.04
Burst Meas. 78 dB	71.46	71.43	-0.5	0.5	-0.03
Ref. 68 dB	68.00	67.96	-1.0	1.0	-0.04
Burst Meas. 68 dB	61.46	61.42	-0.5	0.5	-0.04

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Ref. 58 dB	58.00	57.95	-1.0	1.0	-0.05
Burst Meas. 58 dB	51.45	51.42	-0.5	0.5	-0.03
Ref. 48 dB	48.00	47.98	-1.0	1.0	-0.02
Burst Meas. 48 dB	41.48	41.48	-0.5	0.5	0.00

Detección cuadratica, Factor de Cresta CF5

La respuesta del sonómetro a las secuencias repetidas de salvas tonales. El nivel máximo se mantiene constante para todas las señales y la frecuencia de repetición es de 40 Hz es decir, factores de cresta diferentes.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 138 dB	138.00	137.98	-1.0	1.0	-0.02
Burst Meas. 138 dB	127.08	127.03	-1.0	1.0	-0.05
Ref. 128 dB	128.00	127.97	-1.0	1.0	-0.03
Burst Meas. 128 dB	117.07	117.04	-1.0	1.0	-0.03
Ref. 118 dB	118.00	117.97	-1.0	1.0	-0.03
Burst Meas. 118 dB	107.07	107.03	-1.0	1.0	-0.04
Ref. 108 dB	108.00	107.96	-1.0	1.0	-0.04
Burst Meas. 108 dB	97.06	97.04	-1.0	1.0	-0.02
Ref. 98 dB	98.00	97.96	-1.0	1.0	-0.04
Burst Meas. 98 dB	87.06	87.04	-1.0	1.0	-0.02
Ref. 88 dB	88.00	87.96	-1.0	1.0	-0.04
Burst Meas. 88 dB	77.06	77.03	-1.0	1.0	-0.03
Ref. 78 dB	78.00	77.96	-1.0	1.0	-0.04
Burst Meas. 78 dB	67.06	67.04	-1.0	1.0	-0.02
Ref. 68 dB	68.00	67.96	-1.0	1.0	-0.04
Burst Meas. 68 dB	57.06	57.04	-1.0	1.0	-0.02
Ref. 58 dB	58.00	57.96	-1.0	1.0	-0.04
Burst Meas. 58 dB	47.06	47.05	-1.0	1.0	-0.01
Ref. 48 dB	48.00	47.98	-1.0	1.0	-0.02
Burst Meas. 48 dB	37.08	37.17	-1.0	1.0	0.09

Detección cuadratica. Factor de Cresta CF10

La respuesta del sonómetro a las secuencias repetidas de salvas tonales. El nivel máximo se mantiene constante para todas las señales y la frecuencia de repetición es de 40 Hz es decir, factores de cresta diferentes.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 138 dB	138.00	137.98	-1.0	1.0	-0.02
Burst Meas. 138 dB	121.08	121.01	-1.5	1.5	-0.07
Ref. 128 dB	128.00	127.97	-1.0	1.0	-0.03
Burst Meas. 128 dB	111.07	111.02	-1.5	1.5	-0.05
Ref. 118 dB	118.00	117.97	-1.0	1.0	-0.03
Burst Meas. 118 dB	101.07	101.05	-1.5	1.5	-0.02
Ref. 108 dB	108.00	107.96	-1.0	1.0	-0.04
Burst Meas. 108 dB	91.06	91.02	-1.5	1.5	-0.04
Ref. 98 dB	98.00	97.96	-1.0	1.0	-0.04
Burst Meas. 98 dB	81.06	81.02	-1.5	1.5	-0.04

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Ref. 88 dB	88.00	87.96	-1.0	1.0	-0.04
Burst Meas. 88 dB	71.06	71.02	-1.5	1.5	-0.04
Ref. 78 dB	78.00	77.98	-1.0	1.0	-0.04
Burst Meas. 78 dB	61.06	61.02	-1.5	1.5	-0.04
Ref. 68 dB	68.00	67.96	-1.0	1.0	-0.04
Burst Meas. 68 dB	51.06	51.02	-1.5	1.5	-0.04
Ref. 58 dB	58.00	57.96	-1.0	1.0	-0.04
Burst Meas. 58 dB	41.06	41.06	-1.5	1.5	0.00

Detección cuadratica. Pulsos rectangulares Positivos, CF3

La respuesta del sonómetro a secuencias repetidas de 200 ms. con pulsos rectangulares. El nivel pico de los pulsos rectangulares se ajusta a fin de dar la misma respuesta para todas las frecuencias de repetición.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 138 dB	138.00	137.98	-1.0	1.0	-0.02
Pulse Meas. 138 dB	131.45	131.59	-0.5	0.5	0.14
Ref. 128 dB	128.00	127.97	-1.0	1.0	-0.03
Pulse Meas. 128 dB	121.44	121.59	-0.5	0.5	0.15
Ref. 118 dB	118.00	117.97	-1.0	1.0	-0.03
Pulse Meas. 118 dB	111.44	111.58	-0.5	0.5	0.14
Ref. 108 dB	108.00	107.96	-1.0	1.0	-0.04
Pulse Meas. 108 dB	101.43	101.59	-0.5	0.5	0.16
Ref. 98 dB	98.00	97.96	-1.0	1.0	-0.04
Pulse Meas. 98 dB	91.43	91.58	-0.5	0.5	0.15
Ref. 88 dB	88.00	87.96	-1.0	1.0	-0.04
Pulse Meas. 88 dB	81.43	81.58	-0.5	0.5	0.15
Ref. 78 dB	78.00	77.96	-1.0	1.0	-0.04
Pulse Meas. 78 dB	71.43	71.59	-0.5	0.5	0.16
Ref. 68 dB	68.00	67.96	-1.0	1.0	-0.04
Pulse Meas. 68 dB	61.43	61.58	-0.5	0.5	0.15
Ref. 58 dB	58.00	57.96	-1.0	1.0	-0.04
Pulse Meas. 58 dB	51.43	51.58	-0.5	0.5	0.15
Ref. 48 dB	48.00	47.98	-1.0	1.0	-0.02
Pulse Meas. 48 dB	41.45	41.67	-0.5	0.5	0.22

Detección cuadratica. Pulsos rectangulares Positivos CF5

La respuesta del sonómetro a secuencias repetidas de 200 ms. con pulsos rectangulares. El nivel pico de los pulsos rectangulares se ajusta a fin de dar la misma respuesta para todas las frecuencias de repetición.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 138 dB	138.00	137.98	-1.0	1.0	-0.02
Pulse Meas. 138 dB	127.01	127.16	-1.0	1.0	0.15
Ref. 128 dB	128.00	127.97	-1.0	1.0	-0.03
Pulse Meas. 128 dB	117.00	117.16	-1.0	1.0	0.16
Ref. 118 dB	118.00	117.97	-1.0	1.0	-0.03
Pulse Meas. 118 dB	107.00	107.16	-1.0	1.0	0.16
Ref. 108 dB	108.00	107.96	-1.0	1.0	-0.04
Pulse Meas. 108 dB	96.99	97.16	-1.0	1.0	0.17

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Ref. 98 dB	98.00	97.96	-1.0	1.0	-0.04
Pulse Meas. 98 dB	86.99	87.16	-1.0	1.0	0.17
Ref. 88 dB	88.00	87.96	-1.0	1.0	-0.04
Pulse Meas. 88 dB	76.99	77.16	-1.0	1.0	0.17
Ref. 78 dB	78.00	77.96	-1.0	1.0	-0.04
Pulse Meas. 78 dB	66.99	67.16	-1.0	1.0	0.17
Ref. 68 dB	68.00	67.96	-1.0	1.0	-0.04
Pulse Meas. 68 dB	56.99	57.14	-1.0	1.0	0.15
Ref. 58 dB	58.00	57.96	-1.0	1.0	-0.04
Pulse Meas. 58 dB	46.99	47.16	-1.0	1.0	0.17
Ref. 48 dB	48.00	47.99	-1.0	1.0	-0.01
Pulse Meas. 48 dB	37.02	37.28	-1.0	1.0	0.26

Detección cuadratica, Pulsos rectangulares Positivos, CF10

La respuesta del sonómetro a secuencias repetidas de 200 ms. con pulsos rectangulares. El nivel pico de los pulsos rectangulares se ajusta a fin de dar la misma respuesta para todas las frecuencias de repetición.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 138 dB	138.00	137.98	-1.0	1.0	-0.02
Pulse Meas. 138 dB	120.99	121.16	-1.5	1.5	0.17
Ref. 128 dB	128.00	127.97	-1.0	1.0	-0.03
Pulse Meas. 128 dB	110.98	111.17	-1.5	1.5	0.19
Ref. 118 dB	118.00	117.97	-1.0	1.0	-0.03
Pulse Meas. 118 dB	100.98	101.17	-1.5	1.5	0.19
Ref. 108 dB	108.00	107.96	-1.0	1.0	-0.04
Pulse Meas. 108 dB	90.97	91.17	-1.5	1.5	0.20
Ref. 98 dB	98.00	97.96	-1.0	1.0	-0.04
Pulse Meas. 98 dB	80.97	81.17	-1.5	1.5	0.20
Ref. 88 dB	88.00	87.96	-1.0	1.0	-0.04
Pulse Meas. 88 dB	70.97	71.17	-1.5	1.5	0.20
Ref. 78 dB	78.00	77.96	-1.0	1.0	-0.04
Pulse Meas. 78 dB	60.97	61.17	-1.5	1.5	0.20
Ref. 68 dB	68.00	67.96	-1.0	1.0	-0.04
Pulse Meas. 68 dB	50.97	51.17	-1.5	1.5	0.20
Ref. 58 dB	58.00	57.96	-1.0	1.0	-0.04
Pulse Meas. 58 dB	40.97	41.23	-1.5	1.5	0.26

Detección cuadratica, Pulsos rectangulares Negativos, CF3

La respuesta del sonómetro a secuencias repetidas de 200 ms. con pulsos rectangulares. El nivel pico de los pulsos rectangulares se ajusta a fin de dar la misma respuesta para todas las frecuencias de repetición.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 138 dB	138.00	137.98	-1.0	1.0	-0.02
Pulse Meas. 138 dB	131.45	131.60	-0.5	0.5	0.15
Ref. 128 dB	128.00	127.98	-1.0	1.0	-0.02
Pulse Meas. 128 dB	121.45	121.59	-0.5	0.5	0.14
Ref. 118 dB	118.00	117.97	-1.0	1.0	-0.03
Pulse Meas. 118 dB	111.44	111.59	-0.5	0.5	0.15

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Ref. 108 dB	108.00	107.96	-1.0	1.0	-0.04
Pulse Meas. 108 dB	101.43	101.58	-0.5	0.5	0.15
Ref. 98 dB	98.00	97.96	-1.0	1.0	-0.04
Pulse Meas. 98 dB	91.43	91.58	-0.5	0.5	0.15
Ref. 88 dB	88.00	87.96	-1.0	1.0	-0.04
Pulse Meas. 88 dB	81.43	81.58	-0.5	0.5	0.15
Ref. 78 dB	78.00	77.96	-1.0	1.0	-0.04
Pulse Meas. 78 dB	71.43	71.59	-0.5	0.5	0.16
Ref. 68 dB	68.00	67.96	-1.0	1.0	-0.04
Pulse Meas. 68 dB	61.43	61.56	-0.5	0.5	0.13
Ref. 58 dB	58.00	57.96	-1.0	1.0	-0.04
Pulse Meas. 58 dB	51.43	51.58	-0.5	0.5	0.15
Ref. 48 dB	48.00	47.98	-1.0	1.0	-0.02
Pulse Meas. 48 dB	41.45	41.64	-0.5	0.5	0.19

Detección cuadratica, Pulsos rectangulares Negativos, CF5

La respuesta del sonómetro a secuencias repetidas de 200 ms. con pulsos rectangulares. El nivel pico de los pulsos rectangulares se ajusta a fin de dar la misma respuesta para todas las frecuencias de repetición.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 138 dB	138.00	137.98	-1.0	1.0	-0.02
Pulse Meas. 138 dB	127.01	127.17	-1.0	1.0	0.16
Ref. 128 dB	128.00	127.97	-1.0	1.0	-0.03
Pulse Meas. 128 dB	117.00	117.16	-1.0	1.0	0.16
Ref. 118 dB	118.00	117.97	-1.0	1.0	-0.03
Pulse Meas. 118 dB	107.00	107.16	-1.0	1.0	0.16
Ref. 108 dB	108.00	107.97	-1.0	1.0	-0.03
Pulse Meas. 108 dB	97.00	97.16	-1.0	1.0	0.16
Ref. 98 dB	98.00	97.96	-1.0	1.0	-0.04
Pulse Meas. 98 dB	86.99	87.16	-1.0	1.0	0.17
Ref. 88 dB	88.00	87.96	-1.0	1.0	-0.04
Pulse Meas. 88 dB	76.99	77.16	-1.0	1.0	0.17
Ref. 78 dB	78.00	77.97	-1.0	1.0	-0.03
Pulse Meas. 78 dB	67.00	67.16	-1.0	1.0	0.16
Ref. 68 dB	68.00	67.96	-1.0	1.0	-0.04
Pulse Meas. 68 dB	56.99	57.16	-1.0	1.0	0.17
Ref. 58 dB	58.00	57.96	-1.0	1.0	-0.04
Pulse Meas. 58 dB	46.99	47.17	-1.0	1.0	0.18
Ref. 48 dB	48.00	47.98	-1.0	1.0	-0.02
Pulse Meas. 48 dB	37.01	37.28	-1.0	1.0	0.27

Detección cuadrtica, Pulsos rectangulares Negativos, CF10

La respuesta del sonómetro a secuencias repetidas de 200 ms. con pulsos rectangulares. El nivel pico de los pulsos rectangulares se ajusta a fin de dar la misma respuesta para todas las frecuencias de repetición.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. 138 dB	138.00	137.98	-1.0	1.0	-0.02
Pulse Meas. 138 dB	120.99	121.17	-1.5	1.5	0.18

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Ref. 128 dB	128.00	128.01	-1.0	1.0	0.01
Pulse Meas. 128 dB	111.02	111.17	-1.5	1.5	0.15
Ref. 118 dB	118.00	117.97	-1.0	1.0	-0.03
Pulse Meas. 118 dB	100.98	101.17	-1.5	1.5	0.19
Ref. 108 dB	108.00	107.97	-1.0	1.0	-0.03
Pulse Meas. 108 dB	90.98	91.17	-1.5	1.5	0.19
Ref. 98 dB	98.00	97.96	-1.0	1.0	-0.04
Pulse Meas. 98 dB	80.97	81.17	-1.5	1.5	0.20
Ref. 88 dB	88.00	87.96	-1.0	1.0	-0.04
Pulse Meas. 88 dB	70.97	71.17	-1.5	1.5	0.20
Ref. 78 dB	78.00	77.96	-1.0	1.0	-0.04
Pulse Meas. 78 dB	60.97	61.18	-1.5	1.5	0.21
Ref. 68 dB	68.00	67.96	-1.0	1.0	-0.04
Pulse Meas. 68 dB	50.97	51.17	-1.5	1.5	0.20
Ref. 58 dB	58.00	57.96	-1.0	1.0	-0.04
Pulse Meas. 58 dB	40.97	41.23	-1.5	1.5	0.26

Promediación Temporal, Leq-SEL

La respuesta del sonómetro a secuencias repetidas de salvas tonales a 4 kHz de exposición sonora. El nivel pico de las salvas tonales se ajustará de manera que el nivel sea constante para todas las señales.

	Expected [dB Leq]	Measured [dB Leq]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. Cont.	40.00	39.99	-1.0	1.0	-0.01
Leq 1/10	39.99	39.95	-0.5	0.5	-0.04
SEL 1/10	57.79	57.73	-0.5	0.5	-0.06
Leq 1/100	39.99	39.95	-0.5	0.5	-0.04
SEL 1/100	57.79	57.73	-0.5	0.5	-0.06
Leq 1/1000	39.99	39.95	-1.0	1.0	-0.04
SEL 1/1000	57.79	57.73	-1.0	1.0	-0.06
Leq 1/10000	39.99	39.96	-1.0	1.0	-0.03
SEL 1/10000	64.79	64.72	-1.0	1.0	-0.07

Indicacion de saturación. Señal senoidal Inversa de "A"

La función del detector de saturación del sonómetro se verifica con diferentes señales de niveles en torno a los límites de indicación de saturación. Una señal a un nivel correspondiente a 5 dB por debajo del nivel máximo del rango del sonómetro a 1 kHz. La frecuencia de la señal es bajada en pasos 1/3 de octava, y al mismo tiempo el nivel de la señal se incrementa de tal forma para mantener el mismo nivel A-ponderado en frecuencia, hasta que una saturación se detecta.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	
1000Hz <Ref>	135.00	135.02	-1.0	1.0	0.02	
794.33Hz	135.02	135.00	-1.0	1.0	-0.02	
630.96Hz	135.02	135.02	-1.0	1.0	0.00	
501.19Hz	135.02	134.99	-1.0	1.0	-0.03	
398.11Hz	135.02	135.01	-1.0	1.0	-0.01	
316.23Hz	135.02	134.79	-1.0	1.0	-0.23	Overload

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Indicación de saturación, Salva tonal a 4 kHz.

La función del detector de sobrecarga del sonómetro se verifica con diferentes niveles en torno a los límites de indicación de sobrecarga. La señal que se utiliza es un período de 4 salvas tonales a 4 kHz a partir de 5 dB por debajo de Lmax. El nivel de señal se incrementa hasta que una saturación se detecta.

	Expected [dB SEL]	Measured [dB SEL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]	
Ref. 135 dB	105.00	104.93	-2.0	2.0	-0.07	
136 dB	105.93	105.93	-1.0	1.0	0.00	
137 dB	106.93	106.93	-1.0	1.0	0.00	
138 dB	107.93	107.93	-1.0	1.0	0.00	
139 dB	108.93	108.93	-1.0	1.0	0.00	
140 dB	109.93	109.93	-1.0	1.0	0.00	
141 dB	110.93	110.93	-1.0	1.0	0.00	
142 dB	111.93	111.86	-1.0	1.0	-0.07	Overload

Nivel de presión acústica con Ponderación "AI" promedio

La respuesta del sonómetro a secuencias de repetidas señales impulsivas de 4 kHz al medir el nivel en LAIeq. El nivel máximo de las sñales impulsivas es constante para cada nivel. La duración de las señales impulsivas es de 1000, 20, 5 y 1 ms. La frecuencia de repetición de la señal es de 0,2 Hz.

	Expected [dB SPL]	Measured [dB SPL]	Accept - Limit [dB]	Accept + Limit [dB]	Deviation [dB]
Ref. Cont., 140dB.	140.00	140.00	-1.0	1.0	0.00
Burst 1000 mS, 140dB.	136.70	136.74	-0.5	0.5	0.04
Burst 20 mS, 140dB.	131.00	130.98	-1.0	1.0	-0.02
Burst 5 mS, 140dB.	125.90	125.79	-2.0	2.0	-0.11
Burst 1 mS, 140dB.	119.10	118.96	-2.0	2.0	-0.14
Ref. Cont., 130dB.	130.00	130.00	-1.0	1.0	0.00
Burst 1000 mS, 130dB.	126.70	126.72	-0.5	0.5	0.02
Burst 20 mS, 130dB.	121.00	121.00	-1.0	1.0	0.00
Burst 5 mS, 130dB.	115.90	115.72	-2.0	2.0	-0.18
Burst 1 mS, 130dB.	109.10	108.94	-2.0	2.0	-0.16
Ref. Cont., 120dB.	120.00	120.00	-1.0	1.0	0.00
Burst 1000 mS, 120dB.	116.70	116.74	-0.5	0.5	0.04
Burst 20 mS, 120dB.	111.00	110.96	-1.0	1.0	-0.04
Burst 5 mS, 120dB.	105.90	105.70	-2.0	2.0	-0.20
Burst 1 mS, 120dB.	99.10	98.94	-2.0	2.0	-0.16
Ref. Cont., 110dB.	110.00	109.99	-1.0	1.0	-0.01
Burst 1000 mS, 110dB.	106.69	106.73	-0.5	0.5	0.04
Burst 20 mS, 110dB.	100.99	100.98	-1.0	1.0	-0.01
Burst 5 mS, 110dB.	95.89	95.75	-2.0	2.0	-0.14
Burst 1 mS, 110dB.	89.09	88.95	-2.0	2.0	-0.14
Ref. Cont., 100dB.	100.00	99.98	-1.0	1.0	-0.02
Burst 1000 mS, 100dB.	96.68	96.73	-0.5	0.5	0.05
Burst 20 mS, 100dB.	90.98	91.00	-1.0	1.0	0.02
Burst 5 mS, 100dB.	85.88	85.78	-2.0	2.0	-0.10
Burst 1 mS, 100dB.	79.08	79.01	-2.0	2.0	-0.07
Ref. Cont., 90dB.	90.00	89.98	-1.0	1.0	-0.02
Burst 1000 mS, 90dB.	86.68	86.72	-0.5	0.5	0.04
Burst 20 mS, 90dB.	80.98	80.96	-1.0	1.0	-0.02

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Burst 5 mS, 90dB.	75.88	75.80	-2.0	2.0	-0.08
Burst 1 mS, 90dB.	69.08	68.97	-2.0	2.0	-0.11
Ref. Cont., 80dB.	80.00	79.99	-1.0	1.0	-0.01
Burst 1000 mS, 80dB.	76.69	76.73	-0.5	0.5	0.04
Burst 20 mS, 80dB.	70.99	70.96	-1.0	1.0	-0.03
Burst 5 mS, 80dB.	65.89	65.74	-2.0	2.0	-0.15
Burst 1 mS, 80dB.	59.09	59.02	-2.0	2.0	-0.07
Ref. Cont., 70dB.	70.00	69.99	-1.0	1.0	-0.01
Burst 1000 mS, 70dB.	66.69	66.73	-0.5	0.5	0.04
Burst 20 mS, 70dB.	60.99	60.96	-1.0	1.0	-0.03
Burst 5 mS, 70dB.	55.89	55.76	-2.0	2.0	-0.13
Burst 1 mS, 70dB.	49.09	49.00	-2.0	2.0	-0.09
Ref. Cont., 60dB.	60.00	59.97	-1.0	1.0	-0.03
Burst 1000 mS, 60dB.	56.67	56.72	-0.5	0.5	0.05
Burst 20 mS, 60dB.	50.97	51.02	-1.0	1.0	0.05
Burst 5 mS, 60dB.	45.87	45.70	-2.0	2.0	-0.17
Burst 1 mS, 60dB.	39.07	39.02	-2.0	2.0	-0.05
Ref. Cont., 50dB.	50.00	49.97	-1.0	1.0	-0.03
Burst 1000 mS, 50dB.	46.67	46.72	-0.5	0.5	0.05
Burst 20 mS, 50dB.	40.97	40.95	-1.0	1.0	-0.02
Burst 5 mS, 50dB.	35.87	35.81	-2.0	2.0	-0.06
Burst 1 mS, 50dB.	29.07	29.09	-2.0	2.0	0.02
Ref. Cont., 40dB.	40.00	40.02	-1.0	1.0	0.02
Burst 1000 mS, 40dB.	36.72	36.76	-0.5	0.5	0.04
Burst 20 mS, 40dB.	31.02	30.95	-1.0	1.0	-0.07
Burst 1000 mS, 30dB.	36.72	36.69	-0.5	0.5	-0.03

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APPENDIX D

DATA FOR VEGETATION QUADRATS

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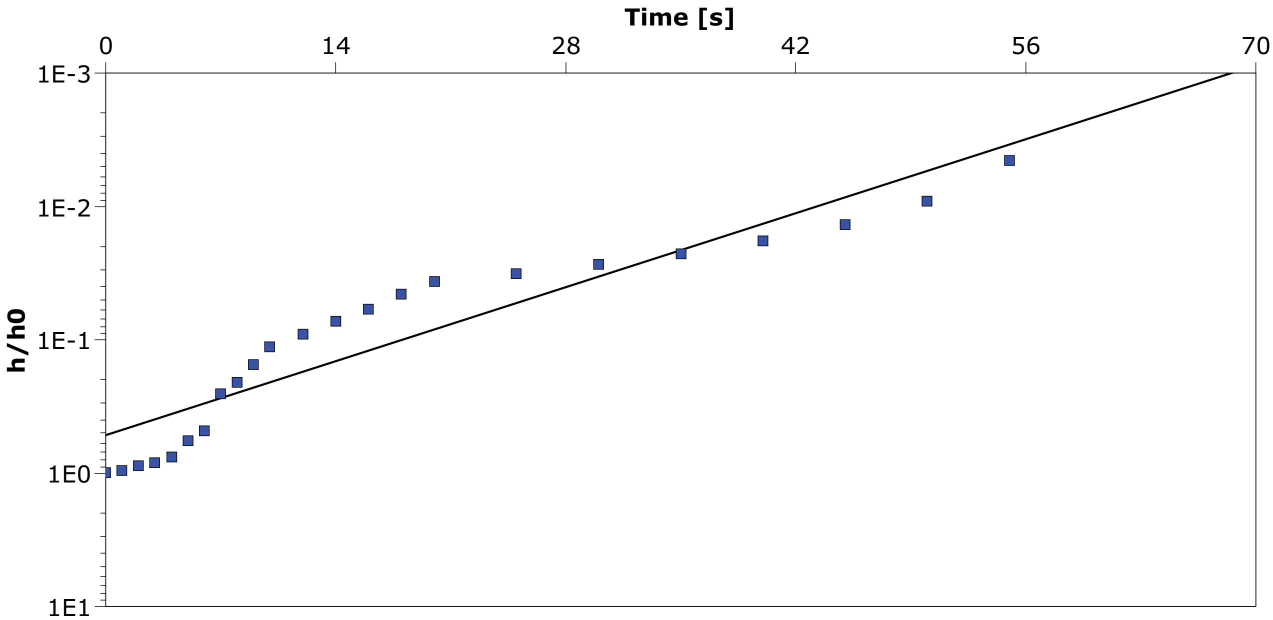
Osaimi Engineering Office Geotechnic & Materials Specialists K.S.A.	**Slug Test Analysis Report**
	Project: KBR JUBAIL MAIN SITE
	Number: A554-IK-FSC-042
	Client: KBR

Location: JUBAIL 2	Slug Test: MW -1 (Slug Test)	Test Well: MW-1
Test Conducted by: G. Nawaz		Test Date: 13/10/2010
Analysis Performed by: A. Pinto	Hvorslev	Analysis Date: 07/12/2010
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/h]	
MW-1	9.42×10^{-2}	

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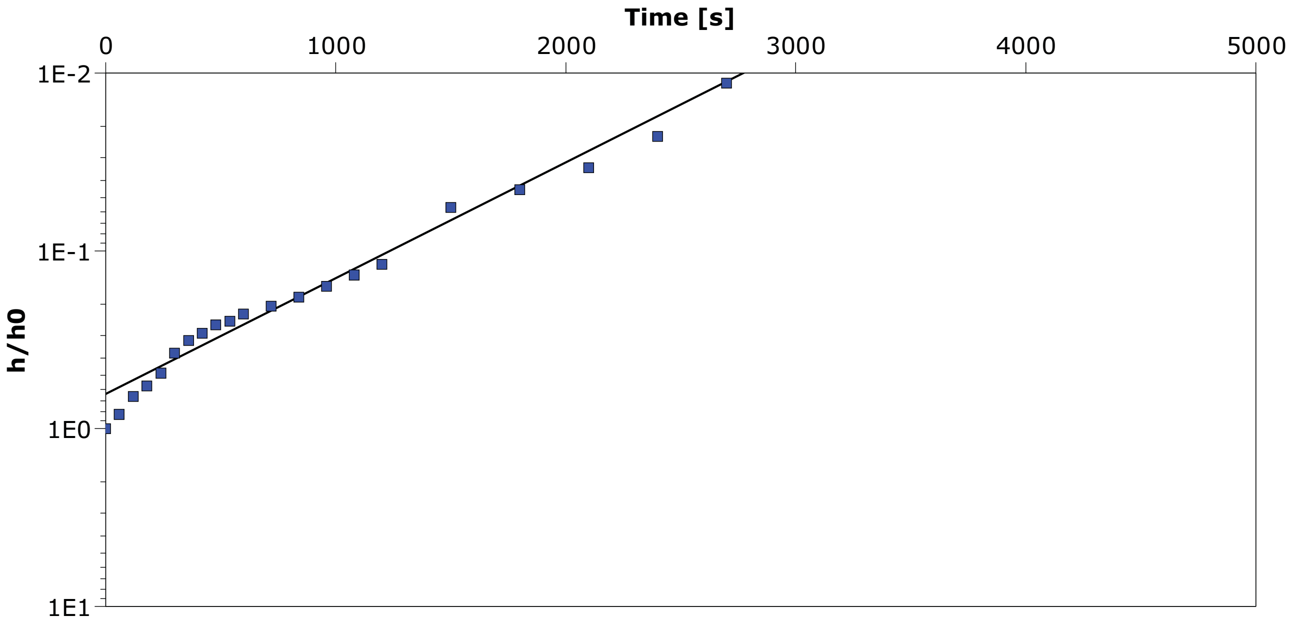
Osaimi Engineering Office Geotechnic & Materials Specialists K.S.A.	**Slug Test Analysis Report**
	Project: KBR JUBAIL MAIN SITE
	Number: A554-IK-FSC-042
	Client: KBR

Location: JUBAIL 2	Slug Test: MW-2 (Slug Test)	Test Well: MW-2
Test Conducted by: G. Nawaz		Test Date: 11/10/2010
Analysis Performed by: A. Pinto	Hvorslev	Analysis Date: 07/12/2010
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/h]	
MW-2	1.55×10^{-3}	

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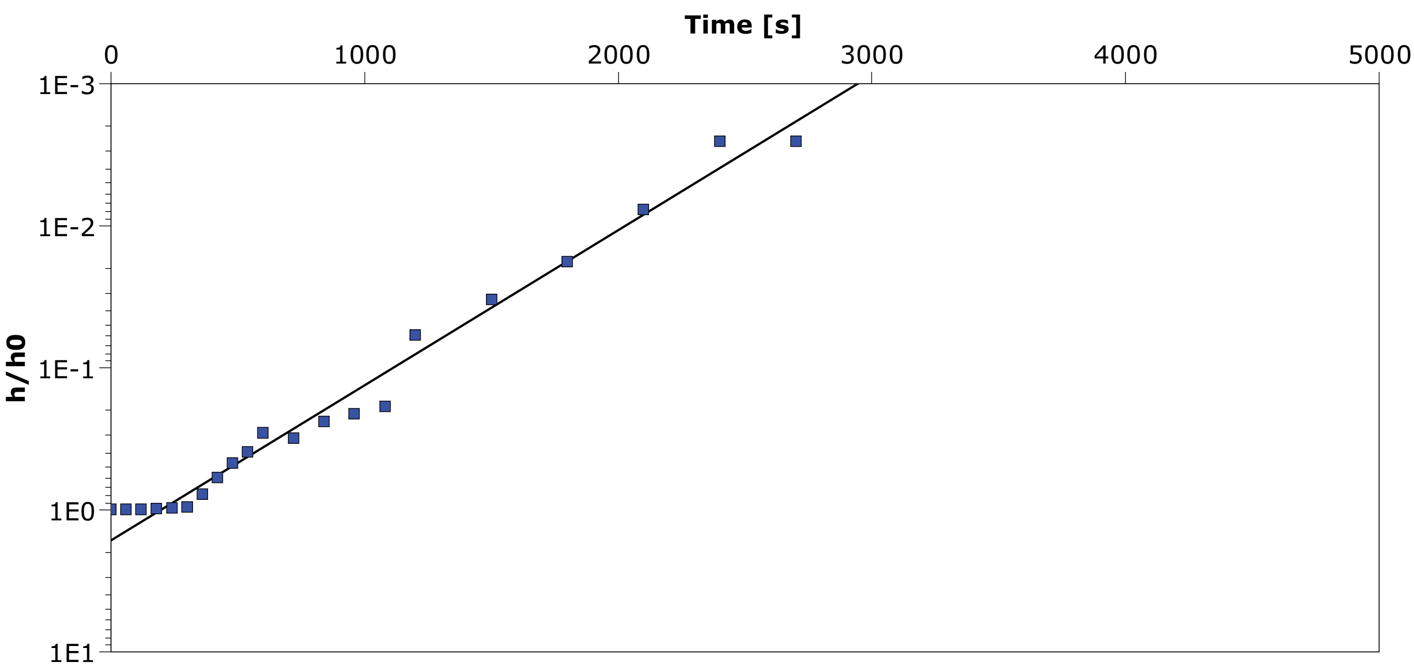
Osaimi Engineering Office Geotechnic & Materials Specialists K.S.A.	**Slug Test Analysis Report**
	Project: KBR JUBAIL MAIN
	Number: A554-IK-FSC-042
	Client: KBR

Location: JUBAIL 2	Slug Test: MW-3 (Slug Test)	Test Well: MW-3
Test Conducted by: G. Nawaz		Test Date: 12/10/2010
Analysis Performed by: A. Pinto	Hvorslev	Analysis Date: 07/12/2010
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/h]	
MW-3	2.60×10^{-3}	

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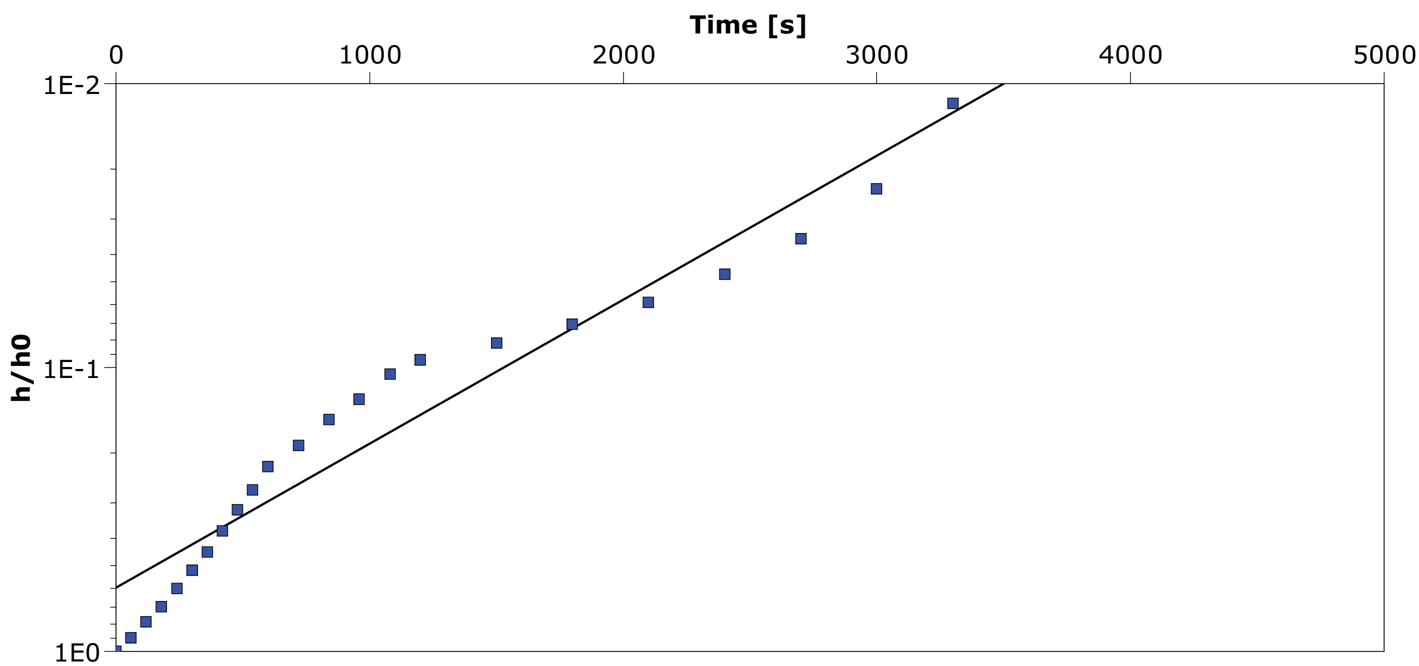
Osaimi Engineering Office Geotechnic & Materials Specialists K.S.A.	**Slug Test Analysis Report**
	Project: KBR JUBAIL MAIN SITE
	Number: A554-IK4FSC-042
	Client: KBR

Location: JUBAIL 2	Slug Test: MW-4 (Slug Test)	Test Well: MW-4
Test Conducted by: G. Nawaz		Test Date: 12/10/2010
Analysis Performed by: A. Pinto	Hvorslev	Analysis Date: 07/12/2010
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/h]	
MW-4	1.21×10^{-3}	

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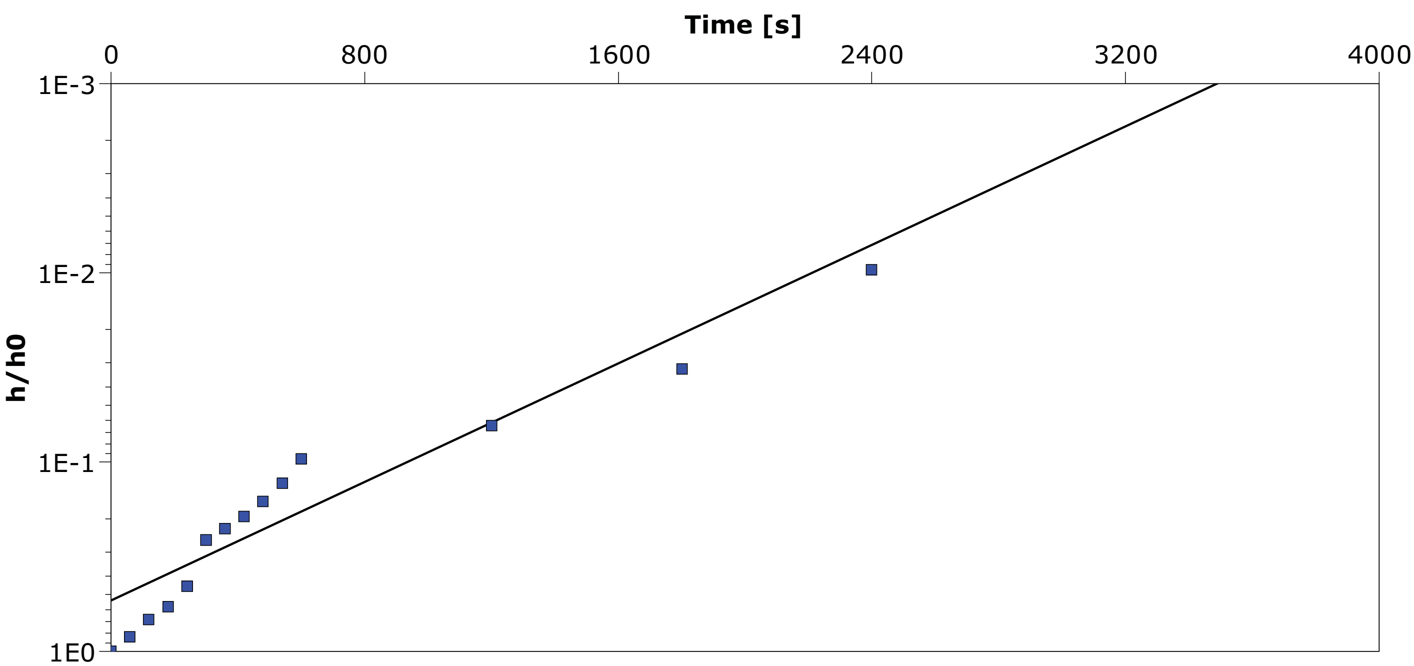
Osaimi Engineering Office Geotechnic & Materials Specialists K.S.A.	**Slug Test Analysis Report** Project: KBR JUBAIL MAIN Number: A554-IK-FSC-042 Client: KBR

Location: JUBAIL-2	Slug Test: MW-5 (Slug Test)	Test Well: MW-5
Test Conducted by: A. Pinto		Test Date: 12/10/2010
Analysis Performed by: A. Pinto	Hvorslev	Analysis Date: 07/12/2010
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/h]	
MW-5	1.86×10^{-3}	

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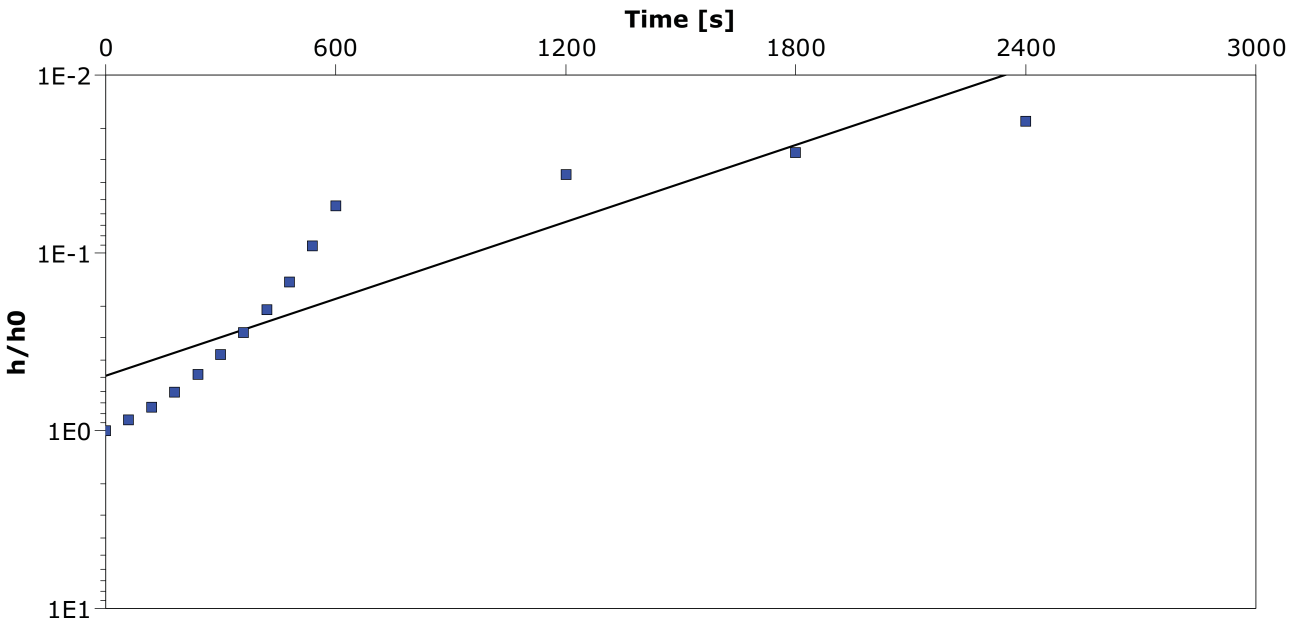
Osaimi Engineering Office **Geotechnic & Materials Specialists** **K.S.A.**	**Slug Test Analysis Report**
	Project: KBR JUBAIL MAIN SITE
	Number: A554-IK-FSC-042
	Client: KBR

Location: JUBAIL 2	Slug Test: Slug Test 6	Test Well: MW-6
Test Conducted by: G. Nawaz		Test Date: 12/10/2010
Analysis Performed by: A. Pinto	Hoverslev	Analysis Date: 07/12/2010
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [ft/d]	
MW-6	1.35×10^{-1}	

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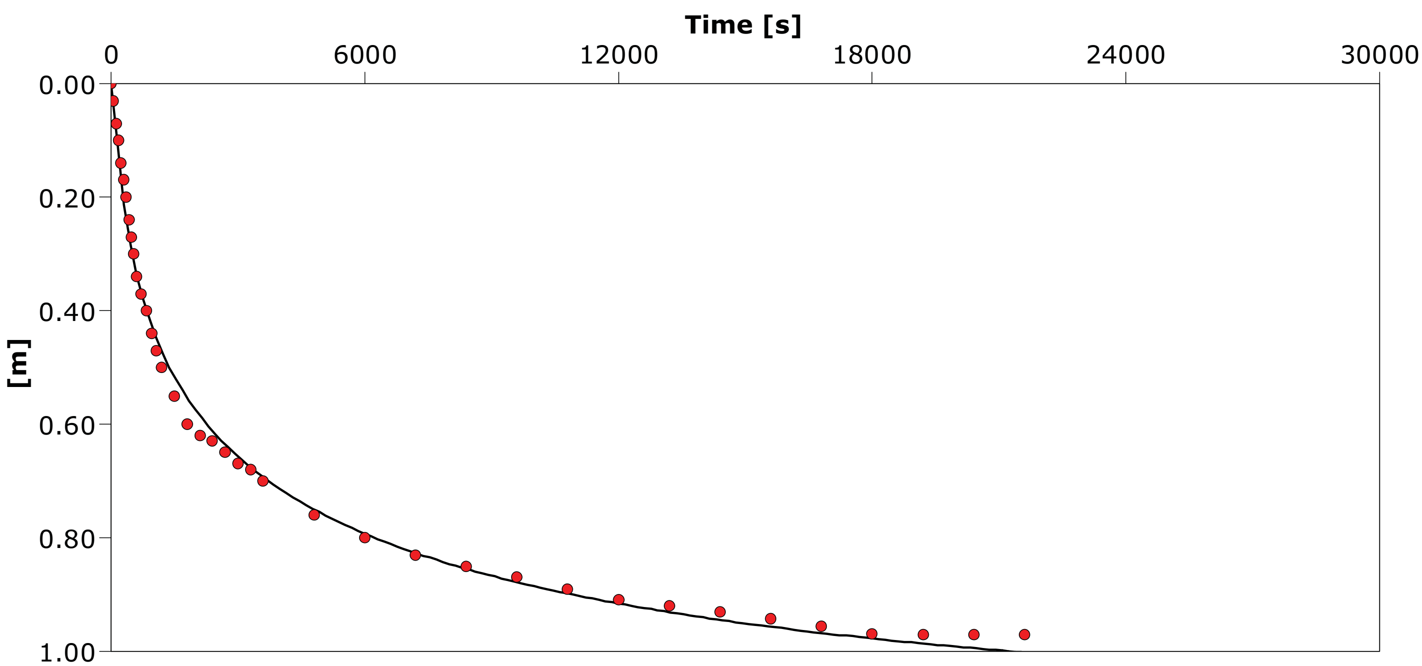
Osaimi Engineering Office Geotechnic & Materials Specialists K.S.A.	**Pumping Test Analysis Report**
	Project: KBR JUBAIL MAIN SITE
	Number: A554-IK-FSC-042
	Client: KBR

Location: JUBAIL 2	Pumping Test: OBSERVATION WELL-1	Pumping Well: PW
Test Conducted by: G. Nawaz		Test Date: 10/10/2010
Analysis Performed by: A. Pinto	Hantush-Jacob	Analysis Date: 02/12/2010
Aquifer Thickness: 50.00 m	Discharge Rate: 5.13 [U.S. gal/min]	



Calculation using Hantush

Observation Well	Transmissivity [m²/h]	Hydraulic Conductivity [m/h]	Storage coefficient	Hydr. resistance [s]	Leakage factor [m]	Radial Distance to PW [m]
OW-1	4.13×10^{-1}	8.27×10^{-3}	1.59×10^{-3}	2.42×10^{7}	5.27×10^{1}	5.0

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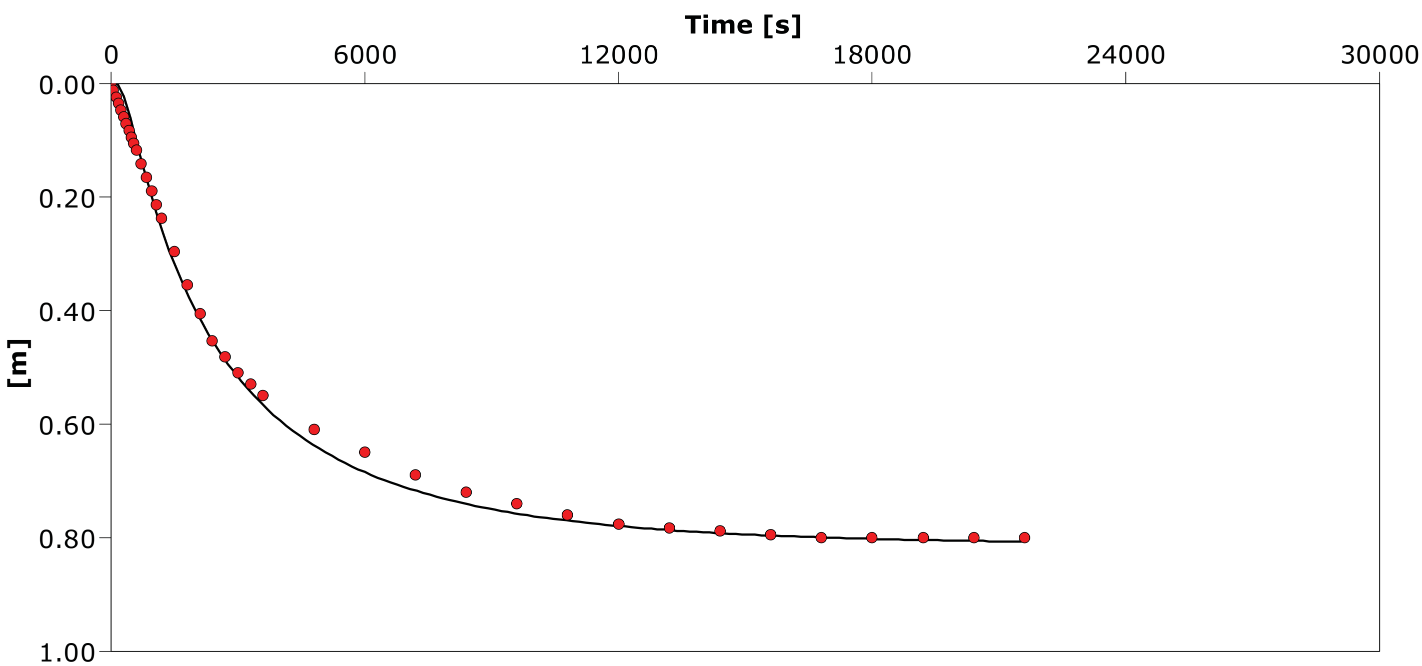
Osaimi Engineering Office Geotechnic & Materials Specialists K.S.A.	**Pumping Test Analysis Report**
	Project: KBR JUBAIL MAIN SITE
	Number: A554-IK-FSC-042
	Client: KBR

Location: JUBAIL 2	Pumping Test: OBSERVATION WELL-2	Pumping Well: PW
Test Conducted by: G. NAWAZ		Test Date: 10/10/2010
Analysis Performed by: A. Pinto	Hantush-Jacob	Analysis Date: 02/12/2010
Aquifer Thickness: 50.00 m	Discharge Rate: 5.13 [U.S. gal/min]	



Calculation using Hantush

Observation Well	Transmissivity [m²/h]	Hydraulic Conductivity [m/h]	Storage coefficient	Hydr. resistance [s]	Leakage factor [m]	Radial Distance to PW [m]
OW-2	1.68×10^{-1}	3.37×10^{-3}	5.36×10^{-4}	1.20×10^{7}	2.37×10^{1}	15.0

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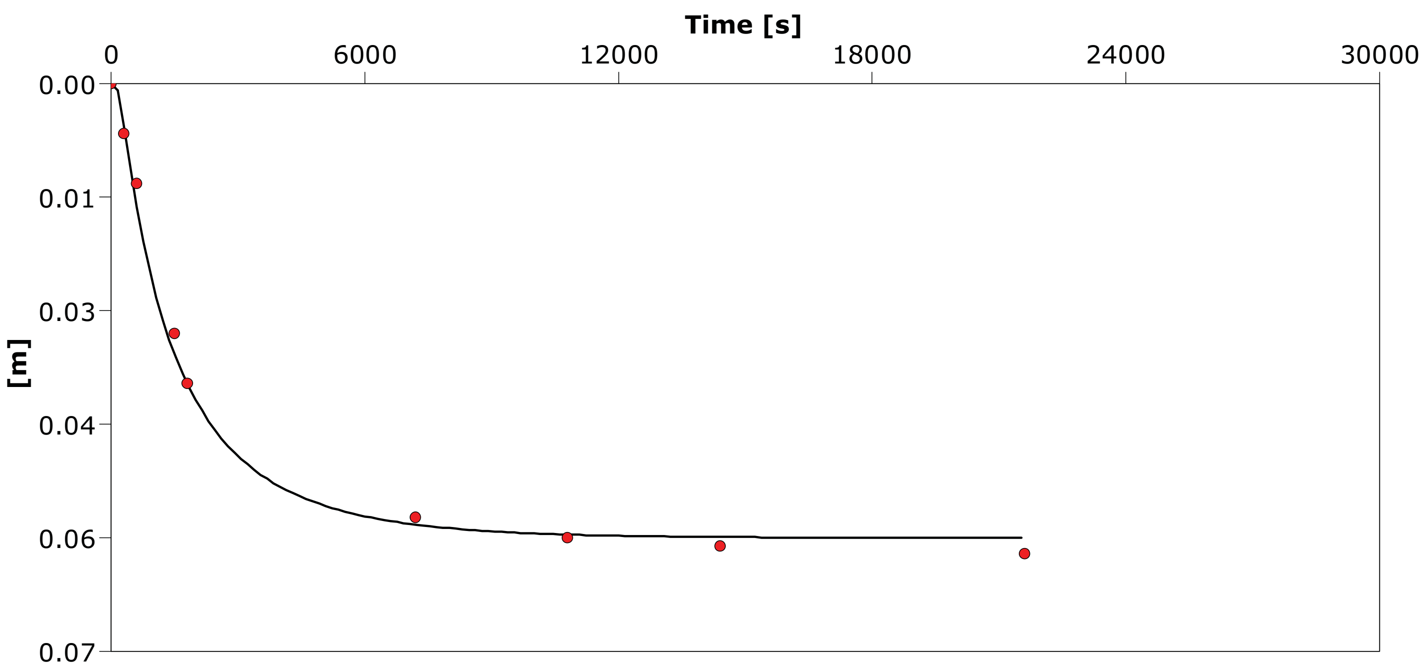
Osaimi Engineering Office Geotechnic & Materials Specialists K.S.A.	**Pumping Test Analysis Report**
	Project: KBR JUBAIL MAIN SITE
	Number: A554-IK-FSC-042
	Client: KBR

Location: JUBAIL 2	Pumping Test: OBSERVATION WELL 3	Pumping Well: PW
Test Conducted by: G. Nawaz		Test Date: 10/10/2010
Analysis Performed by: A. Pinto	HANTUSH-JACOB	Analysis Date: 02/12/2010
Aquifer Thickness: 50.00 m	Discharge Rate: 5.13 [U.S. gal/min]	



Calculation using Hantush

Observation Well	Transmissivity [m²/h]	Hydraulic Conductivity [m/h]	Storage coefficient	Hydr. resistance [s]	Leakage factor [m]	Radial Distance to PW [m]
OW 3	2.20×10^{0}	4.40×10^{-2}	9.90×10^{-5}	3.38×10^{7}	1.44×10^{2}	100.0

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RAS TANURA INTEGRATED PROJECT
APPENDIX D-2
GROUNDWATER CHEMISTRY RESULTS

Borehole ID			BH07	BH11	BH24	BH30	BH41	BH45	BH49	BH62	BH65	BH78	BH83	BH90
Sample Date	**Unit**	**Screening Criteria**	20/05/2009	28/05/2009	20/05/2009	20/05/2009	20/05/2009	28/05/2009	20/05/2009	20/05/2009	20/05/2009	20/05/2009	20/05/2009	20/05/2009
Total Petroleum Hyrdrocarbons (TPHs)		**Dutch (Intervention)**												
C6 - C10 Fraction (GRO)	mg/L	600*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
C10 - C28 Fraction (DRO)	mg/L	600*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Polycyclic Aromatic Hydrocarbons (PAHs)														
PAH by GCMS	mg/L	–	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nonmetallic Inorganic Parameters														
Free Cyanide	mg/L	1.5	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Total Metals / Major Cations														
Arsenic	mg/L	0.06	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Barium	mg/L	0.625	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	mg/L	0.006	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	mg/L	0.03	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Copper	mg/L	0.075	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Lead	mg/L	0.075	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Mercury	mg/L	0.0003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/L	0.075	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	mg/L	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	mg/L	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	mg/L	0.8	**0.22**	**0.28**	**0.16**	**0.4**	**0.22**	**0.16**	**0.32**	**0.24**	**0.36**	**0.18**	**0.28**	**0.24**

Notes:

*Dutch Intervention Standard is for Mineral Oil, which for the purposes of screening in this report is considered to be GRO+DRO
FD = Field Duplicate
BOLD indicates result exceeds the Laboratory Method Detection Limit (LMDL)
Exceeds KSA Ambient Groundwater Prescribed Concentration Value
Exceeds Dutch Target Value
Exceeds both the Dutch Target and Intervention Values

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APPENDIX F

STAKEHOLDER ENGAGEMENT PLAN

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Appendix F Stakeholder Engagement Plan

CONTENTS

TABLES

FIGURES

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F.1. Introduction

The RTIP complex is located in Jubail II (an extension of the Jubail Industrial City [JIC]), in the Eastern Province, Kingdom of Saudi Arabia [KSA]). The complex will occupy a Greenfield area of about 576 hectares (ha). The land area comprising the RTIP site is designated as industrial and it is within the jurisdiction of the Royal Commission for Jubail and Yanbu, to be referred hereinafter as RCJY (primary stakeholder for this project). The project will also occupy a tank farm and loading and unloading facilities at the Jubail King Fahd Industrial Port (KFIP). The nearest residential areas (within 20 km from RTIP, e.g. Jubail old town and JIC Community Area) are located to the south and southwest of the proposed RTIP (as noted in Figure Error**! No text of specified style in document.**-1).

Identifying and classifying key stakeholders potentially affected by RTIP activities is an essential and initial element of consultation. To the extent possible, the RTIP EIA project team will meet with key stakeholders at various stages of the project and solicit feedback on the key findings of this EIA study.

Given the necessity to address and effectively plan for stakeholder consultation per World Bank/IFC standards and similarly accepted international standards (including the Equator Principles), RTIP has developed this stakeholder engagement plan that describes primary potential project stakeholders and methods to involve them. This plan considers the cultural context and the nature of JIC as an industrial park.

This stakeholder engagement plan has been prepared considering current cultural practices in KSA with regards to the consultation process. This means that the plan is focused only on the primary stakeholders of RTIP, which include local governmental agencies. RCJY has been established by the government to manage industrial parks in Jubail, Yanbu and Ras Azzor to ensure that the sustainable development of these parks is maintained. RCJY considers that it represents both government and residents of these parks. RCJY is heavily engaged with both government and communities on the development of these parks.

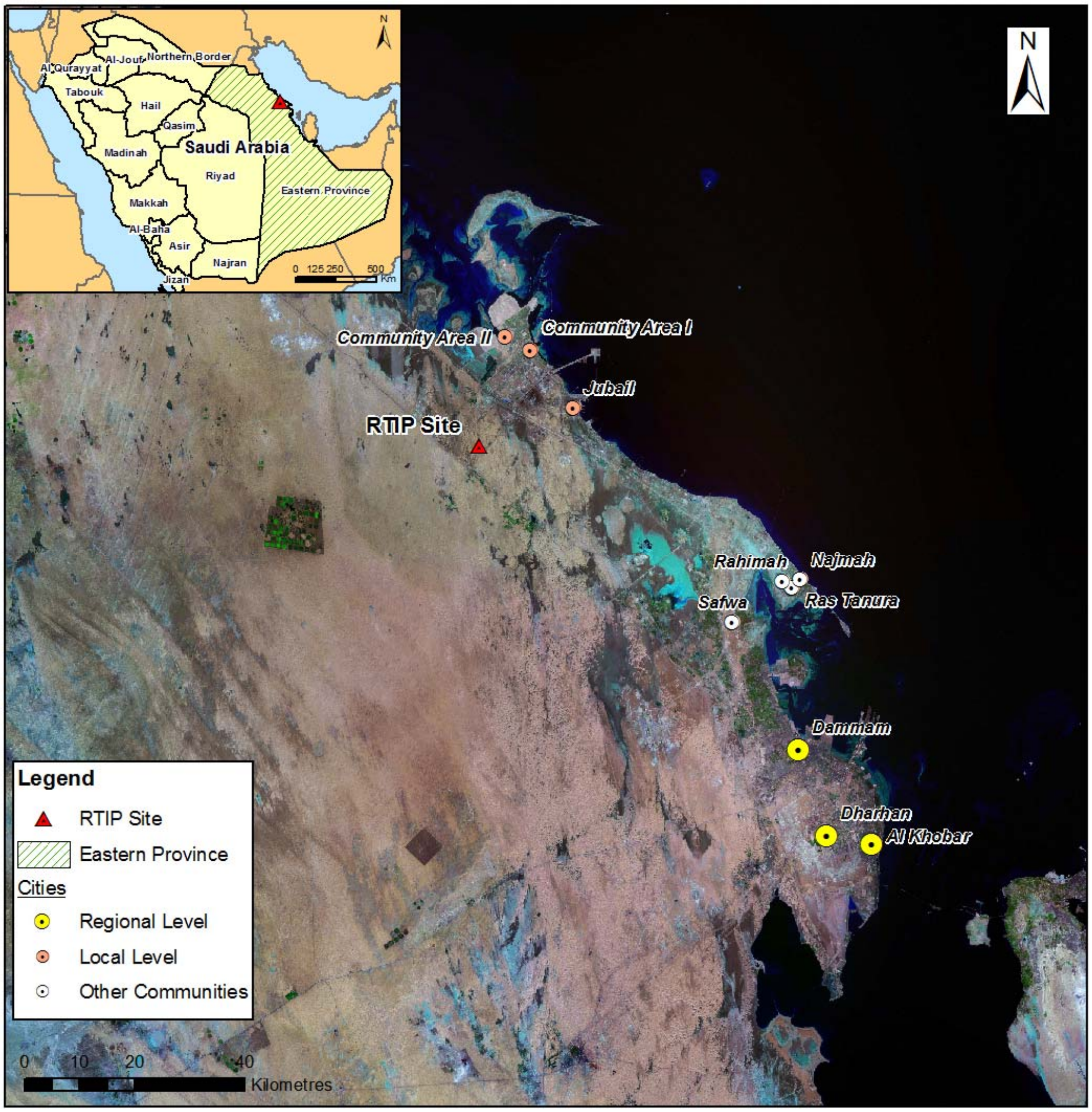

Figure Error! No text of specified style in document.**-1 Project Location and Nearest Populated Areas in the Eastern Province**

Source: Landsat images (2000) from NASA modified by CH2MHILL

F.2. Scope for Engagement

The General Environmental Regulations that govern the Environmental Impact Assessment process in the Kingdom of Saudi Arabia do not require public consultation or stakeholder engagement for projects to be conducted in the country. Further, cultural norms in the Kingdom preclude the application of the normal model of stakeholder engagement with respect to public disclosure.

Therefore, a proposed approach to engagement has been developed that promotes the spirit of the transparency noted in the international guidelines for public consultation and engagement while complying with cultural mandates for appropriateness of such actions. The main objective of this plan is to inform stakeholders of activities involved in the RTIP, and any potential affects from their activities.

For this purpose, key stakeholders have been identified at different levels: national, regional, and local. At a local level, the primary stakeholder is the RCJY which will be involved in the review of the RTIP EIA Report, and will provide feedback about the project and the proposed Environmental Management Plan. Any communication with regional and national government authorities will be channelled through the RCJY.

The implementation of this engagement plan would reflect a commitment to execute the RTIP according to corporate, industry, and international guidance for social responsibility and consultation.

F.3. Stakeholder Identification

Stakeholders potentially affected and/or interested in the project have been identified (at the group not individual level). Due to the nature of the area (industrial city), the key stakeholders of the project are governmental agencies.

Table F-1 presents the envisaged potential concerns by stakeholder for the RTIP. The purpose of this is to anticipate the type of information of interest for each group. The potential concerns have been classified in the following three main groups:

- *Environmental concerns:* Project activities (including waste) and proposed management to minimize or avoid their negative effects on the onshore and biological environment, air quality, and marine environment;

- *Social concerns*: Employment through the different project phases, increase in traffic and demand of services and infrastructure, housing, economic impact, social pathologies due to ongoing presence of foreign workers with lifestyle and cultural difference, and the proposed management to handle them;

- *Technical and health concerns*: Work conditions, medical emergency response, workers and community safety conditions, project activities that could pose impacts on workers and community health (e.g., air and noise emissions, increase in traffic); and proposed management to minimize or avoid their negative effects on the wellbeing of community and workers.

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Table F-1 Key Stakeholder List

Level	Type of Organisation	Name and/or Title	Key Potential Concerns about RTIP	Description
Local	Governmental	Royal Commission for Jubail and Yanbu	Environment, Social, Technical & Health	The RCJY was established as an independent organization of the Saudi government. It is governed by a Board of Directors and its Chairman reports to the Council of Ministers. The office of Chairman formulates policy and provides enforcement oversight. Under Directorate General authority, RC is the primary regulatory agency within JIC-II. RCJY provides managerial functions regarding infrastructure and is responsible for health, safety, environmental (HSE) and security issues. The RCJY represents the PME within the city with respect to environmental related issues. As a result of the RCJY centralized regulatory authority, all local projects related consultations will be scheduled with it. RCJY received a mandate to develop the physical and social infrastructure that is required for the industrial development of Jubail and Yanbu areas.
Local	Governmental	Saudi Ports Authority	Environment & Technical	KSA is divided into 14 provinces, each led by a regional governor, who reports to the Minister of Interior. The RTIP complex is located in the Eastern Province governorate. The governor and his staff govern the region according to state policies and regulations.
Local	Governmental	Municipal Council Members of Jubail		
Regional	Governmental	Governor of Eastern Province		
Source: CH2M HILL, 2011				

F.4. Stakeholder Engagement Plan

This stakeholder engagement plan addresses the local and regional stakeholders identified in Table F-1. Given the cultural norms of Saudi Arabia, engagement with stakeholders must be transmitted through leaders. This plan intends to increase agency's awareness of site activities to promote a project understanding and achieve transparency throughout the project execution process. This action plan, therefore, notes activities necessary to engage key project stakeholders using communication methods that meet the cultural norms of the country.

F.4.1. Engagement with the Royal Commission

Considering the key role of the RCJY in the success of the engagement process, and as a primary stakeholder of the RTIP project, the project team will have continuous communication with the RCJY.

The RCJY has responsibilities to achieve development within their jurisdiction that is balanced against the need for environmental conservation, sustainable development, protection of health, safety, security, and the needs of local people. Jubail Industrial City- Phase II (JIC-II) has been built for this purpose and, therefore, the RCJY has been identified as the primary stakeholder.

The RCJY has a well established permitting process that each investor must pursue. The licensing process within JIC-II includes the followings:

- Preliminary inquiry to allocate a land within JIC-II;
- Obtain a Conditional Site Allocation from RCJY;
- Obtain Industrial and Commercial Licenses from the Ministry of Commerce and Industry;
- Obtain Gas/Feedstock commitment from Saudi Aramco;
- Submit Environmental Impact Assessment to RCJY;
- Obtain an Environmental Permit to Construct from RCJY; and
- Obtain an Environmental Permit to Operate from RC.

F.4.2. Action Plan for Stakeholder Engagement

Engagement routes for governmental authorities will involve more direct communication with Owner representatives and will largely be conducted through meetings. This channel provides the mechanisms for communication and engagement. Attempts should be made to inform stakeholders of the project to satisfy the letter and the spirit of consultation and disclosure prescribed by international funding agencies.

Table F-2 presents the goals, and activities to be undertaken as part of the stakeholder engagement process.

Table F-2 Action Plan for Stakeholder Engagement

Goal and Objective		Action Plan	Method and Timing	Stakeholder Target Group
1	Communicate with the RCJY and government agencies, as appropriate.	-Involve RCJY delegates at an early stage of the project to understand government authorities' project expectations. -Maintain communication between project sponsors and government agencies.	Meeting with the RCJY and keep continous communications during all stage of the project. Contact RCJY representatives before work begins, provide status reports during the effort (as possible), and provide follow-up correspondence upon completion.	RCJY

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Table F-2 Action Plan for Stakeholder Engagement

Goal and Objective		Action Plan	Method and Timing	Stakeholder Target Group
2	Develop a comment and response process for key Government authorities; track all outreach and consultation that is done.	-Outline the process and timeline and communicate it to all parties. -Develop and maintain an outreach tracking file and populate registry and data fields for consultation recording. - Periodically review and revise the process (as necessary).	Track information such as name stakeholder or group and contact information; date, time, and type of contact, nature of the comment, and project owner's response. Internally discuss process for addressing issues/concerns that are raised. Assign one person to manage this process and who is responsible for ensuring that these tasks are conducted.	Government Authorities Through RCJY

Source: CH2M HILL, 2011

F.5. Initial Results of the Stakeholder Engagement Plan

The stakeholder engagement process begun with the reconnaissance visit to RTIP, in which representatives from KBR, the Owner and CH2M HILL met with the RCJY. The RCJY is a key local stakeholder in this project. Initial consultation was conducted through a meeting in 29th September 2010 at the Royal Commission Environmental Control Department in Jubail, which included the following individuals:

- Ahmet Aksakol: Royal Commission in Jubail
- Benson Pair: KBR
- Albishri Hussein: Royal Commission in Jubail
- Dennis Davis: Owner
- Imad Khalid Osman: RGME
- Kazem Bakri: Owner
- Khalaf Al-Anazi: Owner
- Ali Al Mubarak: Royal Commission in Jubail
- Peter Kirk: CH2M HILL

- Abdulaziz Al-Thebiani: Royal Commission in Jubail
- Wilhelm Alheit: CH2M HILL
- S.A.M. Ismail: Royal Commission in Jubail
- Ghurmalla A. Ghamdi: Owner

During the meeting the EIA methodology was presented and RCJY endorsement of the EIA baseline activities gained. The stakeholder engagement process will then continue with a subsequent meeting with the RCJY to discuss the results and conclusions from the EIA.