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ES.1 INTRODUCTION

The Saudi Arabian Mining Company (Ma’aden) intends to develop the Umm Wu’al Phosphate Project in the Kingdom of Saudi Arabia. This Project is based on the exploitation and processing of the Umm Wu’al phosphate deposit, taking advantage of existing and future railway infrastructure, linking the phosphate deposits of Umm Wu’al in the northern region with the Industrial City of Ras Al Khair on the Arabian Gulf (see Figure ES.1 below).

The implementation of those elements of Umm Wu’al Phosphate Project to be developed at Ras Al Khair Industrial City will increase ammonia and fertiliser production and export from the Kingdom of Saudi Arabia.

The Project will be part funded by international banks and export credit agencies from OECD countries and, therefore, the Environmental and Social Impact Assessments (ESIAs) have been developed with regard to international environmental standards, notably the World Bank Group, and specifically the International Finance Corporation’s (IFC), Performance Standards on Environmental and Social Sustainability (2012) and the Equator Principles (as reviewed in 2013).

Due to the nature and scope of the Project, the assessment of the two main sites will be subject to different national regulatory requirements, namely the Presidency of Meteorology and Climate (PME) (for the development at Umm Wu’al) and the Royal Commission for Jubail and Yanbu (for the development at Ras Al Khair). A separate ESIA will therefore be produced for each Project site.

Figure ES.1: Location of the Umm Wu’al Phosphate Project Sites
ES.2 PROJECT DESCRIPTION

The Umm Wu’al Mine and Waad Al Shamaal Phosphate Industrial Complex in the Sirhan-Turaif region of northern Saudi Arabia will include the following components: Mine, Beneficiation, Phosphoric Acid Plant, Sulphuric Acid Plant, Purified Phosphoric Acid Plant, Sodium TriPolyPhosphate Plant, Mono and Dicalcium Phosphate plant and the associated infrastructure required to process the extracted ore.

The processed materials will be transported from Umm Wu’al via existing railway infrastructure approximately 1,500km to Ras Al Khair Industrial City, on the Arabian Gulf where the materials will be further processed as fertiliser products or stored for export.

Ras Al Khair is an existing Industrial City and Port facility located on a peninsula in the Eastern Province of Saudi Arabia; the facility will be expanded to include new chemical production plants for Ammonia, Diammonium Phosphate and Nitrogen Phosphate Potash. Proposed developments also include all supporting infrastructure, storage and handling facilities and connection to existing utilities within the Ras Al Khair Industrial City. For the purpose of this report, the new developments proposed by Ma’aden at the Ras Al Khair Industrial City will be referred to collectively as the Ras Al Khair Industrial Complex (‘the Project’).

ES.2.1 SITE LOCATION

Ras Al Khair Industrial City is located on a peninsula in the Eastern Province of Saudi Arabia; the Industrial City is accessible by a 27km road linked to the Abu Hadriyah highway. The closest sizable population centre is Nuairiyah which lies approximately 68 km to the west of the peninsula (93 km by road) and has a population of 26,470 (according to the 2010 census). Nuairiyah is located on a major link road from Riyadh to Kuwait and Jubail to Jordan. Figure ES. 2 illustrates the site location and the existing and proposed land use on the Ras Al Khair peninsula.

ES.2.2 FACILITIES

The existing Ma’aden Phosphate Company (MPC) facility at Ras Al Khair will be expanded to include new chemical production plants for Ammonia, Diammonium Phosphate (DAP) and Nitrogen Phosphate Potash (NPK). The proposed industrial development includes the required supporting infrastructure and a Material Storage and Handling Facility to manage the import and use of Merchant Grade Phosphoric Acid (MGA) and Raffinate and Sulphuric Acid, as well as the export of MGA and Purified Phosphoric Acid (PPA) all of which will be produced at the Umm Wu’al mine site. These materials will be transported approximately 1500km from Umm Wu’al to the Ras Al Khair Industrial City via existing and expanded railway infrastructure.

The Design Life for the Ras Al Khair Industrial Complex is 25 years.

The majority of the Project components will be located within the existing operational plot of MPC which already includes various facilities that can support the Project operations. These include:

• A number of administrative and miscellaneous warehousing buildings/facilities;
• Road layout and utility networks (including gas, electricity and water);
• On-site sanitary wastewater treatment plant with sufficient capacity to support the new development; and
• Irrigation Pond.

There is currently no industrial wastewater treatment facility at Ras Al Khair, but it is understood that a treatment plant, with capacity of 25,000m$^3$/day, is planned for the Industrial City. A new surface water Retention Pond will be constructed as part of the proposed Ras Al Khair Industrial Complex development.
Figure ES. 2: Site Location - Ras Al Khair Industrial City, the MPC Proposed Industrial Complex and Surrounding Industries / Land Use
ES.2.2.1 AMMONIA PLANT

The proposed Ammonia Plant is designed to produce 1.1 Mtpa of Liquid Ammonia from Natural Gas. The ammonia product will be stored in adjacent tanks for access by the DAP/NPK Plant. It is anticipated that the Project will also produce quantities of ammonia not required in the production process, which can be exported or sold domestically.

The main raw materials to be used for ammonia production are natural gas, process air, and desalinated water in combination with a number of catalysts. The existing Desalination Plant will provide both desalination and process water to the Ammonia Plant. All process units are designed to recycle all condensate generated in the plant and its utilities, minimising the amount of water required.

The Ammonia Plant will be self-sufficient in steam consumption during normal operation. The surplus steam from the plant will be used to supply power to the new DAP & NPK plants and new material handling areas. Electrical power for start-up will be provided by the common grid, and emergency power will be supplied by a diesel generator for safe shut down in case of total power failure.

Wastewater effluents will be routed to separated sewer/management systems to prevent mixing of any effluents.

ES.2.2.2 DIAMMONIUM PHOSPHATE (DAP) AND NITROGEN PHOSPHATE POTASH (NPK) PLANT

The DAP/NPK Plant will produce ammonium phosphate-based granular fertilisers (DAP 2.2 Mtpa and NPK 0.76 Mtpa) which will be sold primarily into the international markets.

The main raw materials used in the process are concentrated phosphoric acid, ammonia, sulphuric acid, urea, potassium chloride (potash) and filler. The liquid raw materials will be pumped from the Materials Storage and Handling Facility proposed in the south-east corner of the Project site to local storage within the DAP/NPK Plant and also from the Ammonia Plant storage tanks. Urea and filler will also be stored onsite, whereas potash will be imported to and stored at the Port for transfer to the DAP/NPK Plant via conveyor.

DAP/NPK product will be stored adjacent to the production units prior to transfer to the port for export via conveyor.

Power to the plant will be supplied from the Ammonia Plant, whilst the new Port Substation will supply all electrical loads associated with the new ship loading and unloading facilities. Emergency generators will be required and some power will also be provided by the Saudi Electricity Company.

There will be no disposal of liquid effluent from the process, instead these will be collected in the sumps / waste water tanks and recycled to the process. Stormwater / spent firewater will either be used for irrigation or transported to a Royal Commission-approved industrial waste water treatment plant.

ES.2.2.3 MATERIALS STORAGE AND HANDLING

The Materials Storage and Handling Facility will facilitate the import and use of MGA + Raffinate and sulphuric acid and the export of MGA and PPA. New rail sidings are required on the eastern side of the MPC Complex to link this area to the Port and to the Umm Wu‘al site in the north.

It is anticipated that the Saudi Ports Authority (SEAPA) will allocate three berths at Ras Al Khair Port to Ma‘aden for the Project: two dry berths for export of bulk NPK/DAP and import of Potash; and one berth dedicated to liquid export i.e. Ammonia, PPA and MGA.

ES.2.3 CONSTRUCTION

The construction works will be undertaken in close proximity to the current operating equipment and storage, notably the existing Ammonia Plant.

A detailed construction execution plan will be developed during the next phase to ensure safe construction of the facilities close to existing operational plant. Safe construction at this site has been successfully undertaken previously, and consideration and the controls, coordination
and interfaces will be included to ensure construction of this project is completed with the same success.

ES.2.4 COMMISSIONING

In line with normal industry practice, there will be a need to undertake activities to clean and test systems ready for operations. A schedule for commissioning will be developed, and stakeholders engaged in contributing to the development of this schedule. A valid Environmental Permit to Operate shall be obtained from the Royal Commission prior to any process commissioning.

Hydrotest wastewater will be discharged to the existing evaporation pond and analysed for compliance with irrigation and/or coastal water discharge standards.

ES.2.5 WORKFORCE

During the construction phase, the workforce is estimated to average 2,100 workers reaching a maximum of 3,260 workers. A temporary accommodation camp will be located close to the construction area and the workers will be transported by dedicated bus. Construction work will take place over a 10 hour work day, 6 days per week.

The industrial complex operations staffing is estimated to be between 519 and 536, of which 8% will be Saudi nationals, rising to 88% after 6 years. The plant will operate 24 hours/day and all year round. Staff will operate on an 8hr shift, working a 6 day working week.

ES.3 CONSIDERATION OF ALTERNATIVES

The proposed facilities at Ras Al Khair have been developed following the consideration of a range of project and design alternatives including:

- “Do Nothing” option;
- Location alternatives;
- Configuration and alternative production options;
- Pollution control alternatives; and
- Wastewater pre-treatment alternatives.

Potential social and environment factors were included in the identification and selection of alternatives during the Front End Design Phase (FEED).

In addition, as the project progressed the proposed facilities were tested against Best Available Techniques (BAT), as required under the Royal Commission Environmental Regulations (RCER-2010), and the International Finance Corporation (IFC) Performance Standards.

ES.4 SUMMARY OF SIGNIFICANT IMPACTS

The ESIA for the Ras Al Khair Industrial Complex has been undertaken according to RCER-2010, and World Bank Group and IFC guidance. It has considered all potential impacts of the construction, commissioning, operation and decommissioning of the Project on the environment, employees, and local community. Furthermore, it has also considered these effects in combination with each other and with other development in the area.

The Environmental Assessment includes an Environmental Management and Monitoring Plan (EMMP), and an outline Environmental Emergency Response Plan (EERP). These plans detail the measures identified in this phase for mitigation of any impacts, and provide guidance for emergency preparedness in the event of an accident. These plans are considered as “live” documents, which are updated with any further recommendations identified in future phases.
The EMMP will be supported by a series of management plans which will be developed through the project and updated accordingly. A description of some of these plans (referred to as 'EMPs' in the following sections) is outlined in the EMMP (ESIA, Appendix A).

The results of the impact assessment are summarised below. Potential impacts predicted as being of medium to high significance were assessed against appropriate mitigation measures to predict the residual impact significance. Potential impacts of lower significance were also identified, and although specific mitigation measures are not required for these aspects, a series of recommendations which are considered as good management practices are identified.

**ES.4.1 AIR QUALITY AND METEOROLOGY**

Impacts of the Project on air quality were assessed against current air quality conditions, using Royal Commission approved models. The contributions from the Project were compared as additional contributions to the existing industries to determine the overall impact of the Project on air quality. The potential impact of greenhouse gases has also been assessed as required by the IFC’s Performance Standard 3 and Equator Principles 2.

**ES.4.1.1 RESULTS**

Concentrations of most pollutants released from the project such as sulphur dioxide, ozone, nitrogen oxides, and carbon monoxide all fall below the Royal Commission Standards, even when combined with contributions from existing surrounding industries.

However, particulate matter is present in high background concentrations around the site, and is dominated by contributions from dust storms in the area. The results of the modelling indicated that the additional contributions from the Project will be minimal and will be most noticeable during construction.

Releases of Fluorides during operation are considered to be of medium significance, even though the modelling shows that the releases fall below the Royal Commission standards. The assessment of medium significance has been based on the project contributing approximately 25% of the total releases for the area.

The Project will generate emissions of greenhouse gases throughout its operation. The International Energy Agency estimated the total carbon dioxide emissions in KSA as 446 Million tonnes in 2010 (IEA, 2012). Of this total, 104 Million tonnes were from manufacturing and industry.

Wherever possible the production of carbon dioxide (CO₂) has been reduced in all stages of the project. A CO₂ recovery process has been included within the Ammonia Plant and the Project will be linked to a facility that will provide electrical power through the construction of steam turbine generators, powered by natural gas.

The total estimated CO₂ emissions generated by the Project including operations and vehicle emissions would be approximately 1.3 Million tonnes. This exceeds the 100,000 tonne threshold defined by the World Bank/IFC standards. However, the current anticipated design is utilising the best available techniques to reduce emissions to the extent feasible for this industry, and all measures to reduce emissions further are being pursued in the FEED Stage for the Ammonia Plant.

Whilst the Project emissions represent only 0.3% of the total CO₂ emissions in KSA, the impact of the Project is considered to be high.

**ES.4.1.2 MITIGATION AND RECOMMENDATIONS**

**ES.4.1.2.1 MITIGATION**

To mitigate the potential significance of impacts associated with Fluoride emissions, the following is required:
Ma’aden shall consider and make available this ESIA for use in cumulative impact assessments of future developments of the Industrial City.

The following measures were identified to reduce potential impacts associated with GHG emissions:

- The FEED Contractor shall document a full BAT analysis to demonstrate that best available techniques are used to capture CO\textsubscript{2} emissions. This process would include expansion on the alternatives discussed in Section 3 Consideration of Alternatives including:
  - Investigate design options for reducing greenhouse gas emissions (specifically for the Ammonia Plant). This assessment should consider other options for the capture and use of CO\textsubscript{2};
  - Reduce CO\textsubscript{2} emissions during the design period where possible using BAT; and
  - Record BAT assessment findings.

- The Operator shall:
  - Conduct annual quantification and reporting (as appropriate for Category B Projects) in accordance with the guiding principles of the Equator Principles / International Finance Corporation.

ES.4.1.2.2 RECOMMENDATIONS

Construction Phase

Recommendations for the construction phase are focussed on the reduction of dust impacts and include the following:

Development and implementation of the Construction Environmental Management Plant (CEMP) to consider measures such as:

- During transport, covering all dust generating stockpiled materials with a suitable weighted tarpaulin;
- Establishment of pedestrian routes within the construction area to be used by workers;
- Minimise the amount of materials stockpiled as far as is practicable, with any required stockpiles aligned parallel to the prevailing wind direction;
- Covering of any exposed soils in heavily trafficked areas such as roads or carparks with gravel or crushed stone to reduce wind blown dust generation;
- A reduced construction site speed limit to prevent the generation of large dust clouds form vehicles;
- Subject to water availability and the time of the year, surface spraying of road surfaces with water and a soil binding agent;
- Periodic grading of any uneven surfaces that arise on construction traffic routes.

Prior to commencement of construction activities, development of an Air Quality & Dust Monitoring Plan should be considered as part of the CEMP to ensure appropriate on-site mitigation measures are implemented.

Operations Phase

Recommendations for the operational phase are focused around the monitoring of emissions and development and implementation of an Operational Environmental Management Plan (and EERP as appropriate) which should consider the following measures:

- Undertake monitoring of emissions as detailed by the Royal Commission with reporting to the relevant authorities;
• Appropriate maintenance of important mitigation equipment such as scrubbers, catalyst beds etc.;
• Identify responsibilities for maintaining competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency (including accidental releases of hazardous substances); and
• Minimising use of auxiliary and back up boilers.

Prior to the commencement of operations, ambient air quality data will again be gathered and such data sets built on during the course of operations.

In addition, the operator should undertake regular audits of the relevant management plans to confirm their ongoing effectiveness.

ES.4.2 TERRESTRIAL ENVIRONMENT

The site is currently part of the existing industrial complex, and as such the sensitivity of the soils is low. Groundwater beneath the site was recorded at depths of between 3.43 and 4.11 mbgl, with a temperature between 25 and 29°C, and slightly saline due to its proximity to the sea. There are no existing surface water courses on the site.

The assessment of effects considered impacts from all phases on soils and groundwater using the source-pathway-receptor method, and includes some modelling of impacts on groundwater resources.

ES.4.2.1 RESULTS

The impact assessment identified limited potential for impacts on the soil resource and site drainage as a result of construction and operation. This is due to the existing site conditions, where some work has already been undertaken for construction of the adjacent site.

However, pollution of the soils and groundwater from accidental spills during all phases was identified to be of medium significance. The groundwater is likely to have connectivity to the sea, and therefore the potential exists for any pollution to affect the wider area. The modelling, however, suggests that the release of pollutants from accidental spills is likely to be rare, and therefore the potential for impacts is reduced.

It is likely that construction activity will require the dewatering of any excavations. The existing information for the site suggests that this water would currently fail the Royal Commission standards. The design will include facility for capture and treatment of this water prior to any discharge.

There is also potential for impacts during operation from leakage of chemicals from the plant facilities, or from catastrophic failure of the plant. The likelihood of this occurring, however, is considered to be low.

ES.4.2.2 MITIGATION AND RECOMMENDATIONS

ES.4.2.2.1 MITIGATION

The following mitigation measures were identified to mitigate potential impacts of high or medium significance:

• Analysis and pre-treatment of water from dewatering activities prior to discharge to achieve discharge standards;
• Contractor to construct designated refuelling and vehicle maintenance areas;
• Hazardous materials storage to be within bunded area with adequate capacity for volumes stored;
• Absorbents and secondary containment to contain and recover potential release of hazardous materials;
• Dedicated area for wash out following concrete delivery;

• The EPC Contractor and Operator shall develop, implement and maintain an EERP and EMP/s relevant to the various project phases which will include a spill response/ control plan;

• Prior to construction, the EPC contractor shall conduct an investigation of the soil and groundwater quality at the site - to include the construction of permanent groundwater monitoring wells where required;

• Project Proponent shall prepare and submit a Permit Application for authorisation to construct groundwater monitoring wells in accordance with Royal Commission regulations; and

• EPC Contractor to identify process hazards and appropriate control measures.

ES.4.2.2.2 RECOMMENDATIONS

Construction, Commissioning & Decommissioning Phases

The prevention and reduction of pollution from accidental spills is the main focus of the recommendations for the construction, commissioning and decommissioning phases of the work. These include:

• Adherence to minimum technical standards of construction plant;

• Availability of pumps and spill mitigation materials such as absorbent granules to contain and recover hazardous substances following release;

• Implementation of procedures to be followed in the event of accidental release of hazardous substances;

• Regular audits of the management plans should be undertaken by the contractor to confirm their ongoing effectiveness; and

• Following decommissioning and demolition of the facility, a survey of the soil and groundwater quality at the site should be completed to confirm that the presence and operation of the facility has not led to an unacceptable deterioration of the site’s terrestrial environment. Should soil or groundwater contamination be identified that could have been caused by the facility, a specific remedial plan will be developed to define the extent of contamination and remedial measures to be implemented.

Operational Phase

Recommendations for the operational phase are focused on the prevention of accidental releases of pollutants from either spills or from failures of plant. These include:

• The implementation of routine plant inspection and maintenance schedules and procedures;

• Documentation of plant start-up and shut-down procedures;

• Provision of training for all staff in environmental awareness and procedures to be following in the event of an accidental release of pollutants; and

• Provision of pumps and spill mitigation materials such as absorbent materials to contain and recover hazardous substances releases.

ES.4.3 BIOLOGICAL RESOURCES

The Project area has been substantially modified as a result of the industrial development of the existing facilities and therefore terrestrial species at the site are limited. Details of historical surveys were evaluated, and site walk-overs were undertaken as part of this ESIA process.

There is potential for mammals and reptiles to be present at the site, although no species have been recorded as part of the recent surveys. The Ras al Khair peninsula does support a large variety of birds, some of which are classed as vulnerable at an international level.
The impact assessment also considers the potential impacts of the facilities at the Port for the storage and exportation / importation of materials at the port.

**ES.4.3.1 RESULTS**

Due to the industrial nature of the existing sites, impacts on terrestrial flora and fauna during all phases are limited, and all potential impacts are considered to be low.

The impacts on marine habitats are also considered to be low for most species and habitats during all phases. However, there is potential for impacts from the loading and unloading of hazardous materials, where spillage could cause harm to habitat such as the existing seagrass beds. Any pollutant entering the sea could also be dispersed and impact on habitats further off-shore, such as coral islands. As a result this potential impact on these habitats is considered to be high prior to mitigation.

**ES.4.3.2 MITIGATION AND RECOMMENDATIONS**

**ES.4.3.2.1 MITIGATION**

The following mitigation measures were identified to mitigate potential impacts of high or medium significance:

- Ensure adequate maintenance of jetty storage facilities, including checking for release of materials;
- Ensure training of staff to ensure competency in operation of loading/unloading equipment;
- Incorporation of procedures for spill events to the EERP / EMMP as appropriate;
- Ensure regular maintenance of loading/unloading equipment; and
- Decommissioning Plan to be developed shall identify all possible sources of contamination and outline appropriate control and disposal measures that protect the natural environment.

**ES.4.3.2.2 RECOMMENDATIONS**

**Construction, Commissioning, Operation and Decommissioning Phases**

Whilst the impacts during these phases are considered to be mostly low, there still exists the potential for species to be present on site. Therefore recommendations include:

- The development and implementation of an EERP and EMPs should consider the following;
  - Include an overview of the ecological value and sensitivity of the Project area in contractor’s Site Induction. This should include guidance on species identification and actions to take if encountered within Project area;
  - Restriction of any clearance works to the minimum area required;
  - Restriction of vehicle movements to defined routes to minimise risk of wildlife collisions;
  - Enforcement of reduced speed limits on and around the Project area; and
  - Appropriate waste storage to limit the potential proliferation of non-desirable fauna (e.g. rats, flies).
- Anti-nesting devices to be installed to deter birds (birds have previously been found stuck in vents).
ES.4.4 NOISE AND VIBRATION

Potential impacts of the Project on noise and vibration were modelled and assessed using Royal Commission approved methods. The contribution from the Project was compared to the Royal Commission and IFC standards for both daytime and night-time.

ES.4.4.1 RESULTS

Baseline noise measurements taken at the Ras Al Khair Project site boundary are within the Royal Commission and IFC standards. The Project has been designed to comply with the requirements laid down in the Royal Commission Environmental Regulations (2010), and include measures such as housing of potentially noisy plant and equipment. As a result, the modelling shows that potential negative impacts are likely to be of low significance in all phases.

ES.4.4.2 RECOMMENDATIONS

Construction, Commissioning and Decommissioning Phases

A noise and vibration assessment through detailed design will be required to ensure compliance with applicable standards.

Noise monitoring will be required as part of the construction and commissioning phases, and a Noise Management and Monitoring Plan detailing the type, location and frequency of monitoring will be developed as part of the Environmental Management Plans (and updated as appropriate through to decommissioning). This will be implemented prior to commencement of any activities.

The development and implementation of the Plans should consider the following:

- Results of the updated noise modelling (where applicable);
- Use of temporary sound-proof enclosures and anti-vibration measures shall be employed if required to reduce noise levels on site, in keeping with the results of the updated noise and vibration model;
- Maintenance procedures of all equipment in place to minimise noise from equipment;
- Programme and scope of regular audits of the management plan to confirm its on-going effectiveness;
- Suitable measures to reduce the potential risk resulting from noise during installation of any piles;
- Effective silencing of equipment where possible and compliance with any stated requirements of Ma’aden and the RC where appropriate;
- Adherence to reduced noise limits where night time construction is proposed;
- Vehicle Movements to be reduced as far as practicable;
- Construction activities to comply with British Standards for Vibration;
- Plant and equipment that is used intermittently will be shut down or throttled down to a minimum between work periods; and
- Plant and equipment are maintained and lubricated as per the manufacturer’s instructions to avoid friction noise etc.

All construction work would be undertaken using best practicable means following guidance such as BS 5228: 2009 - “Code of practice for noise and vibration control on construction and open sites”, or other internationally recognised guidance for the control of noise and vibration.

Operational Phase

Annual noise monitoring will be undertaken to confirm compliance with Royal Commission Environmental Regulations (2010) and IFC requirements and to identify any further noise
mitigation measures to those implemented as part of the detailed design. Effective noise control will be undertaken on an on-going process.

The Noise and Vibration Management Plan will be updated as required prior to commencing this phase. This may involve consultation with the Saudi Railway Authority (SAR) and Saudi Port Authority (SEAPA) to inform the Plan.

ES.4.5 WASTE MANAGEMENT

There are currently no waste facilities in Ras Al Khair. In line with Royal Commission requirements, all wastes are transported to Jubail Industrial City for treatment and disposal. It is likely that as the Ras Al Khair Industrial City develops further, the Royal Commission will establish treatment and disposal facilities within the City.

The site area has been levelled as part of construction for the existing works, and therefore, only minimal excavations are required. These have been designed to minimise disposal of any soils, with excavated materials being used on site. Any excavated ground identified as contaminated materials would be treated and disposed of at a Royal Commission licensed waste facility.

The Ammonia Plant and the DAP/NPK Plants have also been specifically designed to minimise the volume of waste produced during the production process.

ES.4.5.1 RESULTS

Waste types identified during this phase include:

- Non-hazardous solid wastes: construction debris, wood (pallets), empty drums and containers (plastic and metal), packaging (paper, cardboard, plastics), waste material from the cooling tower basin, municipal wastes and sanitary waste sludge;
- Hazardous solid waste: spent catalysts; batteries; filters; empty oil chemical or paint containers; fabrics contaminated with oil; spill absorbents, spent electrical equipment, oily sludge, and clinical waste; and
- Hazardous liquid waste: waste oils, hydraulic fluids, lubricants and fuels (and drainage waters contaminated with these), solvents, paint, thinners, cleaning chemicals; and contaminated hydro-test water.

There is also potential for industrial wastewater treatment sludge, should an appropriate alternative to the evaporation pond at the Ammonia Plant not be identified by the FEED contractor.

Spent catalysts will not be stored on site, but collected and removed directly from the Ammonia Plant by a licensed contractor. Waste oil will be stored in drums in bunded impervious areas for collection.

Potential negative impacts of medium or high significance from waste management are, therefore, not anticipated during the project lifetime.

ES.4.5.2 RECOMMENDATIONS

Construction, Commissioning and Decommissioning Phases

Impacts from waste arising from the construction of the facility will be mitigated through a range of measures, such as the following:

- A Waste Management Plan for defining how waste materials will be stored, handled and disposed of for the Construction Phase shall be developed as a supporting document to the Environmental Management and Monitoring Plan. The Construction Waste Management Plan shall be continually monitored and re-evaluated to ensure the effectiveness of the plan is maintained.
- This Plan should consider the following:
− All hazardous, non-hazardous, municipal and inert wastes to be stored, handled, transported, recycled, treated and disposed of as per RCER-2010.
− Transportation regulations (particularly those relating to hazardous materials) published by the Ministry of Transportation shall be complied with.
− A RC approved manifest to be prepared before any transportation of hazardous / non-hazardous wastes from site.
− Minimise onsite waste storage times as much as practical (no longer than 180 days as per RCER-2010), and control access to stored wastes;
− Hazardous substances (including wastes) to be stored in appropriate containers, in appropriately bunded and impervious secondary containment areas as detailed in the RCER 2010, Section 4.3.6.
− Provision of appropriate training to employees involved in hazardous waste management on site.

• An audit should be undertaken to verify in detail if the selected waste management facility has the capacity to receive the necessary future quantities of waste and if it is able to accept the associated waste characteristics.

Operational Phases

The recommendations outlined for construction should also be implemented during operation. In addition, specialist contractors will be used for handling and transporting the hazardous waste substances throughout the life-time of the Project. In the case of spent catalysts, the suppliers of the catalysts will remove and dispose of the used catalysts.

ES.4.6 WATER QUALITY MANAGEMENT

There are no natural permanent or semi-permanent surface water bodies within or adjacent to the project site; however, temporary ponding of surface water does occur in response to rainfall events. Areas of surface water may also form where there are excavation works, where the high groundwater level is exposed.

The water quality of the adjacent marine environment is relatively good, although there are indications that low level hydrocarbon pollution incidents do occur, possibly as a result of unlicensed ballast water and fuel discharges from commercial vessels in the area.

ES.4.6.1 RESULTS

The impact assessment has determined that impacts on surface water quality in the area are likely to be low. There is however potential for impacts to the marine environment through accidental spillage of pollutants at the Port during all phases. In addition, hydrotest water has the potential to impact water quality in the Retention Pond if appropriate analysis is not employed prior to discharge. Alternatively, use of the Evaporation Pond for spent hydrotest water may adversely influence the ponds use by other users on site and reduce its capacity to respond to an emergency situation within the MPC Complex.

The design of the facility ensures all wastewaters are separated and routed through different systems. Sanitary wastewater will be treated by the existing facility. A storm water retention pond will be constructed to ensure clean run-off during rainfall is collected and managed before being discharged.

The reuse of uncontaminated stormwater to treat process area storm water and/or demineralised water regeneration effluents will also be considered as part of the detailed design phase.

Monitoring of water quality will be undertaken in line with recommendations from the Royal Commission as part of their approval and permitting process.
ES.4.6.2 MITIGATION AND RECOMMENDATIONS

ES.4.6.2.1 MITIGATION

The following mitigation measures were identified to mitigate the potential impacts identified as medium significance:

- The FEED / EPC Contractor for the cooling tower should consult with Contractors for other Packages to consider options for the reuse of uncontaminated stormwater to treat process area storm water and/or demineralised water regeneration effluents. Ma’aden to facilitate this as required.

- Prior to commencing construction activities, consultation with SEAPA shall take place to agree consultation and engagement procedures going forward relating to activities at the port.

- The EPC Contractor shall develop, implement and maintain a construction phase EERP and a CEMP to be cognisant of SEAPA’s existing and developing procedures for Ras Al Khair Port as well as requirements of the RC. This shall include a surface water protection plan.

- Surface water management systems must be appropriately designed to maintain separate collection, treatment and disposal routes for contaminated water, oily water and uncontaminated surface water.

- Designated refuelling and vehicle maintenance areas will be established.

- Hazardous materials storage to be within bunded area with adequate capacity for volumes stored;

- An adequate quantity of drip trays and spill kits will be provided to contain and recover potential releases of hazardous substances.

- Washing-out of concrete delivery, mixing and pouring plant and equipment will be undertaken in a designated impervious area and all wash water shall be contained for subsequent treatment and re-use and / or disposal to an approved location.

- Prior to pre-commissioning / commissioning, procedures outlining the proposed management, analysis, treatment and discharge/disposal methods and locations for hydrotest water, including justification for any chemical additives, shall be outlined in the Environmental Management and Monitoring Plan.

- The EPC Contractor shall liaise with MPC to confirm available capacity of the existing surface water ponds to accept the calculated volume of water requiring disposal.

- The volume of water to be used shall be minimised through careful planning of the hydrotest sequence and water reuse.

- The EPC Contractor shall control the flow rate of discharge of hydrotest water to the receiving water body (to be determined following water quality analysis in accordance with RCER-2010) to avoid overloading the receiving system/s.

- The EERP developed during the construction phase shall be updated as appropriate to include for the management of hydrotest water and the use of the existing surface water ponds in the event of an emergency.

- The EMMP and EERP shall be developed to acknowledge port operational and incident management plans in consultation with SEAPA (and other port operators as required).

- All staff shall be competently trained and response teams established.

- Designated contained areas for loading the liquid products shall be defined and equipped with appropriate collection systems to contain any spills on land.

- If proximity detection systems are not available to safely detect if marine loading arms are moving beyond safe operating limits, constant manual monitoring during product loading
may be implemented to detect the motion of the loading arm and initiate shutdown procedures if required. Occupational health and safety procedures must be followed at all times during such monitoring. The proposed method of monitoring shall be agreed with the RC and SEAPA as appropriate.

- Minimal drop distances for unloading potash shall be employed.
- Provide an adequate quantity of drip trays and spill kits to contain and recover potential releases of hazardous substances.

ES.4.6.2.2 RECOMMENDATIONS

Construction, Commissioning and Decommissioning Phases

It is recommended that the development of the EMPs for each phase consider the following:

- Minimum technical standard of construction plant;
- Competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency;
- Spill control procedures;
- Procedures to be implemented following an accidental release of hazardous substances;
- Availability of pumps and spill mitigation materials such as absorbent granules to contain and recover hazardous substances releases;
- Management and inspection of vehicles/sub-contractors used to transfer sanitary wastewater from collection tanks;
- Water minimisation, where possible; and
- Schedule for regular audits of construction activities to assess and report on the ongoing effectiveness of measures employed.

Other recommendations include:

- Potentially contaminated wastewater arising from construction activities such as, but not limited to, concrete washes (high alkaline), wheel washes (high sediments), and other equipment/vehicle cleaning activities (potentially containing detergents) is not permitted to infiltrate groundwater or be discharged to the storm water system. All construction wastewaters shall be contained, stored and disposed of as per RCER-2010.
- A Decommissioning Plan to be developed and implemented to detail the procedures to be adopted for the safe decommissioning of the facility’s tanks, pipelines, buildings and infrastructure;
- Implementation of a post-decommissioning survey to confirm that the presence and operation of the facility has not led to an unacceptable deterioration of the quality of surface water. Remedial plans to be developed as appropriate, to detail the remedial measures to be implemented.

Operational Phase

It is recommended that the EMPs and EERP are updated for the operation phase to consider the following:

- Routine plant inspection and maintenance schedules and procedures;
- Procedures for implementing appropriate water quality detection instrumentation and monitoring and reporting the quality and volumes of process and discharges waters to enable compliance monitoring;
- Details of surface water quality monitoring prior to the discharge of collected wastewater to the irrigation and Retention Ponds;
• Procedures for the treatment of any wastewater onsite (e.g. oil separation) and also for the transfer of contaminated wastewater offsite;
• Details of monitoring of dissolved solids to optimise discharge of cooling tower blowdown water;
• Competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency;
• Procedures to be implemented following an accidental release of hazardous substances, including details of containment and recovery measures to be applied; and
• Procedures for co-ordinating site staff actions in emergency situations with off site stakeholders / regulators.

Other recommendations include:
• Adequate pumps and spill mitigation materials such as absorbent materials should be available at all times on site to contain and recover hazardous substances releases.
• Provision of training for staff, sub-contractors and suppliers on the use of spill mitigation materials and equipment and procedures.

ES.4.7 SOCIO-ECONOMIC ASPECTS

The Project will provide many benefits to Ras Al Khair and the surrounding area. The new development will create greater opportunities for employment and for local and regional businesses to provide goods and services to Ma’aden, its contractors and its workers.

Ma’aden has secured appropriate site allocation of the Project site within the Ras Al Khair Industrial City from the RC, who maintain responsibility for environmental management and pollution controlling for the development and operations within the City (i.e. there are no private landowners). No forceful land acquisition or involuntary resettlement is therefore expected as a consequence of the proposed Project.

ES.4.7.1 RESULTS

No potential negative socio-economic impacts are expected as a result of the project.

ES.4.7.2 RECOMMENDATIONS

Implementation of the following measures is recommended to manage the potential impacts identified as being of low significance and to maintain good management practices:
• Employ local resources with skills to suit the required roles where available, and use local companies to supply goods and services wherever feasible;
• Implement a comprehensive training programme to ensure the appropriate skill sets are developed and transferred to new personnel;
• Implementation of a grievance mechanism to ensure worker ‘communities’ have a means of communicating any concerns regarding the facility’s construction or operation to project management;
• Induction training to be provided to all foreign and non-Muslim workers on the local culture and practices, and camp management procedures should be established to minimise interactions and possible tensions; and
• Seek to support employment in the region and within other Ma’aden projects following decommissioning of the Project facilities.
• Ma’aden should work closely with the contractors and Royal Commission to develop hazard prevention programmes. In addition, safety training such as road safety training should be provided to workers and material suppliers should be provided with information on delivery routes and speed limits.
ES.4.8 TRAFFIC AND TRANSPORTATION

Ras Al Khair Industrial City has a modern high capacity road network built to international standards. This network is specifically designed for industrial traffic and is integrated with the national Saudi Arabian road network; the road network is currently used by the existing operations such as the Ma’aden Phosphate Company (MPC) and the Ma’aden Aluminium Company (MAC).

One of the main current sources of road traffic to the Ras Al Khair industrial complex is the transport of molten sulphur by tanker from Berri Gas Plant at Jubail, which represents around 200-300 HGVs per day. This activity is however likely to change to port and rail transport as the rail network develops in the area.

The existing port covers an area of 23 km² and has four berths (one 6m deep with ammonia loading arm and ladders and support yard), a vessel turning basin and an approach channel with wave breaker. Construction of two additional berths is currently being progressed by Port Authority. The port serves more than 80 different industrial projects in the region and has plans for expansion to up to 50 berths by 2030.

The North-South Railway will be utilised by the Project for transfer of materials from the Umm Wu’al Mine and Waad Al Shamaal Phosphate Industrial Complex area to the Ras Al Khair Project site and vice versa. The rail facility is currently being developed to allow sulphuric acid transfers for existing MPC operations. The existing railway system includes a rail head with a large turning loop. A branch line to the north was recently constructed to serve sidings for sulphuric acid deliveries to the existing MPC facilities.

ES.4.8.1 RESULTS

Potential negative impacts of medium or high significance on transport infrastructure are not anticipated to occur as a consequence of the Project commissioning, construction, operation or decommissioning phases.

Implementation of the following measures is recommended to manage the potential impacts identified as being of low significance and maintain good management practices. It is anticipated that this assessment can be built upon during detailed design when detailed Project requirements are realised.

ES.4.8.2 RECOMMENDATIONS

A Traffic and Transport Plan will be developed as part of the Environmental Monitoring and Management Plan, prior to commencement of any activities on site. Further recommendations include:

- Co-ordination and liaison with the Ministry of Transport, Saudi Railway Company, and the Saudi Port Authority (SEAPA) during all phases to ensure coordination of programmes and minimise use of road transport wherever possible;
- Confirmation of capacity within the rail network and availability of trains to deliver materials required during all phases;
- Rail scheduling and operational procedures;
- Confirmation of the capability for Ras Al Khair Industrial Port to accept equipment and materials required for construction;
- Identification of temporary re-routing of traffic and procedures for managing delivery transportation companies;
- Management of start and finish times to reduce peak traffic flows;
• Undertake traffic risk assessments during all phases and implementation of any recommendations;
• Identification of traffic routes for vehicles to the site (including transport for the workforce);
• Implementation of measures to segregate pedestrians from vehicle areas;
• Implementation of driver training and awareness
• Implementation of measures to protect the local community where appropriate.
• Provision of suitable wheel washing equipment to prevent materials being deposited on the public highway;
• Re-use of materials on site to reduce the requirement to import bulk materials from other locations; and
• Schedule of audits of the management plans to confirm ongoing effectiveness.

ES.4.9 UTILITIES INFRASTRUCTURE & USAGE
ES.4.9.1 RESULTS

Significant economic and environmental benefits can be achieved by minimising the use and consumption of utilities services. Direct savings can be realised by the reduction in energy consumption and water supply reduction through the minimisation of wastage and unnecessary uses.

A number of positive impacts have been identified. These include efficiencies associated with a number if tie-ins with existing infrastructure and the MPC operations and also increased security of supply by the provision of new/support utilities. Maintenance of this efficient use of utilities reduces the requirement for importing of utilities services from outside of the Project.

Potential negative impacts of medium or high significance on the utilities infrastructure are not anticipated to occur as a consequence of the Project commissioning, construction, operation or decommissioning phases. In all cases where supply from the existing utilities cannot meet the Project demands, new infrastructure will be installed to service the Project.

Implementation of the following measures is recommended to manage the potential impacts identified as being of low significance and maintain good management practices. It is anticipated that this assessment can be built upon during detailed design when detailed Project requirements are realised.

ES.4.9.2 RECOMMENDATIONS

It is important that the utility requirements for the construction and commissioning phases are detailed and communicated throughout these periods to the relevant suppliers to ensure the timely provision of Project demands.

Prior to commencement of any activities, consultation with existing Ma’aden facility operators will take place to agree the necessary consultation and engagement procedures going forward. For example, it will be necessary to ensure that any tie-ins to the existing utilities are communicated and agreed in advance to ensure these are undertaken at an appropriate time, such as during low periods of current usage.

Utility consumption, such as minimising wastage and unnecessary discharges, and minimising the use of diesel generators should be undertaken throughout the project. Advantage should be taken of the existing utilities where feasible, particularly for water supply and waste water treatment to reduce the amount of water or waste water which requires transportation from/to external sources (such as Jubail).

Auditing and recording of all utility usage, storage and discharges requirements to be undertaken with regard to the requirements in the Royal Commission Environmental Regulations.
During the operational phase, the use and provision of utilities services to be monitored to ensure that there is no overloading of any system. It will be important for MPC divisions, from both the existing and new facilities, to communicate utilities uses and requirements with each other (and other utilities suppliers) to ensure reliable supplies are be maintained throughout.

ES.4.10 HEALTH AND SAFETY

There are very few medical facilities in the Ras Al Khair area. However, there is a medical facility at the existing Ma’aden Ammonia Plant close to the proposed development, and medical facilities at the adjacent Aluminium Plant.

The nearest hospitals are located in Jubail Industrial City approximately 50-60km to the South. The Royal Commission Hospital is located on the Western side of the City, close to the Royal Commission headquarters, while the Jubail Central Hospital, a Ministry of Health facility, is located in the Centre of the City. Both hospitals provide a comprehensive suite of departments and facilities, including outpatients and intensive care, dentistry and emergency.

The Health and Safety of both employees and the local community has been considered as an integral part of the project design. The design process has included HAZID workshops and a series of detailed HSE assessments has been made for specific parts of the facility as part of the Front End Engineering Design process. Eliminating or reducing the risk of many of the potential operational Health and Safety impacts has been a central theme in this phase.

ES.4.10.1 RESULTS

Out of a total of 75,825 workplace injuries in KSA in 2010, approximately half occurred in the construction industry. 21% of all deaths in 2009 to non-Saudi residents occurred as a result of accident or injury.

Potential sources of impacts during the construction phase include exposure to environmental factors (Air Quality, Noise, Water & Contamination), increased vehicle movement, Occupational Health & Safety of Construction Workers (including accidents and injuries, and mental health); and exposure to communicable and non-communicable diseases.

The impact assessment highlighted exposure of the workforce to contaminated soils, workforce accidents, increase of communicable diseases amongst the workforce, and traffic impacts on the community as being of medium significance.

The implementation of safety in design principles reduced the potential impacts during operation considerably. Those identified included exposure of the workforce to Air Quality & Dust impacts, Traffic and Transport (including community effects); Occupational Health, Accidents and Incidents; and Communicable and Non-Communicable Diseases.

Air quality and traffic safety impacts on the community were identified to be of medium significance.

ES.4.10.2 MITIGATION AND RECOMMENDATIONS

ES.4.10.2.1 MITIGATION

The following mitigation measures were identified to mitigate the potential impacts identified as medium significance:

- Ground investigations suggest some degree of soil contamination at the site. Therefore a soil sampling and analysis exercise is to be undertaken in the detailed design phase, with consideration of potential hazardous contaminants such as heavy metals.
- The results of the soil sampling are to be used to undertake a detailed health risk assessment identifying the HSE process and methods to be employed on site during construction to protect the workforce.
- Training and awareness on issues such as defensive driving will be provided to the workforce.
Early engagement with local service providers to assess the capacity of the region to absorb any potential issues is to be undertaken, and this will inform the design and staffing of the facilities to ensure local services are not adversely affected. This consultation is to include all emergency services to ensure agreement is reached on the most effective mechanisms to deal with any major incident, including any evacuation to hospitals in Jubail Industrial City.

A risk assessment will be undertaken which shall define the specific risks and mitigation, including working hours, exposure limits, and use of PPE as required.

Training and awareness on issues such as defensive driving will be provided to the workforce.

Decommissioning will be planned by developing, procedures, and any HSE requirements to ensure the project is decommissioned safely and effectively, using the correct PPE etc in line with RC requirements and intended future use.

ES.4.10.2.2 RECOMMENDATIONS

Construction Phase

- It is recommended that the EPC contractor conduct regular maintenance checks on mobile and fixed plant in relation to exhaust emissions. Any sandblasting activities required should be done in a controlled environment.
- Training and awareness on issues such as defensive driving would be beneficial to the suppliers and contractors.
- Safety performance, procedures and processes, and safety records should form part of any supplier evaluation.

Commissioning, Operational and Decommissioning

Updates to the EERP should consider the following:

- Liaisons with the relevant authorities to ensure services are (a) available, and (b) have sufficient capacity to support the Project workforce and the anticipated nature of any health incidents / issues.
- Provision for evacuation to hospitals in Jubail for any incident types which the local medical facilities cannot treat (e.g. chemical, burns, fractures etc.) and which may be time critical.
- Given the distances involved in any transfer to Jubail, provision of fully training medical staff who can treat to a level which allows safe transfer of the patient to the hospital facilities either through air transport or road ambulance.

Training and awareness on issues such as defensive driving would be beneficial to the suppliers and contractors.

ES.4.11 SUSTAINABLE DEVELOPMENT

The sustainable development assessment identifies that a number of positive and negative impacts associated with the project. These indicate that the Project faces a common challenge in terms of sustainability.

Negative impacts are typically associated with environmental sustainability. The positive impacts, though fewer in number are of greater magnitude, and are associated with socio-economic and infrastructure benefits.

The recommended areas of focus for the Project in terms of sustainability which are to be implemented in future phases include:

- Application of existing Ma’aden project processes, specifically the Environmental and Communities Assurance Manual;
ES.4.12 CUMULATIVE IMPACTS ASSESSMENT

Cumulative impacts were assessed through consideration of the impacts of the Project and other future projects taking place in the vicinity which could affect the same social and environmental resources and receptors that can be expected to have a combined effect. The impact 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 in combination with other future planned projects in the area.

The most significant impacts predicted for the Project are related to the emission of fluorides when combined with existing emissions, and the potential emission of significant volumes of CO₂ gas (primarily associated with the Ammonia Plant). The further expansion of DAP production within and adjacent to the existing facility will contribute further to the ambient concentrations of fluorides in the area with the potential for a collective failure to achieve environmental standards.

There is potential for medium cumulative impacts associated with the management of water from hydrotesting, flushing and cleaning of pipelines and tanks during commissioning. The receiving wastewater system involves the use of the existing evaporation pond within the complex (which is not utilised by other industries external to this Complex) and the Jubail Industrial Wastewater Treatment Plant. The use of these systems will only be required in the event that this water does not achieve water quality standards required of RCER-2010 (irrigation or coastal discharge). Whilst this a temporary impact, it requires proactive consideration and engagement with other stakeholders for emergency situations within the MPC Complex.

The potential for traffic congestion and accidents due to increases in vehicular traffic on community roadways is possible during the development and operation of the Ras Al Khair Industrial Complex and expansion/operation of the Manifa Oilfield facilities, as well as their connections with Jubail and Dammam. The assessment of the proposed Project elements did not identify significant residual impacts on road or rail transport infrastructure due to sufficient carrying capacity. However, cumulatively the development of the Ras Al Khair Industrial City has potential to adversely impact the capacity and safety of the existing infrastructure, if not appropriately managed. Infrastructure investment on the peninsula will expand the current network to meet the needs of the future developments, and there is a need for up-to-date traffic studies and management plans to help inform investment at Government level.

With the development of Ras Al Khair Industrial City, the influx of people, and the increasing industrial activity, may present cumulative air quality issues, and therefore health impacts on both employees and the wider community. Furthermore the development of the industrial zones brings these impacts closer to the communities to the west of the peninsula. These impacts can be readily managed, through strategic planning and assessment of the Industrial City Development.

The wider Ras Al Khair Industrial City Development will provide a significant level of economic development, and access to a wider range of community services and infrastructure available primarily to the associated workforce communities. The operational phase of the Project in combination with that of the proposed future development at Ras Al Khair will significantly contribute to the wider economy through employment opportunities, increased availability of services, enhancement of a significantly underdeveloped area of Saudi Arabia as well as exports and procurement.

Other cumulative impacts are considered to be low, and are detailed in full in Section 17 of the Environmental and Social Impact Assessment for this Project.
ES.5 CONCLUSIONS

The predicted impacts of the proposed Ras Al Khair Industrial Complex Project are within the standards as defined by the Royal Commission in their Environmental Regulations. Many of the impacts are of low significance.

For those impacts identified as High or Medium, mitigation measures have been developed to further reduce the potential significance to Low.

All mitigation measures and recommendations have been detailed in the Environmental Monitoring and Management Plan for implementation during the next phases of the project.

The impact assessment identifies a number of areas where the impacts from the Project when combined with the proposed development of Ras Al Khair Industrial City and Manifa Oilfield, may result in significant cumulative impacts. These include:

- Air Quality – Negative;
- Water Quality Management – Negative;
- Traffic and Transport Infrastructure – Negative;
- Community and Employee Health and Safety – Negative; and
- Socio-Economic Aspects – Positive.

As a key stakeholder in the Ras Al Khair Industrial City development, Ma’aden shall make this ESIA available for use in cumulative impact assessments of future project ESIA, and shall liaise with the Royal Commission, the Saudi Port Authority and Saudi Railway Authority to support collaborative and multi-stakeholder solutions for cumulative impacts.
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1.0 INTRODUCTION

1.1 PROJECT UNDERSTANDING AND OVERVIEW

The Saudi Arabian Mining Company (Ma’aden) intends to develop the Umm Wu’al Phosphate Project in the Kingdom of Saudi Arabia. This project is based on the exploitation and processing of the Umm Wu’al phosphate deposit, taking advantage of existing railway infrastructure, linking the phosphate deposits of Umm Wu’al in the northern region with to Industrial City of Ras Al Khair on the Arabian Gulf (refer to Figure 1-1).

The Umm Wu’al Mine and Waad Al Shamaal Phosphate Industrial Complex in the Sirhan-Turaif region of northern Saudi Arabia will include the following components: Mine, Beneficiation, Phosphoric Acid Plant, Sulphuric Acid Plant, Purified Phosphoric Acid Plant, STPP Plant, MCP/DCP plant and required utilities to process the extracted ore.

The processed materials will be transported from Umm Wu’al via existing railway infrastructure approximately 1,500 km to Ras Al Khair Industrial City, on the Arabian Gulf where the materials will be further processed as fertiliser products or stored for export.

Ras Al Khair is an existing Industrial City and Port facility located on a peninsula in the Eastern Province of Saudi Arabia; the facility will be expanded to include new chemical production plants for Ammonia, Di-Ammonium Phosphate and Nitro Phosphate Potash. Proposed developments also include all supporting infrastructure, storage and handling facilities and connection to existing utilities within the Ras Al Khair Industrial City. For the purpose of this report, the new developments proposed by Ma’aden at the Ras Al Khair Industrial City will be referred to collectively as the Ras Al Khair Industrial Complex (‘the Project’).

![Figure 1-1: Location of the Umm Wu’al Phosphate Project Sites.](image-url)
The industrial units to be developed as part of the Umm Wu’al Project will produce the following products:

- Phosphoric Acid (MGA) 1,500,000 tpy;
- Purified Phosphoric Acid (PPA) 100,000 tpy;
- Sodium Tri-Poly-Phosphate (STPP) 90,000 tpy;
- Mono-Calcium Phosphate and Di-Calcium Phosphate (DCP / MCP) 250,000 tpy;
- Compound Fertilizer (DAP 2,228,094 tpy and NPK 766,920 tpy); and
- Ammonia 1,089,000 tpy.

Ma’aden has awarded a contract to Jacobs Engineering Group to provide a bankable feasibility study and front-end engineering design (FEED) for both elements of the Project (i.e. the Umm Wu’al Mine and Waad Al Shamaal Phosphate Industrial Complex and Ras Al Khair Industrial Complex).

Partnering with Woods Hole Group Middle East (WHGME), a Presidency of Meteorology & Environment (PME) and Royal Commission (RC) approved ESIA consultant, Jacobs’ scope of work includes the preparation of the bankable Environmental and Social Impact Assessments (ESIAs) for both the Umm Wu’al mine and the Ras Al Khair sites as well as the environmental permits required by the Royal Commission for Ras Al Khair.

The Umm Wu’al Phosphate Project will be part funded by international banks and export credit agencies from OECD countries and therefore the ESIAs have been developed with regard to international environmental standards, notably the World Bank Group and specifically the International Finance Corporation’s (IFC) Performance Standards on Environmental and Social Sustainability (2012) and the Equator Principals (as reviewed in 2012).

Due to the nature and scope of the Project and the fact that the assessment of each site will be subject to different regulatory requirements (i.e. PME and RC), a separate ESIA has been produced for each Project site.

1.2 RAS AL KHAIR

The Ras Al Khair Industrial City and Port is located adjacent to existing phosphate and phosphoric acid plants, in an area designated for future industrial development within Ras Al Khair Industrial City (previously referred to as Ras Az Zawr or Ras Al Zour). The Industrial City lies on a peninsula in the Eastern Province of Saudi Arabia on the south-western Arabian Gulf coast, is located approximately 65 km north of Jubail Industrial City and is approximately 200 km south of the Kuwaiti border.

The Ras Al Khair Industrial Complex will introduce the following additional components to the existing Ma’aden Phosphate Company operations in the Industrial City:

- Ammonia production plant;
- Cooling tower;
- Di Ammonium Phosphate (DAP) plant;
- Nitro Phosphate Potash (NPK) plant;
- Utilities connections;
- Raw materials and product storage and handling facilities (process area and port);
- Rail infrastructure (sidings, shelter and weighbridge);
- Roadways; and
- Architectural / Administration buildings.

Figure 1-2 illustrates the locations of the proposed project elements at Ras Al Khair.
Figure 1-2: Indicative Site Location of the Proposed Project Elements at Ras Al Khair
THE ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

The purpose of this ESIA\(^1\) is to identify environmental and social impacts at an early stage of the Project, assess these impacts and where necessary propose mitigations to be implemented. The ESIA is to provide the relevant parties; regulators, lenders and other stakeholders with sufficient information on the proposed Project, to allow them to make informed decisions on the Project. The principal audiences for the Project ESIA are identified as:

- The Royal Commission for Jubail and Yanbu (RC);
- Financial Institutions adopting the Equator Principles (EPFIs); and
- Stakeholders impacted by the Project.

Screening and scoping of the ESIA was undertaken for the Project on the basis of International and National requirements and the potential risks and impacts of the Project. The screening and scoping process undertaken for the Project is detailed within the ESIA Scope of Works document [MD-513-0000-HS-EN-SOW-0001].

1.3.1 ESIA SCREENING

The RC is the responsible authority for the proposed Project developments within the Ras Al Khair Industrial City. The RC Environmental Protection and Control Department (EPCD) controls developments on behalf of the RC. The RC EPCD functions include the development of the Royal Commission Environmental Regulations Volume I, II and III (RCER-2010). These regulations relate to the types of substances discharged, deposited or generated within the industrial cities.

All developers are required to fulfil the requirements of the RCER Volume II Permit Process which includes requirements for the development of an ESIA within the industrial cities. RCER Volume II identifies that facilities will be categorised based on their “size, type of activities, raw materials and products as well as the potential for air emissions, using process and cooling water, generating wastewater and solid waste and noise during their construction and operation”. Facilities will be categorised by the RC as Types I, II or III.

The proposed Project development at Ras Al Khair is expected to be classified as ‘Type I’ and therefore, as per RC requirements, a Permit Application Package (PAP) to include this ESIA will be prepared for submission to the RC in application for an Environmental Permit to Construct.

Equator Principles Financial Institutions (EPFIs) require borrowers to comply with the Equator Principles, to ensure that the Project has been developed in a manner that is socially responsible and reflects sound environmental management practises. The first Principle requires the categorisation of the project based on the magnitude of its potential risks and impacts in accordance with the environmental and social screening criteria of the International Finance Corporation (IFC). The proposed Ras Al Khair Industrial Complex is considered as a Category B project: Projects with potential limited adverse environmental social risks and/or impacts that are few in number, generally site-specific, largely reversible and readily addressed through mitigation measures.

1.3.2 SCOPE OF THE ESIA

The scope of the ESIA includes the commissioning, construction, operation and decommissioning of the proposed project facilities within the process area of the Ras Al Khair Industrial Complex, including road and rail interconnections, and materials storage and loading/unloading areas. Also, the storage and loading/unloading activities at the Port are assessed for potential impacts during commissioning, construction, operation and decommissioning of the supporting infrastructure. Saudi Railway Company (SAR) and Saudi Port Authority (SEPA) are responsible for generating separate ESIs for the railway line connecting the two sites and the port expansion respectively.

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\(^1\) Referred to as an Environmental Impact Assessment (EIA) with RCER-2010.
The ESIA Scope of Works identified the following primary issues which required detail study as part of the assessment:

- Ambient Air Quality and Stack Emissions;
- Water Quality Management;
- Solid Waste Management;
- Terrestrial Environments;
- Noise;
- Biological Resources;
- Socio-Economic Aspects; and
- Traffic and Transport.

1.3.3 PREPARATION OF THE ESIA

The baseline environmental and social conditions at the Project site have been determined by reference to existing literature and the collection of baseline data; these activities were subcontracted to WHGME. Environmental modelling studies have been undertaken for Air Quality, Traffic, Terrestrial Environment and Noise.

Following a review of various project / design alternatives considered as part of the Project development, this ESIA examines the possible impacts from the proposed Project using the methodology described in Section 5.0 Impact Assessment Methodology and identifies possible mitigation measures and the residual impact(s).

1.4 REPORT STRUCTURE

The structure of the ESIA is as follows:

ES Executive Summary. This provides an overview of the Umm Wu’al Phosphate Project phases relevant to the Ras Al Khair site, potential environmental and social impacts and proposed mitigation and monitoring strategies.

Section 1 Introduction. This section provides a description of the Project, including the key components of the project and an overview of the processes to be undertaken at the facility.

Section 2 Policy, Legal and Administrative Framework. This section summarises the key elements of national, local, and international legislation that apply to the proposed Ras Al Khair elements of the Umm Wu’al Phosphate Project. A summary of the relevant aspects of the legislation and regulations is provided.

Section 3 Consideration of Alternatives. This section provides a description of the alternatives considered as part of the Project development including the ‘Do Nothing’ scenario, and includes a description of the application of Best Available Techniques (BAT) within the Project.

Section 4 Detailed Description and Layout of the Proposed Development. This section provides an outline of the proposed works at Ras Al Khair including a process description, preliminary plans and the different phases of the Project (construction, commissioning, operation and decommissioning) with their proposed schedules.

Section 5 Impact Assessment Methodology. This section details the criteria applied to the assessment of potential impacts arising from the proposed Project elements described in the Section 4. It provides definitions of impact magnitude and significance as they apply to the potential effects on environmental aspects.

Section 6 Air Quality & Meteorology. This section presents the results and conclusions of the assessment of ambient air quality in the vicinity of the facility in order to establish baseline conditions, and the predicted impacts resulting from air emissions during the various stages of development of the Project including those relating to upset and emergency conditions.
Section 7 Terrestrial Environment. This section presents the findings of the onshore physical environment baseline survey, its evaluation and the likely impacts on the physical environment. The investigation addresses regional and local geological and hydrogeological conditions, characterises the soil and groundwater quality and presents results of modelled spill scenarios to determine potential impacts on receptors.

Section 8 Biological Resources. This section details the literature review and the baseline assessment and presents the evaluation of the potential environmental impacts to ecology during the lifetime of the Project.

Section 9 Noise & Vibration. This section 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 assessment of the likely environmental impacts on receptors resulting from noise generated during the lifetime of the Project (in light of applicable criteria, existing noise levels in the area and modelling based predictions).

Section 10 Waste Management. This section presents the findings of the baseline investigation detailing the waste management facilities that are available for the Ras Al Khair elements of the Project. The potential environmental impacts resulting from waste management during the lifetime of the Project are evaluated.

Section 11 Water Quality Management. This section provides an overview of the predicted impacts on the water environment and/or wastewater treatment facilities due to various wastewater discharges resulting from the various Project phases at Ras Al Khair.

Section 12 Socio-Economic Aspects. This section includes a general description of the socio-economic characteristics on a national and regional level including demography, economic activity, infrastructure, and education. Each characteristic is assessed subjectively by review of existing published information. This section includes also a description of the archaeological and cultural characteristics on a national and regional level. Potential impacts on the socio-economic and cultural aspects are evaluated for each phase of the Project.

Section 13 Traffic and Transport Infrastructure. This section summarises available traffic information and existing infrastructure and transport system. Potential impacts of the Project on the usage and demands on public transport systems, railways and the port are assessed.

Section 14 Utilities Infrastructure and Usage. A review of the existing utilities infrastructure and usage is documented in this section. Potential impacts of the Project on the existing utilities infrastructure are assessed and any potential benefits where the Project enables major improvement to local infrastructure are identified.

Section 15 Health and Safety Aspects. This section presents a brief description of the potential health and safety issues associated with the Project at Ras Al Khair.

Section 16 Sustainable Development. This section includes an analysis of how the sustainable development elements are integrated into both the Ras Al Khair ESIA and the Project itself. Project life cycle phases have been considered into each analysis where applicable.

Section 17 Cumulative Impacts Assessment. This section includes an assessment of the cumulative effects that are likely to result from the Project 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 18 Summary of Impacts and Mitigation. This section summarises in table form the potential impacts identified and the corresponding mitigation measures / recommendations that have been identified in light of their applicability and cost effectiveness including any interactive impacts between issues.

Section 19 Abbreviations & Acronyms. This section comprises a list of abbreviations and acronyms contained within the ESIA Report.

Section 20 Reference List. This section comprises a list of references used in the ESIA.
APPENDICES

Appendix A  Environmental Management & Monitoring Plan (EMMP). This appendix summarises the development of a plan to monitor the implementation of the proposed mitigation measures / options during the life of the Project. It translates the findings and recommendations of the ESIA process into a succinct, clearly defined set of procedures and plans for implementation on the ground level. The EMMP identifies those parties responsible for implementing the mitigation measures identified and integrates with existing documents including corporate and site specific management policies. The EMMP includes an outline of environmental action plans, and staffing and training recommendations.

Appendix B  Environmental Emergency Response Plan Outline. This document outlines the suggested procedures regarding incidents that can potentially impact worker safety, public health and/or cause environmental damage during the operation phase of the Project.

Appendix C  Stakeholder Engagement Plan. This document outlines the approach to be taken in supporting the communications and engagement objectives, processes and deliverables required to support the delivery of the Umm Wu’al Phosphate Project. Methods for effective two-way stakeholder consultation are outlined for development and implementation by Ma’aden during the life of the project, ensuring that mechanisms for feedback and response are incorporated into the communication cycle list.

Appendix D  Ambient Air Quality Assessment. This Appendix details the methodology, input data, assumptions and results of the air dispersion modelling undertaken for point and fugitive emission sources at the Ras Al Khair Industrial Complex process area.

Appendix E  Terrestrial Environment. This Appendix provides a comparison of the laboratory analytical results for groundwater sampling events against water quality standards. Also, BIOSCREEN model input and relevant output screens produced by the spill modelling are provided.
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2.0 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

2.1 INTRODUCTION

The highest institutional authority for the environment within the Kingdom of Saudi Arabia (KSA) is the Presidency of Meteorology and Environment (PME). The PME has overall authority for ensuring that development projects in the Kingdom of Saudi Arabia (KSA) adhere to environmental standards and is the responsible authority for approval of the EIA procedures. All mining projects are also subject to approval by the Ministry of Petroleum and Mineral Resources with the environmental aspects of these projects being reviewed by the Presidency of Meteorology and Environment (PME).

The proposed Ras Al Khair Industrial Complex (the Project) will be located within the Ras Al Khair Mineral Industrial City which is under the jurisdiction of the Royal Commission (RC) for Jubail and Yanbu. Although the PME has the overall authority in the KSA for environmental matters, the RC has been delegated responsibility for environmental matters within the boundaries of the industrial cities of Jubail, Yanbu and Ras Al Khair by means of a Memorandum of Understanding issued by PME. The RC is responsible for environmental management and controlling pollution associated with the development and operation of these industrial cities.

The RC, established by Royal decrees in 1975 and 2009, has developed and adopted the Royal Commission Environmental Regulations (RCER) 2010 to control substances emitted, discharged or deposited, and noise generated within the industrial cities. RCER-2010 includes specific requirements for the application and preparation of an environmental impact assessment as detailed in Volume II, Appendix C. Under the RCER-2010 all new and modified facilities within the industrial cities are required to take part in the RC Environmental Permit Program.

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 Ministry of Petroleum and Mineral Resources and Ministry of Municipalities and Rural Affairs. Since the Project shall seek international financing, the Project shall also reference the international guidance and standards of the World Bank Group and specifically the International Finance Corporation (IFC - part of the World Bank Group), as appropriate. Also, in accordance with the requirements of the IFC and the RC, the Project shall utilise Best Available Techniques (BAT) for environmental control (refer to Section 3).

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 of this document. As the guidelines and standards are presented as a summary, the full and most recent legislation will be consulted prior to implementation of any mitigation or monitoring actions.

All relevant standards, guidelines and performance thresholds which are introduced in the following sections are referenced as relevant within the individual technical assessment Sections of this ESIA: Sections 6 – 16.

2.2 LOCAL AND NATIONAL POLICIES

2.2.1 ROYAL COMMISSION

The RC Environmental Protection and Control Department (EPCD) controls developments on behalf of the RC. The functions of the RC EPCD include the development of the Royal Commission Environmental Regulations Volume I, II and III (RC, 2010). These regulations (referred to as RCER-2010) relate to the types of substances emitted, discharged, deposited or generated within the industrial cities.
The current RCER-2010, which were enacted in January 2011 comprise the following:

- Volume I: Regulation and Standards - which includes all regulations, standards and guidelines required to operate an industrial facility in a manner which protects the environment and public health;
- Volume II: Consolidated Permit Program - which sets out the steps to be followed to obtain the necessary “Environmental Permit to Construct and the “Environmental Permit to Operate” from the RC in order to construct and operate industrial and other facilities within the industrial cities; and
- Volume III: Penalty System - which sets out the penalty system in event of non-compliance.

As directed in clause 1.5 of the RCER-2010 Volume I, in the event that the RCER do not specify a standard relevant to the project site, then the project shall use for reference other recognised regulations as a basis for technical justification in the following order:

- Saudi National / Presidency for Meteorology & Environment (PME);
- The U.S. Environmental Protection Agency (US EPA);
- U.S. State environmental rules and guidelines;
- European Union (EU) members environmental rules and guidelines; and
- Other internationally recognised and accepted regulatory bodies.

2.2.2 ESIA REQUIREMENT

The requirements for conducting an Environmental Impact Assessment (EIA) are outlined in clauses 1.1.7, 1.1.8 and 1.1.9 of RCER-2010, Volume I for all new projects or the modification of existing facilities. Developers planning to establish Type I and II industries within the industrial city are required to conduct an EIA to ensure all the objectives are met according to regional, national and international standards. In compliance with the IFC Performance Standards, the EIA for the Ras Al Khair Industrial Complex is expanded to form an Environmental and Social Impact Assessment (ESIA).

Proposed developments will be assessed by the RC based largely on the EIA submission to determine whether a development should be permitted and to ensure adequate design controls are utilised to avoid or mitigate against adverse effects by examination of the alternatives. The integration of the EIA into the design and evaluation process improves the overall environmental quality of new developments and increases its sustainability.

The typical format and content for an EIA expected by the RC is included in Appendix C of RCER-2010 Volume II.

2.3 INTERNATIONAL GUIDELINES AND POLICIES

2.3.1 THE WORLD BANK GROUP

The World Bank Group is a family of five international organisations that makes leveraged loans:

- International Bank for Reconstruction and Development (IRBD);
- International Development Associated (IDA);
- International Finance Corporation (IFC);
- Multilateral Investment Guarantee Agency (MIGA); and
- International Centre for Settlement of Investment Disputes (ICSID).

Of most relevance to the Project is the IFC.
The IFC is an international financial institution which offers investment, advisory, and asset management services to encourage private sector development in projects. It was established in 1956 as the private sector arm of the World Bank Group to advance economic development by investing in strictly for-profit and commercial projects which reduce poverty and promote development.

To provide a means of managing the social and environmental risks and impacts on projects, the IFC have developed their Performance Standards on Social and Environmental Sustainability (revised in 2012). The Performance Standards are designed to help avoid, mitigate, and manage risks and impacts as a means of doing business in a sustainable way, including stakeholder engagement and disclosure obligations of the client in relation to project-level activities. The IFC Performance Standards (IFC, 2012) are:

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts
- Performance Standard 2: Labour and Working Conditions
- Performance Standard 3: Resource Efficiency and Pollution Prevention
- Performance Standard 4: Community Health, Safety, and Security
- Performance Standard 5: Land Acquisition and Involuntary Resettlement
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
- Performance Standard 7: Indigenous Peoples
- Performance Standard 8: Cultural Heritage

The IFC developed the World Bank Group Environmental, Health, and Safety Guidelines (EHS Guidelines) to provide technical reference documents with general and industry-specific examples of Good International Industry Practice as defined in IFC’s Performance Standard 3: Resource Efficiency and Pollution Prevention. The IFC uses these Guidelines as a technical source of information during project appraisal activities. The following guidelines of IFC are relevant to the Project:

- General Environmental, Health, and Safety Guidelines, April 30, 2007;
- Environmental, Health, and Safety Guidelines for Large Volume Inorganic Compounds Manufacturing and Coal Tar Distillation, December 10, 2007;
- Environmental, Health and Safety Guidelines for Phosphate Fertilizer Plants Manufacturing, April 30, 2007;

On applying these Guidelines, the IFC expect that when host country regulations differ from the levels and measures presented in the EHS Guidelines, projects will achieve whichever is more stringent. If less stringent levels or measures are appropriate in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification of such an alternative should demonstrate that the choice for any alternate performance level protects human health and the environment.

2.3.2 EQUATOR PRINCIPLES

The Equator Principles, established in June 2003, and subsequently reviewed in 2006 and 2013, is a risk framework for identifying, assessing, and managing environmental and social risks in project finance transactions. This framework is based on the IFC Performance Standards and the World Bank Group EHS Guidelines. Equator Principles Financial Institutions (EPFIs) have adopted the Equator Principles in order to ensure that the Projects financed are developed in a manner that is socially responsible and reflects sound
environmental management practices. The principles comprise a set of ten broad principles that are underpinned by the environmental and social policies, standards and guidance of the IFC. The Equator Principles are as follows:

- Principle 1: Review and Categorisation;
- Principle 2: Environmental and Social Assessment;
- Principle 3: Applicable Environmental and Social Standards;
- Principle 4: Environmental and Social Management System and Action Plan;
- Principle 5: Stakeholder Engagement;
- Principle 6: Grievance Mechanism;
- Principle 7: Independent Review;
- Principle 8: Covenants;
- Principle 9: Independent Monitoring and Reporting; and
- Principle 10: Reporting and Transparency.

2.3.3 ESIA REQUIREMENT

When a Project is proposed for financing, the EPFI is required to categorise the Project based on the magnitude of its potential risks and impacts. This screening is undertaken using the following categorisation scheme of the IFC:

- Category A: Projects with potential significant adverse environmental and social risks and/or impacts that are diverse, irreversible or unprecedented;
- Category B: Projects with potential limited adverse environmental social risks and/or impacts that are few in number, generally site-specific, largely reversible and readily addressed through mitigation measures; and
- Category C: Project with minimal or no adverse environmental and social risks and/or impacts.

The Ras Al Khair Industrial Complex element of the Umm Wu'al Phosphate Project is considered to be a Category B Project.

2.3.4 PROJECT COMMITMENTS

This ESIA report developed during the Front End Engineering (FEED) Stage of the Project has been conducted in accordance with the requirements of the RC (RCER-2010) as well as the IFC's Performance Standards and the Equator Principles (EPIII) as far as practicable (see Table 2-1 and Table 2-2 respectively).

Those Performance Standards highlighted in *italics* have been identified as having limited or no relevance to the Project.
## IFC Performance Standards

### Performance Standard 1

**Assessment and Management of Environmental and Social Risks and Impacts**

Requirements: Environmental and Social Management System (ESMS): a methodological approach to managing environmental and social risk and impacts in a structured way on an ongoing basis. The ESMS will incorporate: (i) policy; (ii) identification of risks and impacts; (iii) management programmes; (iv) organisational capacity and competency; (v) emergency preparedness and response; (vi) stakeholder engagement; and (vii) monitoring and review.

Objectives:
- To identify and evaluate environmental and social risks and impacts of the project.
- To adopt a mitigation hierarchy to anticipate and avoid, or where avoidance is not possible, minimise, and, where residual impacts remain, compensate/offset for risks and impacts to workers, Affected Communities, and the environment.
- To promote improved environmental and social performance of clients through the effective use of management systems.
- To ensure that grievances from Affected Communities and external communications from other stakeholders are responded to and managed appropriately.
- To promote and provide means for adequate engagement with Affected Communities throughout the project cycle on issues that could potentially affect them and to ensure that relevant environmental and social information is disclosed and disseminated.

The following documents demonstrate adherence to this Performance Standard during FEED Stage:
- Environmental and Social Impact Assessment (ESIA), specifically the Socio-economic assessment (Section 12);
- Environmental Monitoring Management Plan (EMMP) (Appendix A of this ESIA);
- Environmental Emergency Response Plan (EERP) (Appendix B of this ESIA); and
- Stakeholder Engagement Plan (SEP) (Appendix C of this ESIA).

Ma'aden will establish an ESMS relevant to the Project and support any ongoing management and reporting as required.

Ma'aden will use the ESMS to manage the implementation of the actions necessary to meet the applicable requirements of all Performance Standard.

### Performance Standard 2

**Labour and Working Conditions**

Requirements are outlined for: Working Conditions and Management of Worker Relationship; Protecting the Work Force; Occupational Health and Safety; Workers Engaged by Third Parties; Supply Chain.

Sections 12 and 15 of the ESIA consider potential impacts that the proposed project could pose on workers' health and conditions as well as proposing measures to manage and monitor them. These have been integrated to the EMMP and EERP as appropriate (Appendices A and B).
### IFC Performance Standards

**Objectives:**
- To promote the fair treatment, non-discrimination, and equal opportunity of workers.
- To establish, maintain, and improve the worker-management relationship.
- To promote compliance with national employment and labour laws.
- To protect workers, including vulnerable categories of workers such as children, migrant workers, workers engaged by third parties, and workers in the client’s supply chain.
- To promote safe and healthy working conditions, and the health of workers.
- To avoid the use of forced labour.

### Performance Standard 3: Resource Efficiency and Pollution Prevention

**Objectives:**
- To avoid or minimise adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities.
- To promote more sustainable use of resources, including energy and water.
- To reduce project-related GHG emissions.

The ESIA documents how potential impacts on human health and the environment were identified and assessed. Section 3 of the ESIA specifically identify and describe the assessment of the key strategic and technological alternatives that have been considered for the Project, and the integration of best available technology (BAT) principles within the facility design in order to minimise significant impacts.

The Project will emit more than 25,000 tonnes of CO₂ equivalent annually (primarily associated with the CO₂ vent of the Ammonia Plant); therefore GHG emissions have been estimated and are reported within Section 6. Ma’aden are required to quantify GHG emissions annually.

### Performance Standard 4: Community Health, Safety and Security

**Objectives:**
- To anticipate and avoid adverse impacts on the health and safety of the Affected Community during the project life from both routine and non-routine circumstances.

To ensure that the safeguarding of personnel and property is carried out in accordance with relevant human rights principles and in a manner that avoids or minimises risks to the Affected Communities.

Due to the location of the Project, this Standard is of limited relevance as it is considered unlikely to increase community exposure to risks and impacts. Sections 12 and 15 identify and assesses potential impacts that the proposed project could pose on workers and community’s health as well as proposing measures to manage and monitor them. These have been integrated to the EMMP and EERP as appropriate (Appendices A and B).
<table>
<thead>
<tr>
<th>IFC Performance Standards</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Performance Standard 5</strong></td>
<td>Land Acquisition and Involuntary Resettlement</td>
</tr>
<tr>
<td><strong>Biodiversity Conservation and Sustainable Management of Living Natural Resources</strong></td>
<td>Due to the location and scope of the Project this Standard is considered to be of limited relevance. However, an assessment of biological resources was undertaken due to the proximity of the Arabian Gulf. This is documented in Section 8 of the ESIA.</td>
</tr>
<tr>
<td><strong>Indigenous Peoples</strong></td>
<td>Due to the location and scope of the Project this Standard is considered to be of limited relevance. No specific impact assessment of indigenous people was undertaken as part of the ESIA.</td>
</tr>
<tr>
<td><strong>Cultural Heritage</strong></td>
<td>Due to the location and scope of the Project this Standard is considered to be of limited relevance. No specific impact assessment of cultural (or archaeological) heritage was undertaken as part of the ESIA (refer to Section 12 Socio-Economic Aspects).</td>
</tr>
</tbody>
</table>
Table 2-2: Ma’aden’s Commitment to the for the Equator Principles (EPIII) Ras Al Khair Industrial Complex

<table>
<thead>
<tr>
<th>Equator Principles</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principle 1</strong></td>
<td>Review and Categorisation</td>
</tr>
<tr>
<td></td>
<td>Categorisation of the project based on the magnitude of its potential risks and impacts in accordance with the environmental and social screening criteria of the International Finance Corporation (IFC).</td>
</tr>
<tr>
<td><strong>Principle 2</strong></td>
<td>Environmental and Social Assessment</td>
</tr>
<tr>
<td></td>
<td>Assessment process to address, to the EPFIs satisfaction, the relevant environmental and social risks and impacts of the proposed Project. The Assessment Documentation should propose measures to minimise, mitigate and offset adverse impacts in a manner relevant and appropriate to the nature and scale of the proposed Project.</td>
</tr>
<tr>
<td></td>
<td>For Category A, and as appropriate, Category B Projects, the Assessment Documentation includes an Environmental and Social Impact Assessment (ESIA).</td>
</tr>
<tr>
<td><strong>Principle 3</strong></td>
<td>Applicable Environmental and Social Standards</td>
</tr>
<tr>
<td></td>
<td>Compliance with host county legislation/permits is required to be addressed in the first instance.</td>
</tr>
<tr>
<td></td>
<td>For Projects located in Non-Designated Countries, the assessment is required to evaluate compliance with the respective IFC Performance Standards and World Bank Group EHS Guidelines.</td>
</tr>
<tr>
<td></td>
<td>For Project located in Designated Countries, the relevant host country laws, regulations and permits apply.</td>
</tr>
</tbody>
</table>
## Equator Principles

### Principle 4  Environmental and Social Management System and Action Plan

An ESMS to be developed and maintained by the Client for all Category A and B Projects. An Environmental and Social Management Plan is also required to address issues raised in the Assessment and incorporate actions required to comply with the applicable standards.

Ma’aden will establish and maintain an ESMS. Appendix A of this ESIA report includes an Environmental Management & Monitoring Plan (EMMP) developed to address and manage the environmental aspects and impacts related to the construction, commissioning and operation of the Project. The EMMP is considered appropriate as an ESMP. It is anticipated that all applicable standards will be met to the satisfaction of the EPFI. However, if deemed necessary by the EPFI to prepare an Action Plan (AP) to address any gaps identified, Ma’aden will work with the EPFI to resolve this.

### Principle 5  Stakeholder and Engagement

For all Category A and Category B Projects, effective stakeholder engagement must be demonstrated as an ongoing process in a structured and culturally appropriate manner with affected communities and where appropriate other stakeholders.

For projects with environmental or social risks and adverse impacts, disclosure should occur early in the Assessment process, in any event before the Project construction commences, and on an ongoing basis.

Due to the location and nature of the Project, the risk/impacts to communities or indigenous people is considered limited. However, the Socio-Economic Assessment of the ESIA (Section 12) and the Stakeholder Engagement Plan (SEP) (Appendix C) both address stakeholder engagement appropriate to this Project.

The SEP outlines the approach to be taken in supporting the communications and engagement objectives, processes and deliverables required to support successful delivery of the Umm Wu’al Phosphate Project. It also identifies the range of people and organisations that may be regarded as stakeholders in the Project, and describes the strategy to be used for engaging with these stakeholders in a culturally appropriate manner.

The SEP will continue to be developed by Ma’aden for the life of the Project.
<table>
<thead>
<tr>
<th>Principle</th>
<th>Equator Principles</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principle 6</td>
<td><strong>Grievance Mechanism</strong></td>
<td>For all Category A and, as appropriate, Category B Projects, the client will, as part of the ESMS, establish a grievance mechanism designed to receive and facilitate resolution of concerns and grievances about the Project's environmental and social performance.</td>
</tr>
<tr>
<td>Principle 7</td>
<td><strong>Independent Review</strong></td>
<td>For all Category A and, as appropriate, Category B Projects, an independent Environmental and Social Consultant not directly associated with the client will carry out and Independent Review of the Assessment Documentation including the ESMP, ESMS and the Stakeholder Engagement process documentation in order to assist the EPFI's due diligence, and assess Equator Principles compliance.</td>
</tr>
<tr>
<td>Principle 8</td>
<td><strong>Covenants</strong></td>
<td>The client will covenant in the financing documentation: to comply with all relevant host country environmental and social laws, regulations and permits; to comply with the ESMP and AP (where applicable), to provide periodic reports to the EPFI demonstrating compliance; and to decommission facilities, where applicable and appropriate, in accordance with an agreed decommissioning plan.</td>
</tr>
<tr>
<td>Principle 9</td>
<td><strong>Independent Monitoring and Reporting</strong></td>
<td>To assess Project compliance with the Equator Principles and ensure ongoing monitoring and reporting after Financial Close and over the life of the loan, the EPFIs will for all Category A and, as appropriate, Category B Projects, require the appointment of an Independent Environmental and Social Consultant, or require that the client retain qualified and experienced external experts to verify its monitoring information which would be shared with the EPFIs.</td>
</tr>
<tr>
<td>Principle 10</td>
<td>Reporting and Transparency</td>
<td></td>
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<tr>
<td>--------------</td>
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<tr>
<td></td>
<td>Ma'aden will liaise with the EPFI to confirm requirements for disclosing the Assessment Documentation (e.g. Executive Summary of the ESIA) online for this Category B Project.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>There is potential for the Project to emit more than 100,000 tonnes of CO₂ equivalent annually; therefore annual reporting of such emissions will be required of Ma'aden in this instance.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Equator Principles</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Comment</strong></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Reporting and Transparency</td>
<td></td>
</tr>
<tr>
<td>For all Category A and, as appropriate, Category B Projects:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• The client will ensure that, at a minimum, a summary of the ESIA is accessible and available online.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• The client will publicly report GHG emission levels during the operational phase for Projects emitting over 100,000 tonnes of CO₂ equivalent annually.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>EP III Annex A Notes:</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Clients are encouraged to report publicly on Projects emitting over 25,000 tonnes. In some instances, public disclosure of the full alternatives analysis or project-level emissions may not be appropriate.</em></td>
<td></td>
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</tr>
</tbody>
</table>
2.4 OTHER STANDARDS AND GUIDANCE

The following standards, principles and guidelines have also been used as reference in undertaking the ESIA for the Ras Al Khair Industrial Complex.

2.4.1 MA’ADEN ENVIRONMENTAL MANAGEMENT

In 2007, Ma’aden established its corporate Environmental Management System functions and policies. Environmental aspects of activities, products and services are assessed for significance and moderated by a Ma’aden cross-functional team. Aspects assessed include air and water emissions, releases to land, use of raw materials and natural resources, use of energy and emission of heat, radiation and vibration, waste and by-products, and physical attributes. The impact of activities on wildlife and biodiversity are also assessed.

The Ma’aden Phosphate Company Safety, Health, Environment and Quality Policy (2012) indicates Ma’aden’s commitment to improve the environmental (as well as health, safety and quality) performance and standards associated with its activities.

The Ma’aden Project Manual implements the Safety, Health, Environment and Quality Policy, primarily through the Environment and Communities Assurance guide (MD-101-SMPM-PM-EN-GUI-0001) and Environmental Protection Requirements (MD-101-SMPM-PM-EN-PEI-0001), while Ma’aden’s Engineering Standard and Project Specifications also include Environmental Health & Safety Design Criteria (MD-101-SMEM-EC-GE-CRT-0001).

2.4.2 PRESIDENCY OF METEOROLOGY AND ENVIRONMENT

Although the Ras Al Khair lies outside of the jurisdiction of the PME, where relevant guidance or standard is not provided by the RC, the PME policy will be referred to. The PME is the competent authority for environmental regulation in Saudi Arabia and is responsible for the general regulatory framework for the development and enforcement of environmental rules and regulations.

The PME General Environmental Regulations and Rules for Implementation were enacted in October 2001. Appendix 1 of the General Environmental Law and Rules for Implementation, 2001 outline the environmental protection standards relevant to facilities in the Kingdom of Saudi Arabia.

The PME (2001) General Environmental Protection Standards for New Facilities (Standard 7) are outlined as:

- All new major facilities as well as major modifications to existing facilities shall be designed, operated and maintained so as to avoid exceedances of the ambient environmental standards as promulgated for the Kingdom at the time of approval of the design.

- Each new major facility or major modification of an existing facility shall incorporate the best available technology for control of pollutant discharges and for the disposal of wastes resulting from the operation of the facility.

- All new facilities and modifications of an existing facility shall be designed and operated so as to avoid the discharge of any toxic substance, whether specifically regulated or not, in sufficient quantities to be harmful to public health.

In 2012, the PME developed a number of guidance standards revising the current General Standards for the Environment (specifically document number 1409-01) issued by the PME in Appendix 1 to the General Environmental Law and Rules for Implementation. These standards came into effect on 24th March 2012.

2.4.3 THE QUINTET

The Quintet Committee is a consultee for projects that will require construction within the foreshore or marine coastal environments. The body consists of representatives from the PME, Ministry of Agriculture (MOA), the Coast Guard, the Ministry of Finance (MOF) and, depending on the location of a project, the Yanbu or Jubail Municipality. The committee is required to be consulted with and given access to project documentation such as the EIA that
is required to be undertaken by a PME approved contractor. Typically documentation will be required to be submitted in Arabic, and typically meetings are also undertaken in Arabic. Quintet approval for projects is usually coordinated through the relevant municipality. Early engagement of the Quintet is important to avoid delays on approvals. At present, the current scope of works do not include developments on/in the foreshore and marine environments and therefore consultation with the Quintet is not envisaged at this time.

2.4.4 ISLAMIC PRINCIPLES FOR THE CONSERVATION OF THE NATURAL ENVIRONMENT

The sustainable use of natural resources and the conservation of the environment are Islamic principles pertaining to the right and privilege of all people. Islamic principles hold that the protection, conservation and development of the environment and its natural resources are a mandatory duty to which every Muslim should be committed.

The Islamic trust of stewardship towards the natural environment has been summarised as follows:

- There should be no extravagance, excessive use or over-utilisation,
- There should be no illegitimate or unlawful attempts at destroying natural resources,
- There should be no damage, abuse, pollution or distortion of the natural environment in any way, and
- There should be no construction and development of the earth, its resources, elements and phenomena without the improvement of natural resources, the protection and conservation of all existing forms of life, the cultivation of land, and the reclamation and cleaning of the soil, air and water.

As ownership of all environmental elements is a common and shared right, it is the responsibility of both individuals and the ruling authorities to uphold these duties, especially in terms of prevention or treatment of damage. The State is therefore seen as having the right in Islamic law to hold individuals, organisations, establishments and companies responsible for whatever measures are necessary to protect and conserve the environment and natural resources.

2.4.5 LABOUR LAW

Royal Decree No. M/51 Labor Law (2005), is the principal legislation defining the Occupational Health and Safety rights of all workers within Saudi Arabia. The law seeks to provide the guiding principles for workers rights in terms of pay, welfare, working hours and conditions and access to healthcare. The most relevant chapters and articles are detailed below.

Part VI – Work conditions and circumstances provides the regulations for pay, working hours, leave and rest periods.

- Chapter 2 (Articles 98 – 100) sets out the guidelines for working hours, which seeks to ensure that workers do not work more that 8 hours a day (40 hours per week), either through regular working patterns, or through averaging across a three week period for shift workers. Working hours are reduced for the period of Ramadan.
- Chapter 3 (Articles 101 - 108) defines the daily and weekly resting periods for all workers, including the provision of time for prayer, minimum rest times, and meals.
- Chapter 4 (Articles 109 - 118) provides the relevant guidance for the provision of annual and sick leave, including the regulations for remuneration.

Part VIII - Protection against occupational hazards, major industrial accidents and work injuries, and health and social services, is the principal section related to the protection of the health of workers.

- Chapter 1 (Articles 121 – 126) defines the general level requirements on employers to protect workers from occupational hazards.
- Chapter 2 (Articles 127 – 131) defines the employers responsibilities for the prevention of
major accidents.

- Chapter 3 (Articles 132 – 141) defines the rights of employees in the event of work injury or workplace induce disease, including remuneration.

- Chapter 4 (Articles 142 - 148) defines the employers duties to provide health and social facilities for workers, including the provision of first aid facilities, access to medical supplies, and welfare facilities including prayer rooms. Article (148) requires employers to provide transportation for employees from their residence to work location where access to transport is limited.

2.4.6 INTERNATIONAL CONVENTIONS

Saudi Arabia has ratified, accessed or is signatory to a number of International Agreements and Conventions. Those of potential significance to the Project include:

<table>
<thead>
<tr>
<th>Date</th>
<th>International Convention</th>
<th>Accession/Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>International Convention for Safety of Life at Sea (SOLAS)</td>
<td>Accession 1985</td>
</tr>
<tr>
<td>1985</td>
<td>Vienna Convention for the protection of the Ozone Layer, Vienna</td>
<td>Accession 1993</td>
</tr>
<tr>
<td>1987</td>
<td>Montreal Protocol on substances that deplete the ozone layer and its Amendments</td>
<td>Accession 1993</td>
</tr>
<tr>
<td>1990</td>
<td>Cairo Declaration on Human Rights in Islam</td>
<td>Signed 1990</td>
</tr>
<tr>
<td>1992</td>
<td>Protocol to the International Convention on Civil Liability for Oil Pollution Damage</td>
<td>Accession 2006</td>
</tr>
<tr>
<td>2000</td>
<td>Cartagena Protocol on Biosafety to the Convention on Biological Diversity, Montreal</td>
<td>Accession 2007</td>
</tr>
</tbody>
</table>

1 "Accession" is the act whereby a state accepts the offer or the opportunity to become a party to a treaty already negotiated and signed by other states. It has the same legal effect as ratification. Accession usually occurs after the treaty has entered into force.

2 Adopted in 2000 as a supplementary agreement to the Convention on Biological Diversity and entered into force on 11 September 2003
At a regional level, the Kingdom of Saudi Arabia is a signatory to the Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution, 1978 (hereafter the Convention) which is the basic legal instrument binding the eight States of the region to coordinate their activities towards protection of their common marine environment. It requires contracting States to establish national standards, laws and regulations about protection and preservation of the marine environment to ensure that development projects and human activities do not cause any damage to the environment. 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, establishes three protocols for protecting the marine environment. These are:

- 1989, ROPME Protocol Concerning Marine Pollution Resulting from Exploration and Exploitation of the Continental Shelf;
- 1990, ROPME Protocol for the Protection of the Marine Environment Against Pollution from Land-Based Sources;
- 1978, ROPME Protocol Concerning Regional Co-operation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency.

The KSA 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.

2.5 RELEVANT ENVIRONMENTAL STANDARDS AND GUIDELINES

In addition to the relevant guidance/requirements of IFC, Equator Principles and the OECD Guidelines for Multinational Enterprises where appropriate, the Project must specifically adhere to the environmental guidelines and standards set by the RC and Ma’aden as appropriate.

As referred to in Section 2.2.1, in the event that the RCER-2010 do not specify a standard relevant to the project site, then the project shall use for reference other recognised regulations as a basis for technical justification in the following order:

- Saudi National / Presidency for Meteorology & Environment (PME);
- The U.S. Environmental Protection Agency (US EPA);
- U.S. State environmental rules and guidelines;
- European Union (EU) members environmental rules and guidelines; and
Other internationally recognised and accepted regulatory bodies.

The IFC requires that when host country regulations differ from the levels and measures presented in the IFC Environmental, Health, and Safety Guidelines, projects are expected to achieve whichever is more stringent.

The hierarchy of standards to be used for the Umm Wu’al Phosphate Project is presented in Figure 2-1.

In addition to the RCER-2010, the Project should also demonstrate compliance with the requirements as set out in the:

- Relevant Licensors’ Specification; and
- Royal Commissions Design Criteria (RCDC 2006).

2.5.1 INTERNATIONAL ENVIRONMENTAL STANDARDS

As indicated in Figure 2-1 above, where numerical standards have not been developed by the RC or the PME, the regulatory assessment criteria for the ESIA will be derived from other international standards or guidelines, including US and EU regulations. Specific reference has been made to best international practice as documented in the following guidance:

- General Environmental, Health, and Safety (EHS) Guidelines, April 30, 2007;
- Environmental, Health and Safety Guidelines for Large volume inorganic compounds manufacturing and coal tar distillation, December 10, 2007;
- Environmental, Health and Safety Guidelines for Phosphate fertilizer plants manufacturing, April 30, 2007;
2.5.2 AIR ENVIRONMENT

2.5.2.1 AMBIENT AIR QUALITY STANDARDS

The IFC General EHS Guidelines (2007) require that project air ‘emissions do not result in pollutant concentrations that reach or exceed ambient quality guidelines and standards’. Standards are those established through national legislative and regulatory processes, and guidelines refer to levels ‘primarily developed through clinical, toxicological, and epidemiological evidence’.

IFC guidelines for ambient air quality standards are provided in IFC General EHS Guidelines on Air emissions and Ambient Air Quality (April 30, 2007).

The RC defines ambient air as ‘any air on the external side of a pollution source’s boundary fence to which the public have access’. This includes industrial areas neighbouring a pollution source.

RCER-2010, Volume I outlines the Ambient Air Quality Standards (AAQS). These regulations state that “these standards do not apply to individual facilities or sources, but are considered an objective, which should meet in order to protect the health and well-being of the general public”. The standards for each pollutant consist of one or more concentration limits, each with an associated averaging period. The RCER-2010 require that the AAQS are used to establish the need for BAT analysis (refer to Section 2.5.7 and Section 6 of this ESIA).

Ambient air quality criteria and standards applicable to the Project comprise the following:

- IFC General EHS Guidelines on Air emissions and Ambient Air Quality, Table 1.1.1 WHO Ambient Air Quality Guidelines (April 30, 2007); and
- RCER-2010, Volume I, Section 2, Table 2A & 2A-1 for the AAQS.

2.5.2.2 SOURCE AIR EMISSION STANDARDS

Air quality criteria and standards used during the design and assessment of the Project comprise the following:

- IFC, EHS Guidelines, Large Volume Inorganic Compounds Manufacturing and Coal Tar Distillation (December 10, 2007):
  - Table 1 outlines the guideline air emission levels relevant to Chemical Acid Plants (including ammonia and nitrogen oxide).

- IFC, EHS Guidelines, Phosphate Fertiliser Plants Manufacturing (April 30, 2007):
  - Table 1 outlines the guideline air emission levels specific to Phosphate Fertiliser Plants (including particulate matter).

- IFC, EHS Guidelines, Nitrogenous Fertilisers (April 30, 2007):
  - Table 1 outlines the guideline air emission levels for nitrogenous fertiliser plants.

- RCER-2010, Volume I, Section 2 – Air Environment:
• Source Emission Standards (Section 2.2 and Table 2B): Table 2B lists the source emission standards that apply to individual facilities or point sources. The industry standards of relevance to the Ras Al Khair Facility:
  – General – all facilities (SN 1);
  – Ammonia Fertilisers (SN 4);
  – Ammonia Sulphate manufacturing (SN 6)
  – Combustion Facilities (SN 13);
  – Mineral Processing Plants (Non-Metallic) (SN 29); and
  – Phosphate Fertiliser (SN 33).
• General air quality regulations (Section 2.3);
• Point source emission regulations (Section 2.4 – 2.6);
• Fugitive emissions regulations (Section 2.8);
• Storage of Volatile Organic Compounds Regulations (Section 2.9);
• Loading and unloading of organic compounds regulations Section 2.10); and
• Continuous emissions monitoring (Section 2.11).
In addition, the following guidance has been referred to:
• RCDC, 2006, Chapter 2, Section 2.02 – Air Environment Criteria.

2.5.3 WATER ENVIRONMENT

2.5.3.1 AMBIENT WATER QUALITY STANDARDS
The coastal receiving water criteria for the Arabian Gulf are specified in:
• RCER-2010, Volume I, Table 3A.

2.5.3.2 WATER QUALITY CRITERIA AND STANDARDS
Water quality criteria and standards used during the design and assessment of the Project comprise, but are not limited to, the following:
• IFC, EHS Guidelines, Large Volume Inorganic Compounds Manufacturing and Coal Tar Distillation (December 10, 2007);
  Table 2 outlines the guideline effluent emission levels specific to industries in this sector.
• IFC, EHS Guidelines, Phosphate Fertiliser Plants Manufacturing (April 30, 2007):
  Table 2 outlines the guideline effluent emission levels specific to Phosphate Fertiliser Plants (including to fluoride and temperature).
• IFC, EHS Guidelines, Nitrogenous Fertilisers (April 30, 2007):
  Table 2 outlines the guideline effluent levels for nitrogenous fertiliser plants.
• RCER-2010, Volume I, Section 3 – Water Environment:
  • Coastal water quality water criteria (Section 3.1);
  • Water quality discharge standards (Section 3.2);
  • General water quality requirements (Section 3.3);
  • Industrial wastewater discharge standards (Section 3.4);

3 RCER-2010 permit coastal discharges only following prior authorisation from the Royal Commission and in compliance with the standards quoted in Volume I)
• Stormwater runoff regulations (Section 3.7);
• Sanitary Wastewater Discharge Regulations (Section 3.8);
• Marine-related discharge Regulations (Section 3.10); and
• Groundwater regulations (Section 3.11).
• Tables 3B and 3B-1: Wastewater Pre-treatment Standards at the point of discharge to the Central Wastewater Treatment Facilities.
• Table 3C lists: Water Quality Standards for Direct Discharge to Coastal Waters.

In addition, the following guidance has been referred to:
• RCDC, 2006, Chapter 2, Section 2.03 – Water Environment Criteria.

2.5.4 HAZARDOUS MATERIAL MANAGEMENT AND TRANSPORT

2.5.4.1 HAZARDOUS MATERIAL MANAGEMENT AND TRANSPORT CRITERIA AND STANDARDS

The definition of hazardous materials relating to the Ras Al Khair facility is provided by RCER-2010, Volume I, Section 4 – Hazardous Materials Management and includes hazardous wastes.

Criteria and standards relating to the classification, storage and transport of hazardous materials which were used during the design and assessment of the Project comprise the following:

• IFC, General EHS Guidelines, April 30, 2007:
  • Hazardous Materials Management (Guideline 1.5);
  • Occupational Health and Safety (Guideline 2.0);
  • Transport of Hazardous Materials (Guideline 3.5);
  • Emergency Preparedness and Response (Guideline 3.7).

• RCER-2010:
  • Classification of hazardous materials (Section 4.1);
  • Hazardous materials storage and handling regulations (Section 4.3);
  • Hazardous Material Transportation Regulations (Section 4.4);
  • Underground Storage Tank Regulation (Section 4.5); and
  • Waste Classification (Section 5.1).

In addition, the following guidance has been referred to:

2.5.5 WASTE MANAGEMENT

2.5.5.1 WASTE CLASSIFICATION

Criteria and standards relevant to waste classification and management used during the design and assessment of the Project comprise the following:
• IFC General EHS Guidelines (April 30, 2007), Guideline 1.6 Waste Management;
• RCER-2010, Volume 1, Section 5 – Waste Management;
• Waste Classification (Section 5.1);
• Waste Transportation Regulations (Section 5.3); and
Municipal Waste Collection (Section 5.5).

In addition, the following guidance have been referred to:

- RCDC, 2006, Chapter 2, Section 2.04 – Criteria for Miscellaneous Activities – Hazardous Material Handling and Storage Criteria; Hazardous Materials Transportation; and
- RCDC, 2006, Chapter 2, Section 2.05 – Solid Waste Management.

2.5.6 NOISE

2.5.6.1 ENVIRONMENTAL NOISE STANDARDS

Noise criteria and standards used during the design and assessment of the Project comprise, but are not limited to, the following:

- RCER-2010, Volume I, Section 7 – Noise.

In addition, the following guidance have been referred to:

- RCDC, 2006, Chapter 2, Section 2.06 – Noise Control Criteria.

2.5.7 OTHER CONSIDERATIONS

2.5.7.1 BEST AVAILABLE TECHNIQUES

The EU Directive on Integrated Pollution Prevention and Control (IPPC) introduces the definition of Best Available Techniques (BAT). In the Kingdom of Saudi Arabia, the Royal Commission Environmental Regulations specifies that a BAT assessment must be performed for new, reconstructed and modified facilities with:

a) Point sources emitting greater than 100 tonnes/yr before control of any of the parameters listed in RCER-2010, Volume I, Table 2A.
b) Any source emitting greater than 10 tonnes/yr before control of any hazardous air pollutants identified in RCER-2010, Volume I, Table 2C.
c) Any industrial wastewater pre-treatment prior to discharge to the Industrial Wastewater Treatment Plant.

The RCER-2010 requires that all facilities utilise Best Available Techniques (BAT) for environmental control. It defines this as:

‘the application at facilities of the most effective and advanced production processes, methods/technologies or operational practices to prevent and, where that is not practicable, to reduce emissions or discharges. BAT must as a minimum achieve emission or discharge standards in these Regulations taking into account energy, environmental and economic impacts and other costs to the facility.’

The RC may request BAT Analysis to be conducted on one or more technologies proposed within the project. The requirement for BAT analysis and the processes to be followed are detailed in Appendix B of RCER-2010 Vol II.

As part of the assessment of alternatives within the ESIA, best available techniques will be considered. The following BAT reference documents (BREFs) produced by the European Commission are considered of relevance to the project:

- European Commission (2009) Reference Document on BAT for Energy Efficiency; and
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3.0 CONSIDERATION OF ALTERNATIVES

3.1 INTRODUCTION

This Section firstly provides an overview of the justification for the Umm Wu’al Phosphate Project and associated proposed facilities at Ras Al Khair and then describes various feasible project and design alternatives considered. It outlines how potential social and environment impacts are considered for the Front End Engineering Design (FEED) phase and provides justification for the selected alternatives, with a focus on the alternatives where social and environment outcomes are a determining factor in selecting the preferred alternative. Consideration is given to the application of Best Available Techniques (BAT) to the Project in accordance with the requirements of the Royal Commission Environmental Regulations (RCER) 2010 in addition to International Finance Corporation (IFC) Performance Standards. Through their Performance Standard 3, the IFC outlines requirements for Resource Efficiency (Greenhouse Gases and Water Consumption) and Pollution Prevention (General, Hazardous Materials Management and Pesticide Use and Management). The objectives for this Performance Standard are as follows:

- To avoid or minimise adverse impacts on human health and the environment by avoiding or minimising pollution from project activities;
- To promote more sustainable use of resources, including energy and water; and
- To reduce project-related greenhouse gas (GHG) emissions.

The RCER-2010 specify that a BAT assessment must be performed for new, reconstructed and modified facilities with:

a) Point sources emitting greater than 100 tonnes/yr before control of any of the parameters listed in RCER-2010, Volume I, Table 2A.

b) Any source emitting greater than 10 tonnes/yr before control of any hazardous air pollutants identified in RCER-2010, Volume I, Table 2C.

c) Any industrial wastewater pre-treatment prior to discharge to the Industrial Wastewater Treatment Plant.

RCER-2010 also requires that all facilities utilise BAT for environmental control. It defines this as:

‘the application at facilities of the most effective and advanced production processes, methods/technologies or operational practices to prevent and, where that is not practicable, to reduce emissions or discharges. BAT must as a minimum achieve emission or discharge standards in these Regulations taking into account energy, environmental and economic impacts and other costs to the facility.’

The project and design alternatives considered for the proposed Ras Al Khair Industrial Complex include:

- “Do Nothing” option;
- Location alternatives;
- Configuration and alternative production options; and
- Pollution control alternatives.

Following the consideration of these alternatives, the selected Project elements are developed to FEED. Section 4 Detailed Description and Layout of the Proposed Development provides a detailed description of the ensuing Project design option which was brought forward to the environmental and social impact assessment process.
3.2 PROJECT JUSTIFICATION

One of the priorities of the Ninth National Development Plan (2010-2014), produced by the Ministry of Economy and Planning, and other government strategy such as Vision 2020 is the diversification of the industrial sector and diversification of exports to reduce the Kingdom’s dependence on hydrocarbon extraction and refinement. The Kingdom of Saudi Arabia (KSA) has some of the largest phosphate reserves in the world and the growth of the phosphate industry is likely to play a pivotal role in national development. The Saudi Arabian Mining Company (Ma’aden) was formed by Royal decree in 1997 to facilitate the development of Saudi Arabia’s mineral resources. Ma’aden is a key strategic organisation which has been tasked with the primary purpose of developing the mining industry and leading the privatisation of the mining sector within the KSA. Current forecasts of market conditions indicate global demand for fertiliser products has increased supported by the development of the expanding economies in the larger developing countries (such as India, China, and Brazil) along with the sustained demands of the United States and Europe.

Figure 3-1 below provides a diagram showing the global fertilizer trade-flow, production and consumption. It is based on 2010 fertilizer trade flows above the threshold of 400,000 product tonnes, the main countries producing fertilizer products and raw materials in 2011, and the fertilizer consumption in main consumption countries for years: 2010/11 to 2015/16 (International Fertiliser Industry Association 2013).
Figure 3-1: Global fertiliser trade-flow, production and consumption (International Fertiliser Industry Association 2013).
3.3 DO-NOTHING OPTION

Not developing the Umm Wu’al Phosphate Project constitutes the ‘Do-Nothing’ option. In such a scenario, the Project would not adversely influence the current environmental conditions, however the economic benefits of developing the Project would not be realised. The development of the mining and mineral industry is one of the key strategies for diversifying the economy of Saudi Arabia. The Do-Nothing Option will not help growth and diversity in the Saudi economy, given that a significant percentage of the Kingdom’s GDP is based on the development and export of oil and natural gas resources. This dependence reduces the resilience of the economy during times of global financial instability, such as during the Global Recession of 2009. Industrial diversification is an imperative to ensure that the Kingdom maintains economic growth.

Therefore, and as detailed in the following Sections of this Environmental and Social Impact Assessment (ESIA), if the Project follows internationally accepted protocols, relevant legislation, as well as applying identified project-specific mitigation and monitoring measures, the Project will be developed with an acceptable level of environmental and social impacts, and will significantly contribute to the Kingdom’s economy.

3.4 LOCATION ALTERNATIVES

A desktop site selection study was commissioned by Ma’aden in 2002 to assess four locations (Ain Dar, Ras Abu Qamis, Jubail and Ras Qaryah) for the establishment of a downstream industrial area to accommodate phosphate and aluminium processing plants (SAPL 2002). The study assessed the suitability of the locations based on a financial review and assessment of environmental impacts. Following this a further location (Ras Al Khair, formally known as Ras Az Zawr) was included and assessed.

The assessment was based on the establishment of an industrial facility which would support an aluminium refinery (1.4 Mtpa alumina) and smelter (0.6 Mtpa aluminium), and a phosphate complex (2.9 Mtpa); and assumed a doubling in production capacity over the first 10 years. The risks and costs associated with sites were compared against the following criteria: Land Availability; Geotechnical; Infrastructure; Energy Availability; Water Availability; Waste Disposal; Institutional, Training and Monitoring requirements; and Environmental and Social Impacts.

The assessment results is summarised in Table 3-1 below:

<table>
<thead>
<tr>
<th>Location</th>
<th>Site Description</th>
<th>Site Suitability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ain Dar</td>
<td>Greenfield site located inland c.100 km southwest of Dammam. The proposed industrial site is 56 km south of the Ain Dar village (pop. 2,500) and 23 km southwest of the Saudi Cement Co cement works.</td>
<td>Disregarded due to the large distance (c.100 km) from the Arabian Gulf leading to high seawater supply cost.</td>
</tr>
<tr>
<td>Ras Abu Qamis</td>
<td>Greenfield site situated on the Arabian Gulf coast near the KSA/Qatar border. The industrial site would be positioned near the existing township on the Ras Abu Qamis coastline.</td>
<td>Disregarded due to the lack of existing infrastructure and remoteness to reliable power services. Shoreline also adjacent to Ghaghah Island, which is a National Commission for Wildlife Conservation and Development protected area and proposed nature reserve.</td>
</tr>
</tbody>
</table>
### Location | Site Description | Site Suitability
---|---|---
Jubail | The industrial city of Jubail is located on the Arabian Gulf coast c.50 km northwest of Dammam. This site has a large network of infrastructure and existing industrial facilities. The industrial site would be located within Industrial Park West, a new area to be fully commissioned by 2007, adjacent to the existing industrial city. | Disregarded as the site would not be available until 2007. Other issues included: Potential 'fatal flaw' regarding supply of adequate sea water, long connections to port and waste areas, space restrictions for secondary industries using hot metal, and high ongoing operating cost and restricted strategic freedom.

Ras Qaryah | The Ras Qaryah site is located on the Arabian Gulf coastline, c.90 km south of Dammam. Saudi Aramco (SA) have a power plant and the Saline Water Conversion Company also run a desalination plant at the proposed site. Dhulum, a village of about 2,500 residents, is located on the coast about 6 km south of the site. | Disregarded due to the restricted through flow of sea water which will likely lead to environmental issues, the requirement for a complicated sea water intake design due to seasonal issues with jellyfish, lack of clarity regarding transfer of site ownership and rights of way, and no port development possible even for smaller vessels.

Ras Al Khair | Located on the Arabian gulf coast, in an undeveloped desert area in the Northeast region of Saudi Arabia. This site is situated c.90 km northwest of Jubail has been earmarked for the development of a large 2,350 MW SWCC power and desalination plant. | Preferred location due to availability of land, seawater, power generation and desalinated water. Also it is a suitable location for the construction of a large port which can meet the needs of the developments. Environmental and Social issues are also considered to be limited.

The site location at Ras Al Khair was considered the most suitable for cost and environmental reasons. Since the assessment was undertaken the Ras Al Khair peninsula has been developed by Ma’aden Phosphate Company (MPC) and Ma’aden Aluminium Company (MAC) for the production of phosphate and aluminium. This has led to the designation of the area as an industrial city with controlling jurisdiction on environmental matters transferring from the Presidency of Meteorology and Environment (PME) to the Royal Commission. See Section 2 Policy, Legal and Administrative Framework for more information. The establishment of the Ras Al Khair Industrial Port (by SEAPA), the North-South railway line (by SAR) and the other infrastructure and utilities, to support the MPC and MAC facilities has further lead to the Ras Al Khair site to become an ideal location for the development of the facilities required for this Project. The infrastructure constructed as part of these previous projects will be utilised where possible to minimise construction and operating costs and utilising this existing industrial area will minimise environmental and social impacts in comparison to developing a green field site.

### 3.5 SITE LAYOUT ALTERNATIVES

With Ras Al Khair Industrial City identified as the preferred option for the development of the Project facilities, Jacobs undertook a location study to assess the feasibility of constructing the new plants and facilities on the existing Ma’aden Phosphate Company (MPC) complex. The study assessed the layout options to identify a location which would allow the use of the existing available land without impacting on the current operations and a planned expansion of the existing DAP plants. The benefits, advantages, disadvantages and associated risks of locating new plant and facilities on the MPC complex where identified including a potential for reduction in OPEX costs and utilisation / development of existing utilities.

The existing MPC complex covers an area approximately 1.9km x 1.5km and contains processing plants for Ammonia, Di-Ammonium Phosphate (DAP), Phosphoric Acid, Sulphuric Acid, and Desalination. The location of the new facilities within the MPC complex would allow for the integration of the new plants with the existing infrastructure, reducing the overall construction and operating costs of the Project. However, careful consideration must be given to the environmental and social impacts of developing the site within the existing MPC complex, including any potential for increased water demand and the need for additional water treatment facilities.

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Project Name: UMM WU’AL PHOSPHATE PROJECT

Ma’aden Phosphate Company (MPC) and Ma’aden Aluminium Company (MAC) have developed the Ras Al Khair peninsula for the production of phosphate and aluminium. The area has been designated as an industrial city with controlling jurisdiction on environmental matters, and the establishment of the Ras Al Khair Industrial Port (by SEAPA), the North-South railway line (by SAR) and other infrastructure and utilities, have supported the development of the MPC and MAC facilities. The infrastructure constructed as part of these previous projects can be utilised to minimise construction and operating costs and reduce environmental and social impacts compared to developing a green field site.

The site location at Ras Al Khair was considered the most suitable for cost and environmental reasons. Since the assessment was undertaken the Ras Al Khair peninsula has been developed by Ma’aden Phosphate Company (MPC) and Ma’aden Aluminium Company (MAC) for the production of phosphate and aluminium. This has led to the designation of the area as an industrial city with controlling jurisdiction on environmental matters transferring from the Presidency of Meteorology and Environment (PME) to the Royal Commission. See Section 2 Policy, Legal and Administrative Framework for more information. The establishment of the Ras Al Khair Industrial Port (by SEAPA), the North-South railway line (by SAR) and the other infrastructure and utilities, to support the MPC and MAC facilities has further lead to the Ras Al Khair site to become an ideal location for the development of the facilities required for this Project. The infrastructure constructed as part of these previous projects will be utilised where possible to minimise construction and operating costs and utilising this existing industrial area will minimise environmental and social impacts in comparison to developing a green field site.

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The existing MPC complex covers an area approximately 1.9km x 1.5km and contains processing plants for Ammonia, Di-Ammonium Phosphate (DAP), Phosphoric Acid, Sulphuric Acid, and Desalination. The location of the new facilities within the MPC complex would allow for the integration of the new plants with the existing infrastructure, reducing the overall construction and operating costs of the Project. However, careful consideration must be given to the environmental and social impacts of developing the site within the existing MPC complex, including any potential for increased water demand and the need for additional water treatment facilities.
Acid, a Power and Desalination Plant (PDP), and also a number of administrative and storage buildings. The plot is fully serviced by an existing road layout and utility networks. The site is split into high and low security zones in the Northern and Southern halves of the complex respectively. New rail sidings are required on the Eastern side of the complex linking it to the existing port and to the Umm Wu’al Mine site in the North.

The study concluded that the new plants and facilities can be situated on the current MPC complex, utilising areas of the existing low security zone to the south, without affecting the existing MPC operations or plans for a potential future DAP expansion (proposed additional 2 Mtpa). The study identified numerous challenges associated with construction of the Project facilities at the existing MPC complex, however all of these can be managed or designed-out and therefore the impact on the existing operations was considered to be minimal. Numerous advantages to MPC were identified including the opportunity to share OPEX costs, reducing the operating cost of DAP production by $45/tonne (assuming 30% increase in fixed costs), as well as operational and storage benefits. Overall it was recommended that the Project facilities be constructed at the existing MPC complex.

### 3.6 POLLUTION CONTROL OPTIONS (AMMONIA)

The Ammonia Plant is a stand-alone plant, with its own facilities, which is designed to produce Liquid Ammonia from Natural Gas. It is comprised of the following sections: Natural Gas Desulphurisation and Compression, Steam Reforming, CO Conversion, CO$_2$ Removal, Methanation and Ammonia Synthesis. Secondary plant objectives include Waste Heat Recovery, Ammonia Refrigeration and Purge Gas, and Hydrogen Recovery. The raw materials required for the process are natural gas, process air and desalinated water. In addition, a number of catalysts are required. Natural gas is to be sourced from Saudi Aramco for use as a feedstock and fuel. Process air (nitrogen) will be sourced from local companies via tankers.

The process of natural gas reforming with steam and air is the simplest and most efficient way of ammonia synthesis gas production. The European Fertiliser Manufacturers Association (EFMA), BAT booklet No.1 (2000) has compared natural gas reforming, heavy oil and coal gasification to provide the following approximate relative consumption figures, based on modern technological standards for each route, at European economic conditions:

<table>
<thead>
<tr>
<th></th>
<th>Natural gas</th>
<th>Heavy oil</th>
<th>Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy consumption</td>
<td>1.0</td>
<td>1.3</td>
<td>1.7</td>
</tr>
<tr>
<td>Investment cost</td>
<td>1.0</td>
<td>1.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Production cost</td>
<td>1.0</td>
<td>1.2</td>
<td>1.7</td>
</tr>
</tbody>
</table>

During the Feasibility Study Pre-works two varying capacities of ammonia plant were assessed, namely a 3,300tpd and 2,200tpd. Studies into the potential yield of the upstream processing units and cost analysis of production volumes determined that the 3,300tpd processing plant would provide sufficient volumes for use as a feedstock in the production process of the DAP/NPK plants and would be the most cost effective option, allowing further export of ammonia as a product. This plant rated capacity is therefore based on one line of 3,300tpd (as 99.8% NH$_3$), with an on stream factor of 330 days per year and 24 hours operation.

The primary reformer stack meets the Royal Commission (RC) threshold for the application of Best Available Technologies (BAT) analysis as outlined in Clause 1.1.12 of RC Environmental Regulation (RCER) 2010, Volume I: (a) Point sources emitting greater than 100 t/y before control of any of the parameters listed in RCER-2010, Volume I, Table 2A. Flue gas will be discharged from the primary reformer stack into the atmosphere. The main constituent in the flue gas which requires pollution control is Nitrogen Oxide (NOx). Sulphur Dioxide (SO$_2$), Carbon Monoxide (CO) and Carbon Dioxide (CO$_2$) are removed as part of the ammonia synthesis process. The BAT analysis for pollution control of these emissions is provided in the Sections below.
Further pollution control measures for the management of industrial effluents are also summarised. The anticipated emission volumes from the auxiliary boiler stack are below the thresholds provided in RCER 2010 and therefore have not been included in the assessment below.

3.6.1 NOX CONTROL

Several techniques are available for the control of NOx emissions from the Ammonia Plant reformer boilers: Low NOx Burner; Flue Gas Recirculation; Ultra-Low Nitrogen Fuels; Bias Burner Firing; Selective Non-Catalytic Reduction; and Selective Catalytic Reduction.

Low NOx Burner

The use of low NOx burners is the most common form of NOx reduction in boilers. Low NOx burners provide a stable flame that has several different zones. For example, the first zone can be primary combustion. The second zone can be Fuel Reburning (FR) with fuel added to chemically reduce NOx. The third zone can be the final combustion in low excess air to limit the temperature. This can be one of the least expensive pollution prevention technologies with high Destruction or Removal Efficiency (USEPA 1999). This is applicable to the Project.

Flue Gas Recirculation

Flue Gas Recirculation involves the recycling of part of the exhaust gas back in to the boiler via the furnace hopper or the burner wind box by means of an additional fan. Recirculation of cooled flue gas reduces the temperature of the flame by diluting the oxygen content of combustion air and by causing heat to be diluted in a greater mass of flue gas. Heat in the flue gas can be recovered by a heat exchanger. This reduction of temperature lowers the NOx concentration that is generated. The use of Flue Gas Recirculation is feasible in this case but its application has a significant capital cost.

Bias Burner Firing

Bias Burner Firing requires the lower burners to be fired with a much higher fuel content than the upper burners and is applicable to large boilers only. This variation in fuel content allows air staging which limits the oxygen content in the lower burners. In some cases, it may be beneficial entirely to restrict fuel flow to the top burners, allowing only air from the lower burners to pass through, which results in an even more significant effect. However this technique is very boiler-specific (very large size boilers with vertical furnace arrangement and multiple rows of burners) and is not practical for application to the size of the boiler involved in the project and is eliminated on technical grounds.

Selective Catalytic Reduction

Selective Catalytic Reduction (SCR) is a post-combustion treatment which uses a catalyst to react injected ammonia to chemically reduce NOx. It can achieve up to a 94% destruction or removal efficiency and is one of the most effective NOx abatement techniques (USEPA 1999). The catalyst creates a surface for reacting the NOx and ammonia, and allows for the reaction to occur within normal boiler flue gas temperature ranges. SCR has historically used precious metal catalysts, but can now also use base-metal and zeolite catalysts. The base-metal and zeolite catalysts operate at much different temperatures than the precious metal catalysts. The active ingredient in most NOx catalysts is vanadium pentoxide ($V_2O_5$). However, this technology has a high capital cost and requires a substantial amount of space for the equipment. In addition, catalysts have a finite life in flue gas and some ammonia “slips through” without being reacted. There is also the requirement for the constant supply of ammonia. SCR is similar to Selective Non-Catalytic Reduction (SNCR), in that urea solutions or ammonia is reacted with NOx forming nitrogen and water. The key difference between SCR and SNCR systems is that ammonia in injected upstream of a catalyst unit, which accelerates the reaction and allows the reaction to proceed in a significantly cooler environment.

Selective Non-Catalytic Reduction

Selective non-catalytic reduction (SNCR) is a post-combustion treatment in which ammonia as a reducing agent is injected into the flue gas stream. As an alternative, urea solutions can be used as a source of ammonia, converted to ammonia either externally or in-situ. The ammonia
reacts with the oxides of nitrogen, forming nitrogen and water. Without the benefit of a catalyst, the reaction temperature is very high (760 to 815°C), which makes SCNR only effective in a relatively high, narrow temperature range. The ammonia injected must also be delivered at an appropriate ratio to the amount of NOx present. This is not a widely used technique for boiler applications due to typical temperature of boiler exhausts. Furthermore where injection of ammonia is planned at a combustion zone with an appropriate temperature, a further complication is the continuously changing position of the zone with various boiler load variations. The capital and operating costs for this NOx control technique is very high. In addition, the Project will need a supply of ammonia for the lifetime of the project.

Summary of Options

Table 3-2 below provides a summary assessment of the NOx control options for steam boilers in the ammonia plant. Scores range from 1-3, with 3 indicating the most preferred, 1 the least.

<table>
<thead>
<tr>
<th>NOx reduction</th>
<th>Waste generation</th>
<th>Chemical / Energy Use</th>
<th>Footprint</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low NOx Burner</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Flue Gas Recirculation</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>SNCR</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>SCR</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>

The analysis concludes that the most suitable NOx control measure for the Ammonia Plant is the use of low NOx burners. While SCR and SNCR provide better recovery from these processes than low NOx burners, the high capital costs and the large footprints required for these units reduce their viability.

3.6.2 SOx CONTROL

Emissions of SOx from the primary reformer stack are considered to be negligible (<1 ppm). The production process will use sweet natural gas as a feed stock and fuel which is considered to be a low sulphur fuel. Additionally a desulphurisation unit shall be included in the beginning of the steam reforming process to remove any remaining sulphur compounds from the feed products. The catalyst used in the steam reforming process is highly sensitive to any sulphur compounds so these compounds need to be removed. To achieve the natural gas is preheated to allow any sulphur compounds to be hydrogenated to $\text{H}_2\text{S}$ using a catalyst, and then finally adsorbed on pelletised zinc oxide and removed.

3.6.3 CO AND $\text{CO}_2$ CONTROL

Carbon Monoxide (CO), produced from methane reforming in the primary reformer, reacts with steam in the secondary reformer when cooled gas enters the high-temperature shift converter. The aim of the CO shift operation is to maximise the conversion of CO into Carbon Dioxide ($\text{CO}_2$) and the generation of hydrogen via an exothermic catalytic reaction with steam. $\text{CO}_2$ is a by-product of this reaction. As with all Ammonia Production units, large quantities of $\text{CO}_2$ are expected to be emitted from the Ammonia Plant at Ras Al Khair.

$\text{CO}_2$ emissions associated with the Project could result in negative impacts upon global greenhouse emissions. As described in Section 2 Policy, Legal and Administrative Framework, the proposed Project is subject to the IFC Performance Standards and the Equator Principles, and as such, this section considers IFC Performance Standard 3 (Resource Efficiency and Pollution Prevention) and Equator Principle 2 (Environmental and Social Assessment) which include requirements for the analysis of greenhouse gases (GHGs).

The Equator Principles require alternative analysis to evaluate less GHG intensive alternatives where a Project is expected to emit more than 100,000 tonnes of $\text{CO}_2$ equivalent annually. For all projects, the IFC requires the client to consider “alternatives and implement technically and financially feasible and cost-effective options to reduce project-related GHG emissions during the design and operation of the project”.

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**Jacobs Doc Nº.** 60-R400-WH/G.06f/0072

**Date** August 2013
Both the IFC and the Equator Principles require CO\textsubscript{2} emissions to be quantified annually where a Project is expected to emit more than 25,000 (IFC) or 100,000 (EPs) tonnes of CO\textsubscript{2} equivalent annually. According to the Equator Principles (Annex A), quantification of GHGs should be conducted in accordance with internationally recognised methodologies and good practice—for example, the GHG Protocol. However, as the proposed Ammonia Plant will be of similar size and design to that of the existing plant, the emission level recorded for the CO\textsubscript{2} vent is considered as a good estimate of the proposed emission (167,199 kg/hr CO\textsubscript{2}). As this exceeds the thresholds noted above, an analysis of available technologies to reduce CO\textsubscript{2} emissions has been undertaken and is outlined below. This will require development by the FEED Contractor for the Ammonia Plant.

The Ras Al Khair Ammonia Plant will be designed to minimise the amount of waste requiring treatment. In the Steam Reforming Section natural gas is converted to a mixture of CO\textsubscript{2} and CO in two reformers, which reduce the methane content. The process gas is routed to the CO Conversion Section. Flue gas is emitted from a primary reformer stack. The CO\textsubscript{2} - CO mixture is cooled and the CO converted to CO\textsubscript{2} by action of steam and iron & copper catalyst in a two step process. In Ammonia production, the CO\textsubscript{2} is removed in a chemical or physical absorption process (as it is a poison for the Ammonia Synthesis catalyst). The existing Ammonia Plant at Ras Al Khair uses an activated MDEA (methyldiethanolamine) solution to remove CO\textsubscript{2} from the process gas. The CO\textsubscript{2} enriched MDEA solution is flashed removing the CO\textsubscript{2} as gas and allowing the MDEA solution to be stripped of impurities and returned to the Absorber Column. The CO\textsubscript{2} gas is emitted via a stack. Table 3-3 provides a list of the solvents used in chemical absorption processes, which are mainly aqueous amine solutions.

### Table 3-3: Overview of Some CO\textsubscript{2} Removal Processes

<table>
<thead>
<tr>
<th>Process name</th>
<th>Solvent/reagent + additives</th>
<th>CO\textsubscript{2} in treated gas (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical absorption systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purisol (NMP)</td>
<td>N-methyl-2-pyrrolidone</td>
<td>Less than 50</td>
</tr>
<tr>
<td>Rectisol</td>
<td>Methanol</td>
<td>Less than 10</td>
</tr>
<tr>
<td>Fluorsolv</td>
<td>Propylene carbonate</td>
<td>Function of pressure</td>
</tr>
<tr>
<td>Selexol</td>
<td>Polyethylene glycol dimethyl ether</td>
<td>Function of pressure</td>
</tr>
<tr>
<td>Processes with chemical reagents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEA</td>
<td>Water/monoethanolamine (20 %)</td>
<td>Less than 50</td>
</tr>
<tr>
<td>Promoted MEA</td>
<td>Water/MEA (25 – 30 %) + amine guard</td>
<td>Less than 50</td>
</tr>
<tr>
<td>Benfield</td>
<td>Water/K\textsubscript{2}CO\textsubscript{3} (25 – 30 %) + DEA, etc.</td>
<td>500 – 1000</td>
</tr>
<tr>
<td>Vetrocoke</td>
<td>Water/K\textsubscript{2}CO\textsubscript{3} + As\textsubscript{2}O\textsubscript{3} + glycine</td>
<td>500 – 1000</td>
</tr>
<tr>
<td>Catacarb</td>
<td>Water/K\textsubscript{2}CO\textsubscript{3} (25 – 30 %) + additives</td>
<td>500 – 1000</td>
</tr>
<tr>
<td>Lurgi</td>
<td>Water/K\textsubscript{2}CO\textsubscript{3} (25 – 30 %) + additives</td>
<td>500 – 1000</td>
</tr>
<tr>
<td>Carsol</td>
<td>Water/K\textsubscript{2}CO\textsubscript{3} + additives</td>
<td>500 – 1000</td>
</tr>
<tr>
<td>Flexsorb HP</td>
<td>Water/K\textsubscript{2}CO\textsubscript{3}amine promoted</td>
<td>500 – 1000</td>
</tr>
<tr>
<td>Alkazid</td>
<td>Water/K\textsubscript{2}methylaminopropionate</td>
<td>To suit</td>
</tr>
<tr>
<td>DGA</td>
<td>Water/diglycolamine (60 %)</td>
<td>Less than 100</td>
</tr>
<tr>
<td>MDEA</td>
<td>Water/methyl diethanolamine (40 %) + additives</td>
<td>100 – 500</td>
</tr>
<tr>
<td>Hybrid systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfinol</td>
<td>Sulphones/DIPA</td>
<td>Less than 100</td>
</tr>
<tr>
<td>TEA-MEA</td>
<td>Triethanolamine/monoethanolamine water/sulpholane/MDEA</td>
<td>Less than 50</td>
</tr>
</tbody>
</table>

Source: European Commission, 2000
The IPPC BAT (Best Available Techniques) Reference Document (BREF) entitled “Reference Document on Best Available Techniques for the Manufacture of Large Volume Inorganic Chemicals – Ammonia, Acids and Fertilisers, 2007” states the following with regards CO₂ emissions:

“The CO₂ formed in the gasification process and in the shift conversion process is normally removed by scrubbing with a solvent. In the process, mechanical energy is needed to circulate the solvent and, in most cases, heat is needed to regenerate the solution. In this way almost pure CO₂ is recovered which is typically vented, although it could be used in other processes, e.g. urea production. CO₂ removal systems using improved solvents consume substantially less energy than other systems. The energy consumption of a CO₂ removal system also depends on the way it is incorporated in the ammonia plant and is affected by the syngas purity and CO₂ recovery.”

As an alternative to the direct emission of CO₂ to the atmosphere, its use in the production of urea or methanol would require significant capital investment from Ma’aden and/or others to include the construction of unplanned urea or methanol production facilities adjacent to / within the MPC Complex. Other possible uses for the CO₂ from the Ammonia Plant could include selling the CO₂ for secondary oil recovery, pumping it down oil wells where it would increase the output of oil, or sequestration through pumping the CO₂ into depleted gas fields or into deep saline aquifers. This again would require significant capital investment.

The Ma’aden Ammonia Plant proposes to use MDEA or MEA to remove CO₂. As part of the works the FEED contractor and Vendor will optimise the CO₂ removal, taking into consideration the best available technologies. The capture and utilisation of CO₂ for use in other Projects should be considered however this will require high capital investment from Ma’aden or other investors.

3.6.4 ANALYSIS OF TECHNOLOGIES (AMMONIA)

To further assess the application of BAT for the Ammonia Plant,

Table 3-4 below provides a comparison between the proposals and the BAT Reference Document (BREF) which includes internationally expected BAT specifically for Ammonia Plants:


While the above BAT reference document does not set legally binding standards, they are designed to give a basis for the guidance of industry.

Table 3-4: Comparison of proposals and international BAT guidance – Ammonia Plant

<table>
<thead>
<tr>
<th>BAT Reference Document (BREF)</th>
<th>Proposals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. BAT for new installations is to apply one of the following plant concepts:</td>
<td>The proposed Ammonia Plant at Ras Al Khair is design to produce liquid ammonia from natural gas via reduced primary reforming (1.b) and synthesis gas generation by CO conversion, CO₂ removal and methanation.</td>
</tr>
<tr>
<td>a. Conventional reforming;</td>
<td>This plant rated capacity is based on one line of 3,300tpd (as 99.8% NH₃), with an onstream factor of 330 days per year and 24 hours per day operation.</td>
</tr>
<tr>
<td>b. Reduced primary reforming; or</td>
<td></td>
</tr>
<tr>
<td>c. Heat exchange autothermal reforming.</td>
<td></td>
</tr>
</tbody>
</table>
2. BAT is to apply one or a combination of the following techniques, and to achieve the NOx concentration emission levels given below:

   a. Selective Non-Catalytic Reduction (SNCR) at the primary reformer, if the furnace allows the required temperature/retention time windows;
   b. Low NOx burners;
   c. Ammonia removal from purge and flash gases; and
   d. Low temperature desulphurisation for autothermal heat exchange reforming.

Emission levels:

   NOx emissions for advanced conventional reforming processes and processes with reduced primary reforming: 90-230 mg/Nm³ (Note 1).

Note 1: Low end of the range – best existing performers and new installations.

3. BAT is to apply a combination of the following techniques and to achieve a net energy consumption of levels between 27.6 - 31.8 GJ(LHV) per tonne NH₃ (under normal operating conditions):

   a. Extended preheating of the hydrocarbon feed;
   b. Preheating of combustion air;
   c. Installation of a second generation gas turbine;
   d. Modifications of the furnace burners to assure an adequate distribution of gas turbine exhaust over the burners;
   e. Rearrangement of the convection coils and addition of additional surface;
   f. Pre-reforming in combination with a suitable steam saving project;
   g. Improved CO₂ removal;
   h. Low temperature desulphurisation;
   i. Isothermal shift conversion;
   j. Use of smaller catalyst particles in ammonia converters;
   k. Low pressure ammonia synthesis catalyst;
   l. Use of a sulphur resistant catalyst for shift reaction of syngas from partial oxidation;
   m. Liquid nitrogen wash for final purification of the synthesis gas;
   n. Indirect cooling of the ammonia synthesis reactor;
   o. Hydrogen recovery from the purge gas of the ammonia synthesis; and
   p. Implementation of an advanced process control system.

Current designs include for low NOx burners (2.b) and Ammonia removal from purge and flash gases (2.c).

SNCR (2.a) has not been included due to the high construction costs.

Low temperature desulphurisation (2.d) has not been included due to the reduced pickup and high construction costs.

The FEED design has not been undertaken for the Ammonia Plant however, an emission value of 43 ng/J (0.1 lb/MBTU) gas fired will aim to be achieved as per RCER 2010 guidelines. This equates to approximately 159mg/Nm³ which is within the BAT range of 90-230 mg/m³.

The plant shall be designed to achieve the guideline energy consumption values using techniques outlined in: 3.a, 3.b, 3.e, 3.g, 3.j, 3.k, 3.o, 3.p.

No gas turbine is included in the design so technique (3.c) is not possible.

The auxiliary boiler must be boiling continuously to allow for an immediate power supply during emergency situations for safe shutdown of the plant. The excess steam is sent to a 22MW electric generator to supply power to the network (3.f).

The process will utilise Johnson Matthey 74 catalyst for smaller catalyst particles in the ammonia converter (3.j).

The design includes a lower pressure ammonia synthesis catalyst on the first loop only (3.k). A higher pressure catalyst shall be used on the second loop.

Design does not require a liquid nitrogen wash for final purification of the synthesis gas (3.m); or indirect cooling of the ammonia synthesis reactor (3.n).

The current estimations show a net energy consumption of approximately 28.9 – 29.7 GJ (LHV) per tonne NH₃ (under normal operating conditions) and 30.6 GJ(LHV) per tonne NH₃ (worst case operating conditions). These values are within the stated guideline values.
<table>
<thead>
<tr>
<th>BAT Reference Document (BREF)</th>
<th>Proposals</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. BAT for partial oxidation is to recover sulphur from flue-gases, e.g. by applying a combination of Claus unit and tail gas treatment and to achieve BAT associated emission levels and required regulation limits.</td>
<td>Design does not include for recovery of sulphur from flue-gases. The SOx from the reformer and boiler depends on the level of sulphur in the natural gas. Present stated levels will result in less than 1ppm SO\textsubscript{2} which is acceptable.</td>
</tr>
<tr>
<td>5. BAT is to remove NH\textsubscript{3} from process condensates, e.g. by stripping.</td>
<td>Design to include high pressure stripping at 40 bar.</td>
</tr>
<tr>
<td>6. BAT is to recover NH\textsubscript{3} from purge and flash gases in closed loop.</td>
<td>Design to include recovery of NH\textsubscript{3} from purge and flash gases in a closed loop.</td>
</tr>
<tr>
<td>7. BAT is to minimise the emissions to air during startup/shutdown and other abnormal operating conditions using options such as:</td>
<td>Design includes a flare for reducing the emissions to air for startup/shutdown and other abnormal operating conditions. The flare operating requirements are estimated as follows:</td>
</tr>
<tr>
<td>a. Minimisation of the startup and shutdown time by using interlocks and a logical operational sequence;</td>
<td>• One full day (24 hours) for start up (half rate of normal operation);</td>
</tr>
<tr>
<td>b. Use of recycled inert gases for preheating;</td>
<td>• One half day (12 hours) for shutdown (half rate of normal operation); and</td>
</tr>
<tr>
<td>c. Application of maximum allowed prudent preheat rates for equipment and catalysts;</td>
<td>• During emergency operations (when reformer is not operational) for safe shutdown (timings as per normal shutdown).</td>
</tr>
<tr>
<td>d. Reduction of the low temperature shift catalyst with an inert gas carrier;</td>
<td>Nitrogen is circulated at start-up before the syngas production starts.</td>
</tr>
<tr>
<td>e. Taking the synloop into operation as quickly as possible; and</td>
<td></td>
</tr>
<tr>
<td>f. Flaring of non treatable vent gases.</td>
<td></td>
</tr>
<tr>
<td>8. General BAT is to minimise energy losses by:</td>
<td>Steam produced in the Ammonia plant will be utilised elsewhere in the Ras Al Khair industrial complex, such as at the DAP/NPK processing plants.</td>
</tr>
<tr>
<td>• Avoiding steam pressure reduction without using the energy;</td>
<td>As discussed above, the auxiliary boiler (which runs continuously for safety reasons) will provide steam to power a 22MW electricity generator.</td>
</tr>
<tr>
<td>• Adjusting the whole steam system in order to minimise excess steam generation;</td>
<td></td>
</tr>
<tr>
<td>• Using excess thermal energy on-site or off-site; and</td>
<td></td>
</tr>
<tr>
<td>• Using steam for generating electrical power, if local factors prevent the use of excess thermal energy on-site or off-site.</td>
<td></td>
</tr>
<tr>
<td>9. BAT is to improve the environmental performance of the production site by a combination of the following techniques:</td>
<td>The implementation of an Environmental Management System (EMS) shall be undertaken by Ma’aden. The EMS will outline the necessary requirements for managing and improving environmental performance at the facility (including necessary audits).</td>
</tr>
<tr>
<td>a. Implementation of an Environmental Management System (EMS)</td>
<td>The location of the proposed facilities enables services to be shared with existing facilities (Section 4 of this ESIA outlines the various ties-ins).</td>
</tr>
<tr>
<td>b. Carry out routine energy audits</td>
<td>Both the Ammonia Plant and the DAP/NPK Plants reduce / eliminate wastewater through recycling condensates, process and scrubbing waters.</td>
</tr>
<tr>
<td>c. Recycling or re-routing mass streams</td>
<td>The existing phosphate production facility at Ras</td>
</tr>
</tbody>
</table>
### BAT Reference Document (BREF)

<table>
<thead>
<tr>
<th>BAT Reference Document (BREF)</th>
<th>Proposals</th>
</tr>
</thead>
</table>
| i. Applying advanced process control systems | Al Khair (which includes DAP production units, operated by Ma’aden Phosphate Company, an affiliate of the Saudi Arabian Mining Company Ma’aden) has recently been received accreditation for the following ISO standards:  
  • ISO 9001 (Quality Management);  
  • ISO 140001 (Environmental Management); and  
  • ISO 50001 (Energy Management). |
| j. Maintenance | The main storage requirements for the Ammonia Plant are for two 30,000 tonnes storage tanks for liquid ammonia and for the diesel day tanks required for the emergency diesel generator. These tanks will be double walled and will be continuously monitored for leaks.  
  The FEED design of the Ammonia Plant will need to consider the storage and disposal options for wash water from MDEA filter washing and blow down from the natural gas venturi scrubber to consideration of BAT. |

10. BAT for storage is to apply BAT given in European Commission (2005) *BREF on Emissions from Storage.*

### 3.7 POLLUTION CONTROL OPTIONS (DAP / NPK)

The Di-ammonium Phosphate (DAP) and Complex Fertiliser (NPK) Plants, referred to as the DAP/NPK complex, will consist of four granulation units arranged in pairs. One pair will consist of two DAP units in one common building and the other pair will consist of one DAP and one NPK unit. The three DAP units will be designed to yield a total of 2,228,094tpy of DAP (grade 18-46-0) and the NPK unit will be designed to yield a total of 766,920tpy NPK (grade 15-15-15). The NPK unit will also be capable of manufacturing other NPK grades and DAP. The DAP units will be designed with an on stream factor of 330 days per year and 22 hours operation per day, and the NPK unit will be designed with an on stream factor of 332 days per year and 22 hours operation per day. The main raw materials are concentrated phosphoric acid, liquid anhydrous ammonia, 98.5% sulphuric acid, urea, potassium chloride and filler.

Each of the tail gas scrubber stacks for the DAP/NPK units (one per unit) meet the Royal Commission (RC) threshold for the application of Best Available Technologies (BAT) analysis as outlined in Clause 1.1.12 of RC Environmental Regulation (RCER) 2010, Volume I: *(a) Point sources emitting greater than 100 t/y before control of any of the parameters listed in RCER-2010, Volume I, Table 2A.* Tail gas from the process will be discharged to the atmosphere once it has been sent to the scrubbing system. The BAT analysis for pollution control of this emission is provided in the Sections below. Further pollution control measures for the management of industrial effluents are also summarised.

#### 3.7.1 GAS SCRUBBING

There are three main pollutants from a DAP/NPK plant, namely particulates, ammonia and fluorides. The main sources of these pollutants are:

- Particulates arise mainly from the drying drum and the equipment vents system (screens, crushers and conveyors). A smaller amount is released in the granulator and cooling drums.

- The main source of ammonia comes from the preneutralizer and granulator with smaller amounts released in the dryer and equipment vent systems.
Fluorides are stripped from the phosphoric acid fed to the preneutralizer, the pipe reactor and from the wet scrubbers that utilise dilute phosphoric acid as a scrubbing medium.

To control the release of these pollutants in combination, a staged scrubbing system is required which utilises a number of varying techniques to reduce final exist gas emissions for each parameter. The utilisation of a staged scrubbing system using dry cyclones and wet acid scrubbing is considered (EFMA BAT No. 8, 2000). The process is described as follows:

**State 1 - Dry Cyclones**

The airstreams from the dryer, cooler and equipment vents are all passed through dry cyclones – one set per airstream – where the majority of the particulates is removed.

**Stage 2 - Dual-mole Wet Scrubbing System**

In the dual mole concept the gases that are most heavily laden with ammonia, namely the exhaust from the granulator and preneutralizer are scrubbed twice to increase the removal of pollutants. Dilute phosphoric acid is used as the scrubbing medium which aids ammonia removal but can slightly raise the fluoride concentrations. More of the remaining particulates are also scrubbed out in these scrubbers.

Because the gases are scrubbed twice, the ‘prescrubber’ can be a simple, low pressure drop particulate scrubber installed in conjunction with a cyclonic separator. The objective in this scrubber is to recover only 80-90% of the ammonia in the gases. A relatively high circulation rate is used to prevent salting out. The scrubber operates with circulating scrubber liquor with a mole ratio of 0.4-0.5.

The primary scrubbing system consists of three venturi-cyclonic scrubbers. The gases from the prescrubber are scrubbed for a second time in one scrubber, the gases from the dryer cyclones are scrubbed in a second scrubber and a third scrubber treats the gases from the cooler and equipment vent cyclones. These scrubbers use the same circulating scrubber liquor having a mole ratio of 0.5-0.6.

The mole ratios in each of the two scrubber circuits are selected to maximise recovery of ammonia while at the same time minimising fluoride stripping from the scrubber liquor. The amount of fluorine stripped from the acid is heavily dependent upon mole ratio and increases exponentially at mole ratios lower than 0.4. The dual mole system is very flexible in that the conditions at which each part of the system works can be selected to meet a specific objective.

**Stage 3 – Final Stage Scrubbing**

A final stage of scrubbing will be installed which treats all of the gases one more time before discharge to the final tail gas stack. This scrubber is a cyclonic scrubber utilising water as the scrubbing medium. This water can be acidified with sulphuric acid as required to control the pH and thus optimise both ammonia and fluoride emissions.

3.7.2 PLANT DUST REMOVAL

In additional to the particulate (dust) removal from the production process. The DAP/NPK plants operate under a small negative pressure in order to prevent the escape of unreacted ammonia, particulates and other gases from the process.

3.7.3 MANAGEMENT OF EFFLUENTS (DAP/NPK)

The efficient use of waste water is required within the facility to ensure that water consumption is kept to a minimum (due to the high costs for processing water in Kingdom) and to ensure that industrial discharges are disposed of as per Royal Commission Environmental Regulation (RCER) 2010. Continuous effluent waste steams from the DAP/NPK plants are likely to be negligible due to the capture and recycling of waste water back into the production process. The recycling of all effluents back into the process is considered to be BAT (EFMA BAT No. 8, 2000).
3.7.4 MANAGEMENT OF SOLID WASTE (DAP/NPK)

The recycling of all solid wastes back into the process is considered to be BAT (EFMA BAT No. 8, 2000).

3.7.5 ANALYSIS OF TECHNOLOGIES (DAP/NPK)

To further assess the application of BAT for the DAP/NPK Plant, Table 3-5 below provides a comparison between the proposals and the BAT Reference Document (BREF) which includes internationally expected BAT specifically for DAP/NPK Plants:


While the above BAT reference document does not set legally binding standards, they are designed to give a basis for the guidance of industry. Note that no phosphate rock digestion (and rock grinding) is included as part of the proposed DAP/NPK production process and therefore these BAT recommendations are not applicable for these units and have been excluded.

Table 3-5: Comparison of proposals and international BAT guidance – DAP/NPK Plant

<table>
<thead>
<tr>
<th>BAT Reference Document (BREF)</th>
<th>Proposals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. BAT is to improve environmental performance of the finishing section by one or a combination of the following techniques:</td>
<td>The design incorporates 1.c (proper sizing of screens and mills). The other options are not considered suitable due to the potential operating issues and/or high capital investment required:</td>
</tr>
<tr>
<td>a. Apply plate bank product cooling.</td>
<td>(1.a) Plate coolers have proven to cause operational problems requiring frequent shutdowns for washing (plates get built up). In addition, they need a cooling tower which consumes water - a valuable commodity in Saudi Arabia.</td>
</tr>
<tr>
<td>b. Recycling of warm air.</td>
<td>(1.b) Recycling of warm air has proved to give operating problems (melting of the dust in the warm air when it is recycled to the burner). A lot of operators who have installed this facility had to remove it.</td>
</tr>
<tr>
<td>c. Select proper size of screens and mills, e.g. roller or chain mills.</td>
<td>(1.d) Recycle surge hoppers are out-dated. Most new plants have eliminated them. They are not necessary in this kind of facility and cause operational problems (caking in the hopper).</td>
</tr>
<tr>
<td>d. Apply surge hoppers for granulation recycle control.</td>
<td>(1.e) On-line sizers require a high capital investment.</td>
</tr>
<tr>
<td>e. Apply online product size distribution measurements for granulation recycle control.</td>
<td></td>
</tr>
</tbody>
</table>

2. BAT is to reduce emission levels to air from neutralisation, granulation, drying, coating and cooling by applying the following techniques and to achieve the following emission levels or removal efficiencies:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Dust removal, such as cyclones and/or fabric filters.</td>
<td>The design includes both 2a (dry cyclones and 2b (wet scrubbers). A three tier scrubbing system is proposed to reduce the air emissions from the process:</td>
</tr>
<tr>
<td>b. Wet scrubbing, e.g. combined scrubbing.</td>
<td>First scrubbing step: Granulator Pre-Scruber - Duct Cyclonic</td>
</tr>
<tr>
<td></td>
<td>Second scrubbing step (a combination of): Granulator Scrubber (Venturi Cyclonic)</td>
</tr>
<tr>
<td></td>
<td>Dryer Scrubber (Venturi Cyclonic)</td>
</tr>
<tr>
<td></td>
<td>Cooler &amp; Dedusting Scrubber (Ventury Cyclonic)</td>
</tr>
</tbody>
</table>
### Emission levels or removal efficiencies:

- **NH₃**: 5-30 mg/Nm³ (Note 1)
- Fluoride (as HF): 1-5 mg/Nm³ (Note 2)
- Dust: 10-25 mg/Nm³ (>80% removal efficiency)
- HCL: 4-23 mg/Nm³

**Notes:**
1. The lower part of the range is achieved with nitric acid as the scrubbing medium, the upper part of the range is achieved with other acids as the scrubbing medium. Depending on the actual NPK grade produced (e.g. DAP), even by applying multistage scrubbing, higher emission levels might be expected.
2. In the case of DAP production with multistage scrubbing with H₃PO₄, levels of up to 10 mg/Nm³ might be expected.

### BAT Reference Document (BREF) vs. Proposals

<table>
<thead>
<tr>
<th>BAT Reference Document (BREF)</th>
<th>Proposals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Third scrubbing step:</strong></td>
<td>Final Tail Gas Scrubber - Packed Tower</td>
</tr>
<tr>
<td>The plant utilises ammoniated phosphoric acid, at a relatively low molar ratio, to scrub gases from Preneutralizer / Pipe Reactor / Granulator, Dryer gases and Cooler and equipment dedusting gases, whereas water is used as scrubbing liquid in the final scrubbing stage for all gases. Licensor guarantees for the DAP/NPK units is provided below and are based on the RCER 2010 guidelines:</td>
<td></td>
</tr>
<tr>
<td>NH₃: 50 mg/Nm³</td>
<td></td>
</tr>
<tr>
<td>Fluoride (as HF): &lt;30 g/t of equiv. P₂O₅ Feed</td>
<td></td>
</tr>
<tr>
<td>Dust: &lt;0.25 kg/Tonne of product</td>
<td></td>
</tr>
<tr>
<td>HCL: Not included.</td>
<td></td>
</tr>
</tbody>
</table>

### 3. BAT is to minimise waste water volumes by recycling washing and rinsing waters and scrubbing liquors into the process, e.g. by using residual heat for waste water evaporation.

All process waste water effluents will be recycled back into the granulator for processing. There is effectively no industrial waste water effluent from these units.

### 4. BAT is to treat the remaining waste water which cannot be avoided with adequate treatment, e.g. biological waste water treatment with nitrification/ denitrification and precipitation of phosphorous compounds.

See above, there will be no remaining industrial waste water. Not applicable.

### 5. BAT is to improve the environmental performance of the production site by a combination of the following techniques:

a. Implementation of an Environmental Management System (EMS)  
b. Carry out routine energy audits  
c. Recycling or re-routing mass streams  
d. Efficiently sharing equipment  
e. Increasing heat integration  
f. Preheating of combustion air  
g. Maintaining heat exchanger efficiency  
h. Reducing waste water volumes and loads by recycling condensates, process and scrubbing waters  
i. Applying advanced process control systems  
j. Maintenance

The implementation of an Environmental Management System (EMS) shall be undertaken by Ma’aden. The EMS will outline the necessary requirements for managing and improving environmental performance at the facility.

The existing phosphate production facility at Ras Al Khair (which includes DAP production units, operated by Ma’aden Phosphate Company, an affiliate of the Saudi Arabian Mining Company Ma’aden) has recently been received accreditation for the following ISO standards:

- ISO 9001 (Quality Management);  
- ISO 140001 (Environmental Management);  
- ISO 50001 (Energy Management).

### 6. BAT for storage is to apply BAT given in European Commission (2005) BREF on Emissions from Storage.

All liquid / liquefied gases tanks are designed to be double-walled or bunded to ensure that there are no spillages.

Appropriate emission control measures have been outlined during FEED for solids storage (e.g. Dedusting Cyclones and covered conveyors), and these will be developed further in accordance with the quoted BREF during EPC.
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4.0 DETAILED DESCRIPTION AND LAYOUT OF THE PROPOSED DEVELOPMENT

4.1 INTRODUCTION

As introduced in Section 1.0 Introduction, the Ma’aden Umm Wu’al Phosphate Project will be based on two sites, namely Umm Wu’al and Ras Al Khair. The mine site at Umm Wu’al will include an open cast mine, beneficiation plant and a number of acid producing plants to process the extracted ore. The proposed industrial complex at Ras Al Khair Industrial City will include an Ammonia Production Plant, a Di Ammonium Phosphate (DAP) / Nitro Phosphate Potash (NPK) Plant and a Materials Storage and Handling Facility. For the purpose of this report, the new developments proposed by Ma’aden at the Ras Al Khair Industrial City will be referred to collectively as the Ras Al Khair Industrial Complex (‘the Project’).

The Ammonia Plant is a stand-alone plant, with its own facilities and is designed to produce 1.1 Mtpa of Liquid Ammonia from Natural Gas which will be stored in adjacent tanks for access by the DAP/NPK Plant. It is anticipated that the Project will also produce quantities of ammonia not required in the production process, which can be exported and sold domestically.

The DAP/NPK Plant will produce ammonium phosphate based granular fertilisers (DAP 2.2 Mtpa and NPK 0.766 Mtpa) which will be sold primarily into the international markets.

Table 4-1 outlines the main components of the Project, highlighting the sub-sections in which a description can be found. Safety and environmental considerations relating to these proposed facilities are discussed in Section 15 and Appendix B of this ESIA.

Table 4-1: Ras Al Khair Industrial Complex Facilities

<table>
<thead>
<tr>
<th>Main Facilities</th>
<th>Sub-Section</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Process Area</strong></td>
<td></td>
</tr>
<tr>
<td>Ammonia Production Plant</td>
<td>4.7.3</td>
</tr>
<tr>
<td>Ammonia Storage Tanks</td>
<td>4.7.3</td>
</tr>
<tr>
<td>Cooling Tower</td>
<td>4.7.3</td>
</tr>
<tr>
<td>DAP/NPK Production Units (3 trains for DAP, 1 train for NPK)</td>
<td>4.7.4</td>
</tr>
<tr>
<td>DAP/NPK Raw Materials and Storage Warehouses</td>
<td>4.7.4</td>
</tr>
<tr>
<td>Roadways</td>
<td>4.7.6</td>
</tr>
<tr>
<td><strong>Materials Storage and Handling Facility</strong></td>
<td></td>
</tr>
<tr>
<td>Storage Area and Tank Farm and handling facilities</td>
<td>4.7.5</td>
</tr>
<tr>
<td>Rail infrastructure</td>
<td>4.7.6</td>
</tr>
<tr>
<td><strong>Ras Al Khair Port</strong></td>
<td></td>
</tr>
<tr>
<td>Loading / Unloading and Storage Facilities</td>
<td>4.7.7</td>
</tr>
</tbody>
</table>

The following processed materials will be transported by rail from the Umm Wu’al mine site to the proposed industrial complex at Ras Al Khair for storage, use and/or export:

- Materials produced at Umm Wu’al for storage and use in the production of DAP/NPK:
  - Merchant Grade Phosphoric Acid (MGA) and Raffinate; and
  - Sulphuric acid.
- Materials produced at Umm Wu’al for storage at Ras Al Khair prior to export:
  - Merchant Grade Phosphoric Acid; and
  - Purified Phosphoric Acid (PPA)
4.2 PROJECT LOCATION

4.2.1 SITE LOCATION

The proposed Ras Al Khair industrial complex will be located within the Ras Al Khair Industrial City which lies on a peninsula in the Eastern province of Saudi Arabia on the south-western Arabian Gulf coast. The Industrial City is located approximately 80 km north of Jubail Industrial City. Figure 4-1 illustrates the site location.

Figure 4-1: Site Location - Ras Al Khair Industrial City

The site is leased by the Ma’aden from the Royal Commission. The Ras Al Khair Industrial City includes its own industrial Port and is connected to Al-Jalamid mine by railway. The site is accessible by a 27 km road, linked to the Abu Hadriyah highway. The closest sizable population centre is Nuairiyah, which is approximately 68 km to the West of the peninsula (93 km by road), with a population of 36,000 made up of 80% of Saudi nationals and 20% of non-Saudis (SOFRECO – TECHNIP, 2012). The site is approximately 4m above mean seal level at Latitude 27°32'15"N and Longitude 49°12'18"E (SOFRECO – TECHNIP, 2012). The planned project is proposed to be installed adjacent an existing fertiliser complex operated by Ma’aden Phosphate Company (MPC).

4.2.2 SITE LAYOUT

The current land use at Ras Al Khair is illustrated in Figure 4-2, and the proposed site layouts of the new process area and the port loading / unloading area are illustrated in Figure 4-3 and Figure 4-4 respectively.
Figure 4-2: Ras Al Khair Proposed Industrial Complex and Neighbour Industries
Figure 4-3: Ras Al Khair Proposed Industrial Complex Layout - Process Area Layout
Figure 4-4: Ras Al Khair Proposed Industrial Complex Layout – Port Loading / Unloading Area Layout
4.2.3 NEIGHBOURING INDUSTRIES

Existing infrastructure and utilities within the Industrial City are expanding following the construction of MPC’s existing fertiliser complex. Also, Ma’aden Aluminium Company (MAC) is currently constructing alumina and aluminium production facilities southwest of the Project site comprising of an alumina refinery, aluminium smelter and aluminium rolling mill. Figure 4-2 illustrated the proximity of the neighbour industries outside the Project boundary.

The Manifa off-shore oilfield development of which its land-based facilities are located approximately 20 km to the north of the Project site began oil production in April 2013. This oilfield is reported to be the world’s fifth-largest and its output will supply the Satorp refinery in Jubail as well as two others in the Western Region (Bloomberg, 2013). The design capacity of this oil field is reported to be 900,000 bpd (barrels per day). Dry-land rigs are linked by a 41 km of causeways with a number of elevated bridges designed to maintain natural water flow in the Manifa Bay (ORME, 2013).

The majority of the Project components will be positioned within the existing operational plot of MPC (as illustrated in Figure 4-3) which includes various facilities that can support the Project operations. Figure 4-5 below provides a simplified layout of the location of the proposed Project facilities adjacent to the existing MPC facilities.

![Figure 4-5: Ras Al Khair Industrial Complex Conceptual Layout: Existing MPC Facilities and Proposed Facilities](image)

The existing MPC complex covers an area approximately 1.9km x 1.5km and contains existing Ammonia, DAP, Phosphoric Acid Plants (PAP), Power and Desalination Plant (PDP) and Sulphuric Acid Plants (SAP) with a number of architectural, administrative and miscellaneous warehousing buildings/facilities. The complex is fully serviced by an existing road layout and

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**Figure 4-5: Ras Al Khair Industrial Complex Conceptual Layout: Existing MPC Facilities and Proposed Facilities**

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**Project Name:** UMM WU’AL PHOSPHATE PROJECT
utility networks. The site is split into high and low security zones in the northern and southern halves of the complex respectively.

The existing seawater cooling system provides seawater from the Arabian Gulf to the existing Ammonia Plant, the SAP trains and the PDP, as well as the collection and conveyance of warm seawater discharges to an ocean outfall. In all cases seawater is used for either direct or indirect process cooling. In addition, a portion of the supply to the PDP is used as feed for the production of desalinated water. The concentrated brine by-product from the PDP is discharged with the seawater used for cooling purposes. This brine effluent is regarded as a variance stream discharge with the return seawater in addition to treated demineralised water regeneration effluents of the Ammonia plant.

There are currently no Royal Commission (RC) licensed industrial wastewater treatment facilities at Ras Al Khair, but it is understood that a treatment plant with capacity of 25,000 m³/day is planned for the Ras Al Khair Industrial City in the future.

An existing sanitary wastewater treatment plant is operational within the Project site and currently has sufficient capacity to support the new development. However, it is understood that an additional RC operated sewage treatment plant with initial capacity of 8,333 m³/day is planned for the Ras Al Khair Industrial City.

The existing MPC facilities currently utilise three surface ponds for water management. An Irrigation Pond receives treated sanitary wastewater and neutralised wastewater from the Ammonia Plant and blow down from the PDP auxiliary boiler. An adjacent Evaporation Pond receives neutralised wastewater from the SAP, and a Retention Pond (located south of the existing administrative buildings) receives surface water collected across the site. The proposed Project will utilise the existing Irrigation Pond, but a new surface water Retention Pond will be constructed.

There are currently no RC licensed waste management facilities located within the Ras Al Khair Industrial City. Wastes requiring treatment and disposal are currently transported to the Industrial City of Jubail in accordance with Clause 5.3.1 of RCER-2010, Volume I (refer to Section 10 Waste Management). As the Ras Al Khair Industrial City develops further, the RC will establish treatment and disposal facilities within the City.

Future Developments

The Jubail and Yanbu industrial cities have developed into the world’s largest hubs for processing hydrocarbons. In addition to hydrocarbons however, the Kingdom of Saudi Arabia (KSA) has an abundance of mineral reserves which can be utilised to help diversify the national economy and reduce dependence on oil exports, and it is a current goal of the Saudi Government to fully exploit such mineral reserves. The RC has presented plans for the future development of the Ras Al Khair Industrial City which support the Government’s goal (primarily for phosphate and bauxite).

The primary, secondary and downstream industries currently within the industrial programme for Phase I of the Ras Al Khair Industrial City are as follows (RCJY, undated):

- Phosphate – primary and downstream;
- Aluminium – primary and downstream;
- Industrial minerals – primary;
- Steel plant - primary;
- Zinc / Copper Smelters – primary and downstream;
- Metals and fabrication - secondary;
- Energy goods and services - secondary; and
- ‘Offshore’ and ‘support’ clusters.
Figure 4-6 provides a conceptual layout for both the existing and anticipated future industrial expansion for Ras Al Khair. The current area of the peninsula under the jurisdiction of the RC is illustrated (total area 94 km$^2$).

The Royal Commission has also presented future expansion plans for Phase II of the Industrial City which proposes to utilise an area to the east and southeast of the peninsula inclusive of land reclamation (RCJY, undated).

MPC are currently investigating the potential for expanding DAP production at Ras Al Khair with an additional 2 million tonne/year DAP. The proposed location for these additional production facilities and storage are illustrated in Figure 4-3 (items 39 and 40). However, as these plans have yet to be realised, this expansion is considered within Section 17 Cumulative Impacts Assessment, but is not assessed in detail by this ESIA Report (Sections 6-16).

4.3 WORKFORCE AND NUMBER OF EMPLOYEES

During the construction phase, the workforce is estimated to be approximately 2,200 on average reaching a peak of 3,300 direct workers (Q1 of 2016 of the current schedule). Construction work week will be 10 hours per day for 6 days per week. A temporary accommodation camp will be located close to the construction area and the workers will get to the site mainly by dedicated bus transport.

During the operation phase, the industrial complex operations staffing is estimated to be between 519 and 536. Table 4-2 details the anticipated operational personnel for the first 20 years of the proposed facilities at Ras Al Khair. The anticipated shift schedules are as follows:

- Morning shift (07:00 – 15:00): 6 days on, 1 day off;
- Evening shift (15:00 – 23:00): 6 days on, 1 day off;
- Night shift (23:00 – 07:00): 6 days on, 1 day off.
Table 4-2: Operational Manpower for years 2017 - 2037

<table>
<thead>
<tr>
<th>Role</th>
<th>Number of Personnel</th>
<th>Years 2017 - 2020</th>
<th>Years 2021 - 2023</th>
<th>Years 2024 - 2033</th>
<th>Years 2034 - 2037</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEO Saudi</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>VP Saudi</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Manager Saudi</td>
<td>11</td>
<td>14</td>
<td>22</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Manager NS</td>
<td>6</td>
<td>16</td>
<td>1</td>
<td>2</td>
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</tr>
<tr>
<td>Supervisor Saudi</td>
<td>84</td>
<td>80</td>
<td>85</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Supervisor NS - Western</td>
<td>9</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Supervisor NS - Eastern</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Skilled Saudi</td>
<td>167</td>
<td>146</td>
<td>146</td>
<td>146</td>
<td></td>
</tr>
<tr>
<td>Skilled NS - Eastern</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Semiskilled Saudi</td>
<td>86</td>
<td>94</td>
<td>94</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>Semiskilled NS - Eastern</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Unskilled Saudi</td>
<td>103</td>
<td>113</td>
<td>113</td>
<td>113</td>
<td></td>
</tr>
<tr>
<td>Unskilled NS - Eastern</td>
<td>37</td>
<td>33</td>
<td>33</td>
<td>33</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>536</td>
<td>532</td>
<td>519</td>
<td>522</td>
<td></td>
</tr>
</tbody>
</table>

4.4 PROJECT SCHEDULE

Project phases and planned timing is summarised in Table 4-3.

Table 4-3: Ras Al Khair Industrial Complex Schedule

<table>
<thead>
<tr>
<th>Project Phase</th>
<th>Start</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front End Engineering Design and Bankable Feasibility Study</td>
<td>July 2012</td>
<td>July 2013</td>
</tr>
<tr>
<td>ESIA Scoping Meeting with the Royal Commission</td>
<td>October 2012</td>
<td>October 2012</td>
</tr>
<tr>
<td>Royal Commission Review of PAP (and ESIA)</td>
<td>July 2013</td>
<td>January 2014 (estimated)</td>
</tr>
<tr>
<td>EPC Contract Award &amp; Commencement of Detailed Engineering</td>
<td>Ammonia: July 2013</td>
<td>Others: August 2013</td>
</tr>
<tr>
<td>Construction including Pre-commissioning</td>
<td>Ammonia: January 2014</td>
<td>Others: August 2014</td>
</tr>
<tr>
<td>Facility Ready For Start Up</td>
<td>Ammonia: January 2017</td>
<td>Others: April 2017</td>
</tr>
</tbody>
</table>

4.5 CONSTRUCTION PHASE

The Engineering Procurement and Construction (EPC) Contractors will be responsible for producing Construction Execution Plans which will be progressively updated to reflect the transition requirements as the Project moves through its different stages.

Development of the Construction Execution Plan begins with the preparation of a preliminary construction plan and schedule for each work package; this includes all of the key dates throughout the construction phase. Critical aspects such as road access, construction seasons, construction labour availability and camp requirements are assessed and factored into the plan. A basic constructability review of the process plant and ancillary facilities will be included in the preliminary plan. The above information is also to be incorporated into the
Health, Safety, Security and Environment (HSSE) Plan for the area, which will also address aspects such as traffic management, access and egress, etc.

From the preliminary construction plans a conceptual project execution plan and general construction contracting strategy can be developed. Other outputs from this planning development process include:

- identification of construction services requirements;
- completion of contractor and labour resource survey;
- preparation of the critical path Project schedule, including the financing period, basic and detailed engineering, and procurement, construction and commissioning phases.

4.5.1 DESCRIPTION OF CONSTRUCTION AREAS

One of the key considerations for the construction phase for the Ras Al Khair Industrial Complex is the need to undertake the construction works within an operational site, in close proximity to the operating equipment and storage, notably the existing Ammonia Plant with its potential hazards, including gas leakage. This arrangement has occurred previously during the construction of the existing facilities and, with the required controls, coordination and interfaces, a safe and productive construction phase can be achieved.

Construction of the new plant areas and associated facilities will need to consider a number of factors, including:

- Minimising impact of construction operations on existing operations, including production schedules;
- Location of construction offices and material laydown areas;
- Movement of construction vehicles on site;
- Security – maintaining security of existing site as well as construction areas; and
- The need to undertake construction activities in close proximity to existing (live) plant.

There is space available within the existing low security zone, in the southern half of the plot for construction offices and material laydown areas. This area can be utilised on the understanding that existing operations are not interrupted or impacted on in any way. Figure 4-7 illustrates the anticipated construction and layout areas at the process area.
Additional lay down areas located adjacent to each of the main new plant areas (Ammonia, DAP/NPK and Material Storage and Handling Facility) may be required in order to minimise the time required to transport construction materials and plant to each of the new plant construction areas, and also to minimise crossings of the existing busy site roads and the existing high security zone.

To facilitate the construction works and minimise their impact on existing site operations it may be necessary to create a number of temporary entrances into the site. These could be located in between the lay down areas adjacent to the new plant areas and the site itself. The need to maintain the existing security of the site in general is of prime importance, notably around the existing high security area. Therefore access control points may be needed at any temporary entrances created into the site.

Parts of the existing plant may need to be shut down to allow certain construction activities to take place, for example a temporary shutdown of DAP filling/discharging from storage tanks whilst tie-in to existing product pipelines takes place. Construction operations will have to be sequenced to suit existing site operations and shutdowns in order to avoid any unnecessary impact.

The EPC Contractor will be required to have a thorough process in place for the receipt, check and storage of materials, including the preservation of stored materials as per the vendor’s recommendations. Preservation of materials will be closely monitored by the Project Management Contractor (PMC) to ensure compliance. The PMC will also ensure full compliance with the material traceability requirements of the Project and compliance with local and industry standards.
Grading activities required to build infrastructure and units is expected to result in an elevation at a level of +5m. Therefore such activities are not anticipated to create a significant change in the topography of the site.

4.5.2 DESCRIPTION OF CONSTRUCTION ACTIVITIES

Initial construction works are likely to include the following:

- Geotechnical investigations;
- Site preparation (site clearance etc);
- Relocation / demolition of any buried infrastructure;
- Earthworks;
- Provision of site drainage;
- Set up temporary site facilities and camp infrastructure;
- Allocate work areas and install temporary security fencing; and
- Identification, arrangement and distribution of utilities, fuels etc required.

The main activities of the following construction phases will include excavations, backfilling, compaction, civil works, steelwork (e.g. pipe racks), pipework, equipment installation, electrical and instrumental installation, building erection and tie-in works such as isolation of tanks and pipelines during normal operation of existing facilities. Total plant shut-down may be required in some instances to facilitate tie-ins. As the groundwater level at Ras Al Khair is less than 4 mbgl, dewatering activities are likely to be required.

Temporary site drainage system will be designed and constructed by the EPC Contractor. Site ground levels would be sloped so that a gradient is formed to direct surface water to construction collection pits/channels at the site perimeters. These will tie in with the existing surface water drainage system. Dewatering pumps would be available to remove water from excavation pits where required.

The main types of plant machinery expected to be used during the construction phase are:

- **Site Preparation:** Dozer, Rock breaker, Excavator, Loader, Dump truck, Compactor.
- **Foundations:** Concrete plant, Mixer, Pump, Piling equipment, Concrete saw.
- **General:** Small diesel generator, Compressor, Cranes and other transportation and heavy lifts machinery.

4.5.3 TEMPORARY FACILITIES

The EPC Contractors and Ma’aden are responsible for the engineering, construction, commissioning, operation, maintenance and decommissioning of all temporary site facilities.

It is anticipated that the existing camp facilities at Ras Al Khair Industrial City may be utilised as the activities associated with the adjacent Aluminium Facility reduce. Construction camps will be equipped with the utilities and support services necessary to accommodate the workforce, such as water, electricity, air conditioning, laundry, canteens, recreational and medical services.

4.5.4 TRAFFIC AND LOGISTICS

The construction works will be performed in many areas at the same time to meet the tight schedule. This will result in large movements of personnel and materials throughout the Industrial City. The construction execution is to be performed using the existing road system for access, and the requirement for significant integration with normal operational activities.

The EPC Contractor will perform a traffic and logistics study to assess roads and determine access requirements via other modes of transport. On completion of this survey, construction
lay down areas, dimensions of all road and jobsite clearance limitations will identified. As Ras Al Khair Port does not currently have the required infrastructure to support transport of equipment and materials, it is anticipated that Damman Port will be utilised. However, in the instance that oversized equipment cannot travel inland, barges will operate from Damman to Ras Al Khair Port (dredging works are not anticipated for this transport). Traffic Management Plans for the transport of equipment and materials will be produced by the EPC Contractor to address transport by ship, land and also customs.

4.6 PRE-COMMISSIONING & COMMISSIONING PHASE

The RCER-2010 require that a valid Environmental Permit to Operate is obtained from the RC prior to any process commissioning.

A Commissioning Management Plan (CMP) will be prepared for the Project. The purpose of this plan is to define the strategy and resources required to commission the Project facilities and define the responsibilities of all parties during commissioning activities to ensure they are undertaken in a safe, organised and efficient manner.

The CMP sets out the requirement for the commissioning team to ensure that:

- all commissioning work is carried out safely;
- all commissioning work complies with environmental requirements;
- all commissioning work respects the needs of the local community;
- all commissioning works meets the client's requirements; and
- all commissioning work complies with the PMC policies and procedures.

The CMP will determine the definitive turnover sequence for the process plants. The CMP will need to be developed in outline soon after the mobilisation of the EPC Contractors to allow the sequencing to be incorporated into the Level III/IV overall Project work schedules.

In line with normal industry practice, there is expected to be a move from work package-based construction to operable system-based construction and commissioning activities during the final phases of the construction period, and this will need to be communicated via the Project schedule.

The PMC Lead Planner will produce the overall consolidated commissioning schedule with sufficient detail to enable the commissioning process for all of the Project facilities to be coordinated and completed within the Project timescales. Each stakeholder will have the opportunity to contribute to the commissioning schedule prior to its final agreement.

Commissioning managers from Ma'aden and their agents where relevant will be responsible for the coordination of the commissioning activities and for compliance with safe working practices.

During the commissioning process for the plants, regular meetings will be held to ensure the communication process is maintained and that the appropriate knowledge transfer takes place across operable systems and facilities, and also between the EPC Contractors.

4.6.1 DESCRIPTION OF PRE-COMMISSIONING & COMMISSIONING PHASE

Main activities and sequence of operations during the pre-commissioning and commissioning phase can be summarised as follows:

- Hydrotesting of pipelines and tanks;
- Flushing & cleaning of pipelines;
- System dry-out;
- Inerting;
- Systematic conformity check of equipment;
• Static, de-energized test of equipments;
• Preliminary check;
• Functional check;
• Operational test;
• Pre-Start-up activities.

4.6.2 HYDROTESTING OF PIPELINE AND TANKS

Hydrotesting of pipelines, tanks, and vessels will be conducted using fresh (desalinated) water in order to meet quality criteria needed for this activity and to avoid corrosion damage to the equipment prior to start-up. In particular tanks, filled to a preset level, will be required to maintain this loaded state for a certain period of time before being drained. The total quantity of fresh water to be used during hydrotesting activities is not available at this stage, but the total quantity will be minimised through hydrotest water reuse by transferring it from one tank to another. However, as the tanks have different volumes, careful planning in the hydrotest sequence will be applied, considering the construction schedule, applicable engineering standards and project specifications. The fresh water needed for hydrotesting activities will be supplied through the existing seawater desalination system at Ras Al Khair Industrial Complex. Discharge of hydrotest wastewater is likely to be routed to the existing evaporation pond and analysed to determine compliance with irrigation and/or coastal water discharge standards. The rate of discharge will be controlled in order to avoid overloading the receiving system. Wastewater failing to achieve such standards will be tankered off-site the Jubail industrial wastewater treatment plant for treatment.

4.7 OPERATION PHASE

4.7.1 PRODUCTION CAPACITY

Implementation of the Umm Wu’al Phosphate Project elements at Ras Al Khair Industrial City will increase the ammonia and fertiliser production and export from the Kingdom of Saudi Arabia while also providing a Material Storage and Handling Facility to manage the use/export of MGA, sulphuric acid and PPA which are produced at the Umm Wu’al mine site.

The Ammonia Plant will be designed for producing anhydrous ammonia with daily and annual capacities of 3,300 tpd and 1,089,000 tpy respectively. Bulk of ammonia will be used as a raw material to produce DAP, and the balance is planned to be exported from Ras Al Khair Port.

The combined DAP units (3No. trains) will be designed to yield 2,228,094 tpy of DAP 18-46-0 grade. The NPK unit (1No. train) will be designed to yield 766,920 tpy of NPK 15-15-15 grade. Both products will be exported from Ras Al Khair Port.

The Design Life for the Ras Al Khair Industrial Complex is 25 years.
The Block Flow Diagram shown in Figure 4-8 illustrates the proposed operation of the Ammonia and DAP/NPK Units at Ras Al Khair.
The Ammonia Plant is a stand-alone plant, with its own facilities and is designed to produce Liquid Ammonia from Natural Gas. It is comprised of the following sections: Natural Gas Desulphurisation and Compression, Steam Reforming, Carbon Monoxide (CO) Conversion, Carbon Dioxide (CO₂) Removal, Methanation and Ammonia Synthesis. Secondary plant objectives include Waste Heat Recovery, Ammonia Refrigeration and Purge Gas & Hydrogen Recovery.

This plant rated capacity is based on one line of 3,300 tpd (as 99.8% NH₃), with an on stream factor of 330 days per year and 24 hours operation.

Raw materials are natural gas, process air and desalinated water. In addition, a number of catalysts are used in the process. Natural gas will be sourced from Saudi Aramco for use as feedstock and fuel. Nitrogen will be sourced from local companies via tankers.

Key Project components proposed for the Ammonia Plant are outlined in Table 4-4.

Table 4-4: Key Project Component Associated with the Ammonia Plant

<table>
<thead>
<tr>
<th>Process Unit Area</th>
<th>Plant Off-sites and Utilities</th>
<th>Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia Production Plant</td>
<td>Demineralisation Unit and Water Tanks</td>
<td>Main Control Room, To contain Operation Shelter and Training Room.</td>
</tr>
<tr>
<td>Boiler Feed Water System (pump &amp; deaerator) and Process Condensate System</td>
<td>Auxiliary Boiler (normal flow expected to be 40 tph; maximum flow (during emergency situations) expected to be 150 tph) and Steam Turbine Generator (STG) with power production of 22 MW.</td>
<td>Substations (3No.): Main 115/34.5kV substation for complex; Ammonia Process substation; and Ammonia Utility substation.</td>
</tr>
<tr>
<td>Flaring System (process and synthesis gas flare; ammonia flare; and ammonia storage tanks flare)</td>
<td>Nitrogen Storage and Distribution System</td>
<td>Operator cabins and labour cabins</td>
</tr>
<tr>
<td></td>
<td>Two Emergency Generators (adjacent to administration / maintenance area and one adjacent to the Materials Storage and Handling Facility) and Diesel Oil Storage</td>
<td>Warehouse</td>
</tr>
<tr>
<td></td>
<td>Ammonia Storage (2 x 30,000 t double wall storage tanks) and Handling System</td>
<td>Central laboratory extension</td>
</tr>
<tr>
<td></td>
<td>Lube Oil System</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Instrument and Plant Air Distribution</td>
<td>Shelters for analyser shelters (2 or more), compressors and pumps.</td>
</tr>
<tr>
<td></td>
<td>Closed Loop Cooling Water System</td>
<td>Emergency Diesel Generator building</td>
</tr>
<tr>
<td></td>
<td>Clean Storm Water Collection and Plant Effluent Treatment and Collection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sewage Collection &amp; pumping (to existing STP)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Port-Ship Loaders</td>
<td></td>
</tr>
</tbody>
</table>

4.7.3.1 RAW MATERIALS

The main raw materials to be used for ammonia production are natural gas, process air and desalinated water. In addition, a number of catalysts are used in the process.

The existing MPC Desalination Plant will provide both desalination and process water to the Ammonia Plant.
The raw material types and the processes in which they are used for ammonia production are summarised in Table 4-5.

### Table 4-5: Raw Materials for Ammonia Production

<table>
<thead>
<tr>
<th>Raw Material/Feedstock</th>
<th>Process</th>
<th>Delivery &amp; Storage Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>Fuel: primary reformer, package (auxiliary) boiler, start-up heater, flare / pilot burner; and Feedstock</td>
<td>Pipe supplied by Saudi Aramco</td>
</tr>
<tr>
<td>Desalinated and process water</td>
<td>Desalinated Water is used as feed to the Demineralised Water Unit (make-up water). Process (Service) Water can also be provided as required by the new Ammonia Plant outside normal operation. Recycling of condensates will minimise the consumption of desalinated water as make up water.</td>
<td>Pipe from existing MPC Power and Desalination Plant storage.</td>
</tr>
<tr>
<td>Seawater return water</td>
<td>Cooling Tower make up (blowdown and evaporation losses)</td>
<td>Seawater return headers of the existing plants.</td>
</tr>
<tr>
<td>Catalysts</td>
<td>Natural Gas Desulphurisation (Hydrogenation); Natural Gas Desulphurisation; CO Conversion; Methanation; Ammonia Synthesis; and CO₂ Removal</td>
<td></td>
</tr>
<tr>
<td>Antifoam agent</td>
<td>CO₂ Removal</td>
<td></td>
</tr>
<tr>
<td>Oxygen scavenger</td>
<td>Boiler Feed Water Treatment: May be required during start-up or upset plant conditions</td>
<td></td>
</tr>
<tr>
<td>Chemical agent for pH control</td>
<td>Boiler Feed Water Treatment: PH control</td>
<td></td>
</tr>
<tr>
<td>Corrosion inhibitor</td>
<td>Chemicals for Circulating Cooling Water</td>
<td></td>
</tr>
<tr>
<td>Biocide</td>
<td>Chemicals for Circulating Cooling Water</td>
<td></td>
</tr>
<tr>
<td>Sodium Hydroxide (50%)</td>
<td>Water treatment (demineralisation unit, polishing unit, neutralisation)</td>
<td>Rail tanker-Storage Tank at Materials Storage and Handling Facility – Pipe to Plant</td>
</tr>
<tr>
<td>Sulphuric acid (98%)</td>
<td>Water treatment (demineralisation unit, polishing unit, neutralisation); Regeneration of ion exchangers</td>
<td>Rail tanker-Storage Tank at Materials Storage and Handling Facility – Pipe to Plant</td>
</tr>
<tr>
<td>Resin</td>
<td>Water treatment (condensate polishing – demineralisation unit and polishing unit)</td>
<td>Road Supplied by specialist providers</td>
</tr>
</tbody>
</table>

### 4.7.3.2 PROCESS DESCRIPTION

#### Natural Gas Supply and Distribution

The Natural Gas Supply System is designed to condition and distribute natural gas to users within the Ras Al Khair Industrial Complex. The RC is currently working with Saudi Aramco to route an additional natural gas pipeline from existing metering stations to the battery limit of the proposed Ammonia Plant. An overground pipeline will then route this gas into the process area where it is conditioned using a cyclone separator and cartridge filter, a venturi scrubber and feed gas knock out drum to separate any condensate and liquid present in the natural gas received at the plant battery limit. Liquid collected at this point will be drained to the oily water sewer system. Natural gas is used as a feed material for the ammonia synthesis reaction and also as a fuel supplying the primary reformer, auxiliary boiler, start-up heater and the pilots of the flares (synthesis gas flare, ammonia flare, and ammonia storage tanks flare).

#### Natural Gas Desulphurisation

Natural gas required as feedstock is purified to the needs of the Steam Reforming Unit. In the Desulphurising Section, the natural gas (mostly methane) entering is hydrogenated and passed over a catalyst to convert organic sulphur to hydrogen sulphide, followed by zinc oxide absorbers to absorb hydrogen sulphide. The sulphur-free natural gas is heated prior to...
entering the Steam Reforming Section. Zinc oxide absorbent used to absorb hydrogen sulphide must be discharged once saturated as this reaction is non-reversible.

**Process Air Compression**

A process air compressor supplies air to the secondary reformer. Before entering the compressor, the air which is taken from the atmosphere, is filtered. Process air is compressed to process conditions by a 4-stage centrifugal compressor driven by a condensing medium pressure steam turbine.

**Steam Reforming**

In the Steam Reforming Section, the desulphurised natural gas steam is mixed with process steam and passed over a nickel catalyst to reform methane and higher hydrocarbons, converting these into a mixture of hydrogen, CO₂ and CO. This is achieved using two reformers which reduce the methane content:

- The primary reformer is a box-type furnace containing 408 catalyst-filled tubes arranged in eight rows. The reformer tubes are centrifugally cast of high-alloy chromium/nickel steel (micro alloy). Heat for the endothermic reaction and for heating-up the feedstock and the reaction products is supplied by nine rows of Ultra low NOx type burners positioned in the furnace ceiling on both sides of each tube row. The reforming reaction starts at about 700°C. The process gas leaves the reformer tubes at a temperature of approximately 825°C, still containing about 12.85 mole % (dry) of unconverted methane. Ultra low NOx type burners will be used in the primary reformer. Flue gas will be emitted from a primary reformer stack at which analysers for NOx and SOx will be installed.

- Further reforming of methane down to 0.6 mole % (dry) is carried out in the secondary reformer which is a water-jacket cooled reactor filled with catalyst. During this process step the endothermic reaction heat and the heat for raising the temperature of the gas mixture to about 985°C are generated by internal burning of a fraction of the process gas with the oxygen from the process air. This addition of air serves at the same time to introduce the nitrogen required for ammonia production into the process gas.

**CO Conversion**

The process gas then is cooled in the waste heat recovery section and routed to the CO Conversion Section where the conversion of CO into CO₂ and generation of hydrogen is maximised. The CO₂ - CO mixture is cooled and the CO converted to CO₂ by action of steam and iron & copper catalyst in a two step process:

- High temperature shift (370–450°C), with iron oxide/chromium oxide catalyst; and
- Low temperature shift (190-230°C), with a copper/zinc oxide catalyst.

**CO₂ Removal**

An activated MDEA (methyl-diethanolamine) solution is used to remove CO₂ from the process gas (as it is a poison for the Ammonia Synthesis catalyst). The CO₂ enriched MDEA solution is flashed removing the CO₂ as gas and allowing the MDEA solution to be stripped of impurities and returned to the absorber column and reused. The CO₂ gas is released to the atmosphere via a vent line (approximately 167,199 kg/hr CO₂). The vent line is routed to the steel structure of the flare. The CO₂ vent line will be fitted with a silencer for noise level reduction.

**Methanation**

In the Methanation Section, residual CO and CO₂ in the process gas leaving the CO₂ Removal Section is reduced by converting to methane using a nickel oxide catalyst. The resulting gas is then termed synthesis gas as it meets the specification required for ammonia production.

**Flares**

The methanation stage utilises a synthesis gas flare and an ammonia gas flare to emit gases to the atmosphere (at a common location). Prior to release to the flare stacks, hazardous
gases are removed via a knock out drum gas flare and an ammonia collector. The new flare and the associated systems will be designed to meet the RC standards for noise generation and heat radiation in the surrounding area.

The flare gas pilots (supplied by natural gas) will be continuous, but the flare will only operate during the start-up/shut down of the facility and during emergency operations (when reformer is not operational) for safe shutdown follows:

- one full day (24 hours) for start up (half rate of normal operation); and
- one half day (12 hours) for shutdown (half rate of normal operation).

The operation of relief valves is however difficult to predict for all instances. There is potential for flare burning to occur during normal operation but this should normally only occur during emergencies. Pressure controlled vents are much more likely to send ammonia containing gases on an occasional basis to the flare. The most likely venting is of non ammonia containing gases is any time there is a mismatch of gas production to ammonia production. Also any time the synthesis gas compressor trips out the pressure controlled vent should prevent the relief valve opening. Unplanned venting may occur for approximately 100 hrs a year just due to mismatch at 10 to 15% of normal output. Each year of operation is not expected to have more than 150 hours of venting due to start up, shut down and short emergencies.

Pressure control valves, hand operated valves and safety relief valves from front end of ammonia plant discharge to the synthesis gas flare via a knock out drum gas flare which will safely dispose of hazardous gases e.g. natural gas, process gas etc.

Pressure control valves, hand operated valves and safety relief valves from back end of ammonia plant discharge to the ammonia gas flare via an ammonia collector safely dispose of hazardous gases e.g. ammonia gas, process gas etc. In the case of a high level of ammonia in the collector, liquid ammonia will be transferred to the storage tanks.

On the Ammonia flare when a pure ammonia relief valve blows, the natural gas will be increased automatically help the ammonia burn. This will be built into the control system.

Ammonia Synthesis

Synthesis gas from the Methanation Unit is compressed and cooled. Remaining water vapour and traces of CO₂ are removed in the Synthesis Gas Drying Unit using molecular sieves. Conversion to ammonia and separation of ammonia product then takes place using three ammonia bed reactors. Nitrogen and hydrogen are fed through the Ammonia Bed Reactors with iron catalyst to produce ammonia gas. The ammonia gas is then condensed by heat exchange to ammonia liquid and stored.

Refrigeration Unit

The refrigeration unit serves four purposes:

- Provision of refrigeration duty needed for chilling in the ammonia plant;
- Vaporisation of cooling medium (NH₃) and subsequent condensation and cooling of the ammonia to the downstream plants;
- Cooling of ammonia product to ammonia storage conditions of -33°C; and
- Separation of dissolved inert gases from liquid ammonia product.

Ammonia and Hydrogen Recovery Unit

This ammonia recovery system recovers ammonia contained in the purge gas from the ammonia synthesis loop and flash gas from the let down drum. Ammonia is first absorbed by water and then reclaimed from the water as pure ammonia by distillation.

The hydrogen recovery system is designed to process the purge gas from the ammonia synthesis loop whose ammonia concentration has been reduced to a level of below 50ppmv
before it is sent to this unit. It separates a hydrogen-rich stream from the gas which is recycled to the synthesis gas flow.

Under upset conditions, flash and purge gas from the flash and purge gas absorbers can also be released to the ammonia gas flare via a pressure control valve.

**Demineralised Water System**

The existing MPC demineralisation water system does not have sufficient available capacity to support the new Ammonia Plant therefore a new dedicated system comprising of a Demineralisation Unit and a Polishing Unit will be designed to provide demineralised and polished water to the new process units and utilities.

The Demineralisation Unit will receive the desalinated make-up water, contaminated process condensate, and boiler blow down and be equipped with cations exchangers, anions exchangers and all necessary equipment for resin regeneration. Demineralised water will be used for make-up to closed loop cooling water system.

The Polishing Unit will receive the demineralised water (product of the Demineralisation Unit) and the recycled steam turbine condensate. This Unit will be equipped with mixed bed polishers to treat the stripped ammonia process condensate, desalinated water make up and steam turbine condensate and have all necessary equipment for resin regeneration.

Other components of this system include the following:

- Desalinated water tank (3500 m$^3$ capacity);
- Desalinated water transfer pumps;
- Polished water storage tank of (7000 m$^3$ capacity);
- Polished water transfer pump;
- Neutralisation tank (to have the capacity of holding two times of regeneration waste of demineralisers and mixed beds) with the associated pumps;
- Sulphuric acid and caustic soda storage tanks with associated pumping facilities;
- Air blowers for the mixed bed service; and
- Acid and caustic storage and unloading facilities.

Polished water / boiler feed water will be used for the regeneration of cation/anion exchangers. All the acid and alkali over-flow drains shall be routed to the neutralisation system for proper treatment/disposal (refer to Section 4.7.3.9). The desalinated water and polished water storage tanks will be inter-connected with the existing tanks to facilitate water transfer either way.

A Boiler Feed Water System will be implemented to condition the polished water into boiler feed water. This will include deaerator(s), polished water feed pumps, chemical dosing system ($O_2$ scavenger, pH adjustment), high and low pressure boiler feed water pumps and blow down flash vessels, cooling and recycling facilities.

**Instrument and Plant Air Supply System**

Instrument and process air will be supplied from the process air compressor of the new Ammonia Plant for its own consumption as well as supplying the new DAP & NPK plants, the new material handling areas and interconnection with the existing PDP. The compressor will be steam turbine driven. The air filter will be self cleaning with a separate dust disposal system. To minimise noise levels, acoustic insulation, inlet silencer and anti-surge blow off silencer will be incorporated to the design.

**Ammonia Storage, Handling and Loading Facilities**

As noted in Section 4.7.1, the bulk of ammonia will be used as a raw material to produce DAP, and the balance is planned to be exported from Ras Al Khair Port. When the Ammonia Plant is down, ammonia will be supplied to DAP from the Ammonia Storage Tanks (see Table 4-6).
Table 4-6: Mass Flow at Ammonia Battery Limit

<table>
<thead>
<tr>
<th>Flow location</th>
<th>Normal (DAP in Operation) kg/hr</th>
<th>Max (DAP Shut down) kg/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>To Storage tanks</td>
<td>54,419</td>
<td>137,755</td>
</tr>
<tr>
<td>To DAP</td>
<td>83,342</td>
<td>0</td>
</tr>
</tbody>
</table>

Two double-walled ammonia storage tanks of 30,000t capacity will be provided adjacent to the existing ammonia storage tanks. A flare system will be installed for tank boil-off gases in the event of refrigeration failure, and the tank relief valves will discharge at roof area to atmosphere. The boiler-off gas compressors will be motor-driven. Compressed ammonia is condensed by heat exchangers with cooling water in an ammonia condenser and any liquid ammonia formed will be fed back to the tanks. The existing ammonia storage tanks have a flare with a rated capacity of 4,200kg/hr, and a similar capacity is anticipated for the new tanks.

Provision of integration of the existing and new storage facilities and systems will be established by the FEED/EPC Contractor, e.g. transfer of ammonia from the new Plant to the existing storage tanks and vice versa.

Ammonia will be pumped through a new export line, using two transfer pumps (1,000tph each), to the Port for direct loading to ship via a loading arm. A vapour return line will also be installed, returning vapour back to the storage tanks at the process area. The liquid loading berth at the Port is approximately 3.5km from the Ammonia storage area. Ship loading capacity will be 1,000tph.

Acid and caustic storage and handling facilities (associated with the Demineralised Water System) within the kerbed area will include installation of chemical unloading pumps connected each storage tank.

Nitrogen will be sourced from local companies via tankers and stored at a new tank facility equipped with evaporators to provide gaseous nitrogen. Liquid storage tank sizing will be determined by the FEED/EPC Contractor to hold up to about seven days consumption under normal flow conditions, but is expected to be approximately 168m³.

**Sea Water Closed Looped Cooling Tower System & Closed Loop Cooling Water System**

It is currently proposed that the new ammonia plant utilises a new sea water cooling tower instead of the once through sea water cooling currently utilised by other facilities in the Ras Al Khair Industrial City. The cooling water system required for the production of ammonia will comprise sea water closed loop cooling tower system and closed loop cooling water system. This may be supplemented with air coolers and fin fan cooling to optimise the water cooling requirements. Mechanical Draft Sea Water Cooling Tower is currently recommended to meet the project requirements.

The circulating pumps receive sea water from the base of the cooling tower. The circulating pumps discharge splits into two with one section supplying sea water cooling loads and the other the fresh cooling water closed loop system. The sea water cooling loads consist of a pair of ammonia condensers followed immediately downstream by five steam turbine condensers. The five steam turbine condensers are arranged in parallel and include the natural gas, air, synthesis gas, refrigeration and power generator turbine condensers respectively. The closed loop cooling water system will be equipped with a buffer tank and circulation pumps. The two sections (sea water cooling load and fresh cooling water closed loop system) then combine into common pipework before returning to the cooling tower to complete the closed loop of the cooling water system.

Sea water make up water supply for the new plant cooling tower will be supplied from the existing plants sea water once through system. Tie-ins will be provided at the seawater supply
headers of the existing PDP and SAP plants. Demineralised water will be used as make up water for the closed loop fresh cooling water.

Measures such as cooling tower acceptance tests and fan units installed such that they are free from vibration and unbalance problems, will manage noise levels within the required standards.

**Central Laboratory**

The existing Central Laboratory will be expanded to locate the new analyser equipment required for the Project, including a continuous emission monitoring for environmental compliance monitoring of the reformer flue gas. Liquid effluents from the laboratory will continue to be managed by the existing drainage and treatment system.

4.7.3.3 TIE-IN WITH EXISTING MPC

Interconnections are required to integrate the new Ammonia Plant facilities with the existing MPC facilities. Interconnects include but are not limited to:

- Electrical distribution including above and below ground routings as appropriate;
- Instrumentation distribution including above and below ground routings as appropriate;
- Water supply and return for cooling water, supply of process water, potable water, and firewater;
- Interconnecting (off-plot) pipe-racks;
- Interconnecting (off-plot) roads including main access routes to/from new plant;
- Storm-water drainage for new (off-plot) roads;
- Connections (where applicable) for contaminated drainage and sanitary systems to existing treatment facilities. Due to levels of new plant areas and existing system, sanitary system may require lift station; and
- Industrial waste water is to be consolidated and stored locally within each plot area for tanker removal where appropriate.

4.7.3.4 WATER CONSUMPTION

Desalinated and potable will be supplied by the existing PDP via new pumps and storage tank. Three storage tanks of 30,000m$^3$ capacity are available for fire and process water as part of existing facilities. Existing firewater pumps and process water pumps may also be utilised. The current design of the existing fire water system at MPC is based on a maximum flow of 740m$^3$/h.

All process units will be designed on the basis of recycling all condensate generated in the plant and its utilities. Recycling of condensates will minimise the consumption of desalinated water as make up water.

The normal flow rate of feed water to the Demineralisation Unit will be 241m$^3$/hr. Approximately 114m$^3$/hr of this flow will comprise desalinated water, although this will vary depending upon condensate return. Flow rates of process condensate and blow down water will be 11 m$^3$/hr and 14 m$^3$/hr respectively.

Recovered turbine steam condensate from surface condensers, traps etc. will be processed in water treatment units to produce polished water, which is used as boiler feed water. A Boiler Feed Water System including deaerotor(s) and a chemical dosing system will be required to condition polished water into boiler feed water.

The production of potable water from the existing PDP is currently limited as a large part of the production is already committed to a long-term supply to the Port. Therefore an increase in production of potable water will be required as part of the Project. This will involve a new potable water unit to remineralise the desalinated water. There is sufficient desalinated water available from the existing systems. Potable water will be derived from the remineralisation of
desalinated water supplied from the existing PDP. A tie-in to the existing Ras Al Khair potable water distribution system will feed a new potable water storage tank (1,000m$^3$).

A sea water cooling supply from the existing MPC supply header is not envisaged due to supply limitations. However, make up for the cooling tower (4,180m$^3$/hr) can be taken from the seawater return headers of the existing MPC ammonia, PDP and SAP plants. Demineralised water will be used as make up water for the close loop fresh cooling water.

4.7.3.5 POWER CONSUMPTION

The Ammonia Plant will be self-sufficient in steam consumption. The steam is generated by the ammonia production process through boilers, and it runs two turbines which drive the synthesis gas compressor and the refrigeration compressor. An additional turbine provides the power to the Ammonia Plant.

Electrical power will be supplied by common grid (34.5kV via underground cables to substation) during plant start up. Additional power generation shall be completed inside the Ammonia Plant. Excess steam is produced by the process, so a steam turbine generator (STG) will be provided to convert the excess into electrical power (a total of 22MW). Power for the electricity generator is derived from excess waste heat steam extracted from the waste heat boilers with the balance provided from the auxiliary boiler. Part of the power will be used within the Ammonia Plant and the remaining generated power not consumed by the Plant (13MW) shall be fed to the common (MPC) grid. This arrangement represents the continuous case. At start-up and in emergencies, the auxiliary boiler will go to maximum output but at that time the reformer will normally not exceed 70% of normal at most. This means that maximum combustion emissions will correspond to normal operation plus any over production possible. This could be around 10% extra when catalysts are new and plant equipment is in good shape during cooler weather.

Emergency power will be supplied by a diesel generator for a safety shut down in case of total power failure. The plant shall be designed in that way, that it can continue its operation in case an electrical power supply fails (either failure of 34.5kV feeders or failure of internal power supply by STG).

In normal operation the plant shall be completely fed by the STG and further export some energy to the external mains through one of the two 34.5kV incomers from the external grid. In case of failure of the coupled 34.5kV incomer from the external grid, the faulty supply shall be decoupled. The second 34.5kV incomer from the external grid shall then be synchronised and coupled with the STG; otherwise the STG shall change over to island operation mode.

As the plant is not configured for black-start, external grid power should be available during start-up period. Under the normal operating conditions, no external power is needed (island mode).

In case of STG failure, the plant shall be fed by the redundant 34.5kV incomers from the external grid.

The detailed design of the Ammonia Plant will consider all main pumps to be driven with steam turbines and standby pumps to be driven by electric motors.

4.7.3.6 FUEL CONSUMPTION

A dedicated diesel storage tank will be provided for the emergency power diesel generator. This will be supplied by road tanker. The size of the storage tank will be established by the FEED/EPC Contractor, but as a guide, the existing MPC facility utilises a tank with storage capacity of 12m$^3$. Natural gas will fuel the primary reformer, auxiliary boiler, start-up heater and the pilots of the flares (synthesis gas flare, ammonia flare, and ammonia storage tanks flare).

4.7.3.7 OTHER UTILITIES

The Ammonia Plant will have the capacity to meet the maximum steam demands of the DAP/NPK plants and the Material Handling Facility in addition to the requirement within the Ammonia Plant. A small use at the Port area may also be required.
A letdown station / desuperheater shall be provided to reduce the medium pressure steam header pressure to the required conditions for the other site users (by the injection of recycled condensate together with pressure and temperature control to produce low pressure steam).

All condensate will be collected and returned to a deaerator for use in the desuperheaters. The requirement for a deaerator will be evaluated by the FEED/EPC Contractor based on the quantity of condensate returned and boiler feed water required.

The following is a summary of the utilities that are to be supplied to the new Ammonia Plant by the existing MPC facilities at the Ras Al Khair site.

- The existing sea water supply/return headers to the MPC Plants will be used to supply make-up water to the new Ammonia Plant's Sea Water Closed Loop Cooling Water System. Similarly, the cooling tower blow down is to be discharged to the sea water return line of the existing MPC Ammonia Plant.

- The existing PDP (and/or new potable water unit) will supply Desalinated Water and Potable Water to the new Ammonia Plant. The Desalinated Water is used as feed to the Ammonia Plant's Demineralised Water Unit. Process (Service) Water can also be provided as required by the new Ammonia Plant outside normal operation.

- The existing MPC fire water system facilities are to be evaluated to verify that they are adequate to supply the required fire water for the new Ammonia Plant.

The following is a summary of the utilities which can be exported by the new Ammonia Plant:

- The new Ammonia Plant will produce a surplus of steam, therefore the medium and low pressure steam headers will be designed with suitable tie-ins to supply the steam required for new DAP & NPK plants and new material handling areas.

- The new Ammonia Plant will include a facility to produce instrument and process air for its own consumption. In addition, it will also export Instrument and Plant Air to new DAP & NPK plants and new material handling areas.

4.7.3.8 EMISSIONS

As the FEED for the Ammonia Plant has not commenced at the time of writing, the finalised emissions are not available at present. However, as the new plant will be designed to be similar to the existing plant, the emission data provided by Ma'aden for the existing Plant have been used for the purpose of this ESIA where appropriate. Further details are provided in Sections 6 and 9 of this ESIA.

Air Emissions

The primary point source emissions sources are the Primary Reformer Stack and the Auxiliary Boiler Stack. Online NOx and SOx analysers will be implemented at the primary reformer stack and auxiliary boiler stack for continuous environmental compliance monitoring of the flue gas emitted.

The existing Auxiliary Boiler Stack is 30m high with a diameter of 4.5m and is rated at 100t/hr, and although the new Ammonia Plant will be designed similar to the existing, the new Auxiliary Boiler Stack will be rated at 150t/hr and therefore may have slightly different dimensions (note the RC require a minimum stack height of 30m; RCER-2010, Volume I, clause 2.4.6).

MDEA / MEA System Stripped Gases

In case of MDEA /MEA Liquid wash for scrubbing system, the stripped gases from the stripper shall be properly & safely disposed off.

Stripped Gas Flare system from MDEA /M.E.A. desulphurization section must be designed to meet Royal Commission/IFC emission standards. Design sulphur content shall be considered as a basis. The FEED Contractor will determine the requirements for a dedicated incinerator system to burn stripped gases. The exhaust can be connected to reformer stack to meet emission criteria.
Noise Emissions

The main sources of noise are anticipated as follows:

- Reformer;
- Compressors;
- CO\textsubscript{2} vent;
- Cooling tower; and
- Air cooled heat exchangers.

Acoustic insulation and vent silencers shall be provided if required to reduce noise level to acceptable level as per regulation from compressor/turbine under normal conditions.

4.7.3.9 WASTEWATER STREAMS

The effluent treatment and disposal system will be divided into the following sections:

- Chemical and oily water sewer system;
- Demineralised water regeneration effluents;
- Non-contaminated storm water drainage system; and
- Sanitary sewer system (refer to Section 4.7.8).

Each sewer system will be designed and constructed independent of each other and no mixing of effluents shall occur at any time.

**Chemical and Oily Water Sewer System**

The FEED Contractor appointed for the Ammonia Plant will fully define the components of this system. Chemically contaminated wastewater from the process areas at the Ammonia Plant, ammonia storage area and utility cooling water system area will collect in an independent chemical pit. The chemical pit will consist of a hold up capacity of 72 hours of normal plant effluent flow to meet emergencies with pumping facility. Analysers for the following parameters will be provided for this system: Ammonia (as nitrogen); Oil; pH; Total Dissolved Solids; and Temperature.

Treatment methods for waste streams will be defined by the FEED Contractor following consideration of Best Available Techniques.

Treated water complying with RCER irrigation standards will be directed to the existing Irrigation Pond. If water does not meet the RCER irrigation standards, this will be transported to Jubail Industrial City for industrial wastewater treatment (subject to compliance with RCER wastewater pre-treatment standards). Direct discharge of this water (treated or untreated) to the Arabian Gulf is prohibited without authorisation from the Royal Commission.

A separate oil water sewer system and pit will collect drains from all sources where drain or wash water could be mixed with oil but is free of any process chemicals, e.g. pump drains and package compressor drains. Oil will be separated and removed and the wastewater can then be treated with either caustic or sulphuric acid if required depending on the pH. The separated oil will be recovered and pumped to a truck for offsite disposal. Water will then be pumped to the existing Irrigation Pond (subject to compliance with RCER, 2010). If water does not meet the RCER irrigation standards, alternative disposal/reuse methods will be required.

Water of MDEA filters washing and natural gas venturi scrubber blow down from the existing Ammonia Plant are diverted to an evaporation pond within its battery limits and sludge is removed by a specialist contractor. The FEED Contractor for the new Plant is required to establish an alternative treatment method for this waste stream following consideration of Best Available Techniques.
Demineralisation Plant Regeneration Water

The effluent streams from the various units of the demineralisation plant will be directed to a demineralisation neutralisation tank where the water will be adjusted for pH using sulphuric acid or caustic soda. Boiler blow down is directed to the Demineralisation Plant to be recycled. Waste water pumps in the basin will pump out to the irrigation pond (subject to RCER, 2010 standards) or if the pH is out of specification, the water will be recycled back to the basin to be appropriately dosed online to achieve a required pH. The demineralised regeneration water is a saline stream, similar in composition to the seawater return of the existing Ammonia Plant. Therefore, as an alternative to the irrigation pond, the regeneration water may be discharged to the seawater return header if authorised by the RC.

Cooling System Discharges

Cooling tower blow down (volume to be confirmed by the FEED Contractor) will be discharged to the return sea water header of the existing MPC PDP. In the event of a drain down of the complete system, closed loop fresh cooling water collected from various coolers will be disposed of to appropriate treatment facility (this water will contain chemicals which are injected to the fresh water).

4.7.4 NITRO PHOSPHATE POTASH (NPK) AND DI-AMMONIUM PHOSPHATE (DAP) PLANTS

The DAP / NPK complex will consist of four (4) granulation units arranged in pairs. One pair will consist of two (2) DAP units in one common building (DAP 1 and DAP 2) and the other pair will consist of one (1) NPK and one (1) DAP unit (DAP 3).

The combined DAP units will be designed to yield 2,228,094tpy of DAP 18-46-0 grade. The NPK unit will be designed to yield 766,920tpy NPK 15-15-15 grade. The unit will also be capable of manufacturing other NPK grades and DAP.

The DAP unit will be designed with an on stream factor of 330 days per year and 22 hours operation per day, and the NPK unit will be designed with an on stream factor of 332 days per year and 22 hours operation per day.

The main raw materials are concentrated phosphoric acid, liquid anhydrous ammonia, 98.5% sulphuric acid, urea, potassium chloride and filler.

The area within the battery limits of the DAP/NPK Plants (one meter outside the perimeter of each of the two DAP/NPK set of twin plants) will be divided into a solids dry area (concrete building) and a liquids wet area (scrubbing system external structure).

Key Project components proposed for the DAP/NPK Plant are outlined in Table 4-7.
Table 4-7: Key Project Components Associated with the DAP/NPK Plant

<table>
<thead>
<tr>
<th>Process Unit Area</th>
<th>Plant Off-sites and Utilities</th>
<th>Buildings</th>
</tr>
</thead>
</table>
| DAP and NPK process plants | Off-site and Maintenance Area:  
- Operating & Maintenance (O&M) workshop and outdoor paved storage yard;  
- Electrical substation (maintenance);  
- Road Weighbridge House;  
- Diesel generator building;  
- Fuel storage area;  
- Firefighting water storage tanks; and  
- Potable/process water tank. | Two-storey admin building including first aid/medical centre and rescue/fire fighting |
| 2No. DAP/NPK product storage buildings (warehouses) and associated conveyors between production units and towards Port storage sheds. | Administration Area:  
- Electrical Substation (admin)  
- Additional car parking and road access within administration area | Two-storey central laboratory |
| 1 No. raw material storage building | | Two-storey training centre |
| Maintenance, stores and operation building | | Facility Rail Workers House and Cafeteria |
| Storage tanks with bund walls for secondary containment | | Sanitary block building |
| Road access | | |
| Waste water pits | | |
| Contaminated water drainage systems for paved areas within process units | | |

4.7.4.1 RAW MATERIALS

Raw materials for the DAP/NPK process will be stored in the Materials Storage and Handling Facility and at the Port (Potash) before transport to the process plants.

A fleet of road trucks will transport the Potash from a storage facility at the Port (refer to Section 4.7.7) to a sub-divided storage building adjacent to the process plants in which Urea and Filler will also be stored. The road trucks will unload their cargo into a below ground hopper. A bucket style elevator conveyor will lift the products from the below ground hopper to a transfer station with a diverter chute. The transfer station allows the product to be conveyed to either the storage facility or onto a storage bypass conveyor heading to the DAP/NPK Process plant.

One common raw material belt conveyor will be provided for the building housing DAP 1 and DAP 2 and a separate common raw material belt conveyor will be provided for the building housing DAP 3 and NPK.

Liquid raw materials will be pumped from the Materials Storage and Handling Facility to local storage within the DAP/NPK plant and also from the Ammonia Plant storage tanks.

The raw material types and the processes in which they are used for DAP/NPK production are summarised in Table 4-8.
Table 4-8: Raw Materials for DAP / NPK Production

<table>
<thead>
<tr>
<th>Raw Material/Feedstock</th>
<th>Process</th>
<th>Delivery &amp; Storage Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filler</td>
<td>DAP and NPK Plants</td>
<td>Truck – Process Area storage building. Sourced within KSA</td>
</tr>
<tr>
<td>Urea</td>
<td>NPK Plant</td>
<td>Truck – Process Area storage building. Sourced within KSA</td>
</tr>
<tr>
<td>Potassium Chloride (K₂O; potash)</td>
<td>NPK Plant</td>
<td>Ship – truck - Port storage building - conveyors - Plant</td>
</tr>
<tr>
<td>Phosphoric Acid (P₂O₅) and Raffinate</td>
<td>Scrubbing; Preneutraliser Reactor.</td>
<td>Rail tanker-Storage Tank at Materials Storage and Handling Facility – Pipe to Plant</td>
</tr>
<tr>
<td>Sulphuric Acid</td>
<td>Preneutraliser Reactor; Granulation Pre-scrubber Tank; and Tailgas Scrubber</td>
<td>Rail tanker-Storage Tank at Materials Storage and Handling Facility – Pipe to Plant</td>
</tr>
<tr>
<td>Liquid Ammonia</td>
<td>Preneutraliser Reactor; Granulation; Ammonia vapourisation.</td>
<td>Pipe from storage tanks within Ammonia Plant battery limit</td>
</tr>
<tr>
<td>Colouring and Coating Agents</td>
<td>Final product conditioning</td>
<td>Truck – Storage Tank at Materials Storage and Handling Facility – Pipe to Plant Sourced within KSA</td>
</tr>
<tr>
<td>Coating Oil</td>
<td>Final product conditioning</td>
<td>Truck – Storage Tank at Materials Storage and Handling Facility – Pipe to Plant Sourced within KSA</td>
</tr>
<tr>
<td>Anti-foam Agent</td>
<td>Scrubbers; Preneutraliser / pipe reactor tank.</td>
<td>Truck – Storage Tank at Materials Storage and Handling Facility – Pipe to Plant.</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Fuel to dryer burner</td>
<td>Pipe Supplied by Saudi Aramco</td>
</tr>
<tr>
<td>Process Water</td>
<td>Preneutraliser Reactor (reaction of ammonia vapour and phosphoric acid); Scrubbing (removal of both dust and volatiles); Prescrubber and Scrubber tanks; and Tailgas Scrubber.</td>
<td>Pipe from existing MPC Power and Desalination Plant storage.</td>
</tr>
<tr>
<td>Medium Pressure Steam</td>
<td>Granulation</td>
<td>Ammonia Plant (by desuperheating and demineralised water (start-up) and recovered condensate during normal operation</td>
</tr>
<tr>
<td>Low Pressure Steam</td>
<td>Preneutraliser and product coating (coating oil dosing pumps – low pressure steam jacketed pipes and spray nozzle)</td>
<td>Ammonia Plant (expanded medium pressure steam)</td>
</tr>
<tr>
<td>Instrument Air</td>
<td>Ammonia Plant</td>
<td></td>
</tr>
</tbody>
</table>

4.7.4.2 PROCESS DESCRIPTION

**Raw Materials Handling**

Hoppers and conveyor belts will be used to distribute the raw materials to the process.

**Slurry Preparation and Granulation**

A Preneutraliser and Pipe Reactor are used to react phosphoric acid, sulphuric acid and scrubber liquor with ammonia to produce ammonium phosphate slurry. Gases generated into the Preneutraliser are drawn towards a Fumes Pre-Scrubber to recover most of the evolved ammonia losses. The granulation system transforms the slurry and solid raw materials (filler for DAP and filler, urea, potash for NPK depending on the grade required) into a granular fertiliser product with the required composition and size. Gases developed in the granulator are drawn through the Granulator Pre-scrubber, to recover most of the evolved dust and ammonia losses.
Drying

The rotary drum dryer then dries the solids for transport to screening and cooling stage of the process. Hot air is supplied by a natural gas fired Combustion Chamber. Air for combustion and dilution are supplied by separate fans. The Dilution Air is used to reduce the temperature of the combustion gases to the level required for drying the product and avoiding excessive temperatures to prevent product decomposition, ammonia emission and fumes formation.

The dryer exit gas contains some dust that is removed in the dryer cyclones, collected in the cyclones hoppers and returned to the Recycle Conveyor.

Screening and Crushing

A series of process screens are used to separate out the on-size product from both the fines/small product fraction and the oversize, which is crushed in oversize mills. Fines and oversize elements are returned back to the screening process via the Recycle Conveyor Belt. The Recycle Conveyor will be designed to receive the following:

- Dust from all cyclones;
- Fines from all screens;
- Crushed oversizes from all crushers;
- Overflow from recycle regulator conveyor;
- Filler and spillage from the raw material collection conveyor (and urea and potash for NPK grades); and
- Occasionally, plant spillage introduced back into the system by payloader through the feeding system, consisting on a small hopper, a spillage conveyor and a spillage recovery elevator that discharges on belt conveyor, which introduces spillage into the production building.

The Recycle Conveyor should operate at rather low speed, to avoid mechanical problems, and its cover should be tight and large enough, to avoid dust emission. This conveyor discharges into the Granulator Elevator that feeds all the recycle and filler / spillage to the granulator.

Final Product Conditioning and Storage

Commercially sized product is cooled using chilled air in the Rotary Cooler Drum and then passed on to a final screening to remove any fines before entering a Coating Drum. Dust present in the air leaving the Product Cooler is recovered in a battery of cyclones, collected in cyclones hoppers and finally discharged to the recycle conveyor. After the cyclones, the dedusted air will be sent to the Cooler and Dedusting scrubber for scrubbing.

Coating oil and colouring agent (as required) are added to the Coating Drum for caking and colouring control respectively. Cooler exhaust air is drawn by Cooler Exhaust Fan through cyclones and the Cooler and Dedusting Scrubber.

After coating and colouring, product falls by gravity to the Final Product Conveyor, which will send product to the final storage, outside battery limits via a series of covered conveyors. One product conveyor will exit each process unit (total of four conveyors) crossing the battery limit and terminate at a local transfer tower.

It is proposed that two number 50,000t capacity DAP/NPK storage buildings will be located adjacent to the DAP/NPK process plants inside the battery limits. One building will be dedicated to DAP and the other will be sub-divided to allow DAP and multiple NPK grades to be segregated. Additional product storage space for 465,000t of product is also proposed in the Port area (refer to Section 4.7.7). The products will be reclaimed from each of the storage sheds by automated reclaimers and conveyed by a series of parallel conveyors to the Port storage sheds. At this early stage of development it is considered that the available transport corridors on plot and going to the Port are sufficient to accommodate the proposed mechanical handling systems and their operations/maintenance requirements.
Dust and Fumes Collection

All process equipment in the plant operates under a small negative pressure in order to prevent the escape of unreacted ammonia, other gases and dust from the process.

Most of the dust is removed and returned to the process as recycle via the Recycle Conveyor.

Air containing ammonia, water vapour and dust from the Preneutraliser and Pipe Reactor / Granulator is vented to the Granulator Pre-Scrubber, where ammonia and a major portion of the dust are removed by reacting with the phosphoric acid contained in the circulating scrubber solution.

From the Pre-Scrubber the gas flows to the Granulator Scrubber, where most of the remaining ammonia and dust are removed.

Air leaving this Scrubber is drawn by the Granulator Exhaust Fan and feeds the Tail Gas Scrubber, to recover fluorine evolved during phosphoric acid washing and to complete ammonia and dust recovery.

Gas containing ammonia and dust from the Dryer, flows through the Dryer Cyclones, to remove a major portion of the dust, which is returned to the Recycle Conveyor.

Gases from the cyclones flow to the Dryer Scrubber drawn by the Dryer Exhaust Fan located downstream of the scrubber, and from there to the Final Tail Gas Scrubber for further ammonia and dust removal.

Air containing dust from the solids handling equipment (conveyors, elevators, screens, etc) is vented into the Dedusting Cyclones, where most of the dust is removed.

Air from the cyclones flows to the Cooler & Dedusting Scrubber to be jointly washed with the gases coming from Cooler Cyclones. The common Cooler and Dedusting Exhaust Fan provide the required suction from the previous scrubber, as well as pushing through the Final Tail Gas Scrubber.

A complete dedusting system will be implemented to avoid a dusty environment within the production building. Its detail design will be progressed at EPC stage. There is a heating system to provide hot air for each dedusting air suction point, in order to reduce air relative humidity, to avoid water condensation in the ducting system and to minimise duct plugging.

Scrubbing

A series of scrubbers are used to remove both dust and volatiles, which are mainly ammonia, hydrofluoric acid and some silicon tetrafluoride. The scrubbing system for this plant consists of the following:

First scrubbing step:

- Granulator Pre-Scruber – Duct Cyclonic

Second scrubbing step:

- Granulator Scrubber – Venturi Cyclonic
- Dryer Scrubber – Venturi Cyclonic
- Cooler and Dedusting Scrubber – Venturi Cyclonic

Third scrubbing step:

- Final Tail Gas Scrubber – Packed Tower

The plant utilises ammoniated phosphoric acid to scrub gases from Preneutraliser / Pipe Reactor / Granulator, Dryer and Cooler and equipment dedusting, whereas water is used as scrubbing liquid in the final scrubbing stage for all gases.

First scrubbing step:

The gases from the Preneutraliser and the Pipe Reactor / Granulator (containing most of the ammonia) are first scrubbed in the Granulator Pre-Scruber which is irrigated by a solution of
phosphoric acid slightly ammoniated until a mole ratio of about 0.4-0.5 (the low molar ratio gives maximum performance for ammonia recovery). Ammonium phosphates are formed by the reaction of ammonia (escaping the Preneutraliser and the Pipe Reactor / Granulator) with phosphoric acid.

The latter is fed to the Pre-Scrubber and recirculated by one of the Pre-Scrubber Pumps About 80% to 90% of the ammonia and dust in the gases are removed in the Pre-scrubber.

Second scrubbing step:

Gases coming from previous first step Granulator Pre-Scrubber are further washed in the Granulator scrubber. Dryer gases, after cycloning, are washed in the Dryer scrubber. The exhaust gases from the Cooler cyclones are mixed with the gases coming from dedusting system cyclones, and are jointly scrubbed in the Cooler and Dedusting scrubber.

All three scrubbers share a common scrubber tank and use a diluted solution of phosphoric acid, ammoniated to a mole ratio of about 0.5-0.6. Circulation is provided by a series of pumps.

In addition to removing most of dust, this scrubbing step provides a very good pH for recovering ammonia, without excessive fluorine emissions. The remaining pollutants will be recovered in the last washing step.

Third washing step

Gases from the Granulator scrubber, Dryer Scrubber and from the Cooler and Dedusting Scrubber are finally washed in the Final Tail Gas Scrubber to remove the fluorine evolved during the phosphoric acid washing and to complete the ammonia and dust recovery.

To meet legislative requirements (as a minimum), this scrubber has two washing steps. The first washing stage consists of spray nozzles, all of them on the almost horizontal duct located before the inlet to the scrubbing tower. Gases, after washing, enter into the cyclonic tower and to proceed to the second washing stage, which consists of an irrigated packing, located on the middle-upper part of the scrubber tower.

The second stage washing liquid, before feeding the liquid distributor, is passed through an ammonia evaporator. The scrubbing liquid as it flows through the tubes will cool down and evaporate the liquid ammonia on the shell side of the exchanger. Ammonia vapour will feed the ammonia separator, joining with the evaporated ammonia coming from the Air Chiller. The ammonia vapour will feed the Preneutraliser.

Ammonia Vaporisation

Part of the total required ammonia for production is directly fed, in liquid state, to the Pipe Reactor and granulator ammonia sparger. Remaining ammonia, required for preneutraliser feeding, is vaporised by the Air Chiller System and the Ammonia Evaporator.

Liquid Routing

Phosphoric acid received from the storage tanks is directly fed to the Pre-scrubber Tank, where it mixes with liquid coming from the main scrubber tank mainly consisting of slightly more diluted phosphoric liquor. $P_2O_5$ is fed to this first washing step (as phosphoric acid) and $NH_3$ escaping from the preneutraliser, granulator and pipe reactor will react, so that the molar N/P in this liquid will be about 0.4-0.5. Some small quantities of sulphuric acid may be also added to control N/P ratio and solubility.

Following the Pre-scrubber, the second washing step recovers most of the remaining ammonia and dust.

In the Final Tail Gas Scrubber all the gases will be washed with water. This step provides an efficient removal of dust, ammonia and fluorine. The lower section of the Final Tail Gas Scrubber is equipped with pH control system, linked to the sulphuric acid addition, to provide the most suitable pH for both ammonia and fluorine recovery. Water from Final Tail Gas Scrubber lower section is advanced, as make-up water, to the scrubber tank, where it mixes with part of the phosphoric acid.
After washing all gases in the second step scrubbing, the scrubber liquor is advanced to the Prescrubber.

There are two lines feeding the Prescrubber, one from the main scrubber tank, one directly connected to the Prescrubber tank itself, or to the duct connecting granulator and Prescrubber. This last line may be used to clean the granulator exhaust duct. Finally, the liquid from the Prescrubber tank will be split to the Pipe Reactor Tank and the Preneutriliser Reactor.

In the Pipe Reactor Tank, the Prescrubber liquor will be mixed with more fresh phosphoric acid, to reach the required $P_2O_5$ concentration. Liquor from the Pipe Reactor Tank will feed the resulting phosphoric acid mixture to the Pipe Reactor(s).

To prevent foam formation in the different tanks/ vessels, defoamer can be used.

An underground sump tank will be provided to receive all spillage / liquid from flushing operation, equipped with an agitator. Pumps allow the recovery of the liquid into the process.

There will be two independent Waste tanks, outside plant battery limits and common to each pair of plants, to store the waste liquid from scrubbing system washings. Similarly to the sump tank liquid, this wastewater will be recovered at a later stage into the process.

4.7.4.3 WATER CONSUMPTION

<table>
<thead>
<tr>
<th>Water</th>
<th>Usage (m$^3$/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Water</td>
<td>2781 (based on 22 hour day)</td>
</tr>
<tr>
<td>Potable Water</td>
<td>56</td>
</tr>
<tr>
<td>Desalinated Water</td>
<td>3600</td>
</tr>
</tbody>
</table>

4.7.4.4 POWER CONSUMPTION

The Ammonia High Voltage (HV) Main Switchboard will provide two 34.5kV power supplies to the DAP/NPK area Main Electrical Substation. These supplies will be in the form of underground dual redundant cable circuits.

A new Port Substation will also be provided to supply all electrical loads associated with the new ship loading and offloading facilities. The EPC Contractor will be responsible for liaising with the Port Authority to obtain power supplies to this substation from the existing port power infrastructure.

Low Voltage (LV) Emergency Diesel Generators at each Substation will be installed to supply the area’s emergency power requirements.

In summary, power supply to the process plants and facilities will be outsourced from the Saudi Electricity Company (SEC) as follows:

- HV Primary Distribution: 34.5 kV
- HV Secondary Power: 13.8 kV
- HV Secondary Power: 4.16 kV
- LV Power distribution (Motor Supplies): 480 V
- Small Power: 230 V
- Control and Instrument Power: 230 V

4.7.4.5 FUEL CONSUMPTION

Diesel emergency generators will be located as necessary to provide emergency power for a safe shutdown of the facilities in the event of loss of grid power. Wherever a diesel generator
set is provided, diesel day tank storage will also be provided. Centralised storage to supply these day tanks is provided by the existing MPC facility. The number and sizing of the diesel storage tanks will be determined by the EPC Contractor, but for the purpose of assessment one storage day tank with a total volume of 25 m\(^3\) will be located at the DAP/NPK Plant. This tank is in addition to one proposed at the Ammonia Plant (12 m\(^3\)) and one within the Administration Area (12 m\(^3\)).

4.7.4.6 EMISSIONS, WASTEWATER AND WASTE STREAMS

The point source emissions to the atmosphere via the Tail Gas Scrubber Stack are guaranteed by the Licensor (and compliant with RCER-2010) as follows:

- \(\text{NH}_3\): 50 mg/Nm\(^3\)
- Fluoride (as HF): <30 g/t of equiv. \(\text{P}_2\text{O}_5\) Feed
- Dust: <0.25 kg/tonne of product

The ammonia safety valve and ammonia vents shall be routed back to the ammonia storage tank.

All solid spillages and rejects shall be recycled back to the process.

A dedusting system will be provided within the solids section of the plant to ensure that the working atmosphere inside the plant is dust free (refer to Section 4.7.4.2).

There will be no liquid effluent from the process. All liquid effluents will be collected in the sumps/waste water tanks and recycled to the process. Condensate recovery at Ras Al Khair will take place within the Ammonia Plant.

Potentially contaminated stormwater/firewater will be collected from the process areas and drained through a series of channels to a sump. If monitoring concludes this water does not achieve the RCER-2010 irrigation standards, the contaminated water will be transported by tanker off-site to an appropriate industrial waste water treatment plant (e.g. at Jubail Industrial City).

4.7.5 MATERIALS STORAGE AND HANDLING FACILITY

As illustrated in Figure 4-3 and Figure 4-5, railway sidings with a Materials Storage and Handling Facility is proposed in the south-east corner of the Project site to facilitate the use of MGA + Raffinate and sulphuric acid and the export of MGA and PPA which are produced at the Umm Wu’al mine site. These materials will be transported to the area by rail, but smaller volumes of other materials will arrive via road tankers (refer to Section 4.7.6).

The Materials Storage and Handling Facilities Area will comprise the following key components:

- Storage tanks;
- Bund walls and containment for accidental spillage from product tankage;
- Electrical Substation (handling/storage);
- Road access within storage area and tank farm;
- Contaminated water drainage systems for paved areas within storage areas and separate storm water drainage system for roads;
- Rail tanker unloading facilities; and
- Rail infrastructure (sidings, shelter and other Saudi Arabian Railways (SAR) facilities).

In more detail, rail unloading facilities will be provided at Ras Al Khair to enable for the transfer of the following liquids from rail wagons to storage tanks:

- MGA+Raffinate: MGA and Raffinate will be produced at Umm Wu’al. On arrival at Ras Al Khair, this will be transferred from rail tanker to the storage tanks via bottom
discharge by gravity to underground sumps. It is then pumped to storage tanks for use in the DAP/NPK plants as a feedstock.

- Sulphuric Acid: This will be handled in the same way as described for MGA+Raffinate.
- MGA for Export: This will be unloaded from rail wagons via bottom discharge by gravity to underground sumps and stored in tanks for later pumping to the Port for export.
- PPA: This will be unloaded from rail wagons via bottom discharge by gravity to underground sumps and stored in tanks for later pumping to the Port of Ras Al Khair for export.
- Miscellaneous: Coating, colouring and anti-foam agents unloaded from road tankers.

Storage tank size (and tank type (API 650, API 620, fixed roof, floating roof etc.)) will be confirmed by the EPC Contractor. For MGA + Raffinate and Sulphuric Acid, storage tanks will be designed to feed the DAP/NPK Plant for eight days of full product capacity.

Liquids for unloading will be discharged by gravity to underground tanks placed in reinforced concrete sumps. Each sump will serve a number of rail tanks. Each sump will have two 100% duty standby pumps discharging to the storage tanks. A vapour recovery system will be implemented as required for acid products with associated pumps and storage tanks. Suitable fire-fighting and spillage control systems will be designed and implemented.

The MGA Tank wagons are likely to require high pressure water washing to remove settled material every third trip and a suitably designed system is required to include a pumped wastewater return system directed to the MGA pump sump. This wash water will help flush the sump too. It is expected at this stage of the design that all flushings will be used in the DAP/NPK process.

Similarly to the DAP/NPK process areas (Section 4.7.4.6), potentially contaminated stormwater/firewater will be collected from this area and drained to a sump for transport to an off-site treatment facility.

A summary of the storage tanks to be located at the Materials Storage and Handling Facility is provided in Table 4-10. All listed tanks will have a ‘fixed cone’ roof type.

**Table 4-10: Materials Storage and Handling Facility Storage Tanks**

<table>
<thead>
<tr>
<th>Storage Tank</th>
<th>Fluid Stored</th>
<th>Capacity per Tank (m³)</th>
<th>Dimensions</th>
<th>Target Minimum Days</th>
<th>Number of Tanks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGA &amp; Raffinate</td>
<td>MGA (54% P2O5, 75% H3PO4) + Raffinate (32% P2O5, 44% H3PO4)</td>
<td>4,045</td>
<td>Diameter 22.5m Height 13.5m</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>MGA (For Export)</td>
<td>MGA (54% P2O5, 75% H3PO4)</td>
<td>4,274</td>
<td>Diameter 22.5m Height 14.5m</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>PPA</td>
<td>Purified Phosphoric Acid (62% P2O5, 85 wt% H3PO4)</td>
<td>1,686 (nominal)</td>
<td>Diameter 14m Height 12m</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Sulphuric Acid</td>
<td>Sulphuric Acid (98.5% conc.)</td>
<td>6,540 (nominal)</td>
<td>Diameter 26m Height 15.8m</td>
<td>8</td>
<td>2</td>
</tr>
</tbody>
</table>
4.7.6 RAIL AND ROAD INFRASTRUCTURE

The geographic coverage for rail services relevant to the Umm Wu‘al Phosphate Project is the approximate 1,600km distance between Umm Wu‘al and Ras al Khair. The existing rail infrastructure terminates at Al Jalamid, some 135km from Umm Wu‘al. This link will be extended by Saudi Arabian Railways (SAR) and will include the necessary sidings and turning loop. Similarly, the required sidings at Ras Al Khair will be provided by SAR to service the Ras Al Khair Industrial Complex. The Ras Al Khair sidings will be located outside the Ma‘aden site boundary to the east. This ESIA is concerned only with the facilities at the Ras Al Khair Industrial Complex and connections to Ras Al Khair Port.

SAR extension works will extend to the Project site boundary on its eastern side, and with SAR agreement, the EPC Contractor will construct (on their lands) the offloading infrastructure below track sub base level including reinforced concrete pits and steel pumping sumps for offloaded liquids with associated facilities including service ducts.

Ras al Khair has an existing rail head with a large turning loop, but new rail sidings are required on the eastern side of the plot to link the Materials Storage and Handling Area to the Port and to the Umm Wu‘al site in the north.

The locations of new roads proposed as part of this Project are illustrated in Figure 4-9. A transport corridor from the process plant area to the Port exists and is interconnected with existing roads owned and operated by the Saudi Port Authority (SEAPA).

The EPC Contractor will determine vehicle movements during the construction and operation of the facility and roads will be designed to Royal Commission and Ma‘aden Roadworks specification.
4.7.7 RAS AL KAHIR PORT DEVELOPMENT

It is anticipated that the Saudi Ports Authority (SEAPA) will allocate three berths at Ras Al Khair Port to Ma’aden for the Project:

- Two dry berths for export of bulk NPK/DAP and import of Potash; and
- One berth dedicated to liquid export i.e. Ammonia, PPA and MGA.

The construction and ongoing maintenance (e.g. dredging) of these berths will be the responsibility of the SEAPA and not assessed in detail within this ESIA report.

Refer to Figure 4-10 below for a conceptual proposed layout for the Port.
As the SEAPA will be responsible for the construction of the berths, the proposed Port layout shown in Figure 4-10 is subject to confirmation following on-going communication with SEAPA.

The Project elements proposed at the Port include the following aspects:

- Export storage sheds for DAP & NPK with a minimum of 465,000t total capacity. This storage is anticipated to be provided in three sheds with 155,000t each capacity with two sheds dedicated to DAP and the other shed split between DAP and NPK. A reclaimer and recovery conveyor will be provided in each shed (rated 2,000tph).

- Import storage shed for Potash with 48,000t total capacity.

- A Ship un-loader (grab type) for off-loading Potash imports which arrive as loose bulk on bulk cargo vessels (rated 450tph).

- Material handling conveyor to transport imported Potash from quay-side to storage area (rated 500tph) and then from storage area to truck loading area.
• Material handling conveyor(s) to transport DAP & NPK product from the process plant to the Port storage area (rated 1,500tph) and then from the Port storage area to ship (rated 2,000tph).

• One Mechanical Bulk Ship Loaders (rated at 2,000tph) will be positioned at each of the two bulk export berths.

• A PPA transfer pipeline and a separate MGA transfer pipeline from the Materials Storage and Handling Facility to the PPA and MGA Export Loading Arms in the Port.

• Ammonia loading arm to ship: pumped (approximately 3.5km) from the Ammonia Storage Tanks directly to the Port for direct loading to ship via a loading arm.

• Substation, control and workshop buildings.

• Service corridor from the process plant to the Port and road connections with SEAPA and RC provided roads.

• Emergency diesel generator (rating of 1,000 kVA) in a weather proof noise enclosure.

The anticipated annual product throughputs at Ras Al Khair Port are provided in Table 4-11.

<table>
<thead>
<tr>
<th>Product</th>
<th>Throughput (TPY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAP (Bulk Solid Export)</td>
<td>2,228,094</td>
</tr>
<tr>
<td>NPK (Bulk Solid Export)</td>
<td>766,920</td>
</tr>
<tr>
<td>PPA (Bulk Liquid Export)</td>
<td>78,101</td>
</tr>
<tr>
<td>MGA (Bulk Liquid Export)</td>
<td>151,845</td>
</tr>
<tr>
<td>Ammonia (Bulk Liquid Export)</td>
<td>464,987</td>
</tr>
<tr>
<td>Potash (Bulk Solid Import)</td>
<td>191,767</td>
</tr>
</tbody>
</table>

No storage of Ammonia is intended in the Port area, and it is anticipated that all other material imports and exports will to be via other ports and therefore no other handling/storage facilities in addition to DAP/NPK and Potash are required at the Ras Al Khair Port.

The conveyance of dry materials to/from the Port is illustrated in Figure 4-11 and Figure 4-12, where the orange links represent the flow of materials to be exported via the Port and the green links represent the import flow of materials (potash only).
Figure 4-11: DAP/NPK Simplified Process Flow Diagram – Dry Material Conveyance
Figure 4-12: DAP / NPK Process Plant and Port Materials Handling Study
4.7.8 SITE-WIDE SANITARY AND UNCONTAMINATED STORM WATER MANAGEMENT

Sanitary Waste Water

Within the Ammonia Plant, this water will be collected in sanitary collection pit and then pumped (via non-submersible pump/s) to the existing central sanitary treatment plant. The existing Ammonia Plant utilises a 30m³ collection pit and surface mounted pump with 5m³/hr capacity. A similar arrangement will be employed for the new Ammonia Plant.

Sanitary waste generated within the DAP/NPK process areas and will be diverted into local sumps for buildings that are located within the process units and then collected by tanker and taken to the sanitary treatment plant.

The buildings located within the administration area will have a local sump which will collect all the sanitary drainage from this area. This sanitary waste will then be pumped from the local sump to the sanitary treatment plant.

Sanitary waste water will be treated to meet the RCER-2010 irrigation water quality standards and is therefore routed to the Irrigation Pond. The water will be used for irrigation purposes at the Industrial Complex.

Uncontaminated Wastewater

The new surface water drainage system required to service all new development areas at the Project site is currently proposed as a gravity/pumped system. Rainwater shall be collected from the roofs of buildings and directed into an underground pipe and trench system to perimeter ditches. Channels and gullies shall be provided to convey the uncontaminated surface water from all roads and hard standing areas which are not part of the process areas. Drainage from car and truck parking areas, which shall be impervious, shall be discharged via oil separators with storm water by-passes to the perimeter ditches.

Clean stormwater runoff in the Ammonia area will discharge into the contaminated water system. Outside the Ammonia Plant, the clean stormwater drainage will collect stormwater runoff from the new development areas excluding process and storage areas where the stormwater runoff could potentially be contaminated. These new development areas have been divided up into three main drainage areas listed below:

- Area 1: DAP/NPK Plant
- Area 2: Storage Tank Farm
- Area 3: Operations & Maintenance (O&M)

The clean stormwater runoff will be collected and diverted to three individual sumps using concrete lined channels and concrete pipe culverts at road crossings. The collected clean stormwater runoff will then be pumped via rising mains, from the three individual sumps to a new HDPE-lined clean stormwater retention pond located south of the existing retention pond.

The clean stormwater retention pond has the capacity to hold the first flush of rain. This will be controlled by a concrete weir at the downstream section of the pond. The weir will also allow any excess stormwater runoff to discharge into the existing outfall system. The existing retention pond discharges to the ‘INFRACO Trunk Drain’ and then to sea. In the absence of other (newly constructed) RC storm water drainage system, stormwater from the new retention pond will be discharaged to this trunk drain as it is considered to have sufficient capacity (to be confirmed by the EPC Contractor).

Areas at risk of hydrocarbon pollution, for example car park areas, maintenance areas and fuel storage areas will drain through an oil interceptor prior to discharge to the clean stormwater system.
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5.0 IMPACT ASSESSMENT METHODOLOGY

Section 3 Consideration of Alternatives describes the various project / design alternatives considered as part of the Project development; the selected Project elements have been described in Section 4 Detailed Description and Layout of the Proposed Development. This Section, Impact Assessment Methodology, presents an overview of the general impact assessment methodology applied to the assessment of potential impacts arising from the Project elements so that this is not repeated across Sections 6 – 16.

The impact assessment criteria, outlined in the following sub-sections, have been applied to the assessment of each of the proposed Project elements during construction, operation and decommissioning stages and documented within Sections 6-16. Where specific methods of assessment have been applied for an environmental aspect, these are presented in the relevant Section (6-16).

In accordance with IFC Performance Standard 1 Assessment and Management of Environmental and Social Risks and Impacts, the impact assessment methodology has been developed in accordance with good international industry practice and potential impacts have been identified in the context of the Project’s area of influence.

5.1 ESTABLISHMENT OF BASELINE CONDITIONS

Baseline information for the ESIA has been collated from desk-based studies and literature reviews, sites visits and monitoring, and consultation. These can be summarised as follows:

Literature Review:
- Environmental impact assessment reports previously completed for the Ma’aden Phosphate Project (2005, 2008, and 2012);
- Environmental baseline studies commissioned by Ma’aden at Ras Al Khair following the construction of the existing fertiliser complex (2011 and 2012); and
- Environmental impact assessment report for the adjacent Ma’aden Aluminium Facility.

Site Visits and Consultation:
- October 2012: Environmental Scoping meeting with the Royal Commission;
- September 2012: Preliminary site visit to review existing land use and identify receptors;
- January 2013: Air and noise monitoring and consultations with Ma’aden staff; and
- March 2013: Air and noise monitoring, traffic counts and land use review.

5.2 IMPACT ASSESSMENT CRITERIA

Prediction and evaluation of environmental and social impacts within Sections 6-16 of this ESIA are considered against the baseline (including its value / sensitivity). Supplementary to the Key Principles provided by PME (2001) as a basis for assessing environmental impacts, and in support of the RC’s EIA requirements, the impact assessment methodology applied for this ESIA was developed using a combination of the criteria, methodology and guidance provided by international requirements/best practice. As noted in Section 2 Policy, Legal Administration Framework, in the event that RCER-2010 do not specify a standard relevant to the project site, then the project shall use for reference other recognised regulations as a basis for technical justification. The same principle has been applied to the definition of impact assessment criteria.

The PME Key Principles are as follows:
- “Nature and magnitude of the intended activity and the existence of similar projects at the site or similar sites;
- Extent of depletion by the installation of the natural resources, particularly agricultural lands and mineral resources;
The project's environmental impact assessment (EIA) methodology has been adopted in combination with RC requirements on EIA content. The following factors are considered in classifying each potential impact generated by the Project, as presented in Table 5-1:

- **Frequency**: Occurrence of activity producing the impact, e.g., continuous, intermittent or a single event / less than once per year;
- **Likelihood**: Probability of impact occurrence (e.g., 100%, 50%, 0%);
- **Extent**: Spatial extent of the impact (e.g. within 2km of site boundary, within the industrial city, within 75km, within KSA);
- **Duration**: Extent in time of the impact. Short term impact (less than the life of the 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 RC, the PME or international standards where available.
- **Type of impact**: Positive or negative effect; direct or indirect action.
- **Potential significance**: A combination of all the factors described in the preceding bullet points is used to determine the type and significance of a potential impact prior to mitigation. This is defined as low, medium or high.

Table 5-1 presents the terminology used throughout Sections 6-16 to describe and rank environmental and social impacts according to the categories defined above. Figure 5-1 presents how these criteria are combined in order to assess the significance of the potential environmental and social impacts identified.
### Table 5-1 Terminology Used to Describe Environmental and Social Impacts

<table>
<thead>
<tr>
<th>Category</th>
<th>Terminology</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scope of Impact</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Continuous</td>
<td>Uninterrupted or on a daily basis</td>
</tr>
<tr>
<td>Frequency</td>
<td>Frequent</td>
<td>Once or more per day</td>
</tr>
<tr>
<td></td>
<td>Infrequent</td>
<td>Less than once per day</td>
</tr>
<tr>
<td></td>
<td>Rare</td>
<td>Single event / less than once per year</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Certain</td>
<td>Impact possibility estimated to be 100%</td>
</tr>
<tr>
<td></td>
<td>Likely</td>
<td>Impact possibility estimated as between 50% and 99%</td>
</tr>
<tr>
<td></td>
<td>Unlikely</td>
<td>Impact possibility estimated as &lt; 50%</td>
</tr>
<tr>
<td></td>
<td>No impact</td>
<td>Zero estimated possibility of impact</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
<td>Within 2 km of the Ras Al Khair Industrial City</td>
</tr>
<tr>
<td></td>
<td>Provincial</td>
<td>Outside Ras Al Khair City but &lt; 20 km away</td>
</tr>
<tr>
<td></td>
<td>Regional</td>
<td>Outside Ras Al Khair City but &lt; 200 km away</td>
</tr>
<tr>
<td></td>
<td>National</td>
<td>Within KSA</td>
</tr>
<tr>
<td></td>
<td>International</td>
<td>Outside KSA</td>
</tr>
<tr>
<td>Duration</td>
<td>Short</td>
<td>Less than the life of Project</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>The life of project</td>
</tr>
<tr>
<td></td>
<td>Long</td>
<td>Greater than the life of Project</td>
</tr>
<tr>
<td>Magnitude&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Very low</td>
<td>Defined in relation to the limit criterion where available, e.g.:</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>- Very low: Parameter &lt; 10% limit criterion</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>- Low: Parameter 10 to &lt;50% limit criterion</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>- Medium: Parameter 50 – 100% limit criterion</td>
</tr>
<tr>
<td></td>
<td>Very high</td>
<td>- High: Parameter 100 – 200% limit criterion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Or, for qualitative assessments:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Very low: No degradation/adverse alteration to resource/receptor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Low: Minor degradation/adverse alteration to resource/receptor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Medium: Moderate degradation/adverse alteration to resource/receptor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- High: Significant degradation/adverse alteration to resource/receptor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Very High: Permanent degradation/detrimental alteration to resource/receptor</td>
</tr>
<tr>
<td>Type of Impact</td>
<td>Effect</td>
<td>Positive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
<td>Impact caused solely by activities within scope of Project</td>
</tr>
<tr>
<td></td>
<td>Indirect</td>
<td>Impact which does not result directly from by activities within the scope of Project, but which has a connection with the Project’s presence.</td>
</tr>
<tr>
<td>Potential Significance</td>
<td>Significance</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
</tr>
</tbody>
</table>
Notes:

(1) All terms are characteristics of the impact(s). For example, duration refers to duration of impact, not the activity causing it.

(2) As indicated, the impact magnitude for some environmental aspects can be defined in relation to the limit criterion specified by the RC, PME or international regulations, or best practices when national standards are not available. However, in the absence of definitive quantitative criteria, a qualitative assessment of the magnitude is used relating to the impact type.
Figure 5-1: Combination of EIA Criteria Used to Assess the Potential Environmental and Social Impacts Identified
5.3 IMPACT ASSESSMENT REPORTING

The findings of the assessment process for each environmental aspect are presented in Sections 6 – 16 with the significance of any predicted environmental impacts being defined as Low, Medium or High and documented in **bold italics**.

Impacts predicted as being of medium to high significance are then assessed against appropriate mitigation measures to predict the residual impact significance. An example of how Sections 6 – 16 report the mitigation identified for impacts of medium to high significance is illustrated by Table 5-2. The Identification (ID) Codes assigned to each impact are used to reference the impacts and association mitigation measures through other sections of the ESIA (e.g. Section 18 Summary of Impacts and Mitigation).

*Table 5-2: Example of Impact and Mitigation Summaries*

<table>
<thead>
<tr>
<th>ID Code</th>
<th>Impact</th>
<th>Potential Significance</th>
<th>Mitigation Measure</th>
<th>Significance after Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2</td>
<td>Increase in Vehicle movement will result in potential road traffic accidents during Construction</td>
<td>High</td>
<td>A structured approach to traffic management and vehicle standards should be specified and safety measures should be implemented. Ensure the transport plan for the Project is developed and implemented during the lifetime of the project. Establish pedestrian routes within the construction area to be used by workers;</td>
<td>Medium</td>
</tr>
</tbody>
</table>

5.4 MITIGATION MEASURES AND RECOMMENDATIONS

Two types of mitigation measures are identified through this ESIA Report in order to alleviate or manage the potential impacts identified:

- **Type 1:** Measures to be taken to manage potential impacts considered to be of medium or high significance. Following application of these measures, residual impacts are expected to be lower.
- **Type 2:** Recommended measures that could be taken to manage impacts classified as low/insignificant. These measures can be considered as good management practices.

5.5 CONCLUSION

The impact assessment methodology applied across this ESIA demonstrates an appropriate mitigation hierarchy for predicted impacts which gives preference to the avoidance of impacts over minimisation. This is achieved firstly by the examination of feasible alternatives; alternative project locations, designs, or operational processes, as documented in Section 3 Consideration of Alternatives, and then the remainder of the ESIA outlines the alternative ways identified for dealing with any predicted environmental and social impacts.
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6.0 AIR QUALITY AND METEOROLOGY

6.1 INTRODUCTION & SCOPE

This Section presents a summary of the existing ambient air quality conditions in the vicinity of the Project site and the prediction of potential impacts resulting from air emissions during the various stages of the Project. The phases considered in this assessment include construction, operations and decommissioning, including emissions during upset and emergency conditions. The detailed Project emissions input data as well as modelling results are presented in Appendix D Ambient Air Quality Assessment.

6.2 BASELINE CONDITIONS/ EXISTING ENVIRONMENT

6.2.1 INTRODUCTION

This Section presents a description of the baseline air quality and existing meteorological conditions at the Ras Al Khair Industrial Complex (Project site) based on a desktop review of relevant literature and Project specific baseline data collection during site visits on 19-21 January; 5-11 March; and 16 April in 2013. The literature review includes previous environmental assessments conducted for other developments in the vicinity of the Project site in order to gather information about the regional context. Studies reviewed include:

- Bechtel (2011) Ma’aden Pre-Feasibility Studies for Copper & Zinc (Ras Al Khair Site); and

6.2.2 REGIONAL AIR QUALITY

The Ras Al Khair Industrial City has been designed to accommodate several industrial facilities including aluminium and phosphate plants. As the Project is in very close proximity to existing and proposed plants, this Section draws on information on the baseline air quality and meteorology documented in the recent reports described above.

The Royal Commission (RC) operates a series of environmental and atmospheric monitoring stations in each of the industrial cities to provide reliable baseline information for developers. Although the RC monitoring station at Ras Al Khair is active, the RC have informed that at the time of undertaking this assessment the data has not been normalised and is not ready for use. The RC meteorological data for Jubail was also used for the assessment.

Supplementary air quality monitoring data was collected on site as part of this Project.

6.2.3 METEOROLOGY

The Ras Al Khair peninsula lies within the arid subtropical desert belt. Due to the Asian Monsoon cycle that affects the Arabian Gulf region, there are generally two distinct monsoon seasons that would affect the Project area the winter monsoon (December to March), and the summer monsoon (May to September), with short transitional seasons in between (GHD, 2008).

Detailed historical meteorological data is not available for the exact location of the Project site; therefore available data from the following locations in the vicinity has been used:

- King Fahd International Airport Weather Monitoring Station, located 130km south-east of Ras Al Khair;
• Jubail Weather Monitoring Station, located 65km south-east of Ras Al Khair; and
• Tanajib Pier Weather Station, located 35km north-west of Ras Al Khair.

6.2.4 TEMPERATURE

The annual average temperature in the region is approximately 27°C, and temperatures are in the general range from 3°C in winter to 47°C in summer. During the northern hemisphere winter, central Asia undergoes a period of cooling, and high pressure systems develop, resulting in cool air flows over the Arabian Gulf region. During this time, the temperature can descend to almost 0°C and there are strong winds with occasional rain and thunderstorms. The opposite occurs in summer when the land heats up and low pressure systems are created which draw in moist, humid air. Temperatures of up to 45° to 50°C, lack of rain and strong northwest winds characterise the summer months (GHD, 2008).

Table 6-1 shows the number of days that different meteorological phenomena have occurred at King Fahd International Airport, which is located 130km southeast of Ras Al Khair. Table 6-1 provides historical data (1980 - 2007) for temperature measurements taken at King Fahd International Airport.

**Table 6-1: Meteorological Phenomena Durations (1980 – 2007) – King Fahd International Airport**

<table>
<thead>
<tr>
<th>Month</th>
<th>Thunder Storm</th>
<th>Precipitation</th>
<th>Mist</th>
<th>Fog</th>
<th>Blowing Dust</th>
<th>Dust/Sand Storm</th>
<th>Haze</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>4.0</td>
<td>10.3</td>
<td>11.3</td>
<td>1.9</td>
<td>4.8</td>
<td>0.4</td>
<td>10.0</td>
</tr>
<tr>
<td>February</td>
<td>2.4</td>
<td>5.3</td>
<td>9.4</td>
<td>4.0</td>
<td>7.3</td>
<td>1.0</td>
<td>9.6</td>
</tr>
<tr>
<td>March</td>
<td>4.4</td>
<td>6.6</td>
<td>3.0</td>
<td>1.4</td>
<td>7.4</td>
<td>1.4</td>
<td>10.3</td>
</tr>
<tr>
<td>April</td>
<td>4.6</td>
<td>5.5</td>
<td>0.9</td>
<td>0.1</td>
<td>9.9</td>
<td>0.9</td>
<td>14.3</td>
</tr>
<tr>
<td>May</td>
<td>1.3</td>
<td>0.4</td>
<td>0.4</td>
<td>0</td>
<td>10.3</td>
<td>0.8</td>
<td>14.1</td>
</tr>
<tr>
<td>June</td>
<td>0</td>
<td>0</td>
<td>0.4</td>
<td>0.1</td>
<td>10.3</td>
<td>0.1</td>
<td>13.6</td>
</tr>
<tr>
<td>July</td>
<td>0</td>
<td>0</td>
<td>2.9</td>
<td>0.4</td>
<td>7.8</td>
<td>1.0</td>
<td>19.1</td>
</tr>
<tr>
<td>August</td>
<td>0</td>
<td>0</td>
<td>4.0</td>
<td>1.1</td>
<td>4.6</td>
<td>0.3</td>
<td>23.8</td>
</tr>
<tr>
<td>September</td>
<td>0</td>
<td>0</td>
<td>4.0</td>
<td>1.5</td>
<td>3.3</td>
<td>0</td>
<td>13.4</td>
</tr>
<tr>
<td>October</td>
<td>0</td>
<td>0</td>
<td>11.3</td>
<td>7.8</td>
<td>0.9</td>
<td>0</td>
<td>12.7</td>
</tr>
<tr>
<td>November</td>
<td>1.9</td>
<td>5.6</td>
<td>7.6</td>
<td>1.9</td>
<td>2.8</td>
<td>0.1</td>
<td>7.1</td>
</tr>
<tr>
<td>December</td>
<td>1.9</td>
<td>6.8</td>
<td>11.3</td>
<td>6.2</td>
<td>3.6</td>
<td>0.4</td>
<td>9.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20.5</strong></td>
<td><strong>40.5</strong></td>
<td><strong>66.5</strong></td>
<td><strong>26.4</strong></td>
<td><strong>73.0</strong></td>
<td><strong>6.4</strong></td>
<td><strong>157.1</strong></td>
</tr>
</tbody>
</table>

*Source: Bechtel (2011)*
Table 6-2: Temperature Data (1980 – 2007) – King Fahd International Airport

<table>
<thead>
<tr>
<th>Month</th>
<th>Average (°C)</th>
<th>Extremes (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max</td>
<td>Min</td>
</tr>
<tr>
<td>January</td>
<td>21.2</td>
<td>9.7</td>
</tr>
<tr>
<td>February</td>
<td>23.6</td>
<td>11.3</td>
</tr>
<tr>
<td>March</td>
<td>28.7</td>
<td>14.5</td>
</tr>
<tr>
<td>April</td>
<td>34.7</td>
<td>19.8</td>
</tr>
<tr>
<td>May</td>
<td>40.6</td>
<td>24.7</td>
</tr>
<tr>
<td>June</td>
<td>45.2</td>
<td>27.2</td>
</tr>
<tr>
<td>July</td>
<td>44.8</td>
<td>29.1</td>
</tr>
<tr>
<td>August</td>
<td>41.4</td>
<td>28.6</td>
</tr>
<tr>
<td>September</td>
<td>37.7</td>
<td>24.8</td>
</tr>
<tr>
<td>October</td>
<td>29.0</td>
<td>16.0</td>
</tr>
<tr>
<td>November</td>
<td>23.0</td>
<td>11.7</td>
</tr>
<tr>
<td>Maximum</td>
<td>45.2</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Bechtel (2011)

Figure 6-1 provides information about the historical temperature and humidity data for Jubail during the period 1988-2001, where the maximum recorded temperature was 50° C and minimum was 2.9° C.

6.2.5 HUMIDITY

Daily humidity in the region spans a large range between 10 to 100% between coastal and inland locations in summer. Summer mean relative humidity is about 20 to 30% lower a few km inland compared to the coast. Historical data from King Fahd International Airport is shown in Table 6-3, where minimum recorded relative humidity was 2% and maximum was 100%.
6.2.6 PRECIPITATION

During the winter monsoon (December to March), there is occasional rain and thunderstorms. The long-term average annual rainfall in the area is approximately 80 mm. Historical data for precipitation (1980-2007) from King Fahd International Airport is shown in Table 6-4. The maximum monthly recorded precipitation was 135.5 mm, while maximum daily recorded precipitation was 42.4 mm.

Table 6-4: Precipitation Historical Data (1980 - 2007) – King Fahd International Airport

<table>
<thead>
<tr>
<th>Month</th>
<th>Precipitation (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (mm)</td>
</tr>
<tr>
<td>January</td>
<td>21.7</td>
</tr>
<tr>
<td>February</td>
<td>9.0</td>
</tr>
<tr>
<td>March</td>
<td>5.9</td>
</tr>
<tr>
<td>April</td>
<td>7.0</td>
</tr>
<tr>
<td>May</td>
<td>0.3</td>
</tr>
<tr>
<td>June</td>
<td>0.0</td>
</tr>
<tr>
<td>July</td>
<td>0.0</td>
</tr>
<tr>
<td>August</td>
<td>0.0</td>
</tr>
<tr>
<td>September</td>
<td>0.6</td>
</tr>
<tr>
<td>October</td>
<td>0.0</td>
</tr>
<tr>
<td>November</td>
<td>19.5</td>
</tr>
<tr>
<td>December</td>
<td>23.3</td>
</tr>
<tr>
<td>Maximum</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: Bechtel (2011)
6.2.7 WIND

The Shamal, an Arabic word meaning north, is a feature of both the winter and summer seasons. It is unique to the Gulf region and brings strong winds from the north and northwest across the region. The winter Shamal follows the cold front associated with a depression moving south-eastwards from the Mediterranean, and brings a strong (up to 75kph), cold northerly wind (as cold as 0°C) down from the mountains of Iran. Thunderstorms may form along the cold front, and if there is no corresponding rainfall the winds can induce severe sandstorms, under which visibility can be reduced to a few metres. Strong, cold winds contribute to high seas that can cool the water temperature in the Gulf considerably. Water temperatures have been recorded at 4°C at the surface, and 14°C at 18m below surface. Widespread mortality of coral and other marine groups has been associated with these conditions (Sheppard et al., 1992).

The summer Shamal (from late May to September), known as the wind of 120 days, is more or less continuous over the summer in contrast to the more short-lived winter Shamal. The Summer Shamal forms due to the heat low over Pakistan and Afghanistan creating a secondary low pressure centre to the south of the Zagros Mountains in Iran. The strength of the wind is variable from day to day and weakens at night. This time of year is very hot (with temperatures exceeding 40°C) and dry, with frequent dust storms. The 40-day Shamal occurs between late May and early July and is the most defined period of the summer Shamal (GHD, 2008).

During the course of one year, six distinct wind regimes occur on the Ras Al Khair peninsula following a typical desert wind pattern. Wind velocity may reach up to 75kph, with a predominant north-westerly direction, but the strongest wind recorded at Tanajib Pier between 1997 and 2003 was approximately 46.5kph. Six different wind regimes for the Ras Al Khair peninsula were defined following a study by Barth (2001), with wind velocities characterised by a diurnal pattern of calm winds at night with the highest winds around the middle of the day. This is typical of a desert wind regime. The six different wind regimes can be defined as follows:

- A high energy Mediterranean northwest regime from November to February;
- A bimodal cyclonic end phase in March;
- A moderate easterly spring phase in April;
- A complex transition phase in May – wind directions are complex but velocities are usually high;
- A high energy summer Shamal regime from June to August – strong unimodal north to northeasterly winds; and
- A variable low energy autumn phase in September and October.

Historical wind data has been sourced from the Tanajib Pier meteorological station, approximately 35km northwest of Ras Al Khair. A wind rose for the historical data is shown in Figure 6-2.
An Air Quality Impact Assessment Study for the Ras Al Khair Aluminium Project was conducted by Exponent in 2012. The study involved refined air quality dispersion modelling of the site using three U.S. EPA approved Guideline Models: AERMOD, BLP, and CALPUFF. One year of on-site meteorological data was recorded at the location latitude 27.497 degree north and longitude 49.112 degree east, in the site adjacent to the Ras Al Khair Industrial Complex. Measurements at 2m and 10m for temperature were recorded and at 10m for wind speed and wind direction. The period covered was March 2010 to March 2011. A full year period from 1 April 2010 through 31 March 2011 was selected for driving the air quality dispersion models. An annual wind rose generated for the Project is shown below in Figure 6-3 as provided by Ma’aden. The predominant wind directions range from north and northwest.

Source: Tanajib Pier Meteorological Station

**Figure 6-2: Wind Rose (1996 – 2003) – Tanajib Pier**

An Air Quality Impact Assessment Study for the Ras Al Khair Aluminium Project was conducted by Exponent in 2012. The study involved refined air quality dispersion modelling of the site using three U.S. EPA approved Guideline Models: AERMOD, BLP, and CALPUFF. One year of on-site meteorological data was recorded at the location latitude 27.497 degree north and longitude 49.112 degree east, in the site adjacent to the Ras Al Khair Industrial Complex. Measurements at 2m and 10m for temperature were recorded and at 10m for wind speed and wind direction. The period covered was March 2010 to March 2011. A full year period from 1 April 2010 through 31 March 2011 was selected for driving the air quality dispersion models. An annual wind rose generated for the Project is shown below in Figure 6-3 as provided by Ma’aden. The predominant wind directions range from north and northwest.
6.2.8 DUST

Dust storm events impact air quality in the Arabian Gulf region. Airborne impacts have recently been exacerbated due to grazing pressure and subsequent reduction in vegetation cover increasing wind erosion. Soil moisture, an inhibiting factor to dust production, is very low in the Arabian Gulf region. Therefore soils are highly erodible, particularly when wind speeds of up to 49 knots (or 25 m/s) occur during the Shamal.

Dust storms are predominantly made up of suspended silt and dust particulates and generally originate on the northern side of the Arabian Gulf from the clay soils of Iran and the silty-clayey soils of Kuwait and Iraq (especially the Tigris and Euphrates River basins) (Goudie and Middleton, 2001). During dust transport, the largest particles in the dust storm (with the most mass) fall out of suspension earlier than smaller sized aerosols. Visibility is reduced to a few metres in severe dust storms with high particulate concentration. Aeolian or wind transport may be facilitated in three ways:

- Suspension – small particles (silt, dust) suspended in air;
- Saltation – larger particles (sand particles) which are lifted and continuously dropped out of the air column, “hopping” along the land surface; and
- Surface creep – largest particles (pebble size) which are pushed along the ground, they may be transported by other saltating grains.

Dust source activity in the Arabian Gulf region is greatest during pre-monsoonal (spring) and monsoonal (summer) periods, typically when strong Shamal winds tend to blow. This is shown in Table 6-5.

---

**Figure 6-3: One Year Period Wind Rose (March 2010 - March 2011)**

![Wind Rose Diagram](image-url)
Table 6-5: Jubail Sandstorm / Dust Storm Frequency and Occurrence

<table>
<thead>
<tr>
<th>Month</th>
<th>Sandstorm / Dust Storm Frequency</th>
<th>% of annual total</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>February</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>March</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>April</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>May</td>
<td>29</td>
<td>17</td>
</tr>
<tr>
<td>June</td>
<td>41</td>
<td>24</td>
</tr>
<tr>
<td>July</td>
<td>21</td>
<td>12</td>
</tr>
<tr>
<td>August</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>September</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>October</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>November</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>December</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>170</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: WHGME 2010.

The fine silty areas around the northern parts of Saudi Arabia and Iraq are typical dust storm areas. Typically the following wind speeds (threshold friction velocity) are required to mobilise dust components:

- Active Sand Sheet (0.28 m/s);
- Deflated Sand Sheet (0.62 m/s);
- Smooth Sand Sheet (0.69 m/s);
- Covered desert Floor (0.75 m/s);
- Gravel Lag (1 m/s);
- Playa Deposits (3 m/s); and
- Coastal Plain Deposits (3.5 m/s).

The greatest wind gusts occur during late May – early July during the summer monsoon season. Dust uptake is not as strong during autumn and winter. During winter, dry strong cold fronts bring dust down across the Ras Al Khair Peninsula by the north-westerly Shamal winds. Winter Shamals are typically either 24 to 36 hours or 3 to 5 days in length. The 24 hours Shamals occur 2 to 3 times a month producing gusts up to 40 knots (20.5 m/s). The 3 to 5 day Shamal occurs 1 to 3 times per winter season with wind speeds up to 50 knots (25.7 m/s), also producing high seas of 3 - 4 m.

6.2.9 AMBIENT AIR QUALITY

6.2.9.1 INTRODUCTION

In addition to the prevalent natural windborne dust particulates, existing and known future sources of air pollutants in vicinity of the Project Site include:

- Ras Al Khair Industrial Port;
- Existing Ma’aden Phosphate Company (MPC) Complex including:
Ammonia,
- Di-ammonium Phosphate (DAP) plants,
- Phosphoric Acid Plants (PAP),
- Power and Desalination Plant (PDP), and
- Sulphuric Acid Plants (SAP);

- Adjacent Ma’aden Aluminium Company (MAC) aluminium smelter and refinery;
- Petrol station located to the south of the proposed facility;
- Existing north-south freight railway;
- The Saline Water Conversion Corporation (SWCC) natural gas power plant to be constructed within the Ras Al Khair Industrial City prior to Project development; and
- Traffic on the access roads and surrounding highway.

6.2.9.2 EXPONENT AIR QUALITY STUDY

The February 2012 Exponent Study described in Section 6.2.7 included the monitoring of a number of pollutants including particulate matter (PM$_{10}$), sulphur dioxide (SO$_2$), nitrogen dioxide (NO$_2$), hydrogen fluoride, carbon monoxide (CO), Ammonia (NH$_3$), Non-Methane Hydrocarbon (NMHC) and Volatile Organic Compounds (VOCs) at the Project site from 1 April 2010 through to 30 September 2010. To determine background concentrations, the Exponent study computed an average on the analysed period for each pollutant measured. Calculating contributions of other air emissions sources in the area and adding it to the predicted total air concentration from the Project allows comparison of the relative inputs from the various sources. Because the analysis includes contributions from a number of sources in different sites within the Industrial City, these results are presented as the peak concentration outside the boundary of the Industrial City. This methodology was used in the Exponent study was also applied to the current Project analysis.

6.2.9.3 AMBIENT AIR QUALITY MONITORING DATA

The purpose of background data in a modelling context is to derive justifiable additions to the process contributions to allow a good indication of the overall predicted environmental concentration in a region for comparison to Ambient Air Quality Standards (AAQS). Modelling tools used can actually combine the contemporaneous hourly air concentration derived from a process with the background concentration measured during that hour. This gives the best indication of predicted environmental concentration since the overall results undergo the averaging process within the modelling tools. However, this requires a continuous and extensive data set, which is not available at the Project site.

As ambient air quality data in the Project area is limited. The RC air quality monitoring network at Jubail was the only identified source, which is approximately 65km to the southeast of Ras Al Khair. However as Site 6 of the Jubail network is located approximately 15km to the southwest of the Jubail Industrial City, some distance from industrial development, it represents a conservative estimate of ambient background air concentrations of a Gulf coast location in Saudi Arabia.

The most recent five years of data for Site 6 was used in the assessment from 2008 to 2012. The data has been analysed against the Royal Commission ambient air quality standards as shown in Table 6-6. Violations are shown in bold. The results show that ambient PM10 concentrations are high exceeding the RC standards due to local sand storm events. NOx results are also relatively high, but they tend to be dominated by small periods of elevated levels.
Table 6-6: Air Quality Concentrations at Jubail Monitoring Station (Site 6)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Unit</th>
<th>RC AAQS</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO(_x) 1H3H</td>
<td>µg/m³</td>
<td>660</td>
<td>362</td>
<td>314</td>
<td>333</td>
<td>390</td>
<td>473</td>
</tr>
<tr>
<td>NO(_x) annual</td>
<td>µg/m³</td>
<td>100</td>
<td>33.5</td>
<td>31.7</td>
<td>45.6</td>
<td>36.6</td>
<td>59.3</td>
</tr>
<tr>
<td>CO 1hr H3H</td>
<td>µg/m³</td>
<td>40,000</td>
<td>3123</td>
<td>3442</td>
<td>1634</td>
<td>2159</td>
<td>1531</td>
</tr>
<tr>
<td>CO 8hr 8H3H</td>
<td>µg/m³</td>
<td>10,000</td>
<td>2894</td>
<td>1291</td>
<td>1388</td>
<td>1115</td>
<td>1062</td>
</tr>
<tr>
<td>SO(_2) 1hr H3H</td>
<td>µg/m³</td>
<td>730</td>
<td>42.1</td>
<td>56.8</td>
<td>131</td>
<td>91.1</td>
<td>58.6</td>
</tr>
<tr>
<td>SO(_2) 24hr 24H2H</td>
<td>µg/m³</td>
<td>365</td>
<td>10.2</td>
<td>23.7</td>
<td>34.2</td>
<td>17.8</td>
<td>15.6</td>
</tr>
<tr>
<td>SO(_2) Annual</td>
<td>µg/m³</td>
<td>80</td>
<td>4.1</td>
<td>7.3</td>
<td>11.9</td>
<td>6.5</td>
<td>5</td>
</tr>
<tr>
<td>PM(_{10}) 24hr 24H1H</td>
<td>µg/m³</td>
<td>150</td>
<td>2434</td>
<td>3086</td>
<td>2425</td>
<td>2407</td>
<td>3990</td>
</tr>
<tr>
<td>PM(_{10}) annual</td>
<td>µg/m³</td>
<td>50</td>
<td>321</td>
<td>270</td>
<td>134</td>
<td>229</td>
<td>371</td>
</tr>
</tbody>
</table>

Source: Royal Commission.

To add to existing historical data identified, Gradko air quality monitoring diffusion tubes were deployed at the Ras Al Khair Industrial Complex for this Project for the measurement of SO\(_2\), NO\(_x\), NO\(_x\) 20% and NOx levels at the proposed project site. Diffusion tubes were installed at the mid-north fence (AAQ_1_MN), mid-complex (AAQ_1_MP) and Ras Al Khair Port area (AAQ_1_P) at a height of 1.5 m. Monitoring site locations are shown in Figure 6-4.

Figure 6-4: Gradko Monitoring Sites (January - March 2013)

The two sampling periods were from: January to March 2013; and March to April 2013. The exposed Gradko tubes and control samples (blanks) were sent to Gradko Environmental, in Hampshire, UK for analyses. SO\(_2\) levels were determined by ion chromatography and NO\(_x\) 20% and NOx concentrations were determined by UV spectrophotometry. Results of the analysis are shown below in Table 6-7 and Table 6-8.
Table 6-7: NO2 20%, NOx and SO2 levels at the Project site (January 2013 – March 2013)

<table>
<thead>
<tr>
<th>Sample Period</th>
<th>Parameter</th>
<th>Tube Serial number</th>
<th>Location</th>
<th>Relative location</th>
<th>ug/m³</th>
<th>ppb</th>
</tr>
</thead>
<tbody>
<tr>
<td>21/01/2013-05/03/2013</td>
<td>NOx</td>
<td>078747</td>
<td>27°32’26.60”N 49°11’37.00”E</td>
<td>Mid-North fence (AAQ 1 MN)</td>
<td>20.36</td>
<td>10.6</td>
</tr>
<tr>
<td></td>
<td>NO2 20%</td>
<td>078710</td>
<td></td>
<td></td>
<td>17.7</td>
<td>9.22</td>
</tr>
<tr>
<td></td>
<td>SO2</td>
<td>078673</td>
<td></td>
<td></td>
<td>126.2</td>
<td>47.32</td>
</tr>
<tr>
<td>21/01/2013-05/03/2013</td>
<td>NOx</td>
<td>078746</td>
<td>27°31’59.20”N 49°11’37.00”E</td>
<td>Mid-Complex fence (AAQ 1 MP)</td>
<td>25.18</td>
<td>13.12</td>
</tr>
<tr>
<td></td>
<td>NO2 20%</td>
<td>078709</td>
<td></td>
<td></td>
<td>20.44</td>
<td>10.65</td>
</tr>
<tr>
<td></td>
<td>SO2</td>
<td>078672</td>
<td></td>
<td></td>
<td>299.26</td>
<td>112.22</td>
</tr>
</tbody>
</table>

For samples taken over periods different to the averaging period for the relevant AAQS, scaling factors can be derived. This can involve detailed statistical analysis, and pragmatic approaches have been developed (e.g. Ontario, 2009), which uses the following to compare modelling results and AAQS over different averaging periods, using a conversion factor to scale them appropriately. Similar approaches can be found in the literature. The scaling factor is given by:

\[ \text{Factor} = \left( \frac{T_1}{T_2} \right)^{0.28} \]

Where \(T_1\) and \(T_2\) are the two sampling periods to be compared.

For example, for a 1 month to 1 year comparison, the exposure period \(T_1\) is used with by the number of days per year \(T_2\) to give a scaling factor of 1.8 and then the monthly concentration is divided by 1.8.

Collection of the measurements throughout the period used within the standards is preferable, but this scaling approach will give indicative values of background levels. Therefore, a conversion factor was applied to convert the monthly Gradko monitoring data to annual data and compared to RC standards in Table 6-9 below. Exceedences of the emissions standards are shown in bold.

Table 6-8: NO2 20%, NOx and SO2 levels at the Project site (March 2013 – April 2013)

<table>
<thead>
<tr>
<th>Sample Period</th>
<th>Parameter</th>
<th>Tube Serial number</th>
<th>Location</th>
<th>Relative location</th>
<th>ug/m³</th>
<th>ppb</th>
</tr>
</thead>
<tbody>
<tr>
<td>10/03/2013-16/04/2013</td>
<td>NOx</td>
<td>119182</td>
<td>27°32’26.60”N 49°11’37.00”E</td>
<td>Mid-North fence (AAQ 1 MN)</td>
<td>34.10</td>
<td>17.76</td>
</tr>
<tr>
<td></td>
<td>NO2 20%</td>
<td>119202</td>
<td></td>
<td></td>
<td>23.40</td>
<td>12.19</td>
</tr>
<tr>
<td></td>
<td>SO2</td>
<td>119162</td>
<td></td>
<td></td>
<td>67.22</td>
<td>25.21</td>
</tr>
<tr>
<td>10/03/2013-16/04/2013</td>
<td>NOx</td>
<td>119183</td>
<td>27°31’59.20”N 49°11’37.10”E</td>
<td>Mid-Complex fence (AAQ 1 MP)</td>
<td>21.36</td>
<td>11.12</td>
</tr>
<tr>
<td></td>
<td>NO2 20%</td>
<td>119203</td>
<td></td>
<td></td>
<td>7.66</td>
<td>3.99</td>
</tr>
<tr>
<td></td>
<td>SO2</td>
<td>119163</td>
<td></td>
<td></td>
<td>99.09</td>
<td>37.16</td>
</tr>
<tr>
<td>09/03/2013-16/04/2013</td>
<td>NOx</td>
<td>119181</td>
<td>27°33’19.00”N 49°11’52.90”E</td>
<td>Port area (AAQ 1 P)</td>
<td>27.65</td>
<td>14.40</td>
</tr>
<tr>
<td></td>
<td>NO2 20%</td>
<td>119201</td>
<td></td>
<td></td>
<td>21.74</td>
<td>11.32</td>
</tr>
<tr>
<td></td>
<td>SO2</td>
<td>119161</td>
<td></td>
<td></td>
<td>15.15</td>
<td>5.68</td>
</tr>
</tbody>
</table>

Conversion factor of 1.8 assumed.

Source: Jacobs 2013
6.2.9.4 AMBIENT AIR QUALITY DESCRIPTION

The following is a general description of the pollutants of concern in the project area and a description of ambient measurements related to each.

**Nitrogen Dioxide**

Nitrogen dioxide (NO$_2$) is a brownish gas that can irritate the lungs and cause breathing difficulties at high concentrations. NO$_2$ is generally not directly emitted from an emission source, but is formed through a reaction between nitric oxide (NO) and atmospheric oxygen. NO and NO$_2$ are collectively referred to as NOx and are major contributors to ozone formation. NO$_2$ also contributes to the formation of PM$_{10}$. In high concentrations, the result is a brownish red cast to the atmosphere and reduced visibility.

In the general urban environment the principal sources of oxides of nitrogen (NOx) are traffic, and to a lesser extent industry, shipping and households. In an industrial area like the existing MPC Complex, it is expected that point source discharges from the industries contribute a higher proportion of the NOx present in the ambient air, with the exception of roadside locations.

NO$_2$ concentrations recorded at the Jubail Site 6 monitoring site for 2008-2012 were well within the RC maximum annual and hourly standards. Additionally no exceedences were identified from the in-situ monitoring undertaken as part of this Project. NOx levels from Project monitoring at the Ras Al Khair Industrial Complex were found to be generally low in comparison to the annual averages measured at Jubail Site 6.

**Sulphur Dioxide**

Sulphur dioxide (SO$_2$) is a product of high sulphur fuel combustion. The main sources of SO$_2$ are coal and oil combustion in power stations, industry and for domestic heating. Industrial chemical manufacturing is another source. It can cause plant leaves to yellow, and corrode iron and steel.

The existing SO$_2$ concentrations for the Jubail monitoring station Site 6 2008-2012 were within the RC 1-hour average standards and the 24-hour average at all Air Quality Monitoring Stations (AQMS).

Results of the site monitoring for SO$_2$ show levels that exceed the annual RC standards in the January – March period. Levels were highest in the process area (mid-plant and mid-north fence) and lower near the port. It is noted however that these diffusion tubes are only indicative of conditions and it is understood that the RC are embarking on a more detailed ambient air baseline data gathering programme.

**Carbon Monoxide**

Carbon monoxide (CO) is a colourless gas that interferes with the transfer of oxygen by the blood. CO is emitted almost exclusively from the incomplete combustion of fossil fuels. On-road motor vehicle exhaust is the primary source of CO. In cities, 85 to 95% of all CO emissions may come from motor vehicle exhaust.

Natural background levels of carbon monoxide (CO) range between 0.06 and 0.14 µg/m³. Concentrations in urban areas typically depend on weather and traffic density, and they also vary greatly over time and with distance from the source. The 8-hour average concentrations are generally lower than 20 µg/m³.

In relation to RC standards for the 1-hour average and 8-hour average, none of the AQMSs has recorded above-criteria concentrations.

**Particulate Matter (PM 10)**

Particulate pollution is composed of solid particles or liquid droplets that are small enough to remain suspended in the air. Particulate matter pollution consists of very small liquid and solid particles floating in the air, which can include smoke, soot, dust, salts, acids, and metals. Particulate matter also forms when gases emitted from industrial and combustion sources, and motor vehicles undergo chemical reactions in the atmosphere. Particulate pollution also can
include bits of solid or liquid substances that can be highly toxic. Exposure to such particles can affect both the lungs and heart.

PM\textsubscript{10} refers to particulate matter less than 10 microns in diameter, about one seventh the thickness of a human hair. Major sources of PM\textsubscript{10} include motor vehicles; wood burning stoves and fireplaces; dust from construction, landfills, and agriculture; wildfires and brush/waste burning, industrial sources, windblown dust from open lands; and atmospheric chemical and photochemical reactions. Suspended particulates produce haze and reduce visibility.

The concentrations monitored at Jubail Site 6 for 2008-2012 exceeded RC annual standards and 24 hour RC standards. However, it should be noted that the high concentration of PM\textsubscript{10} in the desert regions are likely to be associated with seasonal high winds, and it would not be possible to separate such natural particulate contributions from anthropogenic contributions.

**Fluorides/Hydrogen Fluoride**

Hydrogen fluoride is a colourless, pungent liquid or gas that is highly soluble in organic solvents (e.g., benzene) and in water. Hydrofluoric acid is the fluoride synthesised on the largest scale. It is produced by treating fluoride minerals with sulphuric acid. Hydrofluoric acid and its anhydrous form hydrogen fluoride are used in the production of fluorocarbons and aluminium fluorides. Fluorides can result in fatal exposure through inhalation or upon contact with the skin. The RC monthly standard for Fluoride is 1 µg m\textsuperscript{-3}. No fluoride monitoring data for the site was identified.

**Ozone (O\textsubscript{3})**

Ozone is a secondary pollutant formed in the lower atmosphere by the action of sunlight (insolation) on NOx and volatile organic compounds (VOCs). Under strong summer insolation, coastal recirculation is likely to become a large natural photochemical reactor. Most of the NOx emissions and other ozone precursors are transformed into oxidants, acidic compounds, aerosols and ozone, which may potentially result 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 AOMSs and means that interpretation of pollution episodes need to be considered on a regional basis in addition to the impact of localised sources.

**Ammonia (NH\textsubscript{3})**

Gaseous ammonia (NH\textsubscript{3}) readily converts gaseous acids, especially sulphuric and nitric acids to fine particles. Associated health effects include eyes, nose, and throat irritation and damage and corneal and skin burns/blistering, intraocular pressure (glaucoma), coughing, pulmonary and laryngeal edema, and chest pains. No ambient monitoring NH\textsubscript{3} data was identified for the site.

6.3 IMPACT ASSESMENT

6.3.1 OVERVIEW

The Project may impact upon the air quality and meteorology environment during construction, commissioning and operational and decommissioning phases. The potential significance of these impacts upon air quality and meteorology at the site is assessed with reference to the methodology presented in Section 5 Impact Assessment Methodology with the sensitivity of the impacted resource / receptor also taken into account. Based on available data, the contributions from the Project (new Ammonia and DAP/NPK plants, Materials Storage and Handling Facility as well as port loading and unloading activities) were compared as additional contributions to the existing plants to determine the overall impact of the Project on air quality. RC Air Quality Standards are used to assess impacts. However, in the absence of RC standards, WB/IFC Air Quality standards are utilised to determine Project impacts.

Additionally, Project analysis has been conducted in accordance with the IFC’s Performance Standards and the Equator Principles related to GHG emissions requirements.
The methodology adopted for this assessment and proposed mitigation measures for each impact are summarised in the following sections. The detailed dispersion modelling methodology and results obtained are presented in Appendix D.

6.3.2 ASSESSMENT METHODOLOGY

6.3.2.1 CONSTRUCTION

Dust emissions will arise from road traffic on un-metalled roads and earth clearance operations in addition to wind driven ‘site erosion’ typical of a site of this nature. The assessment of construction phase impacts on air quality and climate primarily relates to fugitive emissions from dust and vehicle emissions. The US EPA AP42 methodologies were used as the basis of the assessment for the construction phase.

6.3.2.2 COMMISSIONING AND OPERATION PHASES

To inform the impact assessment for this Project phase, air dispersion modelling was undertaken to represent point source emissions and model outputs compared with RC and relevant international standards. The RC ambient air quality standards specify a variety of averaging periods and exceedence limits for different pollutants. The model was run for each year of meteorological data to produce averaged concentrations to assess against each of the relevant ambient air criteria.

The Project site is considered a Type I Facility under the classification of the Royal Commission Environmental Regulations (RCER, 2010). On this basis the CALPUFF modelling system was used to meet RC requirements which allow the dispersion assessment for up to 75km from the source.

CALPUFF is a non-steady-state meteorological and air quality modelling system that simulates pollutant releases as a continuous series of puffs. It is a recommended technique for assessing long-range transport (over 50 km) of pollutants, particularly for cases when the straight-line, steady-state assumptions on which a plume model is based may not be valid (i.e. where there is a high degree of spatial variability of the flow within the boundary layer). The CALPUFF modelling system includes three main components: CALMET Meteorological Model which develops hourly wind and temperature field on a 3-D gridded modelling domain; CALPUFF dispersion model; and CALPOST post-processing package which produces a summary of the CALPUFF simulation results.

CALPUFF is intended for use on scales from tens of metres from a source to hundreds of kilometres. It includes algorithms for near-field effects such as stack tip downwash, building downwash, transitional buoyant and momentum plume rise, rain cap effects, partial plume penetration, subgrid scale terrain and coastal interactions effects, and terrain impingement as well as longer range effects such as pollutant removal due to wet scavenging and dry deposition, chemical transformation, vertical wind shear effects, overwater transport, plume fumigation, and visibility effects of particulate matter concentrations.

As a result, it is appropriate to use the CALPUFF modelling system for both near-field and long-range transport studies. This conclusion is also consistent with the conclusions of the U.S. EPA peer review of the CALMET/CALPUFF modelling system 2.

Background concentrations for the site were developed based on Jubail data (Table 6-6) input into the CALMET model. No existing baseline data was available on the Project site, so data from Site 6 at Jubail as well as the reported individual impact contributions from each of the existing facilities was used to inform the baseline for the Project study. Data gathered from Jubail would in fact represent conservative existing conditions, as the Jubail site is located in a relatively undisturbed area.

Although the RC has installed an air quality and meteorological mobile station at Ras Al Khair, the RC has reported that this data is not as yet adequate to describe the conditions in Ras Al Khair. To that end data meteorological data from MM5, a regional mesoscale model for creating weather forecasts and climate Projections, for Ras Al Khair was used for input into CALMET, which is then input to CALPUFF. The data references a 160 km domain around the Ras Al Khair site to allow for an extra margin of 5km around the site for source
For fugitive emissions, US EPA AP42 guidance was used. This assessment includes the reported individual impact contributions from each of the existing facilities, as well as fugitive emissions resulting from activities at each site. The assessment uses the CALPUFF dispersion model (Scruter et al., 2000) to undertake assessments of the impact on air concentrations of emissions from a range of plant at Ras Al Khair over a large domain surrounding the area. Impacts are assessed using five years of simulated meteorological data suitable for use within CALPUFF. Individual sites are modelled separately; namely the Power plant, the aluminium plant, the existing MPC facility and the new MPC Complex. Total impact is also assessed by combining summed contributions from all industrial sources and also representative background air concentration data derived from a remote RC site. The assessment assumes that all plant are constructed and operating, but is based on available meteorological data, namely for 2008-2012.

Point source emissions were obtained from Ma’aden, and fugitive emission data calculated for a number of activities associated with the site. These were represented within the model and assigned to the relevant site within the assessment.

The modelled pollutant air concentrations resulting from discharges from a source or defined group of sources is known as the process contribution (PC). The overall predicted air concentration resulting from these sources and including additional contributions from other sources on adjacent sites and also ambient background concentrations is known as the predicted environmental concentration (PEC).

The modelling was performed using the following options:

- Stack-tip downwash;
- Transitional plume rise;
- Partial plume penetration with inversion strength computed from temperature gradients;
- Pasquill-Gifford (PG) coefficients for rural areas and McElroy-Pooler (MP) coefficients for urban areas concentration estimates with adjustments to the effective puff height above the ground.

The plants within the model domain (power plant, aluminium plant, existing MPC Complex and new Ras Al Khair Industrial Complex) were represented as a series of point source, area and line emissions, to represent identified stacks, road, railway lines and fugitive emissions from identified areas of the sites. Individual emission sources, point or fugitive, will be assigned to one of four source groups; Power plant, Aluminium plant, Existing MPC Complex or New Ras Al Khair Industrial Complex, thus allowing the peak air concentrations arising from each area to be identified, the PC, and compared to relevant ambient air quality standard (AAQS). Project results were modelled using the Project site fence line as the boundary. For this assessment, the site boundary has been assumed to extend beyond the railway sidings to the east of the site, as fugitive emissions from this area are considered within the assessment.

For the cumulative impact assessment consistent with the Exponent study and other environmental assessments in the area, modelling was conducted with the Ras Al Khair industrial city as the boundary to address compliance with the standards and demonstrate the impacts to the industrial city as a whole where most sensitive receptors would be located.

RC AAQS (RCER-2010) will be the standard for comparison, as the World Bank allows the use of appropriate well established national standards for comparison within its projects.

6.3.2.3 DECOMMISSIONING

At the end of operational lifespan of the Project, the plant structures and equipment will be dismantled and salvaged using the best available techniques at the time of decommissioning.
6.3.3 IMPACTS FROM CONSTRUCTION

6.3.3.1 INTRODUCTION
Impacts from construction could negatively impact air quality on the Project site. Specific potential impacts on the air quality environment due to the construction activities are summarised in Table 6-10 and discussed in the following text.

*Table 6-10: Construction Phase Impacts Assessment*

<table>
<thead>
<tr>
<th>Factor</th>
<th>AQ1</th>
<th>AQ2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Frequency</td>
<td>Continuous</td>
<td>Continuous</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Likely</td>
<td>Likely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Duration</td>
<td>Short</td>
<td>Short</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

6.3.3.2 IMPACTS FROM CONSTRUCTION DUST EMISSIONS

Heavy construction activities are expected to generate dust emissions that may have a temporary impact on local air quality. Dust generation is likely to be particularly significant in a dry environment such as that of Saudi Arabia.

As described in Section 4 Project Description, planned construction would occur over a three year period starting in 2014. Construction work would involve soil disturbance and movement, concrete mixing, excavation, compaction and piling.

Table 6-11 outlines the emission calculations and the parameters and total suspended particulate (TSP) emission rates derived for dust emissions relevant to site clearance and construction activities. These calculations assumed that typical good practice measures such as the mitigation measures and recommendations outlined in the ESIA are in place.
### Table 6-11: Mitigated Dust Emission Calculations – Construction Phase

<table>
<thead>
<tr>
<th>1</th>
<th>Truck Unloading (veh/hr)</th>
<th>35</th>
<th>Estimated maximum truck flow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Truck Volume (Mg)</td>
<td>10</td>
<td>Estimated</td>
</tr>
<tr>
<td></td>
<td>Total Material Handling (Mg/hr)</td>
<td>350</td>
<td>Calculated</td>
</tr>
<tr>
<td></td>
<td>Dust mitigation efficiency (%)</td>
<td>75</td>
<td>For four times daily watering</td>
</tr>
<tr>
<td></td>
<td>TSP emission rate (kg/hr)</td>
<td>0.38</td>
<td>Calculated based on AP-42 Table 11.9-4, Refer to Equation (1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2</th>
<th>Truck Loading</th>
<th>40</th>
<th>Estimated maximum truck flow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2-way truck flow (veh/hr)</td>
<td>40</td>
<td>Estimated</td>
</tr>
<tr>
<td></td>
<td>Truck Volume (Mg)</td>
<td>10</td>
<td>Estimated</td>
</tr>
<tr>
<td></td>
<td>Total Material Handling (Mg/hr)</td>
<td>200</td>
<td>Calculated</td>
</tr>
<tr>
<td></td>
<td>Dust mitigation efficiency (%)</td>
<td>75</td>
<td>For four times daily watering</td>
</tr>
<tr>
<td></td>
<td>TSP emission rate (kg/hr)</td>
<td>0.17</td>
<td>Calculated based on AP-42 Table 11.9-4, Refer to Equation (2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3</th>
<th>Bulldozing</th>
<th>7.9</th>
<th>Mean value from AP-42 Table 11.9-3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moisture content (%)</td>
<td>7.9</td>
<td>Mean value from AP-42 Table 11.9-3</td>
</tr>
<tr>
<td></td>
<td>Silt content (%)</td>
<td>6.9</td>
<td>Mean value from AP-42 Table 11.9-3</td>
</tr>
<tr>
<td></td>
<td>Dust mitigation efficiency (%)</td>
<td>75</td>
<td>For four times daily watering</td>
</tr>
<tr>
<td></td>
<td>TSP emission rate (kg/hr)</td>
<td>0.45</td>
<td>Calculated based on AP-42 Table 11.9-2, Refer to Equation (3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4</th>
<th>Vehicle traffic on unpaved road</th>
<th>4.3</th>
<th>Mean value from AP-42 Table 11.9-3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Silt content (%)</td>
<td>4.3</td>
<td>Mean value from AP-42 Table 11.9-3</td>
</tr>
<tr>
<td></td>
<td>Moisture content (%)</td>
<td>2.4</td>
<td>Mean value from AP-42 Table 11.9-3</td>
</tr>
<tr>
<td></td>
<td>Average weight of vehicle (Mg)</td>
<td>36</td>
<td>Estimated</td>
</tr>
<tr>
<td></td>
<td>2-way truck flow (veh/hr)</td>
<td>100</td>
<td>Estimated</td>
</tr>
<tr>
<td></td>
<td>Average one-way travel distance w/in the site</td>
<td>0.7</td>
<td>Estimated</td>
</tr>
<tr>
<td></td>
<td>Dust mitigation efficiency (%)</td>
<td>75</td>
<td>For four times daily watering</td>
</tr>
<tr>
<td></td>
<td>Dust reduction due to speed control (%)</td>
<td>50</td>
<td>Speed limit reduced to 10 kphr</td>
</tr>
<tr>
<td></td>
<td>TSP emission rate (kg/hr)</td>
<td>4.5</td>
<td>Calculated based on AP-42 Sec 13.2.2, Refer to Equation (4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5</th>
<th>Site erosion</th>
<th>0.85</th>
<th>AP-42 Table 11.9-4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TSP emission rate (Mg/ha/yr)</td>
<td>0.85</td>
<td>AP-42 Table 11.9-4</td>
</tr>
<tr>
<td></td>
<td>Total site area (m²)</td>
<td>28,983</td>
<td>Estimated</td>
</tr>
<tr>
<td></td>
<td>Percentage exposed active work area</td>
<td>50</td>
<td>Estimated</td>
</tr>
<tr>
<td></td>
<td>Dust mitigation efficiency (%)</td>
<td>75</td>
<td>For four times daily watering</td>
</tr>
<tr>
<td></td>
<td>TSP emission rate (kg/hr)</td>
<td>0.03</td>
<td>Calculated</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total TSP emissions (unmitigated)</th>
<th>5.53</th>
<th>kg/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.3e-5</td>
<td>g/s/m²</td>
</tr>
</tbody>
</table>

Source: Jacobs, 2013

**Equation 1**

\[ \text{TSP emission rate (kg/hr)} = 0.001 \ (\text{Total material handling (Mg/hr)}) \]

**Equation 2**

\[ \text{TSP emission rate (kg/hr)} = 0.018 \ (\text{Total material handling (Mg/hr)}) \]

**Equation 3**

\[ EF = 2.6(s + W/3)/M^{1.3108} \]

**Conversion:**

\[ E = (\text{E(281.9)Veh}(L).) \]

\[ \text{E = TSP emission rate (kg/hr)} \]

\[ \text{Veh = 2-way truck flow} \]

\[ \text{L = Ave one way travel distance w/site.} \]

\[ 1 \text{ lb/VMT} = 281.9 \text{ g/VKT} \]

\[ 1 \text{ kg} = 2.2 \text{ lb.} \]
Existing dust levels are already high and construction would substantially contribute to dust levels on the Project site, but construction would add little to existing dust levels outside the property boundary. Since construction dust impacts at the site boundary would be relatively low, impacts are considered to be of low significance.

**Impact AQ1 – Low Significance**

### 6.3.3.3 IMPACTS FROM CONSTRUCTION EXHAUST EMISSIONS

Vehicles and large construction machinery operating during construction are sources of gaseous exhaust emissions, including NOx, CO, PM\(_{10}\) and hydrocarbons. As described in Section 4 *Project Description*, planned construction would occur over a three year period starting in 2014, during which time the number of trucks arriving at the Project area be approximately 180 per day in the peak period. Other vehicle access to the Project site will be restricted to buses used to transport workers, and private cars will not be permitted without prior approval.

Although vehicle exhaust emissions will be released close to ground level (i.e. close to the breathing zone of receptors), these emissions will generally be released in open areas where rapid dispersion and dilution will occur. Thus, the maximum concentrations are expected at or near each facility rather than the site boundary. In addition, such emissions will be limited to the duration of the construction phase.

The magnitude of exhaust emissions associated with construction activity is likely to be low outside the Project site and high near construction area. NOx and CO concentrations from exhaust emissions during construction were projected to be of low magnitude when added to the baseline. However, overall PM\(_{10}\) levels are expected to be high due to the high existing background levels recorded at the AQMS, even though the contribution from the Project will be minimal.

Existing PM\(_{10}\) levels are already high and exhaust emissions from construction would further contribute to PM\(_{10}\) levels on the Project site, but would add little to existing PM\(_{10}\) levels outside the property boundary. According to the RC Guidelines, ambient air is defined as any air on the external side of a pollution source’s boundary fence to which the public have access. Since PM\(_{10}\) emission impacts at the site boundary would be relatively low, impacts are considered to be of low significance.

**Impact AQ2 – Low Significance**
6.3.4 IMPACTS FROM COMMISSIONING AND OPERATIONS

6.3.4.1 INTRODUCTION

Impacts during the commissioning and operations phase would include exhaust emissions from vehicles, emissions from operations of the proposed Ammonia Production Plant and Di Ammonium Phosphate (DAP) / Nitro Phosphate Potash (NPK) Plant, and any emissions associated with operations of the Materials Storage and Handling Facility. Impacts are discussed below by pollutant. Specific impacts on air quality due to operational activities are summarised in Table 6-12 and discussed in the following text. A discussion of fugitive emissions is also included.

Table 6-12: Operational Phase Impacts Assessment

<table>
<thead>
<tr>
<th>Factor</th>
<th>AQ3</th>
<th>AQ4</th>
<th>AQ5</th>
<th>AQ6</th>
<th>AQ7</th>
<th>AQ8</th>
<th>AQ9</th>
<th>AQ10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance /</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Sensitivity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Likely</td>
<td>Likely</td>
<td>Likely</td>
<td>Likely</td>
<td>Likely</td>
<td>Likely</td>
<td>Likely</td>
<td>Likely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
<td>Local</td>
<td>Local</td>
<td>Regional</td>
<td>Local</td>
<td>Local</td>
<td>Local</td>
<td>International</td>
</tr>
<tr>
<td>Duration</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>
6.3.4.2 PROCESS CONTRIBUTIONS

Buildings with a significant height in the vicinity of an air emission source can substantially modify the dispersion characteristics of the emissions, usually interfering with dispersion and reducing its effectiveness. Typical US EPA guidance for dispersion modelling is to include all buildings within a factor of 2.5 times of the stack release height.

The existing MPC Complex is comprised of the following operating plant facilities that would contribute to pollutant emissions.

- Ammonia plant;
- Three Sulphuric Acid Plants;
- Three Phosphoric Acid Plants; and
- Four DAP fertiliser plant, comprising 2 buildings, each with 2 stacks.

Because the Ras Al Khair facility has a complex industrial layout comprising: buildings, tanks, conveyors and pipe-trains of varying sizes, the modelling approach taken was to include all significant structures or groups of structures within the model. Site photographs and aerial photography (2012) was used to identify buildings for inclusion in the model. Building heights were determined for the maximum average height of a structure or group of structures and were identified using design drawings, datasheets and site photographs. Table 6-13 outlines all of the structures included for the operational air emissions modelling for the Project.

Table 6-13: Buildings Represented in the CALPUFF Model

<table>
<thead>
<tr>
<th>Structure (or group of structures)</th>
<th>Existing / Proposed</th>
<th>Number of structures</th>
<th>Building Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing ammonia plant</td>
<td>Existing</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>Existing ammonia storage tanks</td>
<td>Existing</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>Existing Sulphuric acid plant</td>
<td>Existing</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Existing DAP plants</td>
<td>Existing</td>
<td>2</td>
<td>57</td>
</tr>
<tr>
<td>Existing DAP storage warehouses</td>
<td>Existing</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>Existing phosphoric acid plants</td>
<td>Existing</td>
<td>3</td>
<td>40</td>
</tr>
<tr>
<td>Existing sulphuric acid tanks</td>
<td>Existing</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>Existing phosphate warehouse (in south)</td>
<td>Existing</td>
<td>1</td>
<td>32</td>
</tr>
<tr>
<td>Existing power and desalination plant</td>
<td>Existing</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>New ammonia plant</td>
<td>Proposed</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>New ammonia storage tanks</td>
<td>Proposed</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>New DAP/NPK plant</td>
<td>Proposed</td>
<td>2</td>
<td>57</td>
</tr>
<tr>
<td>New DAP/NPK product storage</td>
<td>Proposed</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>New DAP/NPK raw material storage</td>
<td>Proposed</td>
<td>1</td>
<td>29</td>
</tr>
<tr>
<td>New cooling tower</td>
<td>Proposed</td>
<td>1</td>
<td>50</td>
</tr>
</tbody>
</table>
Modelling results include the potential air quality impacts at the point of maximum concentration outside of the Project site boundary within 75km, and at discrete off-site receptor locations.

The stack parameters, tanks and area sources in each of the units depicted above and the pollutant emissions rates used in the modelling analysis are presented in Appendix D. Point sources emissions emanating from the proposed Project facility have been modelled for NO$_2$, CO, SO$_2$, PM$_{10}$, VOC NH$_3$, and Fluorides. The modelling results for the seven pollutants from point sources are included in Table 6-14.

The contributions resulting from the proposed Project facilities are summarised below in Table 6-14 for all five years. The Table shows the peak air concentration averaged over the period of the relevant ambient air quality standard. Cumulative contributions of the project including existing MPC facilities are presented below in Table 6-16. VOC impacts from the Project would be negligible and are not discussed in further detail here.

**Table 6-14: Maximum Modelled Stack Discharge Concentrations for Criteria Pollutants**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>RCER-2010</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOX 1H3H</td>
<td>660</td>
<td>136</td>
<td>176</td>
<td>274</td>
<td>218</td>
<td>123</td>
</tr>
<tr>
<td>NOX annual</td>
<td>100</td>
<td>3.5</td>
<td>4.2</td>
<td>4.2</td>
<td>2.6</td>
<td>3.7</td>
</tr>
<tr>
<td>CO 1hr H3H</td>
<td>40000</td>
<td>24</td>
<td>19.9</td>
<td>22.0</td>
<td>20.4</td>
<td>20.7</td>
</tr>
<tr>
<td>CO 8hr 8H3H</td>
<td>10000</td>
<td>7.3</td>
<td>7.8</td>
<td>8.6</td>
<td>7.4</td>
<td>8.4</td>
</tr>
<tr>
<td>SO2 1hr H3H</td>
<td>730</td>
<td>0.33</td>
<td>0.28</td>
<td>0.3</td>
<td>0.28</td>
<td>0.28</td>
</tr>
<tr>
<td>SO2 24hr 24H2H</td>
<td>365</td>
<td>0.046</td>
<td>0.052</td>
<td>0.05</td>
<td>0.037</td>
<td>0.061</td>
</tr>
<tr>
<td>SO2 Annual</td>
<td>80</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
</tr>
<tr>
<td>PM10 24hr</td>
<td>150</td>
<td>24.8</td>
<td>60.8</td>
<td>26.3</td>
<td>33.9</td>
<td>35.9</td>
</tr>
<tr>
<td>PM10 annual</td>
<td>50</td>
<td>3.5</td>
<td>3.2</td>
<td>2.8</td>
<td>4.0</td>
<td>2.8</td>
</tr>
<tr>
<td>VOC 3hr 3H1H</td>
<td>160</td>
<td>1.9</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Fluorides monthly</td>
<td>1</td>
<td>0.76</td>
<td>0.96</td>
<td>0.85</td>
<td>0.92</td>
<td>0.75</td>
</tr>
<tr>
<td>NH3 1hr H1H</td>
<td>1800</td>
<td>253</td>
<td>1522</td>
<td>510</td>
<td>648</td>
<td>565</td>
</tr>
</tbody>
</table>

Note: All standards and results are µg m$^{-3}$

The calculated process contributions for the Project are also shown at the defined sensitive receptors, in Table 6-15 for the year 2009. All concentrations are below ambient air quality standards.
Table 6-15: 2011 Maximum Concentrations for Pollutant Emissions at Nearby Sensitive Receptors

<table>
<thead>
<tr>
<th>Discrete Receptors</th>
<th>NO&lt;sub&gt;x&lt;/sub&gt; 1H3H</th>
<th>PM&lt;sub&gt;10&lt;/sub&gt; 24H1H</th>
<th>Fluorides 1M1H</th>
<th>NH&lt;sub&gt;3&lt;/sub&gt; H1H</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCER-2010 Standard</td>
<td>660</td>
<td>150</td>
<td>1</td>
<td>730</td>
</tr>
<tr>
<td>Worker accommodation constructed close to site</td>
<td>14.5</td>
<td>6.9</td>
<td>0.17</td>
<td>35.4</td>
</tr>
<tr>
<td>Coast Guard station (close to site)</td>
<td>11.2</td>
<td>6.7</td>
<td>0.25</td>
<td>35.4</td>
</tr>
<tr>
<td>Petrol station (6km south of the site)</td>
<td>8.9</td>
<td>3.5</td>
<td>0.087</td>
<td>18.7</td>
</tr>
<tr>
<td>Housing (to east of aluminium plant)</td>
<td>4.6</td>
<td>2.7</td>
<td>0.039</td>
<td>9.9</td>
</tr>
<tr>
<td>Radio post (10km at the east of the peninsula)</td>
<td>5.1</td>
<td>2.0</td>
<td>0.044</td>
<td>10.6</td>
</tr>
<tr>
<td>The village/fishing port of Manifah ~25km west</td>
<td>3.9</td>
<td>0.96</td>
<td>0.017</td>
<td>7.3</td>
</tr>
<tr>
<td>Nairiyah (68km west)</td>
<td>0.77</td>
<td>0.371</td>
<td>0.008</td>
<td>1.9</td>
</tr>
<tr>
<td>Al Jubail (65km south)</td>
<td>0.84</td>
<td>0.35</td>
<td>0.007</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Note: All standards and results are µg m⁻³
6.3.4.3 CUMULATIVE CONCENTRATIONS

The combined contributions resulting from the proposed Project, existing facilities, and background concentrations are summarised below in Table 6-16 for 2011. The Table shows the peak air concentration averaged over the period of the relevant ambient air quality standard. The site boundary set for the cumulative impact assessment is that of the Industrial City as a whole – this is consistent with the Exponent assessment on the Aluminium plant. Results are compared to the RCER-2010. Any exceedances of RC standards are represented in bold.

**Table 6-16: 2011 Maximum Cumulative Concentrations for Criteria Pollutant Emissions**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>RC AAQS</th>
<th>Power plant</th>
<th>Aluminium works</th>
<th>MPC Existing</th>
<th>MPC New</th>
<th>Total</th>
<th>Total including ambient background</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO\textsubscript{X} 1H3H</td>
<td>µg/m\textsuperscript{3}</td>
<td>660</td>
<td>21.4</td>
<td>64.3</td>
<td>60.6</td>
<td>38.4</td>
<td>90.4</td>
<td>422</td>
</tr>
<tr>
<td>NO\textsubscript{X} annual</td>
<td>µg/m\textsuperscript{3}</td>
<td>100</td>
<td>0.09</td>
<td>0.33</td>
<td>0.86</td>
<td>0.67</td>
<td>1.7</td>
<td>38</td>
</tr>
<tr>
<td>CO 1H3H</td>
<td>µg/m\textsuperscript{3}</td>
<td>40000</td>
<td>18</td>
<td>674</td>
<td>8.4</td>
<td>5.1</td>
<td>676</td>
<td>2161</td>
</tr>
<tr>
<td>CO 8H3H</td>
<td>µg/m\textsuperscript{3}</td>
<td>10000</td>
<td>5.7</td>
<td>223</td>
<td>3.3</td>
<td>2.3</td>
<td>224</td>
<td>1224</td>
</tr>
<tr>
<td>SO\textsubscript{2} 1H3H</td>
<td>µg/m\textsuperscript{3}</td>
<td>730</td>
<td>0.25</td>
<td>232</td>
<td>0.068</td>
<td>0.068</td>
<td>662</td>
<td>676</td>
</tr>
<tr>
<td>SO\textsubscript{2} 24H2H</td>
<td>µg/m\textsuperscript{3}</td>
<td>365</td>
<td>0.066</td>
<td>34.7</td>
<td>89.2</td>
<td>0.02</td>
<td>92.6</td>
<td>97.9</td>
</tr>
<tr>
<td>SO\textsubscript{2} Annual</td>
<td>µg/m\textsuperscript{3}</td>
<td>80</td>
<td>0.001</td>
<td>2.1</td>
<td>7.2</td>
<td>0.001</td>
<td>8.6</td>
<td>15.1</td>
</tr>
<tr>
<td>PM\textsubscript{10} 24H1H</td>
<td>µg/m\textsuperscript{3}</td>
<td>150</td>
<td>0.88</td>
<td>13.2</td>
<td>54.9</td>
<td>16.0</td>
<td>61.8</td>
<td>2624</td>
</tr>
<tr>
<td>PM\textsubscript{10} Annual</td>
<td>µg/m\textsuperscript{3}</td>
<td>50</td>
<td>0.014</td>
<td>0.47</td>
<td>3.6</td>
<td>1.3</td>
<td>4.4</td>
<td>234</td>
</tr>
<tr>
<td>VOC 3H1H</td>
<td>µg/m\textsuperscript{3}</td>
<td>160</td>
<td>0</td>
<td>36.6</td>
<td>3.1</td>
<td>0.35</td>
<td>36.6</td>
<td>36.6</td>
</tr>
<tr>
<td>Fluorides monthly</td>
<td>µg/m\textsuperscript{3}</td>
<td>1</td>
<td>0</td>
<td>0.006</td>
<td>0.65</td>
<td>0.22</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>NH\textsubscript{3} 1H1H</td>
<td>µg/m\textsuperscript{3}</td>
<td>1800</td>
<td>0</td>
<td>17.9</td>
<td>287</td>
<td>78.4</td>
<td>287</td>
<td>287</td>
</tr>
</tbody>
</table>

NB: background data for VOC, Fluorides, or NH3 are not available.

*Total includes peak concentrations plus hourly background concentrations from Jubail

All pollutant concentrations are all shown to be within RC standards, with the exception of PM\textsubscript{10}. All potential Project and cumulative impacts are discussed on a pollutant-specific basis below.
6.3.4.4 IMPACTS FROM NO\textsubscript{X}

Air concentrations of nitrogen oxides are compared to the hourly and annual standards in Table 6-14 and Table 6-15. Maximum hourly concentrations ranged from 123 to 274 µg m\textsuperscript{-3} and annual concentrations were 2.6-4.2 µg m\textsuperscript{-3} during the 2008 to the 2012 period. These are considerably lower than the Ambient Air Quality Standards (AAQS) of 660 µg m\textsuperscript{-3} and 100 µg m\textsuperscript{-3} respectively. The results demonstrate that the site would be well within the relevant environmental regulations. A contour plot of the hourly averaged NO\textsubscript{x} results for 2009 within a 3 km radius of the plant is included in Figure 6-6 demonstrating that concentrations were highest immediately adjacent to the plant.

As shown in Table 6-16, cumulative concentrations were also found to be within RC standards. Therefore, impacts were considered to be of low significance.

*Impact AQ3 –Low Significance*

![Contour Plot of Highest 1H3H Average Ras Al Khair NO\textsubscript{x} Concentration](source: Jacobs 2013)
Air concentrations of carbon monoxide are compared to the hourly and eight hour standards in Table 6-14 and Table 6-15. Maximum hourly concentrations for the Project ranged from 19.9-24 µg m⁻³ and eight hour concentrations from 7.3-8.4 µg m⁻³ during the 2008-2012 period. These are considerably lower than the relevant AAQS's of 40000 µg m⁻³ and 10000 µg m⁻³ respectively. This demonstrates that the Project would be compliant with the relevant environmental regulations. A contour plot of the hourly averaged CO results for 2009 within a 3 km radius of the plant is included in Figure 6-7 demonstrating that concentrations were highest immediately adjacent to the plant.

As shown in Table 6-16, cumulative concentrations were also found to be within RC standards. Therefore, impacts were considered to be of low significance.

**Impact AQ4 –Low Significance**

![Figure 6-7: 2009 Contour Plot of Highest 1H3H Average Ras Al Khair CO Concentration](source: Jacobs 2013)
6.3.4.6 IMPACTS FROM SO$_2$

Air concentrations of oxides of sulphur dioxide are compared to the hourly and 24 hour standards in Table 6-14 and Table 6-15. Maximum hourly concentrations ranged from .28 to .33 µg m$^{-3}$ and 24 hour concentrations were .048 to .061 µg m$^{-3}$ during the 2008 to the 2012 period. Maximum concentrations were well below the 730 µg m$^{-3}$ (hourly), 365 µg m$^{-3}$ (24-hourly) and .80 µg m$^{-3}$ (annual) AAQS’s, demonstrating that the site would be well within the relevant environmental regulations. A contour plot of the hourly averaged SO$_2$ results for 2009 within a 3 km radius of the plant is included in Figure 6-8, demonstrating that concentrations were highest immediately adjacent to the plant.

As shown in Table 6-16, cumulative concentrations were also found to be within RC standards. Therefore, impacts to SO$_2$ were considered to be of low significance.

**Impact AQ5 – Low Significance**

![Figure 6-8: 2009 Contour Plot of Highest 1H3H Average Ras Al Khair SO2 Concentration](Image)

*Source: Jacobs 2013*
6.3.4.7 IMPACTS FROM PM10

Project generated air concentrations of Particulate Matter (PM10) are compared to the 24-hourly and annual standards in Table 6-14 and Table 6-15 respectively. Maximum concentrations were 24.8 to 60.8 $\mu$g m\(^{-3}\) (24-hourly) and 2.8-4.8 $\mu$g m\(^{-3}\) (annual) from 2008 to 2012 and were considerably lower than the relevant AAQS’s of 150 $\mu$g m\(^{-3}\) and 50 $\mu$g m\(^{-3}\) respectively. However, the existing PM10 values were found to be considerably higher than the AAQS’s, demonstrating that high regional background PM10 concentrations are leading to exceedences of the relevant environmental regulations. A contour plot is included in Figure 6-9 of the 24-hourly PM10 concentrations in 2009, demonstrating that concentrations were highest immediately adjacent to the plant.

Given the high baseline concentrations, no amount of mitigation on point source PM emissions (which are very low) will reduce the general PM10 in the local environment. Therefore, PM10 impacts are considered to be of low significance.

**Impact AQ6 – Low Significance**

![Figure 6-9: 2009 Contour Plot of Highest Daily Average Ras Al Khair PM\(_{10}\) Concentration](image)

Source: Jacobs 2013
6.3.4.8 IMPACTS FROM FLUORIDES

Air concentrations of hydrogen fluoride are compared to the monthly RC fluoride standards in Table 6-14 and Table 6-15. Maximum monthly µg m⁻³ emissions ranged from 0.75 – 0.96. These are below the monthly RC AAQS of 1 µg m⁻³. The results demonstrate that the site would be within the relevant environmental regulations. A contour plot of the monthly averaged Fluoride results for 2009 within a 3 km radius of the plant is included in Figure 6-10, demonstrating that concentrations were highest immediately adjacent to the plant.

However, hydrogen fluoride concentrations in the area are already high and currently meet the RC standard. Because, the Project contribution represents nearly one quarter of the total pollutant concentration, Project impacts on Fluorides would be considered of medium significance.

Impact AQ7 – Medium Significance

Figure 6-10: 2009 Contour Plot of the Highest Monthly Average Ras Al Khair Fluorides Concentration

Source: Jacobs 2013
Air concentrations of ammonia are compared to the hourly standard in Table 6-14 and Table 6-15. Maximum hourly concentrations ranged from 253-1522 µg m\(^{-3}\) during the 2008-2012 period. These levels are below than the relevant AQS’s of 1800 µg m\(^{-3}\). This demonstrates that the plant would be compliant with the relevant environmental regulations. A contour plot of the hourly averaged NH\(_3\) results for 2009 within a 3 km radius of the plant is included in Figure 6-11 demonstrating that concentrations were highest immediately adjacent to the plant.

As shown in Table 6-16, cumulative concentrations were also found to be within RC standards. Therefore, impacts were considered to be of low significance.

**Impact AQ8 – Low Significance**

![Contour Plot](image)

*Figure 6-11: 2009 Contour Plot of Highest Daily Average Ras Al Khair NH\(_3\) Concentration*

*Source: Jacobs 2013*
6.3.4.10 FUGITIVE SOURCES

Fugitive emissions sources in the vicinity of the Project would include:

- Loading / unloading of solid raw materials using trucks and conveyors;
- Loading / unloading of product using conveyors;
- Vehicle emissions from cars/coaches/trucks/locomotives whilst attending the site.
- Handling and storage of phosphate ore;
- The adjacent aluminium plant residue area (for aluminium plant wastes);
- The existing phosphogypsum storage area south of the site; and
- Diesel storage tanks.

Fugitive emissions for the Project were modelled based on US EPA AP42 guidance. The methodologies for each emissions source are described in detail in Appendix D. The fugitive emissions from each area described and the methodology used to calculate emissions are summarised in Table 6-17. These fugitive sources were simplistically modelled as six area sources defined by the footprints of the areas of site where these activities take place. They were included in total project operations shown in Table 6-15 above. Fugitive sources modelled as line and area sources are shown as areas delineated by dashed red lines in Figure 6-12. Nearby sensitive receptors are represented by the blue triangles.
### Table 6-17: Projected Maximum Emissions from Fugitive Sources

<table>
<thead>
<tr>
<th>Area/Line</th>
<th>Description</th>
<th>Area (m²)</th>
<th>Activities</th>
<th>Emissions (g/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Existing Operations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Area 1</td>
<td>Storage area for phosphate ore from Al Jamalid for existing PAP</td>
<td>3.78e5</td>
<td>Unloading from rail to truck Unloading from truck to storage area loading on to truck for transfer to conveyor</td>
<td>0.074 (PM₁₀)</td>
</tr>
<tr>
<td>Area 2</td>
<td>Existing PAP/DAP unloading / delivery area</td>
<td>1.2e5</td>
<td>Conveyor unloading of phosphate ore Delivery of urea and filler by lorry</td>
<td>4.9e-3 (PM₁₀)</td>
</tr>
<tr>
<td>Area 3</td>
<td>Dust emissions from existing DAP export area</td>
<td>1.75e5</td>
<td>Conveyor transfer of DAP export</td>
<td>0.0016 (PM₁₀)</td>
</tr>
<tr>
<td>Area 4</td>
<td>Dust emissions from export of existing DAP from port area</td>
<td>1.8e-5</td>
<td>Conveyor transfer of DAP at port for export</td>
<td>0.0016 (PM₁₀)</td>
</tr>
<tr>
<td>Area 5</td>
<td>Dust emissions from existing aluminium residue storage area</td>
<td>1.445e6</td>
<td>Dust emissions from wind erosion</td>
<td>3.89 (PM₁₀)</td>
</tr>
<tr>
<td>Area 6</td>
<td>Dust emissions from existing phosphogypsum storage area</td>
<td>6.44e5</td>
<td>Assumed to be identical to those estimated for the Umm Wu’al phosphogypsum transfers. Unloading of material from conveyor from PAP and beneficiation Truck unloading in waste area</td>
<td>0.052 (PM₁₀)</td>
</tr>
<tr>
<td>Line 7</td>
<td>Emissions from locomotives in existing phosphate ore storage sidings</td>
<td>2.025e5</td>
<td>Locomotive emissions (2 trains per week)</td>
<td>0.0014 (PM₁₀) 0.0022 (VOC) 0.084 (NOₓ) 0.022 (CO)</td>
</tr>
<tr>
<td>Area 12</td>
<td>Vehicle emissions from activities on the site (existing MPC plant)</td>
<td>2.93e6</td>
<td></td>
<td>0.0104 (PM₁₀) 0.015 (VOC) 0.251 (NOₓ) 0.105 (CO)</td>
</tr>
<tr>
<td><strong>New, Project-Related Operations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line 8</td>
<td>Emissions from locomotives while unloading in new MPC sidings</td>
<td>1.25e5</td>
<td>Locomotive emissions (2 trains per day)</td>
<td>0.0096 (PM₁₀) 0.0156 (VOC) 0.59 (NOₓ) 0.15 (CO)</td>
</tr>
<tr>
<td>Area 9</td>
<td>DAP unloading / delivery area for new plant</td>
<td>1.2e5</td>
<td>Delivery of urea and filler by lorry</td>
<td>1.0e-3 (PM₁₀)</td>
</tr>
<tr>
<td>Area 10</td>
<td>Dust emissions from new DAP export area</td>
<td>1.75e5</td>
<td>Conveyor transfer of DAP export</td>
<td>0.0016 (PM₁₀)</td>
</tr>
<tr>
<td>Area 11</td>
<td>Dust emissions from export of new DAP from port area</td>
<td>1.8e-5</td>
<td>Conveyor transfer of DAP at port for export 3 transfers as material will be stored in port area before loading. Also potash will be delivered by sea for new NPK plant</td>
<td>0.00494 (PM₁₀)</td>
</tr>
<tr>
<td>Area 13</td>
<td>Vehicle emissions from new MPC activities on site</td>
<td>2.93e6</td>
<td></td>
<td>5.2e-4 (PM₁₀) 7.5e-4 (VOC) 0.0126 (NOₓ) 5.25e-3 (CO)</td>
</tr>
<tr>
<td>Area 14</td>
<td>VOC emissions from new MPC diesel storage tanks</td>
<td>1.105e4</td>
<td></td>
<td>4.3e-3 (VOC)</td>
</tr>
</tbody>
</table>
Indicative diesel tank sizes were used in the model for VOCs, however subsequent to this modelling tank size estimates were significantly reduced. Tank capacities are expected to be no greater than 25m$^3$ each. Therefore, fugitive VOC emissions associated with these tanks will be less than that quoted in Table 6-17.

Given the scale of Project contributions to emissions shown in Table 6-14 and Table 6-15 as compared to the fugitive emissions sources shown in Table 6-17 above, Project contributions to criteria pollutant sources from fugitive emissions would be minimal and impacts would be considered of low significance.

**Impact AQ9 –Low Significance**

6.3.4.11 GREENHOUSE GAS EMISSIONS

CO$_2$ emissions associated with the Project could result in negative impacts upon global greenhouse emissions. As described in Section 2 Policy, Legal and Administrative Framework, the proposed Project is subject to the IFC Performance Standards and the Equator Principles, and as such an analysis of available technologies to reduce CO$_2$ emissions is provided in Section 3 Consideration of Alternatives. This will however require further development by the Ammonia Plant FEED Contractor / Vendor (in consultation with Ma’aden) which is to undertake a Best Available Technologies (BAT) during FEED.

Although the proposed Project is will generate CO$_2$ emissions through plant operations, energy consumption has been minimised wherever possible throughout all phases of the operational life of the Project (refer to Section 3 Consideration of Alternatives and Section 4 Detailed Description and Layout of the Proposed Development). The total power consumption of the existing and new plants will be approximately 83 MW per hour. The Project will be linked to a facility within the MPC Complex that will provide electrical power through the construction of stream turbine generators, powered by natural gas. The projected electrical power output of the plant serving the Industrial City is 2500 MW per hour. Therefore, Project energy demands represent about 3% of power to be generated locally.

The International Energy Agency (IEA) has estimated the total CO$_2$ emission in KSA was 446 Million Metric tonnes in 2010 (IEA, CO$_2$ Emissions from Fuel Combustion, 2012). Of this total, 104 Million Metric tonnes were from manufacturing and industry. Operation of the Ammonia Plant, operational-related vehicles and rail transport will generate CO$_2$ emissions. Table 6-18 outlines the total major sources of CO$_2$ emissions estimated associated with Project operations. Construction vehicles would also be a source of CO$_2$ emissions, however, the emissions would be temporary and are not included in the discussion below. Energy use from the emergency diesel generator is also excluded from this discussion as it is only operational in emergencies.

### Table 6-18: Total GHG Emissions by Source Category

<table>
<thead>
<tr>
<th>Source</th>
<th>Power (MW)</th>
<th>Distance Travelled</th>
<th>Million BTU Consumed Daily</th>
<th>Annual CO$_2$ Emissions (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational Vehicles (note 1)</td>
<td>46,522 km per day</td>
<td>620.29</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>Trains</td>
<td>3,200 km per day</td>
<td>122.6</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>NH3 Process Emissions</td>
<td></td>
<td></td>
<td>1,324,216 (note 2)</td>
<td></td>
</tr>
<tr>
<td>NH3 Primary reformer</td>
<td></td>
<td></td>
<td>250,000</td>
<td></td>
</tr>
<tr>
<td>NH3 Auxiliary Boiler</td>
<td>22</td>
<td></td>
<td>17</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>1,574,237</strong></td>
<td></td>
</tr>
</tbody>
</table>

Source: Jacobs, 2013. Notes: Calculations are based on Table 2.12 and Table 2.15 of the U.S. Department of Energy’s Transportation Energy Data Book (Davis 2012) and the UK EA GHG emission factors paper. Units: BTU = British thermal units; MW=Megawatts.

Note 1: Vehicle emission estimates are based on the total km/day (‘worst case’ operational scenario) as estimated in Section 13 Traffic and Transport Infrastructure and rates provided by Davis (2012).

Note 2: Emissions based on the generation of 167,199 kg/hr CO$_2$ from the ammonia plant for 24 hours daily operation over 330 days per year.
Assuming the proposed Ammonia Plant will be designed and operated the same as the existing Plant, the total estimated CO$_2$ emissions estimated to be generated annually by the Project including operations and vehicle emissions is 1,574,237t.

During the operational phase GHG emission levels will need to be publicly reported annually (as per Equator Principle 10). Public reporting requirements can be satisfied via regulatory requirements for reporting or environmental impact assessments, or voluntary reporting mechanisms such as the Carbon Disclosure Project where such reporting includes emissions at the Project level.

Although Project emissions represent only 0.33% of total CO$_2$ emissions in KSA, emissions would still represent an incrementally large contribution to GHG emission in the Project area. Therefore, GHG impacts associated with the proposed facility are considered to be of high significance.

**Impact AQ10 –High Significance**

6.4 MITIGATION

Implementation of mitigation measures will be required during construction, commissioning and operation of the Project to minimise potential negative impacts of the activities on the air quality, including construction dust and operational emissions. The mitigation measures are generally management procedures described in the subsequent sections. The following text assesses the impacts predicted as being of low significance following implementation of appropriate mitigation measures to predict the residual impact significance.

6.4.1 CONSTRUCTION

No impacts with a potential negative significance of medium or high on are anticipated to occur as a consequence of the construction phase.

Development and implementation of the Construction Environmental Management Plan (CEMP) should consider measures such as those listed below to reduce dust that would result from construction:

- Covering all dust generating stockpiled materials with a suitable weighted tarpaulin;
- Establish pedestrian routes within the construction area to be used by workers;
- Minimise the amount of materials stockpiled as far as is practicable, with any required stockpiles aligned parallel to the prevailing wind direction;
- Covering of any exposed soils in heavily trafficked areas such as roads or carparks with gravel or crushed stone to reduce wind blown dust generation;
- A reduced construction site speed limit to prevent the generation of large dust clouds form vehicles;
- Subject to water availability and the time of the year, surface spraying of road surfaces with water and a soil binding agent; and
- Periodic grading of any uneven surfaces that arise on construction traffic routes.

Prior to commencement of construction activities, development of an Air Quality & Dust Monitoring Plan should be considered as part of the CEMP to ensure appropriate on-site mitigation measures are implemented.
6.4.2 OPERATION

6.4.2.1 MITIGATION

Table 6-19: Mitigation for Air Quality impacts during the operational phase

<table>
<thead>
<tr>
<th>ID Code</th>
<th>Impact</th>
<th>Potential Significance</th>
<th>Mitigation Measure</th>
<th>Significance after Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQ7</td>
<td>Increase in Fluorides from Project operations combined with existing MPC facilities.</td>
<td>Medium</td>
<td>• Ma’aden shall consider and make this ESIA available for use in cumulative impact assessments of future developments of the Industrial City.</td>
<td>Low</td>
</tr>
<tr>
<td>AQ10</td>
<td>Green House Gas Emissions</td>
<td>High</td>
<td>The FEED Contractor shall document a full BAT analysis to demonstrate that best available techniques are used to capture CO₂ emissions. This process would include expansion on the alternatives discussed in Section 3 Consideration of Alternatives including the following:</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Investigate design options for reducing green house gas emissions (specifically for the Ammonia Plant). This assessment should consider other options for the capture and use of CO₂.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Reduce CO₂ emissions during the design period where possible using BAT.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Record BAT assessment findings.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The Operator shall:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Conduct annual monitoring / quantification of emissions from the Project according to IFC and Equator Principle guidance and reporting findings as required.</td>
<td></td>
</tr>
</tbody>
</table>

6.4.2.2 RECOMMENDATIONS

The site operator shall develop, implement and maintain an Environmental Emergency Response Plan (EERP) and Environmental Management Plan (EMP) for the operational phase, to further protect against impact of local air quality. These plans will detail responsibilities and procedures for environmental and emergency response management during operation, including:

• Emissions monitoring and reporting to relevant authorities;
• Appropriate maintenance of important mitigation equipment such as scrubbers, catalyst beds etc;
• Competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency (including accidental releases of hazardous substances);
• Minimising use of auxiliary and back up boilers
The operator will undertake regular audits of the above management plans to confirm their ongoing effectiveness.

Prior to commencement of operations, ambient air quality data should again be gathered and such data sets built on during the course of operations.
7.0 TERRESTRIAL ENVIRONMENT

7.1 Introduction

7.2 Baseline conditions

7.2.1 Introduction

7.2.2 Regional geological context

7.2.3 Site geological context

7.2.4 Groundwater

7.2.5 Surface water

7.3 Groundwater flow & spill modelling

7.3.1 Introduction

7.3.2 Selection of modelling scenarios

7.3.3 Conceptual site model

7.3.4 Modelling methodology

7.3.5 Modelling results

7.4 Impact assessment

7.4.1 Introduction

7.4.2 Construction Phase

7.4.3 Commissioning

7.4.4 Operations

7.4.5 Decommissioning

7.5 Mitigation

7.5.1 Overview

7.5.2 Pre-construction

7.5.3 Construction

7.5.4 Commissioning

7.5.5 Operations

7.5.6 Decommissioning
7.0 TERRESTRIAL ENVIRONMENT

7.1 INTRODUCTION
This section presents the findings of the onshore physical environment baseline review and assessment of the potential impacts arising from the Project on the physical terrestrial environment. The assessment considers regional and local geological and hydrogeological conditions, characterises the soil and groundwater quality at the site, and presents results of modelled spill scenarios to determine potential impacts on receptors. The existing hydrological conditions and potential impacts on surface water are assessed within Section 11 Water Quality Management.

7.2 BASELINE CONDITIONS

7.2.1 INTRODUCTION
In addition to a review of the previous EIAs commissioned by Ma'aden for the Aluminium and Phosphate Facilities at Ras Al Khair, the terrestrial environment baseline conditions of the Project site have been established taking into consideration the geological and hydrogeological information collated by the following field investigations:

- Geotechnical investigations undertaken in the southern half of the Project site by Riyadh Geotechnique & Foundations between November 2006 and January 2007 to evaluate the subsurface conditions at the site prior to the construction of the existing MPC facilities (RGF, 2007);
- Installation of eleven groundwater monitoring and sampling standpipes across the site adjacent to each of the existing MPC facilities (Gulf Consult, January 2012); and
- Groundwater sampling and analysis at the eleven Gulf Consult monitoring locations in January and December 2012.

The EPC Contractors for the Ras Al Khair Industrial Complex will conduct further investigation as deemed necessary to obtain reliable geo-technical data for design purposes and to supplement the baseline condition understanding presented herein.

7.2.2 REGIONAL GEOLOGICAL CONTEXT

7.2.2.1 GEOLOGY & SOILS
The geology of the eastern region (Ash Sharqiyyah) of Saudi Arabia, as it borders the Arabian Gulf, consists of a thick sedimentary sequence covering the Precambrian crustal plate. This stratigraphic sequence ranges in age from the Paleogene (~65MA) to the Quaternary (~2.5MA to the present day) and forms a wide coastal plain at the Arabian Gulf coast rising gradually inland towards the Summan plateau.

The Paleogene to Eocene sequence comprises the Umm Er Radhume (UER) formation, the Rus formation, and the Ad Dammam formation. These generally comprise limestones, dolomites, marl and shales. The Neogene sequence comprises the Hadrukh, Dam, and Al-Hofuf formations. These comprise sands, marly sands, siltstones, limestone and marl.

Formations from the Quaternary period comprise very variable, generally less than 30m thick, superficial deposits of aeolian sands, wadi-fill, sheetwash, alluvial and sabkha deposits (Rasheeduddin et al, 2001).

A geotechnical study completed by Fugro-Suhaimi Geotechnical Engineers for the construction of the nearby Ma’aden Aluminium Plant encountered two distinctive soil types within the Ras Al Khair (previously referred to as Ras Az Zawr) peninsular: Udipsamment-Torripsamment soils and Torripsamment soils. The Udipsamment-Torripsamment soils comprised shell materials and calcereous sands, with some carbonate sands and coral samples. Localised moderately strong limestone was also encountered. The Torripsamment soils were generally found to comprise loose to medium density sands with calcereous and to a lesser extent carbonate sands and shell fragments.
7.2.2.2 SEISMICITY

Seismic activity is limited throughout Saudi Arabia with only four (4) earthquake events between the magnitudes of 3 and 6 on the Richter scale being recorded between the years 1638-2004. Regional activity is greatest along the western Iranian coast (GHD, 2005).

The Project site is located on the relatively stable Arabian Shelf within the Arabian Tectonic Plate’s northern boundary with the Euroasian Plate. These plates meet along the Zagros thrust fault, which is approximately 450 km northeast of the industrial facility site at Ras Al Khair.

7.2.2.3 GEOMORPHOLOGY

The coastal plain is largely low lying and comprises flat sand sheets of deposited aeolian sand with a number of limestone outcrops, and widely rolling inactive dune systems. Longitudinal sand dunes of up to 10m height and 100m length are present on the Ras Al Khair coastline, oriented in the predominant north-westerly wind direction. Sabkhas, which are planar supratidal salt flats formed in unconsolidated sandy or finer sediments in combination with shallow groundwater levels along arid coastlines, are also present within the region and the study area (see Section 7.2.3.1 below). Sabkhas contain a hard crust approximately 0.5m below the surface, formed by the evaporation groundwater and deposition of calcium carbonate, gypsum, anhydrite, sodium chloride, and other salts in the upper subsurface. This crust inhibits plant growth and impedes drainage of surface water, leading to flooding of the sabkhas after periods of rain.

7.2.3 SITE GEOLOGICAL CONTEXT

7.2.3.1 LITHOLOGY

The 2007 RGF geotechnical investigation in the southern portion of the Project site identified two distinct Quaternary geological units on the basis of the predominant geomorphological feature: Elevated areas of the site were characterised by an extensive field of relatively stable dunes comprising brown, mostly uniformly or poorly graded, medium grained well rounded quartz sand, and fine grained subrounded quartz sand. Lower areas exhibited characteristics of inland sabkhas with deposits noted to be grey or brown clays, silts and sands with colour varying according to lithological content and proximity to the underlying groundwater.

The Quaternary units were reported to either conformably or unconformably overlie Tertiary deposits of the Hadruk Formation, comprising typically grey, green, white and pink calcareous marly sandstone, sandy marl, sandy clay and sandy limestone.

7.2.3.2 STRATIGRAPHY

The geology & soils encountered at the site in 2007 were subdivided on the basis of their lithological and geotechnical properties as follows:

- **Layer 1** - topsoil comprising sand/marl fill material to a depth of 0.5 mbgl (metres below ground level); described as off-white to light brown, silty sand (marl). Standard Penetration Testing (SPT) indicated the soils to be generally medium dense to dense with SPT N-values between 13 and >50 blows for 30cm penetration of the split spoon sampler. RGF interpreted Layer 1 as comprising made ground associated with site development fill.

- **Layer 2** - granular soil comprising brown, silty sand and poorly graded sand with varying amounts of silt extending to the maximum depth of the investigation i.e. 25 mbgl. SPT testing indicated the soils to be generally medium dense to very dense with SPT N-values between 11 and >50 blows for 30cm penetration of the split spoon sampler. Densities increased with depth with frequent refusal encountered below 12m depth.

- **Layer 3** - a very loose to loose soil interbedded at a depth of 2 – 6 mbgl within layer 2 comprising Sabkhah soil formation of grey, silty sand/sandy silt. The in-situ compactness of this layer was found to be generally in a very loose to loose state with
SPT-N values ranging from 1 to 10 blows for 30cm penetration of the split spoon sampler.

The geology & soils encountered at the site during the 2011 intrusive investigation were more generally subdivided by Gulf Consult as follows:

- Layer 1 - Brown loose to medium dense poorly graded fine to medium sand with silt to a maximum depth of 6 mbgl; and
- Layer 2 - Brown dense to very dense poorly graded fine to medium sand with silt from between 2 mbgl and 4 mbgl to the maximum extent of the hole (7 mbgl).

7.2.3.3 SOIL CHEMICAL QUALITY

Sixteen bulk soil samples were obtained during the RGF 2007 investigation and submitted, for the purpose of geotechnical design inputs, for chemical analysis of pH, electrical conductivity, chloride, sulphate and carbonate. On the basis of these analytical results, RGF concluded that subsurface concrete infrastructure should be designed cognisant of the CLASS 5, as defined by CIRIA guidance (CIRIA, 1984; now superseded by Concrete Society / CIRIA, 2008). This class was defined for concretes in contact with soils and ground water with SO\(_3\) concentrations in excess of 2% and 5g/l respectively, requiring BS4027 or 4028 or ASTM Type V cements with adequate protective tanking, a cementitious content of not less than 400kg/m\(^3\), a free water cement ration of not more than 0.4, and a minimum 100mm cover for reinforced concrete.

None of the soil samples obtained during the RGF 2007 investigation were submitted for laboratory analysis of potential contaminants of concern associated with the site’s current or proposed operations. Furthermore, soil samples were not obtained during installation of the 11 groundwater monitoring wells in 2011.

Given the above, baseline soil chemical quality in respect of the site’s current potentially contaminative operations cannot currently be established.

7.2.4 GROUNDWATER

7.2.4.1 AQUIFER UNITS AND CHARACTERISTICS

Based on their varying hydrogeological properties, the regional lithological succession (refer Section 7.2.2.1) can be divided into the following aquifers and intercalated aquitards:

- The UER Aquifer (UER formation);
- The Rus Aquitard (Rus Formation, Midra and Saila shales and Alveolina limestones);
- The Damman Aquifer (Khobar limestone, Orange marl and Alat limestone); and
- The Neogene Aquifer (Dam-Hofuf and Hadrulkh Formations).

Given the Tertiary geology underlying the site, the Neogene Aquifer is considered of most relevance to this impact assessment.

Except for some local facies variations, the aquifers are comprised of limestones, dolomitic limestones and dolomites, whilst the aquitards are shales, marls and anhydrite. As is common in carbonate aquifers, there is great spatial variation in hydraulic properties.

Contemporary aquifer recharge is reportedly insignificant, being sporadic, local and infrequent with the groundwater reserves of the region present due to paleo-recharge between 20,000 and 28,000 years ago.

7.2.4.2 GROUNDWATER ABSTRACTIONS

Groundwater in the eastern Province is reported in Rasheeduddin et al (2001) to be subject to heavy abstraction for irrigation and stock-watering purposes. This has caused depression cones in some areas which further increase groundwater evaporation as the groundwater is drawn up through sandy soils through capillary action. Cones of groundwater depression due to abstractions can overlap and lead to areas with little or no usable groundwater.
Notwithstanding the above, there are no records of groundwater abstractions within the industrial facilities operating at Ras Al Khair. GHD (2005) noted the presence of semi-permanent Bedouin encampments and a Coast Guard facility on the Ras Al Khair peninsula. However, it is considered unlikely that these have got access to potentially present deeper, freshwater aquifers.

The groundwater beneath the site is not considered an important resource for water supply, however, it may act as a pathway to sensitive ecological receptors associated with the marine environment at the Gulf Coast.

7.2.4.3 GROUNDWATER ELEVATION & FLOW CHARACTERISTICS

The regional potentiometric surface slopes from the south-west to the north-eastern coastline of the Arabian Gulf. Regional groundwater flow is therefore anticipated to be towards the coast.

Groundwater was encountered in all 64 exploratory boreholes advanced during the RGF 2007 investigation with groundwater depths of approximately 3.6 mbgl reported. Each exploratory location was reportedly surveyed to a local, site datum by RGF which, when used to derive groundwater elevations suggests that groundwater flow is heavily influenced by site topography.

Two of the sixty-four exploratory boreholes advanced in 2007 were installed with groundwater monitoring standpipe piezometers. Groundwater elevation monitoring at these locations between 29\textsuperscript{th} December 2006 and 13\textsuperscript{th} January 2007 recorded depths to groundwater of between: 3.43 and 4.06 mbgl (location PZ1); and 3.38 and 4.11 mbgl (location PZ2). This monitoring suggests some temporal variation in groundwater elevations; due to the proximity of the sea, groundwater elevations may be subject to tidal influences; however, further interpretation of groundwater flow characteristics on the basis of these results is not possible.

Given the above temporal variation, the aforementioned close correlation between site topography and encountered groundwater levels is somewhat questionable when considering the lack of groundwater depth variation during the investigation period. As such, understanding of groundwater elevations and flow characteristics is based upon monitoring data obtained in 2012.

The groundwater elevation monitoring undertaken at the 11 monitoring locations installed by Gulf Consult in 2011 indicate a localised elevated groundwater table at MW9, falling gradually to the south and more steeply towards locations MW7 and MW8 in the north (refer to Figure 7-1). The number of available data points is, however, limited and therefore a robust interpolation of site-wide groundwater flow directions is not considered possible at this time and can be further defined during the EPC stage where required.

Rising head tests completed at eight exploratory boreholes in 2007 suggest the water-bearing strata underlying the site have hydraulic conductivities of between $2.74 \times 10^{-5}$ and $5.12 \times 10^{-5}$ m/sec, indicating reasonably permeable strata.
Figure 7-1: Groundwater elevation based on Gulf Consult 2011 monitoring locations; the red boundary represents the extent of the survey area.
7.2.4.4 GROUNDWATER CHEMICAL QUALITY

No groundwater samples were obtained and submitted for chemical laboratory analysis as part of the RGF site investigation in 2007; however, two rounds of groundwater sampling and analysis were undertaken by Gulf Consult in January and December 2012.

All 11 groundwater monitoring locations were sampled in January 2012; however, location MW5 was not re-sampled in December 2012. All recovered groundwater samples were submitted for broadly similar analytical suites comprising organic and physical parameters, metals and other inorganic ions, nutrients, Total Petroleum Hydrocarbons (TPH), and Volatile Organic Compounds (VOCs).

In the absence of specific groundwater quality standards, the laboratory analytical results were screened against Water Quality Criteria for Direct Discharge (WQDD) as provided by RCER-2010 (Kingdom of Saudi Arabia, Royal Commission for Jubail and Yanbu, 2010).

Laboratory analytical results for both sampling events screened against WQDD are presented in Tables 7-1a & b (refer Appendix E). Where no referenced standard or quality criteria exist for potentially anthropogenically-derived substances, results were conservatively screened against the laboratory LOR.

The chemical quality of groundwater, as revealed by the above analysis, is summarised below:

General Characteristics

Groundwater beneath the site was recorded as being broadly circum-neutral with a temperature of between 25 and 29°C. Based on recorded electrical conductivities, and chloride and sulphate concentrations, the groundwater is slightly saline, as may be expected given its proximity to the coast.

Inorganic Contaminants

Detectable concentrations of ammonia and nitrate were recorded in all samples submitted for analysis. Concentrations were generally below the WQDD criteria, apart from samples obtained from MW1-3 and MW10 in December 2012 which were found to exceed the WQDD for nitrate.

Detectable concentrations of metals and semi-metalloids were restricted to copper, iron, and manganese in samples obtained in January 2012; however, the December 2012 samples, analysed by a different laboratory, found detectable concentrations of a wider range of inorganic substances. The samples were found to exceed the WQDD for manganese (January 2012 only) and to a lesser extent iron (December 2012 only). A sample obtained from MW10 in December 2012 exceeded the WQDD for mercury.

Organic Contaminants

Samples obtained in January 2012 recorded TPH concentrations of: between 2,100 and 6,600 µg/l in the vicinity of the existing ammonia plant in the north-west corner of the site (MW4–6); 1,900 µg/l adjacent to the proposed DAP/NPK plant (MW9); and 2,900 µg/l to the south-west of the proposed storage area and tank farm (MW3). The LOR for this analytical event was 1,000 µg/l TPH.

In contrast to the above, detectable TPH concentrations were only recorded in December 2012 groundwater samples obtained at locations MW7 – 9 with a maximum concentration of 510 µg/l. All other samples were found to contain less than 50 µg/l. It is noted, however, that the maximum January concentration of 6,600 µg/l was recorded in groundwater sampled from MW5. This well location was not re-sampled during the December sampling event.

Notwithstanding the above, there appears to be considerable differences in TPH concentrations recorded by the two sampling and analytical events, both in terms of the magnitude and location of dissolved phase impacts.
Analysis for a broad suite of VOCs did not record detectable concentrations in all samples obtained during both events with the exception of a trace of bromoform (22 µg/l compared with the LOR of 5 µg/l) in groundwater obtained from MW9 in December 2012.

7.2.5 SURFACE WATER

There is no permanent or semi-permanent surface water within the project site area or in its vicinity other than the temporary presence of ponding stormwater and constructed ponds for the purpose of surface water retention, irrigation and evaporation. Outside of the Project site, stormwater can collect within sabkha from localised rainfall.

The nearest body of surface water that is considered to represent a sensitive environmental receptor to the site is the marine environment of the Gulf coast. Section 11 Water Quality Management further considers the potential impacts on coastal waters of the Arabian Gulf.

7.3 GROUNDWATER FLOW & SPILL MODELLING

7.3.1 INTRODUCTION

Environmental control and mitigation measures are foreseen to be implemented during all phases of the Project to prevent uncontrolled losses of contaminative substances to the terrestrial environment and, due to this, the likelihood of such releases occurring is considered to be low. However, to inform assessment of impact magnitude, groundwater flow and spill modelling was undertaken for three potential pollution scenarios assuming that mitigation on the site might be compromised.

The following sections describe the pollution scenarios considered, the modelling methodology and approach adopted, and the findings of this exercise (together with a discussion of assumptions made and a sensitivity analysis of modelling uncertainties).

Modelling was undertaken using the USEPA’s BIOSCREEN model.

7.3.2 SELECTION OF MODELLING SCENARIOS

The release of contaminative substances to the terrestrial environment may occur via numerous mechanisms during the construction, commissioning, operation and decommissioning of the proposed development. In order to provide focus to the subsequent impact assessment, however, the following potential worst case scenarios (in the absence of mitigation) were modelled:

1. Accidental spillage during site construction, commissioning, operation, or decommissioning for example during routine maintenance or vehicle / plant refuelling activities (Likely Case).
2. Catastrophic failure of a storage tank, for example due to corrosion or over-pressurisation, leading to release of the entire tank contents to ground (Conservative Worst Case); and
3. Chronic leakage from pipe-work, for example from a crack in a pipe or at a single break-point such as a pipe junction, valve, or flange (Reasonable Worst Case).

Modelling of each of the above scenarios was undertaken using the Source-Pathway-Receptor approach, where the source of the contamination is described and potential receptors are identified. The modelling was used as a predictive tool to determine the potential impact on receptors by predicting likely contaminant concentrations at different radial distances from the pollutant source.

7.3.3 CONCEPTUAL SITE MODEL

7.3.3.1 SOURCE CHARACTERISATION

For Scenario 1, the most likely contaminants were considered to be petroleum hydrocarbons such as diesel (fuel) or heavier fractions (such as those present in lubricating oils). As indicated by US EPA (1996), diesel consists of hydrocarbons with 10 to 20 carbon atoms. The
most soluble of the hydrocarbon fractions belonging to this range is represented by the TPH Aromatic C10-C12 range (see also TPH Criteria Working Group, 1997) and therefore this fraction was modelled to assess the impact of diesel entering the groundwater system. For lubricating oils, the heavier aromatic hydrocarbon range of C12 – 16 was adopted for modelling purposes.

For Scenarios 2 and 3, a release of two separate substances, which will be stored at the site, was modelled for each scenario. Diesel was modelled to simulate plume migration subject to natural degradation whilst sulphuric acid was modelled to assess plume migration without degradation processes. Although ammonia will be stored in considerable quantities at the site, ammonia released from storage will likely become gaseous before reaching the groundwater table and therefore modelling of this substance was not considered necessary.

Initial plume concentrations were assumed to be the relevant solubility limit for each contaminant of concern. With regards to plume geometry, an accidentally released volume of 1 m$^3$ (Scenario 1) was assumed to result in an initial plume width of 25 m. For Scenario 2, the total anticipated tank volume was assumed to be released resulting in initial plume widths equal to the total width of the relevant storage area.

Chronic leakage (Scenario 3) was modelled assuming a worst-case for diesel whereby 25 m$^3$ of liquid was lost from containment over the life-time of the plant; and a more reasonable case whereby 1% of a sulphuric acid tank’s volume is lost prior to fault detection. In both instances, the initial plume width is equal to the total width of the Materials Storage and Handling Facility.

The source parameters for each modelling scenario are presented in Table 7-2. Physico-chemical input parameters for each contaminant of concern are presented in Table 7-3.

### Table 7-2: Spill Scenarios Simulated with BIO SCREEN

<table>
<thead>
<tr>
<th>#</th>
<th>Scenario</th>
<th>Likelihood</th>
<th>Cause</th>
<th>Maximum Spill Volume</th>
<th>Initial Plume Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Accidental Spillage of diesel / lubricating oil</td>
<td>Likely</td>
<td>Plant / vehicle maintenance</td>
<td>1 m$^3$</td>
<td>25m</td>
</tr>
<tr>
<td>2</td>
<td>Catastrophic Storage Tank Failure (Diesel / sulphuric acid)</td>
<td>Very Unlikely</td>
<td>Rupture of shell due to overpressure / corrosion</td>
<td>12 m$^3$ (Diesel)</td>
<td>200m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8,300 m$^3$ (Sulphuric Acid)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Chronic Leakage from Pipe-work (Diesel / sulphuric acid)</td>
<td>Unlikely</td>
<td>Gasket / flange / valve leaks</td>
<td>25 m$^3$ (Diesel)</td>
<td>200m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>83 m$^3$ (Sulphuric Acid)</td>
<td></td>
</tr>
</tbody>
</table>

### Table 7-3: Chemical and Physical Properties of the Released Materials

<table>
<thead>
<tr>
<th>Contaminant of Concern</th>
<th>Solubility Limit (mg/l)</th>
<th>Organic Carbon - Water Partition Coefficient (-)</th>
<th>Half Life in groundwater (years)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel Oils (TPH Aromatic C10-C12) (Scenario 1, 2 and 3)</td>
<td>24.5</td>
<td>2511.89</td>
<td>4.11</td>
<td>1, 2</td>
</tr>
<tr>
<td>Lubricating Oils (TPH C12-C16) (Scenario 1, 2 and 3)</td>
<td>5.75</td>
<td>5011.87</td>
<td>4.11</td>
<td></td>
</tr>
<tr>
<td>Sulphuric Acid (Scenario 1 and 2)</td>
<td>1,000,000</td>
<td>6.1</td>
<td>n/a</td>
<td>3</td>
</tr>
</tbody>
</table>

Source:
(1) TPH Criteria Working Group (1997)
7.3.3.2 PATHWAY CHARACTERISATION

Petroleum hydrocarbons such as diesel and lubricating oils will vertically infiltrate the unsaturated zone under the influence of gravity. Due to their relative density compared to water, these substances will float upon the groundwater table as an immiscible liquid and slowly dissolve into the groundwater. The resulting dissolved phase plume will then travel down the hydraulic gradient via advective flow; with the plume migration attenuated by the combined effects of dispersion, diffusion, retardation (sorption onto soil particles), and biological degradation.

Sulphuric acid is soluble in water and has high mobility in soil. During transport through the soil, sulphuric acid will dissolve some of the soil material; in particular, any carbonate based materials. Sulphuric acid may be neutralised to some degree via adsorption during unsaturated zone transport; however, a significant proportion of the acid is expected to reach the shallow groundwater table at the site. Upon reaching the groundwater table, the acid will migrate in the direction of groundwater flow with the plume subject to attenuation via the combined effects of dispersion, diffusion, and retardation.

Modelling input parameters used to characterise contaminant migration along the pathway to the receptor were selected with reference to site data (where available) and review of relevant literature (refer Table 7-4).

Table 7-4: Contaminant Transport Model Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic Conductivity</td>
<td>3.4 m/d</td>
<td>Average of site-derived in-situ permeability tests.</td>
</tr>
<tr>
<td>Hydraulic Gradient</td>
<td>0.0017 – 0.00088</td>
<td>Range determined from piezometric contours (Figure 7-1)</td>
</tr>
<tr>
<td>Effective Porosity</td>
<td>0.2</td>
<td>Assumed from low end of a reasonable range provided for gravelly sand soils (Domenico and Schwartz, 1990)</td>
</tr>
<tr>
<td>Flow velocity</td>
<td>0.015 – 0.029 m/d</td>
<td>Darcy calculation, based on the hydraulic conductivity derived from literature (2.0 m/day). Flow velocity = k * i/n, where k = hydraulic conductivity (3.4 m/day, derived from literature), i = hydraulic gradient (0.0017 – 0.00088, site-specific value) and n = effective porosity (0.2 as defined above)</td>
</tr>
<tr>
<td>Mixing zone thickness</td>
<td>2.75 m</td>
<td>Average value for plumes in sandy soils (range: 1.5 m – 4.0 m) as indicated by USEPA, 1996.</td>
</tr>
<tr>
<td>Soil bulk density</td>
<td>1.7 g/cm³</td>
<td>Average value among those reported in literature for sabkha soils, range: 1.59 – 1.86 g/cm³ (source: Al-Amoudi et. al., 1992 and Al-Shayea et al., 2001)</td>
</tr>
<tr>
<td>Fraction of organic carbon</td>
<td>0.1%</td>
<td>Reference value indicated by ASTM (1995), suggested by the BIOSCREEN manual in case no site-specific measurement of this parameter is available.</td>
</tr>
</tbody>
</table>

7.3.3.3 RECEPTOR CHARACTERISATION

Whilst groundwater beneath the site is not considered an important resource for water supply (no known abstractions and hypersaline conditions anticipated), it may act as a pathway to sensitive ecological receptors associated with the marine environment at the Gulf Coast. As such, the groundwater aquifer beneath the site was considered the critical receptor.

The shoreline is located at a distance of ~2 km from the furthest up-gradient storage area and therefore, given the relatively slow calculated flow velocities, un-attenuated groundwater plumes would take between 30 and 58 days to reach the shoreline. However, groundwater moves faster than the dissolved contaminants, because of mechanical dispersion (occurring as a consequence of the advection processes) and because the aquifer solids (soil particles) temporarily hold or retard the contaminants, especially if these are organics.

7.3.4 MODELLING METHODOLOGY

The data available for the development of the groundwater flow model was limited, as relatively few boreholes and monitoring wells were drilled and installed across the
investigation area at the site. As a result, complex and detailed model development was not considered justified and a simple analytical model was applied instead. Simulations of the contaminants transport in groundwater were conducted by applying the USEPA’s BIOSCREEN model, which simulates plume fate & transport behaviour using the Domenico (1987) analytical solute transport model, and has the ability to simulate advection, dispersion, adsorption and biodegradation processes.

7.3.5 MODELLING RESULTS

7.3.5.1 INTRODUCTION

The following section presents a summary of the principal findings of the spill modelling undertaken in support of the impact assessment. Model input and relevant output screens are presented within Appendix E.

7.3.5.2 SCENARIO 1

Accidental spillage of diesel was found to result in a dissolved phase plume which was predicted not to reach the Gulf Coast within 1,000 years, due to the combined effects of dispersion and retardation along the path length (refer Appendix E, Output 1).

After 100 years, the released diesel was found to result in a maximum plume length of no more than 164 m assuming no degradation occurs (refer Output 2), and no more than 61 m assuming natural degradation occurs according to 1st order decay algorithms (refer Output 3).

Similarly, accidental spillage of lubricating oil was predicted not to impact on the Gulf Coast after 1,000 years of potential groundwater transport (refer Output 4). Calculated plume lengths after 100 years were found to be less than 107 m without degradation (refer Output 5) and less than 38 m assuming degradation occurs (refer Output 6).

7.3.5.3 SCENARIO 2

Even when a more substantial volume of diesel is lost to ground (12 m³ compared to the 1 m³ modeled by Scenario 1), the resulting dissolved phase plume was still not expected to reach the Gulf Coast within 1,000 years (refer Output 7). The maximum calculated plume lengths for diesel 100 years after the Scenario 2 release event were found to be 182 m (no degradation, refer Output 8) and 76 m (degradation, refer Output 9).

Conversely, the sulphuric acid plume modeled under Scenario 2 was predicted to impact upon the Gulf Coast with the plume front arriving approximately 100 – 120 years after the release event (compare Outputs 10 and 11). The maximum predicted concentration entering coastal waters (~3,200 mg/l) was expected to reach the coast after approximately 210 years (refer Output 12).

7.3.5.4 SCENARIO 3

More than doubling the volume of diesel released between Scenario 2 and Scenario 3 was found to have little effect on the maximum plume lengths after 100 years of travelling time, with the dissolved phase plume again expected not to reach the Gulf Coast within 1,000 years (compare Outputs 13 – 15 with Outputs 7 – 9).

For the sulphuric acid, the reduced volume released under Scenario 3 (83 m³ compared to 8,300 m³ for Scenario 2) has little effect on the time taken for the plume to impact upon the Gulf Coast (refer Outputs 16 and 17). The maximum concentration predicted to reach the coast in this case is, however, considerably lower at ~1,700 mg/l compared to approximately 3,200 mg/l under Scenario 2 (compare Outputs 12 and 18).

7.3.5.5 DISCUSSION OF RESULTS

The spill modelling undertaken to inform this impact assessment indicated that release of hydrocarbons at the site are unlikely to impact upon the Gulf Coast given the calculated extent of plume attenuation.

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1 Note: Model outputs displayed include distances quoted in ‘feet’: 1 foot = 0.3048 meters. Distance to the Gulf Coast is approximately 6,500 feet from the furthest up-gradient storage area.
Release of appreciable volumes of diesel, lubricating oil, or other petroleum hydrocarbons into the subsurface will however likely result in the persistent presence of a Non-Aqueous Phase Liquid (NAPL) plume beneath the site. Furthermore, according to the modelling outputs, this NAPL plume will give rise to dissolved phase plumes extending up-to 200 m beneath the site.

In contrast to the above, modelling of sulphuric acid releases indicated that highly soluble contaminants with low sorption capacity have the potential to reach the Gulf Coast approximately 100—120 years after their release, thereby potentially impacting upon the marine environment. It is recognised, however, that the effect of acid neutralisation during subsurface transport is not taken into account in the selected model. Such neutralisation processes may result in lower concentrations reaching the marine environment receptor but will also undoubtedly have a detrimental impact upon the terrestrial environment if they occur. In addition, in the specific case of sulphuric acid, the potential for subsurface exothermic reactions exist which may present further adverse consequences.

7.4 IMPACT ASSESSMENT
7.4.1 INTRODUCTION
The Project may negatively impact upon the terrestrial environment during construction, commissioning, operational and decommissioning phases. The potential significance of these impacts prior to mitigation upon soils and groundwater at the site is assessed with reference to the methodology presented in Section 5 Impact Assessment Methodology with the sensitivity of the impacted resource / receptor also taken into account.

7.4.2 CONSTRUCTION PHASE
7.4.2.1 INTRODUCTION
Construction of the project has potential to impact upon the soils and groundwater at the site from activities such as: levelling, earthworks, facility construction, trenching, excavation and backfilling for subsurface infrastructure, vehicle movements, and dewatering (refer to Section 4 Detailed Description and Layout of the Proposed Development for further details).

Specific potential impacts on the terrestrial environment due to the above activities are summarised in Table 7-5 and discussed in the following text.

Table 7-5: Construction Phase Impacts Assessment

<table>
<thead>
<tr>
<th>Factor</th>
<th>TE1</th>
<th>TE2</th>
<th>TE3</th>
<th>TE4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Frequency</td>
<td>Continuous</td>
<td>Infrequent</td>
<td>Frequent</td>
<td>Infrequent</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Certain</td>
<td>Likely</td>
<td>Likely</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
<td>Local</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Duration</td>
<td>Medium</td>
<td>Short</td>
<td>Short</td>
<td>Long</td>
</tr>
<tr>
<td>Magnitude</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Indirect</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
</tr>
</tbody>
</table>

7.4.2.2 LOSS OF SOIL RESOURCE
The utility of the soil present within the proposed site boundary will be sterilised by virtue of the proposed presence of built infrastructure. The baseline soil conditions, however, suggest that these soils have little or no agricultural value.
Whilst representing an inevitable impact, its significance is considered to be low due to the low sensitivity of the soil resource.

**Impact TE1 – Low Significance**

7.4.2.3 ALTERATION OF SITE DRAINAGE

Construction earthworks may alter existing site drainage through activities such as site levelling / re-grading, and temporary excavations. In addition, earth movements and the trafficking of construction plant across the site may lead to soil compaction, thereby reducing infiltration rates. This may have the combined effect of reducing aquifer recharge and increasing surface water run-off. In turn, this may result in enhanced soil erosion and increased sediment loading for site drainage. However, given the limited spatial extent of soil compaction compared with regional extent of the aquifer, the largely insignificant existing groundwater recharge, the low agricultural value of soils and the poor quality of the local groundwater, this impact is considered to be of low significance.

**Impact TE2 – Low Significance**

7.4.2.4 DEWATERING OF EXCAVATIONS AND DISCHARGE TO SEA

Construction activities may involve dewatering of excavations and subsequent discharge of the water to the sea might be adopted as a disposal route. Based on the available information (refer Section 7.2.4.4), the water currently exceeds the quality criteria for direct discharge for a number of determinants and has the potential to negatively impact on the coastal waters and associated sensitive ecological receptors.

Taking the above considerations into account, this impact is considered to be of high significance.

**Impact TE3 – High Significance**

7.4.2.5 DEGRADATION OF SOIL AND GROUNDWATER QUALITY DUE TO ACCIDENTAL SPILLS

Maintenance activities are likely to be undertaken on construction plant and vehicles during construction. As a result there is potential for accidental release or spills of contaminative substances onto bare soil and subsequent migration to groundwater.

Spills of concrete wash water can affect the soil pH and will increase the amount of suspended and dissolved solids in groundwater as well as potentially lead to the cementation of the soil. Spillages of diesel fuel, lubricating oils, and degreasing solvents all have the potential to negatively impact upon the subsurface environment.

Storage of hazardous substances used during the construction phase may also lead to spillages / releases to ground if not adequately managed.

Due to the low significance of the local geology and poor agricultural value of the site area, the soils are not considered to represent an important resource and therefore the significance of this impact could be considered as low. Groundwater beneath the site, however, is likely to be in hydraulic continuity with the marine environment at the Gulf Coast.

Whilst groundwater beneath the site is not considered an important resource for water supply, it may act as a pathway to sensitive ecological receptors and is therefore considered to represent a sensitive receptor in its own right.

The results of spill modelling (Scenario 1) suggest that the magnitude of minor accidental releases / spillages is likely to be low.

Taking the above considerations into account, this impact is considered to be of medium significance.

**Impact TE4 – Medium Significance**
7.4.2.6 NON HAZARDOUS AND HAZARDOUS WASTE MANAGEMENT ON-SITE AND OFF-SITE

Temporary storage and handling of non-hazardous and hazardous wastes generated during construction may lead to spillages/releases to ground if not adequately managed. An assessment of waste management is presented in Section 10.

7.4.3 COMMISSIONING

7.4.3.1 INTRODUCTION

Commissioning activities which may impact on the terrestrial environment include: hydrostatic testing, flushing/cleaning of pipelines, and accidental release of hazardous substances.

Specific impacts on the terrestrial environment due to the above activities are summarised in Table 7-6 and discussed in the following text.

Table 7-6: Commissioning Phase Impacts Assessment

<table>
<thead>
<tr>
<th>Factor</th>
<th>TE5</th>
<th>TE6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Frequency</td>
<td>Infrequent</td>
<td>Infrequent</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Unlikely</td>
<td>Likely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Duration</td>
<td>Long</td>
<td>Long</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

7.4.3.2 SPILLAGE OF WASTEWATER DURING HYDROSTATIC TESTING, FLUSHING & CLEANING OF PIPES

Hydrostatic testing will be performed for the new tanks and pipelines and well as flushing of pipelines. During these activities the water used has the potential to pick up trace concentrations of hydrocarbons and/or inorganic contaminants. Spillage of the wastewater produced may therefore negatively impact soils and groundwater; however, the impact of wastewater entering the groundwater system is considered less significant when compared to accidental spillages of neat hazardous substances (refer TE4).

Further consideration of the management of wastewater during site commissioning is presented in Section 11 Water Quality Management.

*Impact TE5 – Low Significance*

7.4.3.3 ACCIDENTAL LEAKS DURING PIPE CONNECTIONS

Site commissioning requires connections to be made between new and existing infrastructure. Accidental release of potentially hazardous substances during these activities is considered to be more likely than during other routine construction/commissioning activities and therefore the significance of this impact is considered to be high.

*Impact TE6 – High Significance*

7.4.4 OPERATIONS

7.4.4.1 INTRODUCTION

Operation activities which could potentially impact the terrestrial environment, principally relate to accidental release and spills as well as the degradation of the subsurface environment.
Specific impacts on the terrestrial environment due to the above activities are summarised in Table 7-7 and discussed in the following text.

**Table 7-7: Operational Phase Impacts Assessment**

<table>
<thead>
<tr>
<th>Factor</th>
<th>TE7</th>
<th>TE8</th>
<th>TE9</th>
<th>TE10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Frequency</td>
<td>Continuous</td>
<td>Infrequent</td>
<td>Infrequent</td>
<td>Rare</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Certain</td>
<td>Unlikely</td>
<td>Unlikely</td>
<td>Very Unlikely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
<td>Local</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Duration</td>
<td>Medium</td>
<td>Long</td>
<td>Long</td>
<td>Long</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Indirect</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
</tbody>
</table>

7.4.4.2 ALTERATION OF SITE DRAINAGE

During the operation of the site, the increase in paved areas may impact the natural surface water drainage and the existing superficial aquifer recharge regime. Considering the limited increase in paved areas compared with the regional extent of the aquifer, the dry climate of the area, and the poor quality of the local groundwater, the significance of the impact is considered to be low.

*Impact TE7 - Low Significance*

7.4.4.3 DEGRADATION OF SOIL AND GROUNDWATER QUALITY DUE TO ACCIDENTAL SPILLS

Maintenance activities during site operations may result in the accidental spillage of contaminative substances onto bare soil and subsequent migration to groundwater.

Storage of hazardous substances used during site operation may also lead to spillages/releases to ground if not adequately managed.

Taking into account previous considerations regarding the sensitivity of groundwater beneath the site (refer Impact Ref: TE4) and the results of spill modelling for Scenario 1 (refer Section 7.3.5.2), this impact is considered to be of medium significance.

*Impact TE8 – Medium Significance*

7.4.4.4 DEGRADATION OF SOIL AND GROUNDWATER QUALITY DUE TO LEAKAGE FROM PLANT INFRASTRUCTURE

Taking into account previous considerations regarding the sensitivity of groundwater beneath the site (refer Impact Ref: TE4) and the results of spill modelling for Scenario 3 (refer Section 7.3.5.4), this impact is considered to be of high significance.

*Impact TE9 – High Significance*

7.4.4.5 DEGRADATION OF SOIL AND GROUNDWATER QUALITY DUE TO CATASTROPHIC FAILURE OF PLANT INFRASTRUCTURE

Taking into account previous considerations regarding the sensitivity of groundwater beneath the site (refer Impact Ref: TE4) and the results of spill modelling for Scenario 2 (refer Section 7.3.5.3), this impact could be considered highly significant. The likelihood of a catastrophic failure in site infrastructure is, however, considered to be very unlikely. Given the above, this impact is therefore considered to be of medium significance.

*Impact TE10 – Medium Significance*
7.4.5 DECOMMISSIONING

7.4.5.1 INTRODUCTION

Decommissioning and demolition of the facility and its infrastructure has potential to impact upon the terrestrial environment at the site from activities such as: drain-down and demolition of tanks and pipelines, demolition of structures, excavation and backfilling of sub-surface infrastructure, vehicle movements and refuelling.

Specific potential impacts on the terrestrial environment due to the above activities are summarised in Table 7-8 and discussed in the following text.

Table 7-8: Decommissioning Phase Impacts Assessment

<table>
<thead>
<tr>
<th>Factor</th>
<th>TE11</th>
<th>TE12</th>
<th>TE13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Frequency</td>
<td>Continuous</td>
<td>Infrequent</td>
<td>Infrequent</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Certain</td>
<td>Likely</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Duration</td>
<td>Long</td>
<td>Long</td>
<td>Long</td>
</tr>
<tr>
<td>Magnitude</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Effect</td>
<td>Positive</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Indirect</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
</tr>
</tbody>
</table>

7.4.5.2 RE-RELEASE OF SOIL RESOURCE

The presence of built infrastructure associated with the facility will have sterilized the utility of the soil present within the proposed site boundary. Following removal of the built infrastructure these soils will be available again. This represents a positive impact. However, due to their low quality, and their compaction following presence of the facility infrastructure, the soils are not expected to have agricultural value and the significance of this impact is considered to be low.  

Impact TE11 – Low Significance

7.4.5.3 ACCIDENTAL SPILLS DURING TANK AND PIPE DRAIN-DOWN AND DECOMMISSIONING

The decommissioning of the site requires the drain-down and removal of potentially hazardous substances. The likelihood of accidental releases of hazardous substances during these activities is considered higher than during other decommissioning and demolition activities and therefore the significance of this impact is considered to be high.

Impact TE12 – High Significance

7.4.5.4 DEGRADATION OF SOIL AND GROUNDWATER QUALITY DUE TO ACCIDENTAL SPILLS

Similar to the construction period, plant and vehicles will require refuelling and maintenance during the decommissioning and demolition period. As a result there is potential for accidental release or spills of contaminative substances, such as diesel fuel, lubricating oils and degreasing solvents, from their storage and use onto bare soil and subsequent migration to groundwater.

Due to the low significance of the local geology and poor agricultural value of the site area, the soils are not considered to represent an important resource and therefore the significance of this impact could be considered as low. Groundwater beneath the site, however, is likely to be in hydraulic continuity with the marine environment at the Gulf Coast and may act as a pathway to sensitive ecological receptors and is therefore considered to represent a sensitive receptor.
The results of spill modelling (Scenario 1) suggest that the magnitude of minor accidental releases/spillages is likely to be low.

Taking the above considerations into account, this impact is considered to be of medium significance.

**Impact TE13 – Medium Significance**

7.4.5.5 NON HAZARDOUS AND HAZARDOUS WASTE MANAGEMENT ON-SITE AND OFF-SITE

The drain-down and demolition activities are expected to generate significant quantities of non-hazardous and hazardous wastes that could lead to spillages/releases to ground if not adequately managed. An assessment of waste management is presented in Section 10.
7.5 MITIGATION

7.5.1 OVERVIEW

Implementation of mitigation measures will be required during construction, commissioning, operation and decommissioning of the facility to minimise potential negative impacts of the activities on the terrestrial environment, including the groundwater, associated with the site. The mitigation measures comprise a combination of physical design features of the facility, management procedures and monitoring arrangements and are described in the subsequent sections. The following text assesses the impacts predicted as being of medium to high significance against appropriate mitigation measures to predict the residual impact significance.

7.5.2 PRE-CONSTRUCTION

As noted in Section 7.2.3.3, the chemical quality of soils beneath the site has not been established as part of this study. Characterisation of the site’s soil chemical quality will be necessary prior to commencement of the development.

7.5.3 CONSTRUCTION

7.5.3.1 TERRESTRIAL ENVIRONMENT IMPACTS AND MITIGATION – CONSTRUCTION PHASE

<table>
<thead>
<tr>
<th>ID Code</th>
<th>Impact</th>
<th>Potential Significance</th>
<th>Mitigation Measure</th>
<th>Significance after Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>TE3</td>
<td>Dewatering of excavations and discharge of water to sea</td>
<td>High</td>
<td>• Analysis and pre-treatment of water prior to discharge to sea if required to achieve discharge standards</td>
<td>Low</td>
</tr>
<tr>
<td>TE4</td>
<td>Degradation of soil and groundwater quality due to accidental spills</td>
<td>Medium</td>
<td>• The contractor shall construct designated refuelling and vehicle maintenance areas. These will comprise bunded and sealed areas and all scheduled refuelling and maintenance of construction and transportation vehicles will be undertaken within these designated area(s). • Hazardous material storage tanks, including for fuels, shall be located within bunded and hard surfaced areas with adequate capacity for the volume of hazardous materials stored within. • An adequate quantity of absorbents and dedicated secondary containments (drip trays) will be available to contain and recover potential releases of hazardous substances.</td>
<td>Low</td>
</tr>
</tbody>
</table>
• Washing-out of concrete delivery, mixing and pouring plant and equipment shall be undertaken in a designated area and all wash water shall be contained for subsequent treatment and re-use and / or discharge.

• The EPC Contractor shall develop, implement and maintain a construction phase Environmental Emergency Response Plan (EERP) and a Construction Environmental Management Plan (CEMP) that will include a spill response/ control plan (see below).

• Prior to construction of the facility, the EPC Contractor shall conduct an investigation of the soil and groundwater (using existing well data where available) quality at the site shall be completed to complement the current understanding of the local conditions and to enable the evaluation of the potential impact of the presence and operation of the facility on the terrestrial environment over the lifetime of the Project. This shall include the construction of permanent groundwater monitoring wells where required. The Project Proponent shall prepare and submit a Permit Application for authorisation to construct groundwater monitoring wells (PA-W9) in accordance with RCER-2010 Volume II.

7.5.3.2 RECOMMENDATIONS – CONSTRUCTION PHASE

As required for Impact TE4, the EPC Contractor shall develop, implement and maintain a construction phase Emergency Response Plan (ERP) and a Construction Environmental Management Plan (CEMP) as supporting documents to the Environmental Management and Monitoring Plan (Appendix A of this ESIA). These plans should detail responsibilities and procedures for environmental and emergency response management during construction, and consider the following:

- Minimum technical standard of construction plant;
- Competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency (including accidental releases of hazardous substances);
- Procedures to be implemented following an accidental release of hazardous substances, e.g. during refuelling, including details of measures to be adopted to stop, contain as far as practicable on site, and clean up spills, and to inform the relevant authorities in the event that a spill migrates (or occurs) off-site so that appropriate regional plans can be activated; and
7.5.4 COMMISSIONING

7.5.4.1 TERRESTRIAL ENVIRONMENT IMPACTS AND MITIGATION – COMMISSIONING PHASE

<table>
<thead>
<tr>
<th>ID Code</th>
<th>Impact</th>
<th>Potential Significance</th>
<th>Mitigation Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>TE6</td>
<td>Accidental leaks during pipe connections</td>
<td>High</td>
<td>• The EPC Contractor shall undertake HAZOP studies to identify process hazards for the facility, including during its commissioning, and further control measures will be developed and implemented as required following the identification of specific hazards (see below).</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• The EPC Contractor shall update, implement and maintain the EERP and CEMP developed during the construction phase so they appropriately reflect the changes in the project and ensure their ongoing effectiveness (see below). The EERP will include an updated spill response/ control plan.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• An adequate quantity of absorbents will be available to contain and recover potential releases of hazardous substances.</td>
</tr>
</tbody>
</table>

7.5.4.2 RECOMMENDATIONS – COMMISSIONING PHASE

As required for Impact TE6, the EPC Contractor will undertake HAZOP studies for the facility in consultation with Ma’aden. These shall comprise identification and assessment of potential risks, including from accidental release of hazardous substances, during different stages of the project. This shall include the plant commissioning phase. Mitigation measures and procedures shall be developed for any aspects of the commissioning identified through these studies to pose particular environmental risks.

The main objectives of the HAZOP should include:

- To identify all process hazards associated with design, operation and maintenance of all process facilities;
- To identify appropriate hazard management measures (safeguards) required to eliminate hazards, reduce risks and protect against the identified hazards;

Availability of pumps and spill mitigation materials such as absorbent granules to contain and recover hazardous substances releases. Regular audits of the above management plans should be undertaken by the contractor to confirm their ongoing effectiveness.
• To raise actions and assign responsibility for assessment/evaluation of any potential additional safeguards; and
• To achieve a common understanding of the all requirements towards achieving a safe design.

As required for Impact TE6, the EERP developed during the construction phase shall be updated and implemented during the commissioning phase. The revised document should consider the following:

• Competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency (including accidental releases of hazardous substances);
• Procedures to be implemented following an accidental release of hazardous substances, including details of containment and recovery measures to be applied; and
• Availability of pumps and spill mitigation materials such as absorbent granules to contain and recover hazardous substances releases.

7.5.5 OPERATIONS
7.5.5.1 TERRESTRIAL ENVIRONMENT IMPACTS AND MITIGATION – OPERATIONS PHASE

<table>
<thead>
<tr>
<th>ID Code</th>
<th>Impact</th>
<th>Potential Significance</th>
<th>Mitigation Measure</th>
<th>Significance after Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>TE8</td>
<td>Degradation of soil and groundwater quality due to leakage from accidental spills</td>
<td>Medium</td>
<td>• Hazardous material storage facilities and tanks, including for fuels, shall be located within bunded and sealed areas with adequate capacity for the volume of hazardous materials stored within.</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• An adequate quantity of absorbents and dedicated drip trays will be available to contain and recover potential releases of hazardous substances.</td>
<td>Low</td>
</tr>
<tr>
<td>TE9</td>
<td>Degradation of soil and groundwater quality due to leakage from plant infrastructure</td>
<td>High</td>
<td>• HAZOP studies shall be undertaken to identify process hazards for operation of the facility and further control measures will be developed and implemented as required following the identification of specific hazards (see below).</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Revise, implement and audit a Project Environmental Management and Monitoring Plan (EMMP) and an Environmental Emergency Response Plan (EERP), including details of a spill response/ control plan (see below).</td>
<td>Low</td>
</tr>
<tr>
<td>TE10</td>
<td>Degradation of soil and groundwater quality due to catastrophic failure of plant infrastructure</td>
<td>Medium</td>
<td></td>
<td>Low</td>
</tr>
</tbody>
</table>
7.5.5.2 RECOMMENDATIONS – OPERATIONS PHASE

As noted in Section 7.5.3 above, HAZOP studies shall be completed for the facility. These will aim to identify significant risks associated with the plant, including risks to the environment, and to subsequently amend the design where possible to reduce the risks to as low as reasonable practicable.

In addition to the above, Ma'aden shall develop, implement, audit and maintain a Project Environmental Management and Monitoring Plan (EMMP) and an Environmental Emergency Response Plan (EERP) (refer to Appendix A EMMP and Appendix B EERP Outline respectively). These plans will detail responsibilities and procedures for environmental and emergency response management during operation of the facility. This shall include:

- Routine plant inspection and maintenance schedules and procedures;
- Plant start-up and shut-down procedures;
- Competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency (including accidental releases of hazardous substances);
- Procedures to be implemented following an accidental release of hazardous substances, including details of containment and recovery measures to be applied; and
- Availability of pumps and spill mitigation materials such as absorbent materials to contain and recover hazardous substances releases.

7.5.6 DECOMMISSIONING

7.5.6.1 TERRESTRIAL ENVIRONMENT IMPACTS AND MITIGATION – DECOMMISSIONING PHASE

<table>
<thead>
<tr>
<th>ID Code</th>
<th>Impact</th>
<th>Potential Significance</th>
<th>Mitigation Measure</th>
<th>Significance after Mitigation</th>
</tr>
</thead>
</table>
| TE12    | Accidental spills during tank and pipe drain-down and decommissioning | High                   | • An adequate quantity of absorbents will be available to contain and recover potential releases of hazardous substances.  
• The Ma'aden (and/or their agents as appropriate) shall update, implement and maintain the EERP and EEMP implemented during the operational phase so they appropriately reflect the changes in the project and ensure their ongoing effectiveness (see below). | Low                         |
| TE13    | Degradation of soil and groundwater quality due to accidental spills   | Medium                 | • The contractor shall construct designated refuelling and vehicle maintenance areas. These will comprise bunded and sealed areas and all scheduled refuelling and maintenance of construction and transportation vehicles will be undertaken within | Low                         |
### 7.5.6.2 RECOMMENDATIONS – DECOMMISSIONING PHASE

The contractor shall update (or develop new), implement, maintain and audit the EERP and EEMP so the documents remain to be adequate and effective for the decommissioning phase. The plans shall detail the procedures to be adopted for the safe drain down and demolition of the facility’s tanks, pipelines, buildings and infrastructure. Updates should consider the following:

- Minimum technical standard of demolition plant;
- Competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency (including accidental releases of hazardous substances);
- Procedures to be implemented following an accidental release of hazardous substances, e.g. during tank drain-downs, including details of containment and recovery measures to be applied;
- Availability of pumps and spill mitigation materials such as absorbent granules to contain and recover hazardous substances releases; and
- Minimum technical standard of demolition plant.

Following decommissioning and demolition of the facility, a survey of the soil and groundwater quality at the site should be completed to confirm that the presence and operation of the facility has not led to an unacceptable deterioration of the site’s terrestrial environment. Should soil or groundwater contamination be identified that could have been caused by the facility, a specific remedial plan will be developed to define the extent of contamination and remedial measures to be implemented.
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<td>8.4.3</td>
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8.0 BIOLOGICAL RESOURCES

8.1 INTRODUCTION

The purpose of this Section is to describe the terrestrial and marine ecology baseline relevant to the Project site at the Ras Al Khair Industrial City and to assess the significance of any potential impacts of the Project on the surrounding biological resources.

Woods Hole Group Middle East (WHGME) was commissioned by Jacobs to document baseline conditions and to conduct an impact assessment of biological resources in Ras Al Khair as part of the overall ESIA. The assessment considers the findings of baseline field surveys undertaken in 2003-2004 at Ras Al Khair by GHD (2005) to record habitats and key floral and faunal groups. In addition, a site visit took place in September 2012 to obtain information on the presence of or potential for biological resources within and adjacent to the Project site which has been developed since the GHD surveys in 2005. Using the findings of the previous baseline studies and the 2012 site visit, the biological resources were identified for consideration in the impact assessment process.

8.2 BASELINE CONDITIONS

This section presents an overview of the baseline ecological study conducted for the Project, which included a literature review and a site-specific walk-over survey conducted within the Project site and surrounding vicinity.

The Ras Al Khair Mineral Industrial City has been designed to accommodate a number of industrial production plants such as those for aluminum, phosphate and other supporting industries. As the proposed Project site is adjacent to these facilities, this assessment draws on descriptions of the baseline biological resources reported for these projects including:


In addition, available literature was also reviewed in order to gather information about the typical national, regional and local flora and fauna within the KSA.

To augment the review of existing baseline surveys and the literature review, WHGME conducted a field walk-over survey of the proposed Project area on the week of 8th to 12th September 2012. The survey methodology included the following:

- A walk along the perimeter of the proposed Project site to identify the presence of any flora and/or fauna within and adjacent to the site; and
- Photographic documentation of Project site conditions.

8.2.1 GEOMORPHOLOGY

The coastal plain is largely low lying and comprises flat sand-sheets of deposited aeolian sand with a number of limestone outcrops, and widely rolling inactive dune systems (GHD, 2008). Longitudinal sand dunes of up to 10m height and 100m length are present, oriented in the predominant north-westerly wind direction. Sabkhas, which are planar supratidal salt flats formed in unconsolidated sandy or finer sediments in combination with shallow groundwater levels along arid coastlines, are also present within the region. Sabkhas contain a hard crust approximately 0.5m below the surface, formed by the evaporation of groundwater and the deposition of calcium carbonate, gypsum, anhydrite, sodium chloride, and other salts in the upper sub-surface. This crust inhibits plant growth and impedes drainage of surface water, leading to flooding of the sabkhas after periods of rain. On the southern side of the peninsula, mud flats give way to coastal sabkha which extend considerable distances inland, corresponding with low lying inlets (WHGME, 2010).

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1 A full list of the information sources used during this assessment are indicated in Section 20 References.
8.2.2 PROTECTED AREAS

The Ras Al Khair peninsula (labelled as Ras as-Zaur in Figure 8-1) is located adjacent to the marine boundaries of the Jubail Marine Wildlife Sanctuary (the Sanctuary) which was established in 1992. The Sanctuary covers an area of more than 2,000 km² and includes the two shallow bays of Dawhat ad Dafi and Dawhat al Musallamiya, the stretch of coastline between Abu Ali and Ras Al Khair (formerly Ras az Zawr) and the five coral islands of Harqus, Karan, Kurain, Jana and Juraid (Jones et al., 1996). The Sanctuary was designated as such in response to remediation measures required following the Gulf War oil spill in 1991. Figure 8-1 illustrates the location of the Sanctuary south of Ras Al Khair.

Figure 8-1: Jubail Marine Wildlife Sanctuary south of Ras Al Khair (Jones, et al. 1993, sourced from http://www.jubail-wildlife-sanctuary.info/index.html)
The biological environment at the Ras Al Khair Peninsula is typical of a coastal environment on the eastern coast of the Arabian Gulf. Terrestrial ecosystems have been modified by human activity, grazing and introduced flora and fauna species. These activities and land use types have modified both the value of both vegetation and associated habitats (GHD, 2008).

### 8.2.3 TERRESTRIAL FLORA

*Zygophyllum qatarense*, a small shallow rooted shrub, is the dominant species of many sand-sheet flora communities. Sand-sheets are generally shallow and overlying saline ground such as sabkha fringes or coastal areas. Where the sand-sheet is deeper, *Z. qatarense* is accompanied by *Cyperus conglomeratus*. Closer to the sea, *Halopeplis perfoliata*, *Suaeda* *vermiculata*, *Limonium axillare* and some annuals are often present.

Grasses such as *Aelorupus lagopoides* and *Sporobolus ioclades* are also present across the peninsula, and on deeper sand, *Cyperus conglomeratus* and *Panicum turgidum*. *Phoenix dactylifera* is found where shallow groundwater is available on sabkha fringes and in relatively shallow sands, and is often accompanied by large hummocks of *Calligonum comosum*. In relatively undisturbed areas there are many annuals found in spring, notably *Plantago boissieri*, *Schismus barbatus* and *Cutandia memphitica*. Much of the vegetation on the Ras Al Khair Peninsula fits the above descriptions (Barth, 1998).

The main flora communities in the Ras Al Khair Peninsula are associated with fore-dunes, sabkhas (hypersaline, Intermediate, coastal) and calcareous dunes (mid-slope, ridgeline). None of these communities contain threatened or endangered plant species as listed in the IUCN Red List, 2012.

Biological soil crusts play many important roles in arid regions and coastal sabkha is often coated in a stromatolitic algal mat with a gleyed reducing layer below. These mats are a mixture of cyanophytes, diatoms and bacteria which, as they dry, become a characteristically cracked and peeling layer, potentially extending over many square kilometres (Scott, 1995). Cyanobacteria are halotolerant (salt tolerant) and some species are able to grow in salt-saturated solutions, such as those found in sabkha environs.

Field assessment and vegetation mapping of the Ras Al Khair Peninsula was undertaken in September 2003 and May 2004 (GHD, 2008). Vegetation communities were defined based on topographic, soil and vegetation types using aerial photographs, soil mapping and ground-truthing. Three broad categories of vegetation were identified: coastal dunes (foresetunes); sabkha; and sand-sheets (calcareous dunes).

Of these categories, the following six communities were defined across the peninsula (refer to Figure 8-2). Those identified in italics are specifically relevant to the Project site:

- *Foredunes*;
- *Sabkha (hypersaline)*;
- *Sabkha (intermediate)*;
- *Sabkha (coastal)*;
- *Calcareous dunes (mid-slope)*; and
- *Calcareous dunes (ridgeline)*.

A seventh (artificial) community was also identified relating to the now abandoned research facility. Five central pivot irrigation areas are located on the eastern boundary of the former research facility. They were predominantly clear of vegetation as a result of the agricultural activities.
Figure 8-2: Ras Al Khair Peninsula Vegetation recorded as of 2004 (GHD, 2005).

Location of abandoned Research Farm (pivot irrigation areas and buildings)
Foredunes

Coastal foredunes on the northern beaches of Ras Al Khair Peninsula, particularly to the east of the site, are strongly defined, reaching heights of 2 - 5 m. This may be as a result of the north-facing beach, which is unusual on the eastern coastline. Coastal dune vegetation is primarily restricted to the foredunes running parallel to the beach, with a variable width of up to approximately 250 m. The dominant species observed in this community type were *Lasiurus scindicus* and *Z. qatarense*, with other species including *C. conglomeratus, P. boissieri, Lycium shawii* and a number of annuals such as *Picris cyanocarpa*. The dune heights are recorded as diminishing on the north eastern side of the proposed Aluminium Project site; to the extent they are barely distinguishable.

Sabkha (Hypersaline)

The hypersaline sabkha generally form the ‘core’ of the sabkha area. Predominantly void of vegetation, this community is characterised by featureless flat terrain and surface crusting. In drier months, the sabkha margins are used by vehicles throughout the area as they readily compact into smooth and much faster thoroughfares than the sand sheets.

Calcareous dunes (midslope)

By far spatially dominant, the sandsheet communities demonstrate topographical variations in species composition, which warrant differentiation to midslope, and ridgeline communities. Species composition within the midslope community is variable, but dominated by *L. scindicus, P. turgidum* and *L. shawii*. A number of other grass species were noted, but are dominated by the above species. *L. shawii* is often observed occurring in large clusters. In addition to the dominants, a number of annual and perennial species were identified including *C. conglomeratus, P. boissieri, P. cyanocarpa, Rhanterium epapposum, Gypsophila antari* and *Haplophyllum tuberculatum*. Of these, *P. boissieri* was spatially and numerically dominant in many parts.

Continuous, high grazing pressure by sheep, goats and camels recorded by the previous studies is reported to have had a significant impact on the condition of vegetation communities (GHD, 2005). Whilst all communities were contiguous (other than fragmentation naturally occurring as a result of topographical features such as sabkha), it was considered likely that community composition, species diversity, abundance and susceptibility to climatic stresses have been affected by this pressure (WHGME, 2010).

A recent site visit of the proposed Project area in September 2012 by WHGME showed the absence of any substantial vegetation communities at the Project site (refer to Section 8.2.5). The Project site has been developed since the completion of the historical surveys, and there has been much physical disturbance of the site.

8.2.3.2 TERRESTRIAL FAUNA

Regional Context

Fauna Habitats

Sand Dune and Beaches

Studies by the KFUMP/RT CEW (2001b) describe the prominent macrofauna associated with sand beaches along the Saudi Arabian coastline between Ras Al Mishab (north of Ras Al Khair) to the Gulf of Salwah (which separates the Qatar peninsula from Saudi). This fauna includes sand hoppers, ghost crabs (*Ocypode saratan*), mole crabs (*Hippa sp.*), mud crabs (*Macrophthalmus depressus*), and transient sea birds such as terns (*Stern bengalensis, Hydroprogne caspica*), cormorants (*Phalacrocorax carbo* and *Phalacrocorax nigrogularis*), sea gulls (*Larus argentatus, L. genei, L. ridibundus. and L. ichthyaeetus*) and plovers (*Charadrius biaticula, C. alexandrinus, C. leschenaultia*, and *Pluvialis squatarola*). The most abundant benthic fauna associated with the sand beaches includes polychaetes, nematodes, oligochaetes and molluscs (KFUMP/RT CEW 1996).
Coastal sabkhas support micro-organisms and invertebrates, which provide food for both migratory birds and resident species. Typical species to be found include the black-winged stilt (*Himantopus himantopus*), dunlin (*Calidris alpina*), little stint (*Calidris minuta*), broad-billed sandpiper (*Limicola falcinellus*) and flamingo (*Phoenicopterus ruber*). Within the sabkha waters the crustaceans dominate especially copepods (mostly *Harpacticoida*) whilst ostracods (i.e. seed shrimps) and anostracans (i.e. fairy shrimps) may be intermittently abundant (Hogarth & Tigar, 2002). Semi-aquatic and aquatic insects including members of *Diptera* (i.e. flies and midges), *Odonata* (dragonflies and damselflies), *Hemiptera* (i.e. true bugs) and *Coleoptera* (i.e. beetles) occur in pools where salinity is within tolerable levels (Hogarth & Tigar, 2002).

**Intertidal Habitat**

Intertidal habitats such as rocky, muddy and sandy shores, salt marsh and mangroves also support a large number of invertebrate species such as snails, crabs, polychaete worms, barnacles, sea slugs, sponges and sea squirts. Some of these provide food for several species of waders and shorebirds.

**Fauna Survey**

Baseline fauna studies of the Ras Al Khair Peninsula were undertaken by GHD in September 2003 and May 2004 prior to the construction of both the existing Ma’aden Phosphate and Aluminium Facilities. These studies included static observation (birds), fauna and pitfall trapping (refer to Figure 8-2 for locations), checking for tracks and scats and opportunistic observations over four days in September 2003 and seven days in May 2004. The following sections outline the findings of the literature review and site studies.

Several diverse habitats for wildlife exist in the Ras Al Khair Peninsula, with the southern side forming part of the Jubail Marine Wildlife Sanctuary as part of its terrestrial component. The terrestrial desert habitat supports several reptiles such as the horned Viper (*Cerastes cerastes*), blue-throated agamid (*Acanthodactylus opheodurus*), and the Isabelline shrike (*Lanius isabellinus*). The crested lark and hoopoe lark are residents, while the desert wheatear and warbler can only be seen in winter. The Isabelline shrike is usually only seen on passage (March-May and September-November).

The Red Fox (*Vulpes vulpes arabica*) and the Asiatic Jackal (*Canis aureus*) prey upon mice (*Mus musculus*), gerbils (*Gerbillus spp.*) and Jerboa (*Jaculus spp.*). The Cape hare (*Lepus capensis*) is rarely seen now as a result of hunting, whilst goitered gazelle (*Gazella subgutturosa*) are locally extinct (Jones et al. undated). The Gulf is also a major migratory pathway for numerous bird species, mainly in winter, and in many cases breed regionally.

Invertebrate fauna of the region are relatively poorly studied. A review of arthropod records from the Arabian sabkha (Hogarth & Tigar, 2002) revealed that there are very few resident and some vagrant terrestrial invertebrates, whilst aquatic colonisers (of coastal sabkha) can be relatively abundant. *Hemiptera & Homoptera* (true bugs), *Lepidoptera* (butterflies and moths) and *Coleoptera* (beetles) are all confined to sabkha margins, and *Lepidoptera, Hymenoptera* (social insects including bees, ants and wasps) and *Diptera* (true flies) occur whilst plants are flowering (Hogarth & Tigar, 2002). Granivorous ants and detritivorous beetles may also be found.

During field surveys (GHD, 2005), 32 bird species, four mammal species and six reptile species were identified.

Table 8-1 summarises the mammal, insect and reptile observations and trappings (refer to Figure 8-2 for locations) recorded prior to development of the Project site area. Other species observed include:

- *Scyliorhinus sp* (Cat shark);
• *Ocypode saratum* (Ghost crab);
• Ray washed up on the beach near the Industrial Facility; and
• *Chelonia mydas* (Green turtle).

Images of some of the fauna captured / observed are provided in Figure 8-3 and Figure 8-4.

### Table 8-1: Mammal and Reptile Species Recorded at Ras Al Khair in 2003 and 2004 (sourced from GHD 2005 and WHGME, 2010)

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Survey Method and Location</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Gerbillus cheesmani</em></td>
<td>Cheesman's gerbil</td>
<td>(ET) Sandsheet</td>
<td>May 2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ET) Industrial Facility (8)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ET) Foredune (3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ET) Smelter West (2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ET) Bauxite Residue (1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(PT) Sand Sheet (1) juvenile</td>
<td></td>
</tr>
<tr>
<td><em>Hemiechinus auritus</em></td>
<td>Long-eared hedgehog</td>
<td>(ET) Sand sheet (2 - same individual twice)</td>
<td>May 2004</td>
</tr>
<tr>
<td><em>Vulpes vulpes arabica</em></td>
<td>Red fox</td>
<td>(DS) (1) Road kill on access road and numerous lairs</td>
<td>May 2004</td>
</tr>
<tr>
<td><em>Canis sp.</em></td>
<td>Domestic dog</td>
<td>(SS) track marks of large dog on beach. Also canine skull. Most likely large domestic dog</td>
<td>May 2004</td>
</tr>
<tr>
<td><em>Coleoptera</em></td>
<td>Beetles</td>
<td>(PF) Foredune site (2)</td>
<td>May 2004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(PF) Sand Sheet site (124)</td>
<td></td>
</tr>
<tr>
<td><em>Leiurus quinquestriatas</em></td>
<td>Yellow scorpion</td>
<td>(PF) Inland (7)</td>
<td>May 2004</td>
</tr>
<tr>
<td><em>Galeodes arabs</em></td>
<td>Camel spider</td>
<td>(PF) Inland (4)</td>
<td>May 2004</td>
</tr>
<tr>
<td><em>Cerates cerates gasperetti</em></td>
<td>Sidewinder snake</td>
<td>(DS) Throughout</td>
<td>Sept 2003</td>
</tr>
<tr>
<td><em>Hemidactylus tanganicus</em></td>
<td>Gecko</td>
<td>(PF) Foredune (1)</td>
<td>May 2004</td>
</tr>
<tr>
<td><em>Stenodactylus sp.</em></td>
<td>Gecko</td>
<td>(PF) Foredune (1)</td>
<td>May 2004</td>
</tr>
<tr>
<td><em>Varanus griseus</em></td>
<td>Desert monitor</td>
<td>(DS) Sand Sheet (3)</td>
<td>Sept 2003</td>
</tr>
<tr>
<td><em>Eryx jayakari</em></td>
<td>Jayakars sand boa</td>
<td>(PF) Foredune but tracks found throughout study area</td>
<td>May 2004</td>
</tr>
<tr>
<td><em>Uromastix microlepis</em></td>
<td>Egyptian spiny tailed lizard</td>
<td>(DS) Throughout facility site (6)</td>
<td>May 2004</td>
</tr>
</tbody>
</table>
Figure 8-3: Fauna captured / observed (GHD, 2005)
The shorelines of the Saudi Gulf coastline offer birds an area with a rich food source including small crabs, isopods, molluscs, worms and other invertebrates. Approximately 25 species of seabirds that visit the Saudi coastline rely on the shoreline as a source of food and as a resting area. Only a limited number of birds use the coastal shoreline for nesting, examples being the white-cheeked tern (*Sterna repressa*), Saunders’ little tern (*Sterna saundersi*), Kentish plover (*Charadrius alexandrinus*), and the western reef heron (*Egretta gularis*). The latter breeding on the mangrove covered islets north of Abu Ali and the low cliffs of Jinnah Island (KFUMP/RT CEW, 2001).

*Figure 8-4: Fauna captured / observed (GHD, 2005)*

The shorelines of the Saudi Gulf coastline offer birds an area with a rich food source including small crabs, isopods, molluscs, worms and other invertebrates. Approximately 25 species of seabirds that visit the Saudi coastline rely on the shoreline as a source of food and as a resting area. Only a limited number of birds use the coastal shoreline for nesting, examples being the white-cheeked tern (*Sterna repressa*), Saunders’ little tern (*Sterna saundersi*), Kentish plover (*Charadrius alexandrinus*), and the western reef heron (*Egretta gularis*). The latter breeding on the mangrove covered islets north of Abu Ali and the low cliffs of Jinnah Island (KFUMP/RT CEW, 2001).
Use of the Saudi coastal shoreline is not just limited to seabirds. Inland birds such as the crested lark, hoopoe lark, black-crowned finch lark (*Eremopterix nigerceps*), and bar-tailed desert lark (*Ammomanes cinctura*) are known to frequent the shoreline during the hot summer months. During the winter months, the northern peregrine (*Falco peregrinus*), greater spotted eagle (*Aquila clanga*), and marsh Harrier (*Circus aeruginosus*) feed on overwintering seabirds (KFUMP/RT CEW, 2001).

Bird observations recorded by GHD (2005) are listed in Table 8-2.

**Table 8-2: Bird Species Recorded at Ras Al Khair in 2003 and 2004 (sourced from GHD 2005 and WHGME, 2010)**

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Location</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upupa epops</td>
<td>Hoopoe</td>
<td>DS central facility (tower)</td>
<td>Sept 2003</td>
</tr>
<tr>
<td>Streptopelis decaocto</td>
<td>Collared dove</td>
<td>DS University facility</td>
<td>Sept 2003</td>
</tr>
<tr>
<td>Ualaemon alaudipes</td>
<td>Hoopoe lark</td>
<td>DS edge of sabkha, resident, breeding</td>
<td>May 2004</td>
</tr>
<tr>
<td>Eremopterix nigerceps</td>
<td>Black crowned finch lark</td>
<td>DS breed in summer edge of sabkha and hard dunes</td>
<td>May 2004</td>
</tr>
<tr>
<td>Galerida cristata</td>
<td>Crested lark</td>
<td>DS on beach. Desert species in vegetated areas. Resident. breeding</td>
<td>May 2004</td>
</tr>
<tr>
<td>Callandrella rufescens</td>
<td>Lesser short-toed lark</td>
<td>DS winter visitor (some resident) although some in summer. breeding</td>
<td>May 2004</td>
</tr>
<tr>
<td>Bubo bubo</td>
<td>Eagle owl</td>
<td>SS burrow in spoil pile east of site</td>
<td>May 2004</td>
</tr>
<tr>
<td>Glareola pratincola</td>
<td>Pratincole</td>
<td>DS on edge of sabkha (collared or black winged) migrant or resident. breeding</td>
<td>May 2004</td>
</tr>
<tr>
<td>Lanius minor</td>
<td>Lesser grey shrike</td>
<td>DS near beach (1 Sept11 May)</td>
<td>May 2004</td>
</tr>
<tr>
<td>Lanius collurio</td>
<td>Red-backed shrike</td>
<td>DS near beach (20)</td>
<td>May 2004</td>
</tr>
<tr>
<td>Lanius isabelleinus</td>
<td>Isabelline shrike</td>
<td>DS near beach (1)</td>
<td>May 2004</td>
</tr>
<tr>
<td>Sylvia communis</td>
<td>Whitethroat</td>
<td>DS near beach (2)</td>
<td>May 2004</td>
</tr>
<tr>
<td>Phylloscopus trochilus</td>
<td>Willow warblers</td>
<td>DS (20)</td>
<td>May 2004</td>
</tr>
<tr>
<td>Muscicapra striata</td>
<td>Spotted flycatcher</td>
<td>DS (25) 20 on beach</td>
<td>May 2004</td>
</tr>
<tr>
<td>Motacilla flava</td>
<td>Yellow wagtail</td>
<td>DS (1)</td>
<td>May 2004</td>
</tr>
<tr>
<td>Streptopelia turtur</td>
<td>Turtle dove</td>
<td>DS (1)</td>
<td>May 2004</td>
</tr>
<tr>
<td>Apus apus</td>
<td>Common swift</td>
<td>DS (1) aerial</td>
<td>May 2004</td>
</tr>
<tr>
<td>Merops apiaster</td>
<td>European bee eater</td>
<td>DS (3) aerial</td>
<td>May 2004</td>
</tr>
<tr>
<td>Passer domesticus</td>
<td>Swallows</td>
<td>DS (7) aerial</td>
<td>May 2004</td>
</tr>
<tr>
<td>Psittacula krameri</td>
<td>Ring-necked parakeet</td>
<td>DS (1) aerial</td>
<td>May 2004</td>
</tr>
<tr>
<td>Chlidonias leucopterus</td>
<td>White-winged black tern</td>
<td>DS (1) aerial northeral beaches</td>
<td>May 2004</td>
</tr>
<tr>
<td>Caprimulgus europaeus</td>
<td>Nightjar</td>
<td>DS (1) aerial</td>
<td>May 2004</td>
</tr>
<tr>
<td>Charadrius alexandrius</td>
<td>Kentish plover</td>
<td>DS (24) Inlet. northern beaches and beaches west of the facility site</td>
<td>May 2004</td>
</tr>
<tr>
<td>Himantopus himantopus</td>
<td>Black-winged stilt</td>
<td>DS (1) Northern beaches</td>
<td>May 2004</td>
</tr>
<tr>
<td>Scientific Name</td>
<td>Common Name</td>
<td>Location</td>
<td>Date</td>
</tr>
<tr>
<td>------------------------</td>
<td>--------------------</td>
<td>-------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Areanaria interpres</td>
<td>Turnstone</td>
<td>DS (8) northern beaches</td>
<td>May 2004</td>
</tr>
<tr>
<td>Calidris alba</td>
<td>Sanderling</td>
<td>DS (12) Northern beaches</td>
<td>May 2004</td>
</tr>
<tr>
<td>Actitis hypoleucus</td>
<td>Common sandpiper</td>
<td>DS (1) Northern beaches</td>
<td>May 2004</td>
</tr>
<tr>
<td>Calidris minuta</td>
<td>Little stint</td>
<td>DS (1) Inlet</td>
<td>May 2004</td>
</tr>
<tr>
<td>Sterna repressa</td>
<td>White cheeked tern</td>
<td>DS (4) Inlet Two pairs in breeding plumage</td>
<td>May 2004</td>
</tr>
<tr>
<td>Sterna bengalensis</td>
<td>Lesser crested tern</td>
<td>DS (1) Inlet</td>
<td>May 2004</td>
</tr>
<tr>
<td>Phalacrocorax nigrocularis</td>
<td>Socotra cormorant</td>
<td>DS several flocks breed in winter, previous colonies on islands (outside area) killed off in 1991 gulf war oil spill</td>
<td>May 2004</td>
</tr>
<tr>
<td>Cuculus canorus</td>
<td>Cuckoo</td>
<td>DS (1) Northern beaches</td>
<td>May 2004</td>
</tr>
</tbody>
</table>

A site visit of the proposed Project site conducted by WHGME in September 2012 did not indicate the presence of any noteworthy terrestrial fauna (refer to Section 8.2.5).

8.2.4 MARINE ECOLOGY

8.2.4.1 MARINE AND INTERTIDAL FLORA

This section provides a brief description of the marine ecology offshore from the proposed Project site. Mangrove forests, seagrass beds and algal flats are present throughout the Arabian Gulf, however, KFUMP/RT CEW (2001c) reports a reduction of approximately 40% of intertidal areas due to reclamation projects and that remaining intact areas are probably limited to the Gulf of Salwah south of Ras Al Khair.

A unique feature of the near-shore environments in the Saudi Arabian Gulf coast is the annual extremes of physical conditions, such as salinity and temperature, which are important factors in influencing the range and distribution of intertidal flora species along the Saudi coastline. Despite the extremes in physical conditions, primary production in the Arabian Gulf is high relative to other oceanic and coastal waters (KFUMP/RT CEW, 2001).

Field studies completed as part of the ‘Ma’den Aluminium Project – Ras az Zawr Industrial Facility’ EIA in 2004 by GHD, and later verified in 2010 by the WHGME team, provided field confirmation of the historical habitat map for Ras Al Khair Peninsula and allowed for determination of habitat condition, species composition and abundance of principal communities within the area (GHD, 2005 and 2008; WHGME, 2010). No mangroves were observed on the Ras Al Khair Peninsula during EIA field studies undertaken by WHGME in 2010 and they have not been recorded in the vicinity of the proposed site. Seagrass beds in the area have been observed in deep sandy substrata (KFUMP/RT, 1996). The dominant species of seagrass observed was *Halodule uninervis*. Seagrass beds continue south along the peninsula, with large beds associated with the muddy substrate located within the Ras Al Khair inlet to the south.

There are comparatively few eukaryotic macroalgae (i.e. seaweeds) in the Arabian Gulf compared to similar environments elsewhere in the world (John, 2002). Monthly surveys undertaken since 1996 by the Centre for Environment and Water (2001c at two near-shore reefs (Manifa and Abu Ali both located near the north coast of the Ras Al Khair peninsula) recorded the following macroalgal genera as most abundant: *Sargassum*, *Hormophysa* and *Dictyota*. Less abundant were the genera *Padina* and *Laurencia*. Other observed algae genera included *Udotea*, *Pocockiella*, and *Asparagopsis*

Macroalgal blooms occur on all near-shore reefs along the Saudi Arabian coastline from Safaniya to Tarut Bay, the predominant macroalga species being *Sargassum* spp. Results from studies undertaken by the Centre for Environment and Research (2001c) show that these blooms do not appear to have significant impacts on coral survivorship and health.
8.2.4.2 MARINE AND INTERTIDAL FAUNA

Regional Context

Fish

More than 200 species of fish have been reported from the Saudi Arabian offshore coral cays (Pilcher et al., 2000). Dominant fish species observed on the near-shore Mana reef flats, north of Ras Al Khair include: Neopomacentrus sidensis, U-spot wrasse (Halichoeres stigmaitus), bluespotted dottyback (Pseudochromis persicus), (minstrel sweetlips) Plectorhynchus schotaf, white seabream (Diplodus sargus), and black-spotted butterflyfish (Chaetodon nigropunctatus), with small schools of barracuda (Sphyraena obtusata) occurring regularly (KFUMPRI CEW, 1988b).

The main fisheries centres off Saudi Arabia are based at Jubail, Tarut Island and Qatif. Most operate from dhows using traditional equipment. Pelagic fishes caught include sardines, anchovies ([Engraulis spp.]) and horse mackerel. Demersal fishes also contribute an important proportion of the fisheries - these cover a wide variety of species, including reef fishes. The shrimp industry is fairly important in the Arabian Gulf, with the main fisheries occurring in northern areas. The Tiger Prawn (Penaeus semisculus) is fairly widespread in both muddy and sandy areas while other species are found concentrated in specified areas, such as Tarut Bay in Saudi Arabia, Shatt-al- Arab in Kuwait and Bandar Abbas in Iran. Spawning and nursery areas are known to occur along the coast (GHD, 2008).

Reptiles

Turtles

The two most common species of marine turtle in the Arabian Gulf are the green turtle (Chelonia mydas) and the hawksbill turtle (Eretmochelys imbricata). The leatherback turtle (Dermochelys coriacea), loggerhead turtle (Caretta caretta) and the olive ridley Turtle (Lepidochelys olivae) have also been infrequently sighted in the Arabian Gulf. The green turtle and hawksbill turtle have been reported to nest on the beaches of most Gulf States in the past, but most current nesting activity and sightings of adults occur in the vicinity of the offshore islands of the U.A.E, Saudi Arabia and Kuwait.

Sea Snakes

The following species of sea snake (Hydrophiidae) occur in Arabian Gulf waters:

- Beaked sea snake (Enhydrina schistose);
- Blue-Belted sea snake (Hydrophis cyanocinctus);
- Persian Gulf sea snake (H. lapemoides);
- Ornate Reef sea snake (Hydrophis ornatus);
- Yellow sea snake (Hydrophis spiralis);
- Shaw's sea snake (Lapemis curtus);
- Viperine sea snake (Thalassophina vipherina, also known as Praescutata vipherina);
- Graceful small headed sea snake (Microcephalophis gracilis also known as Hydrophis gracilis); and
- Yellow-bellied sea snake (Pelamis platurus).

Marine Mammals

Species known to occur in the Arabian Gulf include the following:

- Fin whale (Balenoptera physalus);
- Brydes whale (Balenoptera brydei);
- Toothed killer whale (Orcinus orca);
- Bottle-nose dolphin (Tursiops aduncus);
• Spotted dolphin (*Sotalia lentiginosa*); and
• Indo-Pacific humpbacked dolphin (*Sousa chinensis* and *Sousa plumbea*)
• Dugong (*Dugong dugong*)

The dugong is listed as vulnerable in the IUCN 2012 Red List of Threatened Species. No dugongs have been recorded in the waters around the Ras Al Khair peninsula (GHD, 2008).

### Marine Survey

A semi-quantitative assessment of the fish community was undertaken during the field survey of the marine water surrounding Ras Al Khair Peninsula in September 2003 and May 2004 by GHD. The field survey indicated that fish diversity was very low at the time of survey. A total of 44 species of fish were recorded out of which approximately half were associated with the algal and seagrass habitats, with the remaining half associated with reef patches. Surveys of similar size in other reef environments of the world have counted 150 – 200 species. Table 8-3 provides a list of fish species identified during the 2004 marine survey by GHD.

**Table 8-3: Fish Species Identified During Marine Survey May 2004**

<table>
<thead>
<tr>
<th>Family</th>
<th>Species Name</th>
<th>Common Name</th>
<th>Abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dasyatidae</td>
<td>Hymantura uarnak</td>
<td>Honeycomb Ray</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>Taeniura meyeni</td>
<td>Spotted Ray</td>
<td>R</td>
</tr>
<tr>
<td>Hemiphamphidae</td>
<td>Hemirhamphus limbatus</td>
<td>Halfbeak</td>
<td>C</td>
</tr>
<tr>
<td>Scorpaenidae</td>
<td>Synacneia verrucosa</td>
<td>Stonefish</td>
<td>O</td>
</tr>
<tr>
<td>Platyccephalida</td>
<td>Platyccephalus indicus</td>
<td>Flathead</td>
<td>O</td>
</tr>
<tr>
<td>Serranidae</td>
<td>Epinephelus cooides</td>
<td>Hamoour</td>
<td>C</td>
</tr>
<tr>
<td>Pseudochromidae</td>
<td>Pseudochromis persicus</td>
<td>Blueline Dotty back</td>
<td>A</td>
</tr>
<tr>
<td>Apogonidae</td>
<td>Cheilodipterus quinque lineatus</td>
<td>Five-lined Cardinalfish</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Apogon nigrpinnis</td>
<td>Bullseye Cardinalfish</td>
<td>O</td>
</tr>
<tr>
<td>Teraponidae</td>
<td>Terapon puta</td>
<td>Small-scaled Terapon</td>
<td>O</td>
</tr>
<tr>
<td>Gerreidae</td>
<td>Gerres acinaces</td>
<td>Slenderspine Mojarra</td>
<td>O</td>
</tr>
<tr>
<td>Carangidae</td>
<td>Carangoides praestus</td>
<td>Brownback Trevally</td>
<td>O</td>
</tr>
<tr>
<td></td>
<td>C. bajad</td>
<td>Orangespot Trevally</td>
<td>O</td>
</tr>
<tr>
<td>Dasyatidae</td>
<td>Hymantura uarnak</td>
<td>Honeycomb Ray</td>
<td>R</td>
</tr>
<tr>
<td>Lutjanidae</td>
<td>Lutjanus fulviflamma</td>
<td>Black-spot Snapper</td>
<td>C</td>
</tr>
<tr>
<td>Haemulidae</td>
<td>Plecorthynchus sordidus</td>
<td>Black Sweeetlip</td>
<td>A</td>
</tr>
<tr>
<td>Nemipteridae</td>
<td>Scolopsis ghanam</td>
<td>Arabian Spinecheek</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>S. taeniatus</td>
<td>Blotchted Spinecheek</td>
<td>C</td>
</tr>
<tr>
<td>Sparidae</td>
<td>Acanthopagrus bifasciatus</td>
<td>Doublebar Bream</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Diplodus sargus kotschiy</td>
<td>One-spot Bream</td>
<td>A</td>
</tr>
<tr>
<td>Rhabdosargus sarba</td>
<td>Goldlined Bream</td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Sparidentex hasta</td>
<td>Sobaiy Bream</td>
<td></td>
<td>O</td>
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<tr>
<td>Lethrinidae</td>
<td>Lethrinus nebulosus</td>
<td>Spangled Emperor</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>L. lentjan</td>
<td>Pink-ear Emperor</td>
<td>O</td>
</tr>
<tr>
<td>Mullidae</td>
<td>Upeneus tragula</td>
<td>Blackstriped Goatfish</td>
<td>C</td>
</tr>
<tr>
<td>Chaetodontidae</td>
<td>Chaetodon melapturus</td>
<td>Arabian Butterflyfish</td>
<td>R</td>
</tr>
<tr>
<td></td>
<td>C. nigropunctatus</td>
<td>Black-spotted Butterfly</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Heniochus acuminatus</td>
<td>Longfin Bannerfish</td>
<td>O</td>
</tr>
<tr>
<td>Family</td>
<td>Species Name</td>
<td>Common Name</td>
<td>Abundance</td>
</tr>
<tr>
<td>-----------------</td>
<td>------------------------</td>
<td>------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Pomacanthidae</td>
<td>Pomacanthus maculosus</td>
<td>Yellow-bar Angelfish</td>
<td>C</td>
</tr>
<tr>
<td>Pomacentridae</td>
<td>Abudelful vaigiensis</td>
<td>Indo-Pacific Sergeant</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Pomacentrus aquilus</td>
<td>Dark Damsel</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>P. trichrous</td>
<td>Tailtail Damsel</td>
<td>0</td>
</tr>
<tr>
<td>Labridae</td>
<td>Halichoeres zeylonicus</td>
<td>Goldstripe Wrasse</td>
<td>C</td>
</tr>
<tr>
<td>Scaridae</td>
<td>Scarus ghobban</td>
<td>Bluebarred Parrotfish</td>
<td>O</td>
</tr>
<tr>
<td>Sphyraenidae</td>
<td>Sphyraena putnamiae</td>
<td>Barracuda</td>
<td>O</td>
</tr>
<tr>
<td>Mugilidae</td>
<td>Lisa vaigiensis</td>
<td>Squaretail Mullet</td>
<td>C</td>
</tr>
<tr>
<td>Pinguidae</td>
<td>Parapercis nebulosa</td>
<td>Nebulous Sandperch</td>
<td>O</td>
</tr>
<tr>
<td>Blenniidae</td>
<td>Petroscirtes mitratus</td>
<td>Floral Fangtooth</td>
<td>O</td>
</tr>
<tr>
<td>Microdesmidae</td>
<td>Ptereleotris hanae</td>
<td>Filament Dartfish</td>
<td></td>
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<tr>
<td>Gobiidae</td>
<td>Cryptocentrus lutheri</td>
<td>Luthers Prawn-goby</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Amblygobius sphinx</td>
<td>Sphyx Goby</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Vallenciennea puellaris</td>
<td>Maiden Goby</td>
<td>C</td>
</tr>
<tr>
<td>Acanthuriidae</td>
<td>Acanthurus sohal</td>
<td>Sohal Surgeonfish</td>
<td>O</td>
</tr>
<tr>
<td>Siganidae</td>
<td>Siganus canaliculatus</td>
<td>Whitespotted Rabbitfish</td>
<td>C</td>
</tr>
<tr>
<td>Monacanthidae</td>
<td>Aleuterus monoceros</td>
<td>Unicorn Filefish</td>
<td>O</td>
</tr>
</tbody>
</table>

Abundant (A) - many seen on every dive; Common (C) - up to 10 seen on every dive; Occasional (O) - only 5-10 individuals seen in total; and Rare (R) - only 1-2 individuals seen in total.

Epi-Benthic Invertebrates

The Centre for Environment and Water (KFUMP/RT, 2001) undertook marine macroinvertebrate surveys on five coral reefs located along the Saudi Arabian coastline (Safaniya, Manifa, Abu Ali, Ras Tanura and Tarut Bay) between 1995 and 1999. The Manifa and Abu Ali reefs are situated closest to Ras Al Khair Industrial Complex being 30 km away and 42.5 km away respectively. It is estimated that the epi-benthic invertebrate population offshore from the MAC / MPC site would display similar diversity to that found at Manifa reef and Abu Ali reef (WHGME, 2010). The most abundant macroinvertebrate species observed on all reefs was the Echinoid (sea urchin) *Echinometra mathaei*. Other abundant species found on the Manifa and Abu Ali reefs include, black long-spine urchin (*Diadema setosum*), brown sponge (*Agelas schmidti*), a species of oyster (*Chama pacifica*), a clam (*Chlamys ruschenbergenii*), the atlantic pearl oyster (*Pinctada radiata*), sea squirt (*Phallusia nigra*) and Pagurid crabs.

8.2.5 LOCAL BIOLOGICAL RESOURCES

The WHGME project team has visited the Project site on several occasions since 2008 when the Ras al Khair Industrial Complex was still under assessment and during the early construction phase. However from the time when baseline ecological surveys were undertaken in 2003 and 2004 the Project site has been fenced and the sand-sheet habitat has been largely cleared and heavily modified through development. The Project site now supports industrial operations including a sulphuric acid plant, phosphoric acid plant, ammonia production and storage.

The undeveloped parts of the site support occasional occurrences of sparse vegetation, typically at road and rail edges where disturbance is minimal (primarily *Zygophyllum qatarense*). Overall, this area does not support any substantial vegetation (Figure 8-5).

The loss and modification of habitats within the Project area, and current levels of disturbance arising from the industrial operations, has reduced the suitability of this site for faunal species and no noteworthy species were sighted during the site visit in September 2012. Furthermore,
the construction of the aluminium and phosphate plants in the immediate vicinity of the Project site will likely have further reduced the potential for fauna to exist in the Project site. However, terrestrial fauna identified in the 2003-2004 surveys may continue to exist beyond the boundaries of the Ras Al Khair Industrial City.

Figure 8-5: Vegetation Distribution at Ras Al Khair Industrial Complex (September 2012).

The location of the proposed storage facilities and liquid and dry loading facilities at Ras Al Khair port is similarly devoid of terrestrial ecology. Field studies completed as part of the ‘Ma’aden Aluminium Project – Ras az Zawr Industrial Facility’ EIA in 2004, and later verified in 2010 by the WHGME team, provided a field confirmation of the historical habitat map for Ras Al Khair Peninsula and allowed for determination of habitat condition, species composition and abundance of principal communities within the area (GHD, 2005 and 2008; WHGME, 2010) (Figure 8-6).

No mangroves were observed on the Ras Al Khair Peninsula during EIA field studies undertaken by WHGME in 2010 and they have not been recorded in the vicinity of the proposed site. Seagrass beds in the area have been observed in deep sandy substrata (KFUMP/RT, 1996). The dominant species of seagrass observed was Halodule uninervis. Seagrass beds continue south along the peninsula, with large beds associated with the muddy substrate located within the Ras Al Khair inlet to the south.
Figure 8-6: Ras Al Khair Peninsula Marine and Intertidal Communities recorded as of 2004 (GHD, 2005)
Offshore from the Ras Al Khair Chemical Complex, three coral reefs have been identified by KFUMP/RT CEW (1996). These coral reefs are associated with deep sediments. The closest reef is located approximately 1.5 km offshore and is a long narrow reef approximately 30m by 500m in area. Several scattered corals are located inshore of this reef.

The marine survey of the coastal area of Chemical Complex carried out by GHD in May 2004, confirmed a flat rock substratum covered in layers of sand that varied in depth from one to 30 cm. A total of 56 sites were located within this area and encompassed six general habitat types including reef, inlet seagrass, proposed dredge channel, rock flats, mud substrate, and algal/seagrass beds (GHD, 2006 cited in GHD, 2008).

8.2.6 VALUATION OF BIOLOGICAL RESOURCES

To facilitate the assessment of impact significance, the value of the ecological receptors recorded within the Project area has been determined within a defined geographical context. The geographical frame of reference that has been used to assign value is presented in Table 8-4. To fully acknowledge the spatial range associated with some biological resources (e.g. migratory birds) and potential impacts outside national boundaries, a “very high” level of significance will be considered where appropriate.

Table 8-4: Criteria for Valuing Biological Resources

<table>
<thead>
<tr>
<th>Value / Importance</th>
<th>Criteria / Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>Areas of semi-natural vegetation or habitat considered to appreciably enrich the habitat resource within the context of the site and surrounding area. Sustainable populations of uncommon or declining species.</td>
</tr>
<tr>
<td>Provincial</td>
<td>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).</td>
</tr>
<tr>
<td>Regional</td>
<td>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.</td>
</tr>
<tr>
<td>National</td>
<td>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).</td>
</tr>
<tr>
<td>International</td>
<td>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 &gt;1% of a biogeographical population of a species or subspecies.</td>
</tr>
<tr>
<td>Not Valued (Negligible)</td>
<td>Species, population or habitat not meeting any of the above criteria.</td>
</tr>
</tbody>
</table>
8.2.6.1 VALUE OF TERRESTRIAL BIOLOGICAL RESOURCES

The floral species within the Project area are limited due to past development and the current occupation and utilisation of the site. *Zygophyllum qatarense* was recorded at road and rail edges where disturbance is less. This species is common in coastal areas of eastern Saudi Arabia and there are no known conservation threats to this species.

The flora resource of the Project area is valued at the **Local** level.

Terrestrial mammal species historically recorded within Ras Al Khair are listed as species of Least Concern on the IUCN Red List (2012). This indicates that no decline in population size of these species has been detected, and there are no known widespread major threats to their conservation status. Although these species were not recorded within or adjacent to the Project area in September 2012, there is potential for them to be present.

The mammal fauna of the Project area is valued at the **Local** level.

The Egyptian spiny tailed lizard is listed as globally Vulnerable on the IUCN Red List. However, this species was not identified as being present within the Project area during September 2012. As such, the reptile fauna of the Project area is valued at the **Local** Level.

An extensive list of bird species has been recorded in Ras Al Khair. Other than the Socotra cormorant, all species are listed as species of Least Concern on the IUCN Red List (2012). The Socotra cormorant however is listed as Vulnerable on account of population declines. This species has a restricted distribution and breeding colonies are restricted to off-shore islands.

The avifauna of the Project area is therefore valued at the **International** level.

The terrestrial invertebrate fauna historically recorded within Ras Al Khair through pit-fall trapping and direct observation is limited and valued at the **Local** level.

8.2.6.2 VALUE OF MARINE AND INTERTIDAL BIOLOGICAL RESOURCES

It is anticipated that the Saudi Ports Authority (SEAPA) will allocate three berths at Ras Al Khair Port to Ma’aden for the Project:

- Two dry berths for export of bulk NPK/DAP and import of Potash; and
- One berth dedicated to liquid export i.e. Ammonia, PPA and MGA.

The construction and ongoing maintenance (e.g. dredging) of these berths will be the responsibility of the SEAPA and not assessed in detail within this ESIA report. However, this ESIA report does assess the impacts of constructing facilities on the jetty for the storage and exportation / importation of materials. This includes the conveyance of dry materials to/from the Port.

8.3 IMPACT ASSESSMENT

8.3.1 IMPACT ASSESSMENT METHOD

The Project may negatively impact upon biological resources during construction, commissioning, operational and decommissioning phases as well as accidental events. The potential significance of these impacts at the site is assessed with reference to the methodology presented in Section 5 *Impact Assessment Methodology* with the sensitivity of the impacted resource / receptor also taken into account. This approach permits a systematic and rigorous approach to impact identification and characterisation and facilitates the identification of potentially significant impacts on the identified biological resources.

An ecologically significant impact is defined in the context of this assessment as ‘an impact (negative or positive) on the integrity of a defined site or ecosystem and/or the conservation status of habitats or species within a given geographical area’ (IEEM 2006) and whether there is a cultural or economic implications from the impact on the habitat or species in accordance with nationally identified High Conservation Priority species. The assessment of impact takes
into consideration the ‘value’ of each ecological receptor, and the changes that might occur to its conservation status at the defined geographical scale described in Section 7.3.

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.

Impact significance for biological resources is determined by comparing magnitude against the geographic value/importance of such resources (Section 8.2.6). Table 8-5 shows the criteria used to define the type and magnitude of impacts on biological receptors. These are based on currently accepted guidelines produced in the UK (IEEM, 2006).

Table 8-5: Magnitude and Type Definitions for Potential Impacts on Biological Resources

<table>
<thead>
<tr>
<th>Magnitude / Type</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>The change is likely to cause a permanent adverse effect on the integrity of a biological resource receptor.</td>
</tr>
<tr>
<td>Medium</td>
<td>The change adversely affects the biological resource receptor, but no permanent effect on its integrity.</td>
</tr>
<tr>
<td>Low</td>
<td>Minimal or no effect.</td>
</tr>
<tr>
<td>Medium Positive</td>
<td>The change is likely to benefit the receptor in terms of its conservation status, but not so far as to achieve favourable conservation status(^2).</td>
</tr>
<tr>
<td>High Positive</td>
<td>The change is likely to restore an ecological receptor to favourable conservation status, or to create a feature of recognisable value.</td>
</tr>
</tbody>
</table>

8.3.2 CONSTRUCTION AND COMMISSIONING

Construction of the project has potential to impact upon biological resources at the site from activities such as: levelling, earthworks, facility construction, trenching, excavation and backfilling for subsurface infrastructure, vehicle movements, and dewatering (refer to Section 4 Detailed Description and Layout of the Proposed Development for further details).

Specific potential impacts on biological resources due to the above activities are summarised in Table 8-6 and discussed in the following text. Note that the potential impact associated with the construction of berths / expansion of the port area is not assessed as part of this ESIA. However impact of using shipping vessels to deliver heavy construction materials, and for loading / unloading materials during the operational phase are included.

The Port is currently operated by the Saudi Ports Authority (SEAPA) and regulated in part by the RC which is responsible for controlling pollution associated with the development and operation of the industrial city. Any ship movements (e.g. for the transport of heavy construction material) will therefore be required to comply with RCER-2010 clause 3.10 and

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the standards outlined in Table E with regards ballast water in addition to Port Authority requirements.

Table 8-6: Construction Impacts

<table>
<thead>
<tr>
<th>Factor</th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>E4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
<td>Local</td>
<td>Local</td>
<td>Local</td>
<td>International</td>
</tr>
<tr>
<td>Frequency</td>
<td>Infrequent</td>
<td>Infrequent</td>
<td>Infrequent</td>
<td>Infrequent</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Unlikely</td>
<td>Unlikely</td>
<td>Unlikely</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
<td>Local</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Duration</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

The assessment of impacts on biological resources has accounted for the previous modification and disturbance to the Project site which currently supports industrial operations. The Project site is also positioned within the Ras Al Khair Industrial Complex that has undergone significant transformation during recent years. In considering the ambient conditions and environmental context of the Project area, emissions of dust and from construction vehicles are not assessed further as they will not give rise to significant impacts (see Chapter 6: Air Quality and Meteorology).

The loss of vegetation associated with construction of the proposed facilities within the Project area will only impact on common species of Local value. The absence of natural or semi-natural vegetated habitats within the Project area will also contribute to an impoverished invertebrate fauna. As such, the impact on flora and terrestrial invertebrates is predicted to be low adverse significant.

**Impact E1 – Low Significance**

Habitats within the Project area and the port have been modified and currently experience elevated levels of noise and visual disturbance. The Project site is also surrounded by an existing security fence which limits the ingress / egress of larger mammal species.

As such these areas provide unfavourable conditions for notable mammal species, but this does not preclude the presence of more common species including those recorded during the baseline surveys. These species could be directly killed or injured during site clearance works or by construction vehicles. However these species are not currently threatened and the impact on mammals of local value is predicted to be low adverse significant.

**Impact E2 – Low Significance**

Although the Project area and port are likely to support a restricted reptile fauna, there was no evidence of the Egyptian spiny tailed lizard using the site in 2012. In addition to the general unsuitability of the Project area for this species, the existing security fence will likely prevent ingress of this species.

The impact on reptiles of local value is predicted to be low adverse significant.

**Impact E3 – Low Significance**

Coastal bird species will make limited use of the Project area, however a number of the passerine species may utilise nesting opportunities within the site. Bird species may also utilize the existing attenuation and evaporation ponds within the Project area. These waterbodies have the potential to hold contaminated water and therefore pose a risk to bird
species of local value. There will however be minimal further impacts of disturbance to bird species within the Project area and adjacent to the site over and above the existing ambient levels.

The construction of facilities on the port area has the potential to disturb Socotra cormorants. Although this species breeds on off-shore islands, there is potential for Socotra cormorants to utilize the port area and adjacent areas as a roosting site. However the use of the port by Socotra cormorants has not been identified during the most recent baseline surveys.

Impact E4 – Low Significance

The port itself is already operational and is operated by the Saudi Ports Authority (SEAPA). The port currently serves more than 80 different industrial projects in the region. As such, the additional movement of shipping vessels during the construction phase of this project is not predicted to give rise to any further impacts.

No Significant Impact

8.3.3 OPERATION

During the operational phase of the project, impacts on biological resources will be largely restricted to impacts of emissions from the operations (e.g. dust, ammonia, fluorides), industrial wastewaters and the movement of operational vehicles.

Specific potential impacts on biological resources due to the above activities are summarised in Table 8-7 and discussed in the following text. To reiterate, the potential impacts associated with the construction of berths / expansion of the port area are not assessed as part of this ESIA. However impact of using shipping vessels for the loading / unloading of materials during the operational phase are included.

Table 8-7: Operational Impacts

<table>
<thead>
<tr>
<th>Factor</th>
<th>E5</th>
<th>E6</th>
<th>E7</th>
<th>E8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
<td>Local</td>
<td>Local</td>
<td>Local</td>
<td>Regional</td>
</tr>
<tr>
<td>Frequency</td>
<td>Infrequent</td>
<td>Infrequent</td>
<td>Infrequent</td>
<td>Infrequent</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Unlikely</td>
<td>Unlikely</td>
<td>Unlikely</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
<td>Local</td>
<td>Local</td>
<td>Provincial</td>
</tr>
<tr>
<td>Duration</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

Impacts on air quality during the operational phase have the potential to impact on vegetation communities adjacent to the Project area, and in turn the conservation status of faunal populations associated with these plant communities -see Chapter 6: Air Quality and Meteorology.

Section 6 Air Quality & Meteorology identified that fluoride concentrations in the area are already elevated due to existing industrial operations at Ras Al Khair. The Project contribution represents nearly one quarter of the total pollutant concentration and therefore the Project's impact associated with fluoride has been assessed as being of medium significance. However with the implementation of mitigation this impact is predicted to be low.

As a consequence, impacts of air quality on biological resources, principally vegetative communities, are predicted to be low adverse significant.

Impact E5 – Low Significance
Waste streams generated during the operational phase of the project include food waste and industrial wastewaters. The management of food wastes generated during the operational phase in accordance with an operational waste management plan will reduce the attractiveness of the Project area to vermin, which would otherwise increase predation pressure on other species. Similarly the operational site waste management plan will ensure that all waste streams are controlled, treated and disposed of appropriately thereby posing no risk to the natural environment or coastal waters adjoining the site.

Impacts of waste and hazardous materials on biological resources are predicted to be low adverse significant.

**Impact E6 – Low Significance**

There is also an increased risk that faunal species could be involved in collisions with operational vehicles as a consequence of increased road traffic and vehicle movements, although measures will be implemented to enforce speed limits.

**Impact E7 – Low Significance**

The port itself is already operational and is operated by the Saudi Ports Authority (SEAPA). The port currently serves more than 80 different industrial projects in the region. Once berths 5 and 6 are completed, the port is expected to handle approximately 895 tonnes of industrial product exports, 4.34 Mt of mineral exports and imports of approximately 0.66 Mt annually (SEAPA, 2013b). As such, the additional movement of ships during the operational phase of the project is not predicted to give rise to any further impacts.

However the loading and unloading of hazardous materials has the potential to cause significant harm to the marine environment should there be a spillage. Should this impact arise, it is predicted to have a significant impact on marine biological resources (i.e. seagrass beds). Due to dispersal mechanisms, this impact could affect valuable sites off-shore (i.e. coral islands). As a consequence the value of this receptor for the purposes of this impact is Regional.

**Impact E8 – High Significance**

8.3.4 DECOMMISSIONING

During the decommissioning phase of the project, infrastructure will be removed or mothballed. During this process, there is potential for contamination of the natural environment due to the removal and disturbance of an operational industrial facility. Therefore the impact of decommissioning is predicted to be medium adverse significant (Table 8-8).

**Impact E9 – Medium Significance**

**Table 8-8: Decommissioning Impacts**

<table>
<thead>
<tr>
<th>Factor</th>
<th>E9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
<td>Local</td>
</tr>
<tr>
<td>Frequency</td>
<td>Infrequent</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
</tr>
<tr>
<td>Duration</td>
<td>Medium</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Low</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Medium</td>
</tr>
</tbody>
</table>
8.4 MITIGATION / RECOMMENDATIONS

8.4.1 INTRODUCTION

A hierarchical approach to mitigation development has been adopted to manage impacts identified for the construction, commissioning, operational and decommissioning phases of the Project. This approach consists of three distinct stages:

- Avoidance – eliminate impacts wherever possible.
- Minimise – Reduce the effect of negative impacts that cannot be avoided.
- Compensate – Implement compensatory measures for remaining significant impacts.

Implementation of mitigation measures will be required during construction, commissioning, operation and decommissioning of the facility to minimise potential negative impacts of the activities on the water quality. The mitigation measures comprise a combination of physical design features of the facility, management procedures and monitoring arrangements and are described in the subsequent sections. The following text assesses the impacts predicted as being of medium to high significance against appropriate mitigation measures to predict the residual impact significance.

8.4.2 CONSTRUCTION AND COMMISSIONING RECOMMENDATIONS

No medium or high significance impacts identified for the commissioning phase, therefore mitigation measures have not been identified, however the following recommendations are provided for consideration.

The construction phase Environmental Emergency Response Plan (EERP) and a Construction Environmental Management Plan (CEMP) which will be developed by the EPC Contractor as supporting documents to the Environmental Management and Monitoring Plan (Appendix A of this ESIA) will detail responsibilities and procedures for environmental and emergency response management during construction. These Plans should consider the following:

- Include an overview of the ecological value and sensitivity of the Project area in contractor’s Site Induction. This should include guidance on species identification and actions to take if encountered within Project area.
- Restrict clearance works to minimum requisite area.
- Restrict vehicle movements to defined haul / access routes to minimise risk of wildlife collisions with vehicles.
- Enforce speed limits on and around the Project area.

Anti-nesting devices to be installed to deter birds (birds have previously been found stuck in vents).

8.4.3 OPERATIONS PHASE MITIGATION

<table>
<thead>
<tr>
<th>ID Code</th>
<th>Impact</th>
<th>Potential Significance</th>
<th>Mitigation Measure</th>
<th>Significance after Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>E8</td>
<td>Impact on marine habitat</td>
<td>High</td>
<td>• Ensure all storage facilities on the jetty are adequately maintained and checked for possible release of hazardous materials.</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• All staff shall be appropriately trained and competent in the operation of equipment to load and unload ships.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• The EERP / EMMP as appropriate shall include procedures for the event of a spillage at the port and to</td>
<td></td>
</tr>
</tbody>
</table>
ensure all staff are fully trained in the implementation of such procedures.

- All equipment for loading and unloading ships shall be regularly maintained.

8.4.3.1 OPERATIONS PHASE RECOMMENDATIONS

The construction phase EERP and CEMP which will be developed by the EPC Contractor as supporting documents to the EMMP will detail responsibilities and procedures for environmental and emergency response management during construction. These Plans should consider the following:

- Inductions to include an overview of the ecological value and sensitivity of the Project area and guidance on species identification and actions to take if encountered within Project area.
- Restrict vehicle movements to defined access routes to minimise risk of wildlife collisions with vehicles.
- Enforce speed limits on and around the Project area.
- Appropriate waste storage to limit the potential proliferation of non-desirable fauna (e.g. rats, flies).

8.4.4 DECOMMISSIONING PHASE MITIGATION

<table>
<thead>
<tr>
<th>ID Code</th>
<th>Impact</th>
<th>Potential Significance</th>
<th>Mitigation Measure</th>
<th>Significance after Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>E9</td>
<td>Disturbance of contaminated material</td>
<td>Medium</td>
<td>The Decommissioning Plan to be developed shall identify all possible sources of contamination, and outline the appropriate control and disposal measures that protect the natural environment.</td>
<td>Low</td>
</tr>
</tbody>
</table>
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9.0 NOISE & VIBRATION

9.1 INTRODUCTION

This section details the existing noise sources and sensitive receptors that could be affected by noise or vibration generated by the Project, as well as conclusions of the noise baseline survey. An assessment of the likely noise and vibration impacts resulting from noise generated during the lifetime of the Project is then outlined (in light of applicable guidance and standards, existing noise levels in the area and modelling based predictions).

Although much of the engineering design detail for the identified potential noise sources is unconfirmed at the current stage of project design (i.e. FEED), it has been possible to utilise a number of assumptions within the impact assessment to estimate likely noise emissions associated with the proposed Project.

9.1.1 NOISE AND DEFINITIONS

In order to aid the understanding of this section the following definitions and clarifications are detailed.

The sound wave travelling through the air is a regular disturbance in ambient atmospheric pressure. These pressure fluctuations, when of frequencies within the audible range, are detected by the human ear which passes nerve responses to the brain, producing the sensation of hearing. Noise has been defined in a variety of ways and is very much dependant on factors such as the listener’s attitude to the source of the sound and their environment, but is essentially any sound that is unwanted by the recipient.

It is impossible to measure the degree of nuisance caused by noise directly, as this is essentially a subjective response of the listener, but it is possible to measure the “loudness” of that noise. Loudness is related to both the sound pressure (the magnitude of the maximum excursion of the pressure wave around the ambient atmospheric pressure) and the frequency, both of which can be measured.

The human ear is sensitive to a wide range of sound levels; the sound pressure level of the threshold of pain is over a million times that of the quietest audible sound. In order to reduce the relative magnitude of the numbers involved, a logarithmic scale of decibels (dB) based on a reference level of the lowest audible sound is used. Also, the response of the human ear is not constant over all frequencies. It is therefore usual to weight the measured frequency to approximate human response. This is achieved by using filters to vary the contribution of different frequencies to the measured level. The “A” weighting network is the most commonly used and has been shown to correlate closely to the non-linear and subjective response of humans to sound. The use of this weighting is denoted by a capital A in the unit abbreviation (i.e. L_{A_{max}}, L_{A_{eq}}, L_{A_{90}} etc.) or a capital A in brackets after a dB level (i.e. 3 dB(A)).

**Sound Pressure Level**: The sound pressure level (LP or SPL) is the instantaneous acoustic pressure and is measured in decibels (dB). Since the ear is sensitive to variations in pressure, rather than source power or intensity, the measurement of this parameter gives an indication of the impact on people. The SPL is defined as:

\[
SPL = 10 \log_{10} \left( \frac{p^2}{p_{ref}^2} \right) \quad \text{or} \quad SPL = 20 \log_{10} \left( \frac{p}{p_{ref}} \right)
\]

Where \( p \) is the rms pressure of the sound in question (in pascals) and \( p_{ref} \) is the reference sound pressure, defined as the limit of human audibility (2 x 10^{-5} Pa).

\( L_{eq} \): The \( L_{eq} \) is defined as the equivalent continuous sound level and is the most widely used parameter for assessing environmental noise. Since this descriptor is a type of average level, it must by definition have an associated time period over which the measurement is taken.

---

1 Root mean square sound pressure: the value obtained when squaring multiple instantaneous sound pressure level measurements at a given point, averaging these over the time of a complete cycle, and taking the square root of this average.
referring to. This is often included in the abbreviation in the form $L_{eq,T}$, where $T$ is the time period (i.e. $L_{Aeq,5\,\text{min}}$). The formula for calculating the $L_{eq}$ is:

$$L_{eq} = 10\log_{10} \left( \int_{t_1}^{t_2} \frac{p^2}{p_{ref}^2} \, dt \right)$$

In practice, since most modern sound level meters are digital and hence take periodic samples of the sound pressure level, the $L_{eq}$ will be the logarithmic average of all the SPL samples taken in the measurement period.

$L_{max}$: The $L_{max}$ is defined as the maximum rms level recorded during a measurement period.

$L_n$: The $L_n$ is a statistical descriptor and refers to the level that is exceeded for $n\%$ of the time during a particular measurement period. Again, the measurement period that the descriptor refers to is often included in the abbreviation in the format $L_{n,T}$. Two of the most commonly used statistical descriptors used for environmental noise assessments are the $L_{90}$ and the $L_{10}$.

$L_{10}$: The $L_{10}$ refers to the level exceeded for 10% of the measurement period and is commonly used in assessing road traffic noise as it has been found to give a good indication of the subjective human response to this type of noise.

$L_{90}$: The $L_{90}$ refers to the level exceeded for 90% of the measurement period and is widely considered to represent background noise, or the underlying noise in an area between noisy events (such as cars passing etc.).

Free-Field Noise Level: The term “free-field” refers to noise levels that have been measured or predicted in the absence of any influence of reflections from nearby surfaces. In practice, a measurement is considered to be free-field if it was taken at a distance of over 3.5 m from any reflecting surfaces.

Façade Noise Level: This is the noise level measured or predicted at the façade of a building, typically at a distance of one metre, containing a contribution of reflections from the façade itself.

Peak Particle Velocity (PPV) is the instantaneous maximum velocity reached by a vibrating element as it oscillates about its rest position.

Vibration Dose Value (VDV) is a measure of the total vibration experienced over a specified period of time. It takes account of the magnitude of the vibration events and the number and duration of those events. The VDV is given by the fourth root of the integral of the fourth power of the acceleration after it has been frequency weighted.

### 9.1.2 MEASUREMENT OF SOUND

Sound pressure level is generally measured using a sound level meter, which essentially comprises a microphone, input and output amplifiers and a meter or display. Sound level meters also have weighting networks such as A-weighting as described above. The microphone converts the fluctuating sound pressure to a varying electric charge. A windshield is used outdoors or where airflow might generate turbulence at the microphone surface causing spurious readings. Where possible, noise levels are measured or assessed at free-field or façade locations.

### 9.1.3 PSYCHOLOGICAL AND PHYSIOLOGICAL EFFECTS OF NOISE

Noise can have a number of effects; it can annoy or disturb and also result in noise induced hearing impairment. Noise induced hearing impairment is usually as a consequence of occupational noise exposure although it can result from exposure to amplified music. Exposure to noise can result in interference with speech communication, sleep disturbance and annoyance. It is thus important that standards are applied to minimise potential adverse effects of noise.
9.2 BASELINE CONDITIONS

9.2.1 INTRODUCTION

Receptors to noise emissions from the Project site are limited to offices and residential facilities associated with the construction and operation of the Ras Al Khair Industrial City and associated service infrastructure. Noise from these activities will not be audible at the closest sizable population centre (Nuairiyah) located approximately 68 km to the West of the peninsula (93 km by road). In addition to the Project site boundary (as required by RCER-2010), the following receptors were assessed for potential noise and vibration impacts:

- Ma’aden Housing (approximately 8 km south-west of the Project site);
- Temporary Construction Camps (approximately 1.7 km south of Project site);
- Coast Guard Offices (approximately 2.3 km south of the Project site);
- Radio Transmission Facility (approximately 10 km south-east of the Project site); and,
- Petrol Station (approximately 5 km south of the Project site).

Baseline noise monitoring was undertaken to provide details of the existing noise climate and provide a basis for the assessment of likely noise impact. Given existing noise sources on the site, it was especially important to establish existing noise levels to determine cumulative noise impacts associated with the development.

9.2.2 RAS AL KHAIR FIELD SURVEY 2013

Woods Hole Group Middle East (WHGME) conducted noise monitoring at the Ras Al Khair project site on the following dates:

- 19th – 21st January 2013; and
- 5th – 10th March 2013.

Both long-term noise measurements (24 hours) and short-term (15 minutes) measurements were taken along the project site boundary and adjacent to the nearest noise sensitive receptors off-site, such as Ma’aden Housing.

Noise monitoring was undertaken using a Cirrus Research plc CR812A sound level meter. The instrument microphone was at a height of 1.5 m above ground level in free field locations.

Table 9-1 summarises the details for each of the noise monitoring locations and these are illustrated in Figure 9-1.

---

2 Use of this building may cease in the near future, however this is unconfirmed at present.
### Table 9-1: Ras Al Khair Noise Monitoring Location Details

<table>
<thead>
<tr>
<th>Monitoring Location</th>
<th>Co-ordinates</th>
<th>Monitoring Date</th>
<th>Monitoring Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside the MPC plot (InP1)</td>
<td>27°32'10.90&quot;N 49°11'35.20&quot;E</td>
<td>January</td>
<td>Short-term</td>
</tr>
<tr>
<td>Centre of MPC plot (InP2)</td>
<td>27°32'0.21&quot;N 49°11'36.43&quot;E</td>
<td>January</td>
<td>Short-term</td>
</tr>
<tr>
<td>Mid-north fence (MN)</td>
<td>27°32'27.60&quot;N 49°11'37.00&quot;E</td>
<td>January and March</td>
<td>Long-term and Short-term</td>
</tr>
<tr>
<td>Mid-east fence (ME)</td>
<td>27°31'59.40&quot;N 49°12'8.70&quot;E</td>
<td>January</td>
<td>Short-term</td>
</tr>
<tr>
<td>Mid-west fence (MW)</td>
<td>27°31'58.50&quot;N 49°11'12.00&quot;E</td>
<td>January</td>
<td>Short-term</td>
</tr>
<tr>
<td>Northeast corner (NE)</td>
<td>27°32'27.50&quot;N 49°12'7.90&quot;E</td>
<td>January and March</td>
<td>Short-term</td>
</tr>
<tr>
<td>Northwest corner (NW)</td>
<td>27°32'26.94&quot;N 49°11'11.77&quot;E</td>
<td>January and March</td>
<td>Short-term</td>
</tr>
<tr>
<td>Port area (PP)</td>
<td>27°32'54.10&quot;N 49°11'56.00&quot;E</td>
<td>January and March</td>
<td>Short-term</td>
</tr>
<tr>
<td>Ma'aden Housing (HP)</td>
<td>27°29'43.10&quot;N 49°6'36.00&quot;E</td>
<td>January and March</td>
<td>Long-term and Short-term</td>
</tr>
<tr>
<td>Southeast corner (SE)</td>
<td>27°31'25.40&quot;N; 49°12'7.79&quot;E</td>
<td>March</td>
<td>Short-term</td>
</tr>
<tr>
<td>Southwest corner (SW)</td>
<td>27°31'27.53&quot;N; 49°11'12.82&quot;E</td>
<td>March</td>
<td>Short-term</td>
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</tbody>
</table>
Figure 9-1: Map Showing Noise Monitoring Locations at Ras Al Khair
### 9.2.3 NOISE MONITORING RESULTS

Results of the noise monitoring undertaken are detailed in Table 9-2.

**Table 9-2: Noise Monitoring Results Record for January and March Surveys**

<table>
<thead>
<tr>
<th>Date</th>
<th>Starting time (hh:mm)</th>
<th>Period (hh:mm)</th>
<th>Wind speed (km/h)</th>
<th>L_{Aeq} (dB)</th>
<th>L_{AFmax} (dB)</th>
<th>L_{A1} (dB)</th>
<th>L_{A10} (dB)</th>
<th>L_{A90} (dB)</th>
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<tr>
<td><strong>Ma'aden Housing (HP)</strong></td>
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<td>Key site notes:</td>
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</tr>
<tr>
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</table>

\(^3\) It can be seen that the L_{AFmax} noise level detailed for the period commencing at 08:48 on the 8th March was not typical for the HP monitoring location.
### Project Name:
UMM WU’AL PHOSPHATE PROJECT

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<th>$L_{Amax}$ (dB)</th>
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**Northwest Corner (NW)**

Key site notes: all events - Ammonia unit (and flare on occasion)

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<th>Date</th>
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<tr>
<td>10/03/2013</td>
<td>00:36</td>
<td>0:15</td>
<td>13.7</td>
<td>70.3</td>
<td>74.6</td>
<td>73.4</td>
<td>71.9</td>
<td>68.5</td>
</tr>
<tr>
<td>10/03/2013</td>
<td>01:55</td>
<td>0:15</td>
<td>12.2</td>
<td>69.8</td>
<td>78.4</td>
<td>73.6</td>
<td>71.4</td>
<td>67.9</td>
</tr>
<tr>
<td>10/03/2013</td>
<td>08:22</td>
<td>0:15</td>
<td>17.6</td>
<td>69.8</td>
<td>75.8</td>
<td>73.1</td>
<td>71.5</td>
<td>68.0</td>
</tr>
<tr>
<td>10/03/2013</td>
<td>09:06</td>
<td>0:15</td>
<td>14.1</td>
<td>69.9</td>
<td>78.8</td>
<td>74.6</td>
<td>71.6</td>
<td>67.9</td>
</tr>
</tbody>
</table>

**Port Area (PP)**

<table>
<thead>
<tr>
<th>Date</th>
<th>Starting time</th>
<th>Period (hh:mm)</th>
<th>Wind speed (km/h)</th>
<th>$L_{Aeq}$ (dB)</th>
<th>$L_{Amax}$ (dB)</th>
<th>$L_{A1}$ (dB)</th>
<th>$L_{A10}$ (dB)</th>
<th>$L_{A90}$ (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20/01/2013</td>
<td>18:11</td>
<td>0:15</td>
<td>6.5</td>
<td>52.4</td>
<td>62.8</td>
<td>58.8</td>
<td>53.9</td>
<td>50.2</td>
</tr>
<tr>
<td>20/01/2013</td>
<td>0:32</td>
<td>0:15</td>
<td>6.3</td>
<td>54.8</td>
<td>71.2</td>
<td>59.4</td>
<td>55.5</td>
<td>53.2</td>
</tr>
<tr>
<td>21/01/2013</td>
<td>14:49</td>
<td>0:15</td>
<td>7.0</td>
<td>51.5</td>
<td>57.6</td>
<td>54.1</td>
<td>52.9</td>
<td>49.0</td>
</tr>
<tr>
<td>9/3/2013</td>
<td>11:50</td>
<td>0:15</td>
<td>9.6</td>
<td>54.3</td>
<td>57.4</td>
<td>55.3</td>
<td>54.7</td>
<td>53.3</td>
</tr>
<tr>
<td>9/3/2013</td>
<td>12:11</td>
<td>0:15</td>
<td>9.6</td>
<td>54.2</td>
<td>60.1</td>
<td>55.6</td>
<td>54.7</td>
<td>52.9</td>
</tr>
<tr>
<td>9/3/2013</td>
<td>20:01</td>
<td>0:15</td>
<td>16.4</td>
<td>50.4</td>
<td>60.0</td>
<td>53.9</td>
<td>50.9</td>
<td>48.7</td>
</tr>
<tr>
<td>9/3/2013</td>
<td>21:46</td>
<td>0:15</td>
<td>14.9</td>
<td>50.2</td>
<td>57.9</td>
<td>51.6</td>
<td>50.7</td>
<td>48.8</td>
</tr>
<tr>
<td>10/03/2013</td>
<td>00:16</td>
<td>0:15</td>
<td>11.6</td>
<td>52.5</td>
<td>56.8</td>
<td>54.4</td>
<td>53.2</td>
<td>51.0</td>
</tr>
<tr>
<td>10/03/2013</td>
<td>01:34</td>
<td>0:15</td>
<td>13.1</td>
<td>50.6</td>
<td>55.2</td>
<td>51.9</td>
<td>51.0</td>
<td>49.3</td>
</tr>
<tr>
<td>10/03/2013</td>
<td>09:48</td>
<td>0:15</td>
<td>17.7</td>
<td>55.9</td>
<td>77.2</td>
<td>63.5</td>
<td>56.9</td>
<td>50.6</td>
</tr>
<tr>
<td>10/03/2013</td>
<td>10:04</td>
<td>0:15</td>
<td>17.7</td>
<td>55.3</td>
<td>72.8</td>
<td>60.9</td>
<td>56.4</td>
<td>53.2</td>
</tr>
</tbody>
</table>

It can be seen that the $L_{Aeq}$ and $L_{Amax}$ noise levels detailed for the period commencing at 08:42 on the 10 March were not typical for the NE monitoring location.
The following observations have been made from review of the noise level data:

- Non-typical $L_{\text{Amax}}$ noise levels recorded for the period commencing at 08:48 on the 8th March at the HP monitoring location and is not representative of this location. The site team recorded the presence of people in the vicinity of the noise meter near the end of the monitoring period. It should also be noted that expansion works at the housing area are currently underway. Active construction works recorded during just one rotational noise monitoring period (16:09 on 21st January). However, it is possible that some construction activity occurred during the 24 hour survey period when the survey team were absent.

- Non-typical $L_{\text{Aeq}}$ and $L_{\text{Amax}}$ noise levels detailed for the period commencing at 08:42 on the 10 March at the NE monitoring location were not representative of this location. The reason for the high noise level is unknown, but not considered to be associated with the normal operational noise at this location.

- Baseline noise measurements taken at the Ras Al-Khair Project site boundary line, do not currently exceed the RCER-2010 standard or the IFC guidelines.

- Current noise levels at Ma’aden Housing exceed the RCER standard of 50 dB applicable to a residential and institutional zoning district. The daytime and night time $L_{\text{Aeq}}$ noise levels also exceed the IFC guidelines of 55 dB by day and 45 dB by night. However, it should be noted that noise from existing on site noise sources was not audible during the survey periods at Ma’aden Housing, whilst noise from road traffic and construction activities to the east of the monitoring location was noted.

The measured noise levels presented in Table 9-2 above have been used, together with those predicted through the noise modelling exercise (refer to Section 9.3), to determine likely compliance with applicable standards and guidelines.
9.3 IMPACT ASSESSMENT

9.3.1 INTRODUCTION

Noise will be generated at the Project site during construction, commissioning and normal and emergency operations of the proposed facilities.

The criteria for the evaluation of impacts were identified in Section 5 Impact Assessment Methodology and Table 9-3 and Table 9-4 below present the definition of magnitude criteria defined specifically for environmental noise impacts and the significance of noise impact assessment.

### Table 9-3: Magnitude Definitions for Environmental Noise Impacts

<table>
<thead>
<tr>
<th>Noise Level at Location of Receptor</th>
<th>Magnitude of Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below or up to applicable noise limits</td>
<td>Low</td>
</tr>
<tr>
<td>1 to 5 dBA above applicable noise limits</td>
<td>Medium</td>
</tr>
<tr>
<td>6 - 10 dBA above the applicable noise limits</td>
<td>High</td>
</tr>
<tr>
<td>&gt; 10 dBA above the applicable noise limits</td>
<td>Very high</td>
</tr>
</tbody>
</table>

### Table 9-4: Decision Matrix for Significance Assessment of Environmental Noise

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Very High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Very High</td>
</tr>
<tr>
<td>Frequent</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Very High</td>
</tr>
<tr>
<td>Infrequent / Single event</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
</tr>
</tbody>
</table>

In order to assess potential noise and vibration impacts, consideration has been given to applicable standards and guidance. Table 9-5 presents applicable environmental noise limits for the Project based on RCER-2010 with the World Bank Group (the International Finance Corporation) guidelines included as international good practice in Table 9-6. In addition, reference is also made to BS 5228: 2009 - “Code of practice for noise and vibration control on construction and open sites” (Parts 1 and 2) to inform the assessment of the construction phase.

9.3.1.1 ROYAL COMMISSION ENVIRONMENTAL REGULATIONS (RCER-2010)

Volume I of RCER-2010 details regulations and standards to ensure that noise levels are maintained within limits that do not cause nuisance or harm to people or the environment; these are reproduced in Table 9-5 below. The specified environmental noise standards for residential, business and industrial areas, and roadside areas apply to the “noise levels measured at the outside of the facility’s fence adjacent to the source of the noise or to noise levels in public areas”.

The criteria detailed in the table will help form the basis of the assessment. \( L_{A10} \) noise levels attributable to the development should not exceed 75 dB at the boundary of the site or 50 dB at the boundary of residential and institutional districts.
Table 9-5: Noise Criteria for Occupied and Roadside Areas (Table 7 from RCER-2010)

<table>
<thead>
<tr>
<th>Zoning District</th>
<th>Maximum Noise Measured at Property Line – Not to be exceeded &gt;10% of Measured Time (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential and Institutional</td>
<td>50</td>
</tr>
<tr>
<td>Small Business and Commercial</td>
<td>65</td>
</tr>
<tr>
<td>Industrial</td>
<td>75</td>
</tr>
<tr>
<td>Residential Areas</td>
<td>$L_{10}^{(1)}$ 18 hours in dB(A)$^{(2)}$</td>
</tr>
<tr>
<td>Building Interior, Closed Window</td>
<td>70$^{(3)}$</td>
</tr>
</tbody>
</table>

Notes:
1) Roadside criteria based on freely or peak flowing traffic
2) $L_{10}$ (18hrs) represents the noise level which is exceeded 10% of the time over 18 hrs.
3) Noise level measured at a distance of one metre from the facade

9.3.1.2 INTERNATIONAL FINANCE CORPORATION (IFC) GUIDELINES

These guidelines recommend that noise impacts should not exceed the levels detailed in Table 9-6, or result in a maximum increase in noise level of 3 dB at the nearest receptor off-site. Guideline values are for noise levels measured out of doors.

Table 9-6: IFC Ambient Noise Level Guidelines (Table 1.7.1 from IFC, 2007)

<table>
<thead>
<tr>
<th>Receptor</th>
<th>One Hour $L_{Aeq}$ (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daytime 07:00 – 22:00</td>
</tr>
<tr>
<td>Residential; institutional; educational</td>
<td>55</td>
</tr>
<tr>
<td>Industrial; commercial</td>
<td>70</td>
</tr>
</tbody>
</table>

9.3.1.3 BRITISH STANDARD (BS) 5228: 2009

Part 1: Noise

BS 5228-1: 2009 - “Code of practice for noise and vibration control on construction and open sites” contains details of noise levels from different types and sizes of construction equipment. It provides a database on the noise emissions from individual items of plant and equipment to predict noise from demolition and construction methods. The standard also suggests practical ways to mitigate excessive noise.

The standard provides two methodologies for the prediction of significance during typical construction works, based upon noise change and existing measured ambient noise levels. The evaluation criteria are applicable for residential housing, hotels, buildings in religious use, schools and health or community facilities.

---

Part 2: Vibration

BS 5228-2: 2009 - “Code of practice for noise and vibration control on construction and open sites” provides guidance on human responses to vibration and building structural responses to vibration. The British Standard details that it is appropriate to provide guidance for construction vibration in terms of peak particle velocity (PPV). Table 9-7 provides guidance on the effects of vibration levels on occupants of buildings as detailed in BS 5228-2: 2009.

Table 9-7: Guidance on the Effects of Vibration

<table>
<thead>
<tr>
<th>Vibration Level (PPV)</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.14 mm/s</td>
<td>Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.</td>
</tr>
<tr>
<td>0.3 mm/s</td>
<td>Vibration might be just perceptible in residential environments</td>
</tr>
<tr>
<td>1.0 mm/s</td>
<td>It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.</td>
</tr>
<tr>
<td>10 mm/s</td>
<td>Vibration is likely to be intolerable for any more than a very brief exposure.</td>
</tr>
</tbody>
</table>

For building structure response, BS 5228-2: 2009 reproduces the advice given in BS 7385-2: 1993 - “Evaluation and measurement for vibration in buildings – Guide to damage levels from ground borne vibration”. The response of a building to ground borne vibration is affected by the type of foundation, underlying ground conditions, the building construction and the state of repair of the building. Table 9-8 reproduces the guidance detailed on building classification and guide values for cosmetic building damage.

Table 9-8: Transient Vibration Guide Values for Cosmetic Building Damage

<table>
<thead>
<tr>
<th>Type of Building</th>
<th>PPV in frequency range of predominant pulse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 Hz to 15 Hz</td>
</tr>
<tr>
<td>Reinforced or framed structures</td>
<td>50 mm/s</td>
</tr>
<tr>
<td>Industrial and heavy commercial buildings</td>
<td></td>
</tr>
<tr>
<td>Un-reinforced or light framed structures</td>
<td>15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz</td>
</tr>
<tr>
<td>Residential or light commercial buildings</td>
<td></td>
</tr>
</tbody>
</table>

Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 9-8, with major damage at values greater than four times the values in the table. BS 7385-2: 1993 also notes that the probability of cosmetic damage tends towards zero at 12.5 mm/s peak component particle velocity. It can be seen from Table 9-7 and Table 9-8 that the perceptible level and potential complaint level are much lower than the level for cosmetic building damage.
9.3.2 CONSTRUCTION, COMMISSIONING (AND PRE-COMMISSIONING)

Construction of the project has potential to impact upon the baseline noise and vibration conditions at the site from activities such as: ground clearance and excavation, facility construction, HGV movements, diesel generators, compressors and piling.

Specific potential impacts on the noise environment due to the above activities are summarised in Table 9-9 and discussed in the following text.

Table 9-9: Construction Phase Impacts Assessment (Impact at Off-site Receptors)

<table>
<thead>
<tr>
<th>Factor</th>
<th>NV1</th>
<th>NV2</th>
<th>NV3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Frequency</td>
<td>Frequent</td>
<td>Infrequent</td>
<td>Rare</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Unlikely</td>
<td>Unlikely</td>
<td>Likely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local/ Provincial</td>
<td>Local/ Provincial</td>
<td>Local/ Provincial</td>
</tr>
<tr>
<td>Duration</td>
<td>Short</td>
<td>Short</td>
<td>Short</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Low</td>
<td>Very Low</td>
<td>Low</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

During the construction phase, noise levels will fluctuate as the intensity of activities change. Details of the construction equipment to be used are unavailable at this stage of the Project and will be determined by the EPC Contractors. In terms of the assessment of construction noise and vibration, it will be a contract requirement that the EPC Contractor undertake a noise and vibration assessment and ensure compliance with applicable standards and guidelines during this period.

All construction activities must be in compliance with the RCER-2010, and to supplement this, other guidance such as BS 5228: 2009 (Part 1: Noise, Part 2: Vibration), is available.

9.3.2.1 IMPACT FROM INCREASE OF NOISE LEVELS AT RECEIVERS - CONSTRUCTION

Given the significant distance to sensitive receptors, it is considered unlikely that adverse noise impacts will arise at any nearby noise sensitive premises.

*Impact NV1 – Low Significance*

9.3.2.2 IMPACT FROM INCREASE OF VIBRATION LEVELS AT RECEIVERS - CONSTRUCTION

Given the significant distance to sensitive receptors, it is considered highly unlikely that vibration would be an issue.

*Impact NV2 – Low Significance*

9.3.2.3 IMPACT FROM INCREASE OF NOISE AND VIBRATION LEVELS - COMMISSIONING

Overall, the anticipated main activities and sequence of operations during the pre-commissioning and commissioning phase (as summarised in Section 4 Detailed Description and Layout of the Proposed Development) are not anticipated to result in significant noise or vibration impacts at the boundary fence or at the wider receptor locations. However, commissioning of the Ammonia and DAP/NPK Plants may introduce some short-term significant noise levels within the site boundary if high-pressure steam is utilised to flush/clean pipelines. Flaring may also be required during the commissioning phase. No details are available at this time to evaluate the noise impact of intermittent flaring, but as with the cleaning activities, flaring will be of short duration.
Due to the short duration of commissioning activities (which is likely to occur during daytime hours) and distance to sensitive receptors, significant noise or vibration impacts are not anticipated.

**Impact NV3 – Low Significance**

### 9.3.3 OPERATION

There are existing industrial noise sources operating within parts of the site already. Hence, consideration needs to be given to both existing and new noise sources. For the purpose of modelling however using CadnaA Noise Modelling Software Package, predictions have been undertaken of the new noise sources proposed for the process area of the Project site only (inclusive of the materials storage and handling facility). To support the model assessment, consideration is also given to the potential noise and vibration impacts associated with the rail movements and associated loading and unloading activities at off-site rail sidings as well as the proposed loading / unloading and storage activities at the port. Table 9-10 summarises the main components of the Project for reference.

**Table 9-10: Ras Al Khair Industrial Complex Facilities**

<table>
<thead>
<tr>
<th>Main Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Process Area</strong></td>
</tr>
<tr>
<td>Ammonia Production Plant</td>
</tr>
<tr>
<td>Ammonia Storage Tanks</td>
</tr>
<tr>
<td>Cooling Tower</td>
</tr>
<tr>
<td>DAP/NPK Production Units</td>
</tr>
<tr>
<td>DAP/NPK Raw Materials and Storage Warehouses</td>
</tr>
<tr>
<td>Office and Maintenance Area</td>
</tr>
<tr>
<td>Roadways</td>
</tr>
<tr>
<td><strong>Materials Storage and Handling Facility</strong></td>
</tr>
<tr>
<td>Storage Area and Tank Farm and handling facilities</td>
</tr>
<tr>
<td>Rail infrastructure</td>
</tr>
<tr>
<td><strong>Ras Al Khair Port</strong></td>
</tr>
<tr>
<td>Loading / Unloading and Storage Facilities</td>
</tr>
</tbody>
</table>

With regards vibration, depending on the size and criticality of machines, Ma’aden are required to install permanent vibration monitors to monitor vibration at machines which have the potential to vibrate and cause significant outrages. The size / complexity of the each machine will be assessed by the EPC Contractor following FEED in order to determine the individual criticality rating. Considering this, the operation of plant and equipment is not considered likely to result in perceptible vibration outside the boundary of the site. Also, given the very significant distance to sensitive receptors, it is considered unlikely that vibration would be an issue and therefore this is not assessed further in the following impact assessment sub-sections.

### 9.3.3.1 NOISE SOURCES - PROCESS AREA OPERATION

As detailed earlier, although much of the engineering design detail for the identified potential noise sources is unconfirmed at the current stage of project design, it has been to possible to utilise a number of assumptions within the impact assessment to estimate likely noise emissions associated with the proposed Project.

Some noise emission data relevant to the project operational activities is available within the Environmental Impact Study conducted as part of the Ma’aden Phosphate Project Bankable.
Feasibility Study Report (SAPC, 2005). Where suitable noise source data was unavailable, a noise emission value of 85 dB at 1 m (equating to a sound power level, $L_{WA}$, of 93 dB) has been assumed. A summary of the main sources associated with the proposed development is provided below.

**Pumps**

Pumps have been assumed to be at ground level (source at 0.5 m above the ground), and generally between 1 and 3 m from the edge of the tank (for example) that they serve. Where two pumps are shown in close proximity on the available site plot plans, seemingly serving the same plant item, then one of the two has been assumed to be a ‘stand-by’ or ‘backup’ pump, and has not been considered operational within the noise model.

**HVAC Systems**

A single HVAC noise source (with a noise emission of 85 dB at one metre) has been included at each occupied building, i.e. administration and control room buildings. The noise source has been assumed to be at a height of 1 m above the roof of the building. Seven of the larger buildings within the Project site have either 2 or 3 HVAC units on their roofs. A total of 22 HVAC systems have been included within the noise model, these being:

- 2 systems close to the Train Control Building;
- 2 systems at the NPK\DAP Control Rooms;
- 2 systems at the new admin building east of the existing cafeteria; and
- 16 systems in the new administration area, in the centre of the Project site.

**Ammonia Plant**

The proposed new ammonia plant has been modelled as a radiating building, 25 m in height (taken as the mid height, between the roof ridge and eaves), with the following internal noise sources included:

- Natural Gas Compressor (01K001) and Turbine (01MT01);
- Process Air Compressor (02K001) and Turbine (02MT01);
- "C"–Syn Gas Compressor (07K001) and Turbine (07MT01);
- Power Generator Steam Turbine (85MT01); and,
- NH$_3$ Refrigeration Compressor (09K001) and Turbine (09MT01).

The Natural Gas Compressor, the Process Air Compressor, the Syn Gas Compressor and the Steam Turbine have been given an $L_{WA}$ of 121, 119, 117 and 104 dB, respectively. No doors or other open apertures have been included within the building design. The turbines 01MT01, 02MT01, 07MT01 and 09MT01 have been assumed to have an $L_{WA}$ of 93 dB.

The internal surfaces within the Ammonia Plant have been assumed to be highly reflective, while the Sound Reduction Index (SRI) for the walls and ceiling is assumed to be low, at 27 and 25 dB Rw, respectively. These SRI levels are considered low, and are based on assumption of cladding similar to Kingspan AWP 600 to 1000 mm (Vertically Laid) Wall Tiles and Kingspan Roof Tiles.

Two pumps have been included within the ammonia plant area, south of the two new storage tanks. An auxiliary boiler has been included within the noise model, located towards the southwest of the main plant building (approximately 140 m from the site boundary), with a sound power level of 93 dB $L_{WA}$ (and assumed height of 0.5 m above ground level).

It should be noted that the 120 m tall flare stack has not been included within the model, as it will not be operational during typical operations.
Cooling Tower

A cooling tower, measuring 50 m in height and diameter, has been included within the noise model. The cooling tower has been modelled as a radiating cylinder, with a line source running through its centre (with an $L_{WA}$ of 126 dB), thereby generating a sound pressure level of 85 dB at a distance of 1 m from the cooling tower structure.

NPK/DAP Plant

The area within the battery limits of the DAP/NPK Plants will be divided into ‘solid dry’ areas (concrete buildings) and ‘wet areas’ (scrubbing system external structures). There are two main buildings for the ‘solid dry’ processes housing a number of noise sources (as detailed further below). Adjacent to each building are a number of external noise sources located in the ‘wet areas’. As the ‘wet areas’ are external, they do not contribute to an internal noise level within the main plant building.

Wet Area (External)

Ten pumps have been included in the wet areas, six with a sound pressure level of 85 dB at 1 m and four slurry pumps (with power outputs of 75 kW) with sound power levels of 100 dB (as per SAPC, 2005). All pumps have been modelled at a height of 0.5 m above ground.

The gas scrubbers and associated stacks have been included within the noise model (at heights of 14.0 and 62.5 m, respectively). There are a total of four gas scrubbers and four associated stacks, split evenly between the wet areas of both buildings. The noise sources have all been assigned noise emission levels of 110 $L_{WA}$, as per the data reported by SAPC (2005).

A total of twelve fans have been included within the wet areas, each with a sound power level of 108 dB, based on their quoted power outputs available at this stage of the FEED, and the emission data by SAPC (2005). Each fan is external from the main plant building and positioned at a height of 2 m above ground.

Solid Dry Area - Main Buildings (Internal Sources)

The two main NPK/DAP plant buildings have been modelled as radiating buildings, with the following noise sources included within each building (as reported in SAPC, 2005):

- Dryer and Granulator – with an $L_{WA}$ of 115 dB. Two of these sources have been included within each of the NPK/DAP buildings.
- Combustion Chamber – with an $L_{WA}$ of 110 dB. Two of these sources have been included within each of the NPK/DAP buildings.
- Chiller – with an $L_{WA}$ of 110 dB. Two of these sources have been included within each of the NPK/DAP buildings.
- Cooler fan – with an $L_{WA}$ of 104 dB(A). Two of these sources have been included within each of the NPK/DAP buildings.
- Oversized mills – with an $L_{WA}$ of 104 dB(A). Eight of these sources have been included within each of the NPK/DAP buildings.

An open door has been included for each building, on the northern façade. The door has been assumed to be 11 metres in height and 15 metres in width. The internal surfaces within the building have been assumed to be highly reflective, while the SRI for the walls and ceiling have been assumed to be low, at 27 and 25 dB Rw, respectively.

Overland Conveyor

The proposed new overland conveyor has been included within the noise model. A total of three Transfer Towers have been included within the model, located between the NPK/ DAP plant buildings and the raw materials storage buildings (located north of the plant room buildings). A motor noise source and a material handling noise source has been included at each of the Transfer Towers, each assumed to be 85 dB at 1m (equating to and $L_{WA}$ of 93 dB) and at a height of 10 m above ground.
Predictions of likely noise levels have been undertaken using the CadnaA Noise Modelling Software Package, which incorporates the algorithms detailed in ISO 9613, “Attenuation of Sound Propagation Outdoors”, 1993 and 1996, and has been validated by the software manufacturer (DataKustik).

The noise model includes all buildings within the fence line boundary of the Project process area (as depicted in Figure 4-3 of Section 4 Detailed Description and Layout of the Proposed Development), with only the noise sources associated with the proposed new development having been included. Consideration has not been given to any buildings located outside of the MPC facility, such as the Ma’aden Aluminium Company facility located south-west of the Project site. This approach will allow for worst-case noise predictions to be made for off-site sensitive receptors.

**Ground Conditions**

No ground topographical data has been included within the model. It has been assumed that the Project site is flat, and that the noise predictions to be made at the Ma’aden Housing receptors (south-west of the Project site) and the Temporary Camps and Coast Guard Offices (south of the Project site) will generate worst-case noise impact predictions when modelled in the absence of any intervening ground contour data.

The topography of the Ras Al Khair Industrial Complex is composed of sand sheets, which are assumed to be acoustically hard, and as such no acoustic ground absorption within the Project site or between the facility and “off-site” receptors is expected – again a worse case scenario.

**Meteorological Conditions (Temperature and Relative Humidity)**

Average annual temperature of 25 °C has been used, as quoted within the Ma’aden Engineering Manual, Site Data – Ras Al Khair Site report (MD-101-SMEM-EG-GE-SPC-0001). An average annual Relative Humidity of 53 % has been assumed within the noise model, which has been calculated using the hourly meteorological data collected at the Jubail weather station (Site 2) between 2007 and 2012.

**Buildings and Other Structures within the RAK Site Boundary**

Building dimensions have been estimated using the maximum average height of a structure or group of structures identified by reference to design drawings, datasheets, site photographs and discussions with the FEED project team.

**Noise Prediction Receptors**

A total of 276 Project site boundary receptor points have been included within the model, positioned at 25 m intervals around the process area boundary of the Project site, and at a height of 1.5 m above ground. The off-site noise receptors considered are listed in Section 9.2.1.

9.3.3.3 NOISE MODELLING RESULTS AND ASSESSMENT - PROCESS AREA OPERATION

Table 9-11 summarises the results of the noise modelling exercise undertaken for the predicted ‘normal’ operation scenario and Figure 9-2 and Figure 9-3 illustrate the noise contour banding for the process facility area and the wider project area respectively.

While interpreting Figure 9-2 it is important to note the following:

- For assessment of compliance with environmental standards, the modelling results predicted at the site boundary are utilised and not levels predicted within the boundary noise contour plot e.g. adjacent to the cooling tower, which are indicative of the distribution of noise;

- Any alterations to the design of buildings (whether noise emitting or not), and the positions of building and other noise sources will impact upon the noise contour plot;
The plot only illustrates the noise emissions associated with proposed new facility, and does not, therefore, account for the cumulative existing and new plant impacts (these are provided in Table 9-13 and Table 9-14).

**Table 9-11: Predicted Noise Levels**

<table>
<thead>
<tr>
<th>Location</th>
<th>Predicted noise level dB $L_{A_{eq}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern Boundary</td>
<td>46.3 – 67.5</td>
</tr>
<tr>
<td>Northern Boundary</td>
<td>38.2 – 57.3</td>
</tr>
<tr>
<td>Southern Boundary</td>
<td>35.4 – 48.5</td>
</tr>
<tr>
<td>Western Boundary</td>
<td>37.8 – 60.1</td>
</tr>
<tr>
<td>*Mid Eastern Boundary</td>
<td>67.2</td>
</tr>
<tr>
<td>*Mid Northern Boundary</td>
<td>56.6</td>
</tr>
<tr>
<td>*Mid Western Boundary</td>
<td>58.9</td>
</tr>
<tr>
<td>*North Eastern Corner of Boundary</td>
<td>46.5</td>
</tr>
<tr>
<td>*North Western Corner of Boundary</td>
<td>45.2</td>
</tr>
<tr>
<td>*South Eastern Corner of Boundary</td>
<td>47.3</td>
</tr>
<tr>
<td>*South Western Corner of Boundary</td>
<td>45.7</td>
</tr>
<tr>
<td>Ma’aden Housing</td>
<td>&lt;20</td>
</tr>
<tr>
<td>Temporary Construction Camps</td>
<td>34.6</td>
</tr>
<tr>
<td>Coast Guard Offices</td>
<td>31.9</td>
</tr>
<tr>
<td>Radio Transmission Facility</td>
<td>&lt;20</td>
</tr>
<tr>
<td>Petrol Station</td>
<td>&lt;20</td>
</tr>
</tbody>
</table>

**Notes:**

* These locations are comparable with baseline noise monitoring locations.

It should be noted that the Royal Commission noise limits are in terms of $L_{A_{10}}$ whilst the predicted levels are in terms of $L_{A_{eq}}$. In terms of road traffic noise, it is generally considered that $L_{A_{10}}$ noise levels are in the order of 3 dB higher than $L_{A_{eq}}$ noise levels. In addition it should be noted that averaged measured $L_{A_{10}}$ noise levels for the baseline noise survey undertaken did not exceed averaged $L_{A_{eq}}$ noise levels by more than 3 dB. In general averaged $L_{A_{10}}$ noise levels were in the order of 1 dB higher than averaged $L_{A_{eq}}$ noise levels. To determine likely compliance with the Royal Commission noise levels, and to allow a margin of safety in the absence of vendor data, a correction of +5 dB has been applied to the predicted $L_{A_{eq}}$ noise levels.
Figure 9-2: Ras Al Khair Process Area Noise Contour Plot Extract from CadnaA Model (indicative within the site boundary)
Figure 9-3: Ras Al Khair Wider Project Area Noise Contour Plot
Noise levels on the boundary of the site, with a 5 dB correction applied, are predicted to vary by between 40.4 and 72.5 dB $L_{A10}$ during normal operations, with the highest noise levels predicted along the eastern boundary. The highest $L_{A10}$ noise levels predicted on the eastern, northern, southern and western boundaries are 72.5, 62.3, 53.5, and 65.1, respectively. Thus, predicted noise levels are not expected to exceed RCER-2010 or IFC boundary noise limits.

The highest off-site noise level predicted is 34.6 dB$\text{L}_{Aeq}$ at the temporary construction camps and is well below the IFC night time limit for residential, institutional and educational receptors of 45dB$\text{L}_{Aeq}$. In addition with a 5dB correction, the predicted noise level of 39.6 dB$\text{L}_{A10}$ does not exceed the RCER-2010 noise limit of 50dB $L_{A10}$ at the property line of residential and commercial areas. Hence, the predicted off-site noise levels do not exceed RCER-2010 or IFC noise limits.

During emergency and shut down situations, an auxiliary boiler for the ammonia plant will run continuously on maximum load (to allow power instantaneously to the ammonia plant during emergency operations) to allow safe shut down. During this time, the flare stack associated with the ammonia plant will also operate. Hence, during an emergency there is the potential for increased noise levels. The synthesis gas vent and flare system associated with the Ammonia Plant shall consist of the vent header with acoustic insulation. Acoustic insulation will not be applied for all vent and flare lines, but noise levels from all other non-emergency vents and flare systems must ensure compliance with the stipulated limits of RCER-2010. With the EPC contract documents, it is required that excessive noise during start-up and shut down is to be avoided. The EPC Contractor will identify where the potential for such noise exists so as to specify the location of acoustic insulation requirements.

Pressurised systems requiring safety relief valves will operate infrequently and therefore noise emissions have were not predicted for inclusion in the noise model. Such emissions from steam venting during normal start-ups may be temporarily discernible but at relatively short distance, therefore the potential magnitude of such noise is unlikely to be sufficient to cause a significant disturbance.

9.3.3.4 IMPACT FROM INCREASE OF NOISE LEVELS - OPERATION

Specific impacts predicted on the existing noise environment due to the proposed Project elements at the process area and port area are summarised in Table 9-12 and discussed in the following text.

<table>
<thead>
<tr>
<th>Factor</th>
<th>NV4</th>
<th>NV5</th>
<th>NV6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Frequency</td>
<td>Continuous</td>
<td>Frequent</td>
<td>Frequent</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Likely</td>
<td>Likely</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local/ Provincial</td>
<td>Local/ Provincial</td>
<td>Local/ Provincial</td>
</tr>
<tr>
<td>Duration</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Low</td>
<td>Very Low</td>
<td>Low</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>
Process Area Operation – Potential Noise Impacts

Based on the information currently available, it is not considered likely that noise levels attributable to the proposed development would exceed the quoted standard and guideline values. However, the noise assessment is a dynamic process and further consideration will be required during detailed design to confirm the assumptions within this report and to validate the noise model. Table 9-13 and Table 9-14 consider the effects of predicted noise levels on existing noise levels as measured during the baseline surveys.


<table>
<thead>
<tr>
<th>Location</th>
<th>Noise level dB $L_{Aeq}$</th>
<th>Cumulative noise level exceedance over 70 dB(A) $L_{Aeq}$ limit value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Predicted</td>
<td>Existing</td>
</tr>
<tr>
<td>Mid Eastern Boundary</td>
<td>67.2</td>
<td>48</td>
</tr>
<tr>
<td>Mid Northern Boundary</td>
<td>56.6</td>
<td>64</td>
</tr>
<tr>
<td>Mid Western Boundary</td>
<td>58.9</td>
<td>67</td>
</tr>
<tr>
<td>North Eastern Corner of Boundary</td>
<td>46.5</td>
<td>60 $^1$</td>
</tr>
<tr>
<td>North Western Corner of Boundary</td>
<td>45.2</td>
<td>70</td>
</tr>
<tr>
<td>South Eastern Corner of Boundary</td>
<td>47.4</td>
<td>47 $^1$</td>
</tr>
<tr>
<td>South Western Corner of Boundary</td>
<td>45.7</td>
<td>58</td>
</tr>
</tbody>
</table>

**Notes:**

$^1$ Atypical noise measurement omitted.

**Table 9-14: Cumulative Noise Impact – RCER-2010 $L_{A10}$ Standards**

<table>
<thead>
<tr>
<th>Location</th>
<th>Noise level dB $L_{A10}$</th>
<th>Cumulative noise level exceedance over 75 dB(A) $L_{A10}$ limit value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Predicted $^1$</td>
<td>Existing</td>
</tr>
<tr>
<td>Mid Eastern Boundary</td>
<td>72.2</td>
<td>49</td>
</tr>
<tr>
<td>Mid Northern Boundary</td>
<td>61.6</td>
<td>65</td>
</tr>
<tr>
<td>Mid Western Boundary</td>
<td>63.9</td>
<td>70</td>
</tr>
<tr>
<td>North Eastern Corner of Boundary</td>
<td>51.5</td>
<td>60 $^2$</td>
</tr>
<tr>
<td>North Western Corner of Boundary</td>
<td>50.2</td>
<td>71</td>
</tr>
<tr>
<td>South Eastern Corner of Boundary</td>
<td>52.4</td>
<td>47 $^2$</td>
</tr>
<tr>
<td>South Western Corner of Boundary</td>
<td>50.7</td>
<td>59</td>
</tr>
</tbody>
</table>

**Notes:**

$^1$ 5 dB(A) modelling correction applied to all predicted noise levels.

$^2$ Atypical noise measurement omitted.
Baseline noise measurements taken at the proposed Ras Al-Khair Project site boundary line, do not currently exceed the RCER standard or the IFC guideline.

As noted in Section 9.2.3 noise levels at Ma’aden Housing exceed the RCER-2010 standard and IFC (2007) guidelines. The $L_{A10}$ noise level for the 24 hour monitoring session undertaken was 51.2 dB with a $L_{Aeq}$ noise level of 53.6 dB. With a predicted level of <20 dB for the proposed development at Ma’aden Housing, there would be no change to existing levels. Hence, there would be a negligible noise impact at the Ma’aden Housing attributable to the development.

For the vast majority of the locations considered there would be negligible noise increases compared to the existing situation. Compliance with the IFC guidelines and RCER-2010 standards for the cumulative noise levels is considered likely. It should be noted that the construction of the proposed development will provide screening of existing noise sources for some sensitive receptors.

**Impact NV4 – Low Significance**

**Rail Movements and Associated Activities**

There will be rail movements as a consequence of the development, with rail sidings located to the east of the facility. There are expected to be a minimum of two trains a day in each direction (hence four rail movements). The maximum allowable number of wagons is 155 per train. Train speeds are expected to be in the order 40 km/h when loaded and 50 km/h when empty. The nearest noise sensitive receptors are those at the Temporary Construction Camps, located approximately 2.5 km south-west of the rail sidings, whilst the sidings boundary is approximately 80 m from the nearest line. There is the potential for rail movements throughout a 24 hour period and throughout the year, to suit site operations. Given the distance to sensitive receptors however, and the relatively slow speeds, indicative noise calculations demonstrate that the IFC or Royal Commission noise limits would not be exceeded at the Camps as a result of train movements at the rail sidings.

**Impact NV5 – Low Significance**

**Port Activities**

Loading and unloading activities will take place at the port where large warehouses will be located. The nearest noise sensitive receptors are those at the Temporary Construction Camps, located approximately 6 km south-south-west of the port. Given the distances to noise sensitive receptors, it is not considered likely that the activities being undertaken at the port will generate noise levels that will exceed the IFC or Royal Commission noise limits. Existing measured baseline noise levels at the port are well below the Royal Commission standard of 75 dB applicable to industrial zones.

**Impact NV6 – Low Significance**

**DECOMMISSIONING - IMPACT FROM INCREASE OF NOISE LEVELS**

During the decommissioning operations, the presence of heavy vehicles and dismantling activities has the potential to generate high levels of noise in the vicinity of the Project site. As with the construction impact associated with the project, it is anticipated that, due to the temporary nature of the activities and very large distances between sensitive receptors and the Project site; noise and vibration impacts during decommissioning will be low.

Once the facilities have been fully decommissioned, the noise level at the boundaries of the once occupied area will decrease, but as this area is designated at an Industrial City, industry-related noise is likely to remain at the Ras Al Khair peninsula.

**Impact NV7 – Low Significance**
9.4 RECOMMENDATIONS

Potential negative impacts of medium or high significance are not anticipated to occur as a consequence of the Project commissioning, construction, operation or decommissioning phases.

Implementation of the following measures is recommended to manage the potential impacts identified as being of low significance and maintain good management practices. It is anticipated that this assessment can be built upon during detailed design and the need for noise mitigation will be considered further.

9.4.1 CONSTRUCTION PHASE RECOMMENDATIONS

As previously detailed it will be a contract requirement that the EPC Contractors undertake a noise and vibration assessment and ensure compliance with applicable standards. The EPC Contractor will also need to provide a Noise Management Plan to detail responsibilities for noise control, contact telephone number and measures to control noise emissions during construction. Approval of the Noise and Vibration Management Plan is required by the Client before can commence. This can be incorporated to the Environmental Management and Monitoring Report (refer to Appendix A).

All construction work would be undertaken using best practicable means following guidance such a BS 5228: 2009 - “Code of practice for noise and vibration control on construction and open sites”, or other internationally recognised guidance for the control of noise and vibration.

The Noise and Vibration Management Plan should detail measures to control noise and vibration emissions during construction and detail the monitoring to be undertaken. The development and implementation of the Plan should consider the following:

- Details of the noise monitoring programme and procedures for its implementation;
- Monitoring of noise to determine compliance with applicable standards and guidelines and assess the need for mitigation;
- Results of the updated noise modelling (where applicable);
- Use of temporary sound-proof enclosures and anti-vibration measures shall be employed if required to reduce noise levels on site, in keeping with the results of the updated noise and vibration model;
- Maintenance procedures of all equipment in place to minimise noise from equipment;
- Programme and scope of regular audits of the management plan to confirm its on-going effectiveness.
- Suitable measures to reduce the potential risk resulting from noise during installation of any piles;
- Effective silencing of equipment where possible and compliance with any stated requirements of Ma’aden and the RC where appropriate;
- Adherence to reduced noise limits where night time construction is proposed;
- Vehicle Movements to be reduced as far as practicable;
- Construction activities to comply with British Standards for Vibration;
- Plant and equipment that is used intermittently will be shut down or throttled down to a minimum between work periods;
- Plant and equipment are maintained and lubricated as per the manufacturer’s instructions to avoid friction noise etc.

9.4.2 COMMISSIONING PHASE RECOMMENDATIONS

During commissioning, a noise monitoring exercise will be undertaken to ensure compliance with required standards and limits and validate the results of the noise modelling exercise. The
noise monitoring exercise will enable any necessary mitigation measures to be identified. Noise measurements would continue until it is established that there is full compliance with the required standards and limits.

The Noise and Vibration Management Plan will be updated as required prior to commencing this phase.

9.4.3 OPERATION PHASE RECOMMENDATIONS

Annual noise monitoring will be undertaken to confirm compliance with RCER-2010 and World Bank Group (IFC) and to identify any further noise mitigation measures to those implemented as part of the detailed design. Effective noise control will be an ongoing process. The RC may waive or reduce the frequency of monitoring if it can be demonstrated that the facility is consistently in compliance with the applicable standard.

The Noise and Vibration Management Plan will be updated as required prior to commencing this phase. This may involve consultation with the Saudi Railway Authority (SAR) and Saudi Port Authority (SEAPA) to inform the Plan.

9.4.4 DECOMMISSIONING PHASE RECOMMENDATIONS

Prior to decommissioning / closure, Ma’aden should evaluate potential noise and vibration sources associated with planned decommissioning activities, and establish measures to ensure these activities comply with the necessary noise guidelines at the sensitive receptors.

The Noise and Vibration Management Plan should be updated as required prior to commencing this phase.
10.0 WASTE MANAGEMENT

10.1 Introduction

10.2 Baseline Conditions

10.2.1 National Waste Management

10.2.2 Waste Management Facilities in the Industrial City

10.2.3 Waste Management Approach in the Industrial City

10.3 Waste Generated During Project Lifetime

10.3.1 Construction and Commissioning Waste

10.3.2 Operations Phase

10.3.3 Waste Management Approach

10.4 Impact Assessment

10.4.1 Construction and Commissioning

10.4.2 Operation

10.4.3 Decommissioning

10.5 Recommendations

10.5.1 Construction & Commissioning

10.5.2 Operation

10.0 WASTE MANAGEMENT

10.1 INTRODUCTION

The purpose of this Section is to describe the existing waste management facilities that are available for the Ras Al Khair elements of the Project. The potential environmental impacts resulting from waste management during the lifetime of the Project are evaluated.

The Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal is the most comprehensive global environmental agreement on hazardous and other wastes (adopted in 1989). As a signatory of the Convention the Kingdom of Saudi Arabia will encourage:

- Hazardous waste generation will be minimised;
- The disposal of hazardous waste will be in the country of origin as far as is practicable;
- Enhanced controls on exports and imports of hazardous wastes; and
- Co-operation on the exchange of information, technology transfer and the harmonization of standards, codes and guidelines.

Nationally, the Ministry of Transport is responsible for the execution and monitoring of the transport of goods and materials (through licensing).

The Royal Commission Environmental Regulations (RCER) 2010 provide specific standards for the classification, handling, transportation, treatment and disposal of all waste streams. These standards are concordant with the guidelines outlined in the International Finance Corporation (IFC), *Environmental, Health, and Safety Guidelines for Waste Management Facilities* (IFC 2007).

Classification of Waste

In accordance with Section 5.1 of RCER-2010, Volume I, all waste generated should be classified into one of the following categories:

(a) Hazardous Waste: ‘These wastes are defined as any solid, semi-solid, liquid, or contained gaseous waste, or combination of such wastes, which may because of its quantity, concentration, physical or chemical characteristics pose a hazard or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of or otherwise managed’. The classification of hazardous materials includes materials with the characteristics of being ignitable, corrosive, reactive, toxic, radioactive, or a biohazard.

(b) Non-hazardous Industrial Waste: ‘These wastes include solid, liquid, semi-liquid or contained 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’.

(c) Municipal Waste: ‘Municipal wastes 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’.

(d) Inert Waste: ‘Inert wastes are those 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 RC has adopted three tiers of landfill site classifications. Each of these classifications required specific control measures to protect the environment from potential impacts of waste disposal.

Table 10-1 provides the waste accepted by each landfill classification.

**Table 10-1: Royal Commission Landfill Waste Classification**

<table>
<thead>
<tr>
<th>Waste Facility Class</th>
<th>Description of accepted waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>Double lined. Hazardous waste.</td>
</tr>
<tr>
<td>Class II</td>
<td>Single lined. Non-hazardous industrial waste and municipal waste</td>
</tr>
<tr>
<td>Class III</td>
<td>Inert waste</td>
</tr>
</tbody>
</table>

### 10.2 BASELINE CONDITIONS

#### 10.2.1 NATIONAL WASTE MANAGEMENT

The *Ninth Development Plan* (2010 – 2014) for the Kingdom of Saudi Arabia outlines that population growth over the last 40 years has increased pressures on the environment. It further explains that environmental pollutants generated by human activity, most notably solid and liquid waste have increased (MEP 2009).

Currently solid waste in the Kingdom of Saudi Arabia (KSA) is collected by the local municipality and taken to landfill sites; however, these are under pressure due to the increasing quantities of waste and increasing urban populations (MEP 2009a). Further, much waste is dumped in substandard or illegal landfills (IBI Group, October 2011). The World Bank predicts that in KSA, per capita waste generation will be 1.7 kg per person per day by 2025, resulting in a total of 50,424 tonnes per day municipal solid waste (World Bank 2012).

Recycling facilities are slowly increasing, but recent studies indicate that the recycling rate is 10-15% largely from an informal sector extracting paper, metals and plastic from municipal waste (EcoMENA 2013). The *Arab News* reported in October 2012 that the Saudi Environment Society (SES) estimated that Saudi Arabia was losing approximately SR 40 billion per annum due to the current lack of recycling facilities. The government of the KSA is now investing in solving this waste management problem, in part through a 2011 national budget allocation of SR 29 billion for the municipal services sector, including waste disposal and water drainage (*Arab News* 2012). One of the national targets of the Ninth Development Plan is to raise the proportion of recycled waste to 75% (MEP 2009).

#### 10.2.2 WASTE MANAGEMENT FACILITIES IN THE INDUSTRIAL CITY

There are currently no Royal Commission (RC) licensed waste management facilities located within the Ras Al Khair Industrial City. Clause 5.3.1 of RCER-2010, Volume I states that:

- “All wastes generated within Ras Az Zawr [now known as Ras Al Khair] Industrial City shall be transported to Jubail Industrial City for treatment and disposal.”

All wastes generated in Ras Al Khair Industrial City are therefore transported to Jubail Industrial City for treatment and disposal. As the Ras Al Khair Industrial City develops further, the Royal Commission will establish treatment and disposal facilities within the City.

In Jubail Industrial City, there are a number of Royal Commission licensed waste facilities which can accept the various forms of waste including hazardous, non-hazardous industrial, municipal and inert, including:

- The National Environmental Preservation Company (BeeA’h) operate a hazardous waste treatment and disposal facility which accepts industrial and hazardous waste treatment for disposal, recovery, re-use and recycling (BeeA’h 2013). BeeA’h operates a hazardous waste incinerator to destroy liquid hazardous wastes.
The Environmental Development Company (EDCO) operates a Treatment, Storage and Disposal Facility (TSDF) for hazardous and non-hazardous industrial wastes. The treatment technologies include: incineration (utilising rotary kiln hazardous waste incinerators), stabilisation and solidification, chemical and physical treatment, and solar evaporation. EDCO has disposal facilities for: Class I landfill dedicated for hazardous waste disposal, Class II landfills dedicated for industrial waste disposal, and surface impoundments (EDCO 2013).

The United Lube Oil Company (Unilube) collects and refines used motor oils to produce lubricating oil products that are sold for domestic and export markets (Unilube 2013).

Al Bilad Catalyst Company Limited (ABC) in Jubail Industrial City accepts spent catalysts for off-site regeneration and recycling (ABC 2013).

The Royal Commission operates Class II and Class III landfills in Jubail Industrial City which accepts all inert, municipal and other non-hazardous wastes generated within Jubail and Ras Al Khair industrial cities.

10.2.3 WASTE MANAGEMENT APPROACH IN THE INDUSTRIAL CITY

Waste management is controlled in the industrial cities through the application of registration and manifest systems. All waste generators are registered as such with the RC. Wastes can only be transferred from the generation site to treatment or disposal sites by registered waste transporters. The waste treatment, disposal and recycling facilities are registered to handle specific categories of waste by the RC. The manifest system includes the quantities, classification and date of generation, dates of removal by registered transporters and dates and status of acceptance and final disposal by the registered treatment and disposal company. These records are returned to the generator within 30 days of acceptance at the disposal facility and the generator and disposal facility are required to maintain the manifest records for a period of at least 3 years.

10.3 WASTE GENERATED DURING PROJECT LIFETIME

10.3.1 CONSTRUCTION AND COMMISSIONING WASTE

The site areas for construction of the Project facilities have been levelled as part of previous works to prepare the site for construction of the MPC facilities. Cut and fill works are therefore limited to foundations works with all excavated materials expected to be retained on site to maintain a cut and fill balance. However, as the construction site areas are located within an operational industrial complex there is a potential for existing ground contamination. Any excavated ground identified as contaminated materials must be treated and disposed of in an RC licensed waste facility. Section 7 of this report 7 Terrestrial Environment provides an assessment of the potential for existing land contamination, refer for more details.

Much of the transport infrastructure (including asphalt site access roads) has previously been constructed as part of the previous works and therefore minimal waste will be produced. Also, limited waste is expected to be generated as a result of the construction of the temporary accommodation camp since this comprises of prefabricated buildings that will be assembled on site.

The anticipated waste streams resulting from construction and commissioning are:

- Non-hazardous solid wastes: construction debris, wood (pallets), empty drums and containers (plastic and metal), packaging (paper, cardboard, plastics), municipal wastes and sanitary waste sludge;
- Hazardous solid waste: batteries; filters; empty oil, chemical or paint containers; fabrics contaminated with oil; spent electrical equipment and clinical waste; and
• Hazardous liquid waste: waste oils, lubricants and fuels and drainage waters contaminated with these, solvents; paint; thinners; hydraulic fluid; and cleaning chemicals; contaminated hydro-test water.

Table 10-2 provides an estimate of the quantities of non-hazardous waste anticipated to be generated during construction based on the number of construction workers, and estimated construction materials, and equipment. Miscellaneous Construction Waste from the construction of buildings has not been included. This will consist of concrete, and other inert wastes, wood (shuttering, packaging etc), construction off-cuts (steel, plasterboard, wood, plastics) and miscellaneous packaging.

Table 10-2: Non hazardous Construction Waste

<table>
<thead>
<tr>
<th>Waste Stream</th>
<th>Tonnes (note 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete waste</td>
<td>2,429</td>
</tr>
<tr>
<td>Pipework off cuts etc.</td>
<td>2,963</td>
</tr>
<tr>
<td>Steelwork of cuts etc.</td>
<td>1,969</td>
</tr>
<tr>
<td>Electrical Cable Waste</td>
<td>386</td>
</tr>
<tr>
<td>Municipal Waste</td>
<td>3,137</td>
</tr>
<tr>
<td>Solid Sanitary Waste</td>
<td>306</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>11,189</strong></td>
</tr>
</tbody>
</table>

Note 1: Tonnage estimates are based on Waste and Resources Programme (WRAP) Netwaste Tool.

10.3.2 OPERATIONS PHASE

The operation of the Project facilities will generate the following principal waste streams:

• Non-hazardous solid wastes: packaging (paper, cardboard, plastics), municipal wastes, waste material from the cooling tower basin, and sanitary waste sludge;

• Hazardous solid waste: spent catalyst, batteries; filters, empty oil containers, empty grease and chemical containers, contaminated fabrics/spill absorbents, industrial wastewater treatment sludge (only if an alternative to an evaporation pond at the Ammonia Plant for the treatment of MDEA washing and scrubber blowdown is not confirmed by detailed design), oily sludge (including from storm water oil interceptors) and clinical waste; and

• Hazardous liquid waste: waste oils, lubricants and fuels, solvents, hydraulic fluid; and cleaning chemicals.

The management of contaminated wastewaters is addressed in Section 11 – Water Quality Management.

The Ammonia Plant and the DAP/NPK Plants have been specifically designed to minimise the volume of waste produced during the production process. Wastes produced as part of the ammonia synthesis reaction within the Ammonia Plant predominately arise from the replacement and disposal of spend catalysts (from desulphurisation, CO2 removal etc). In the DAP/NPK Plants all off-spec materials including over-size, spillages and dust from the dedusting cyclones are recycled back into the production process. Periodically filters from the tail gas scrubber and scrubbing units will require replacement and disposal. Table 10-3 below summarises the estimated quantities of the main waste streams generated by the Project during the operation of the facility on an annual basis or as per the lifetime of a specific catalyst.
In terms of storage of operational wastes, it is anticipated that spent catalysts will not be stored on site, but collected and removed directly from the Ammonia Plant by a licensed contractor. Waste oil will be stored in drums in bunded impervious areas for collection.

**Table 10-3: Operational Waste**

<table>
<thead>
<tr>
<th>Waste Stream</th>
<th>Source</th>
<th>Quantity</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activated MDEA-Solvent</td>
<td>Ammonia Plant (CO₂ Removal)</td>
<td>42 tonnes/yr</td>
<td>Hazardous</td>
</tr>
<tr>
<td>Antifoam agent</td>
<td>Ammonia Plant (CO₂ Removal)</td>
<td>0.5 tonnes/yr</td>
<td>Hazardous</td>
</tr>
<tr>
<td>Cobalt-Molybdenum Catalyst</td>
<td>Ammonia Plant (Natural Gas Desulphurisation)</td>
<td>14,070 kg (5 year life-time)</td>
<td>Hazardous</td>
</tr>
<tr>
<td>Zinc Oxide Catalyst</td>
<td>Ammonia Plant (Natural Gas Desulphurisation)</td>
<td>216,244 kg (life-time according to sulphur pick-up)</td>
<td>Hazardous</td>
</tr>
<tr>
<td>Nickel oxide catalyst</td>
<td>Ammonia Plant (CO Conversion)</td>
<td>112,200 kg (5 year life-time)</td>
<td>Hazardous</td>
</tr>
<tr>
<td>HT-shift catalyst</td>
<td>Ammonia Plant (CO Conversion)</td>
<td>101,598 kg (5 year life-time)</td>
<td>Hazardous</td>
</tr>
<tr>
<td>LT-shift catalyst</td>
<td>Ammonia Plant (CO Conversion)</td>
<td>191,820 kg (5 year life-time)</td>
<td>Hazardous</td>
</tr>
<tr>
<td>Methanation catalyst</td>
<td>Ammonia Plant (Methanation)</td>
<td>61,478 kg (5 year life-time)</td>
<td>Hazardous</td>
</tr>
<tr>
<td>Ammonia Synthesis Catalyst</td>
<td>Ammonia Plant (Ammonia Synthesis)</td>
<td>513,280 kg (10 year life-time)</td>
<td>Hazardous</td>
</tr>
<tr>
<td>Scrubber filters</td>
<td>DAP / NPK</td>
<td>Unknown (periodic change as required)</td>
<td>Hazardous</td>
</tr>
<tr>
<td>Municipal Waste</td>
<td>All</td>
<td>167 tonnes/yr (Note 1)</td>
<td>Non-hazardous</td>
</tr>
<tr>
<td>Sanitary Waste Sludge</td>
<td>SWTP</td>
<td>175 tonnes/yr (Note 2)</td>
<td>Non-hazardous</td>
</tr>
</tbody>
</table>

Note 1: Based on estimated 1.2kg per person per day (260 days per year) for 536 employees
Note 2: Based on estimate of 0.06% of sanitary waste water is sludge

### 10.3.3 WASTE MANAGEMENT APPROACH

The Project’s approach to waste management is the application of the waste hierarchy, through the implementation of a waste management strategy that is commensurate with good practice within the waste management industry. Appendix A *Environmental Management and Monitoring Plan (EMMP)* of this ESIA, includes details of the Project approach to waste management. This aspect of the plan should be referenced by the EPC Contractor when preparing the Site Waste Management Plan, and developed further by Ma’aden into an Operational Waste Management Plan building on the approach developed to date.

Construction wastes will be segregated for recycling where possible, and residues disposed of in a RC waste facility. Waste storage facilities will be provided on site during construction to facilitate segregation and to provide secure and protected storage for all waste streams.

Excavation waste is intended to be re-used on site. Excavated soils will be visually inspected for contaminants. Where contaminants are suspected, and proven by further testing to be present, the contractor will dispose of excavated contaminated soil to a RC licensed landfill site. Suspected or known contaminants will not be used as fill material on site. Refer to Section 7 Terrestrial Environment which identifies potential areas of land contamination.
Solid waste (including spent catalyst, excess chemicals) shall be collected, regenerated where possible or disposed offsite by local specialist Contractor appointed by Ma’aden’s Environmental Department.

All wastes will be disposed of in accordance with the requirements of Sections 4 and 5 of the RCER 2010.

10.4 IMPACT ASSESSMENT

This Section describes and assesses the impact on existing waste management systems and those resulting from the generation of waste by the Project during construction, commissioning, operation and decommissioning. Potential impacts from dust generation are assessed in Section 6 Air Quality and Meteorology, those from leaching and spillage are assessed in Section 7 Terrestrial Environment and potential impacts on habitat are assessed in Section 8 Biological Resources. The significance of potential impacts are characterised in accordance with methodology described in Section 5 Impact Assessment Methodology.

10.4.1 CONSTRUCTION AND COMMISSIONING

The potential waste management impacts from construction and commissioning are summarised in Table 10-4 and discussed in the subsequent sections.

Table 10-4: Construction Phase Impact Assessment

<table>
<thead>
<tr>
<th>Scope of Impact</th>
<th>WM1</th>
<th>WM2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Frequency</td>
<td>Temporary</td>
<td>Temporary</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Certain</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Extent</td>
<td>Regional</td>
<td>Local</td>
</tr>
<tr>
<td>Duration</td>
<td>Short</td>
<td>Short</td>
</tr>
<tr>
<td>Magnitude</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

Generation of Inert, Non-Hazardous and Hazardous Wastes

Cut and fill exercises are expected to balance during the construction works and therefore no significant impacts are anticipated arising from this waste stream. If the site is unable to accept inert excavation wastes then this material should be reused at other locations within the Industrial City or stored for use at the port for land reclamation exercises (subject to its engineering grade). Excavated ground must be tested for contamination during excavation works to ensure that it is classified as inert. If identified to contain contaminated materials then this material must be transported to an RC licensed waste facility for treatment and disposal. No contaminated fill will be reused. Other non-hazardous (packing, off cuts etc) and hazardous waste streams from the construction works are to be transported to one of the RC licensed waste treatment and disposal facilities identified above. These facilities are specifically designed to cater for the various classifications of industrial waste produced by the construction and operation of industrial facilities in Jubail and Ras Al Khair. These facilities have the capacity to treat, recycle and/or dispose of all non-hazardous and hazardous wastes produced from the construction phase therefore no significant impacts are anticipated.

Impact WM1 - Low Significance
Environmental Degradation due to Incorrect Storage / Spillage

Incorrect storage of both hazardous and non-hazardous waste has the potential to contaminate soils, and surface water, generate litter and encourage vermin. The EPC Contractor is required to generate a Site Waste Management Plan (SWMP), and to store wastes generated during construction and commissioning in accordance with the requirements of RCER-2010, Volume I, Sections 4 and 5 therefore the potential impact is considered to be of low significance. Impact of spills on the soil, groundwater and surface water are addressed in Section 7 Terrestrial Environment and Section 11 Water Quality Management.

Impact WM2 - Low Significance

10.4.2 OPERATION

The operation of the facility will produce both hazardous and non-hazardous waste. The nature of the hazardous waste means it has the potential to be of high significance unless mitigation measures are implemented. The impacts are summarised in Table 10-5 and discussed in the following sections.

Table 10-5: Operation Phase Impact Assessment

<table>
<thead>
<tr>
<th>Scope of Impact</th>
<th>WM3</th>
<th>WM4</th>
<th>WM5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Frequency</td>
<td>Frequent</td>
<td>Frequent</td>
<td>Rare</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Certain</td>
<td>Certain</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Extent</td>
<td>Regional</td>
<td>Regional</td>
<td>Regional</td>
</tr>
<tr>
<td>Duration</td>
<td>Long</td>
<td>Long</td>
<td>Long</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

Generation of Non-Hazardous Wastes

The generation of non-hazardous wastes is reduced during the operation phase in comparison to construction. The primary producers of non-hazardous wastes are municipal waste generated by employees (estimated as 167 t/yr) and sludge generated from the Sanitary Treatment Plant (STP) (estimated as 175 t/yr). Contracts are currently in-place for the collection and transfer of non-hazardous wastes from the existing MPC operations to the RC licensed waste facilities in Jubail Industrial City. Similar contacts will be implemented or these contracts will be extended to handle non-hazardous wastes produced during the operation of the Project facilities. The RC operated waste facility in Jubail Industrial City are capable of handling Class II and III non-hazardous wastes produced during the operational phase of the Project therefore no significant impacts are identified. The STP has capacity to accept sanitary wastewater from the operational phase of the Project, refer to Section 14 Utilities Infrastructure and Usage for more details.

Impact WM3 - Low Significance.

Environmental Degradation due to Generation of Hazardous Wastes

Hazardous wastes produced during the operational phase consist predominately of spent catalysts generated from the Ammonia Plant. Spent catalysts will be collected by the catalyst supplier for regeneration, recycled or disposed if required. The Al Bilad Catalyst Company in Jubail Industrial City is a RC licensed waste facility that is also able to accept spent catalyst.
Other hazardous wastes produced during the operation of the facility will be transported to either the BeeA’h or EDCO waste treatment and handling facilities. Used motor oils will be transported to the United Lube Oil Company (Unilube). These RC licensed waste treatment facilities have the capability to accept hazardous wastes from the operational phase of the Project and therefore no significant impacts are identified.

Impact WM4 - Low Significance.

In addition to the existing RC licensed waste facilities in Jubail Industrial City, over the lifetime of the Project, it is likely that as the Ras Al Khair Industrial City develops, RC licensed waste management facilities will be commissioned in Ras Al Khair Industrial City itself and will therefore be able to accept waste from the Project operations. This will reduce or remove the need to transport wastes to Jubail Industrial City.

Environmental Degradation due to Accidental Events

There is the potential for accidental events during the operation of the Project which may result in the release of hazardous substances. The uncontrolled release of hazardous waste from a storage area has the potential to have a negative impact on the environment through contamination of soil, surface water and groundwater, and wildlife.

Accidental release of wastes could occur during the movement of materials on or off-site or through the use of inappropriate containers, overfilling, or container damage. The accidental release of wastes could contaminate the water, soils and air quality (in the case of volatile substances).

Waste storage areas are contained within the boundaries of the MPC industrial complex, and are therefore on hard-standing and within the contaminated water drainage system, thus accidental spills of hazardous material will be captured, and can be dealt with via operational spill control procedures.

Impact WM5 – Low Significance.

10.4.3 DECOMMISSIONING

The decommissioning of the Project facilities has the potential to impact waste management infrastructure in a similar way as during the construction period. The dismantling of the facility will produce both hazardous and non-hazardous wastes. Hazardous wastes will include decommissioned equipment and storage tanks and their contents. The decommissioning works will be undertaken by a variety of specialist waste contractors as required to demolish, handle, treat and dispose of demolition waste.

The continuing development of the Ras Al Khair peninsula is likely to lead to the establishment of an RC licensed waste management facility or number of facilities which will be able to accept waste produced during the decommissioning of the Project facilities.

The Waste Management Plan first developed for the construction phase will be updated to manage waste related to decommissioning to consider facilities that might then be available.

10.5 RECOMMENDATIONS

Potential negative impacts of medium or high significance from waste management are not anticipated to occur as a consequence of the Project construction, commissioning, operation or decommissioning phases.

Implementation of the following measures is recommended to manage the potential impacts identified as being of low significance and maintain good management practices. It is anticipated that this assessment can be built upon during detailed design when detailed Project requirements are realised.
10.5.1 CONSTRUCTION & COMMISSIONING

Impacts from waste arising from the construction of the facility will be mitigated through measures such as the following:

- A Waste Management Plan for defining how waste materials will be stored, handled and disposed of for the Construction Phase shall be developed as a supporting document to the Environmental Management and Monitoring Plan (EMMP). The Construction Waste Management Plan shall be continually monitored and re-evaluated to ensure the effectiveness of the plan is maintained.

- This Plan should consider the following:
  - All hazardous, non-hazardous, municipal and inert wastes to be stored, handled, transported, recycled, treated and disposed of as per RCER-2010.
  - Transportation regulations (particularly those relating to hazardous materials) published by the Ministry of Transportation shall be complied with.
  - A RC approved manifest to be prepared before any transportation of hazardous / non-hazardous wastes from site.
  - Minimise onsite waste storage times as much as practical (no longer than 180 days as per RCER-2010), and control access to stored wastes;
  - Hazardous substances (including wastes) to be stored in appropriate containers, in appropriately bunded and impervious secondary containment areas as detailed in the RCER 2010, Section 4.3.6.
  - Provision of appropriate training to employees involved in hazardous waste management on site.

- Undertake an audit in order to verify in detail if the selected waste management facility has the capacity to receive the necessary future quantities of waste and if it is able to accept the associated waste characteristics.

10.5.2 OPERATION

Updates to the Waste Management Plan and the EERP (as appropriate) should consider the potential impacts from wastes and spillages of wastes during operation, particularly those requiring control / management by RCER-2010 and the Ministry of Transportation (as noted above in Section 10.5.1). These Plans should be continually monitored and re-evaluated to ensure the effectiveness measures are maintained.

Specialist contractors will be used for handling and transporting the hazardous waste substances throughout the life-time of the Project. In the case of spent catalysts, the suppliers of the catalysts will often be used to remove the used catalysts.
# WATER QUALITY MANAGEMENT

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11.0 WATER QUALITY MANAGEMENT

11.1 INTRODUCTION

This Section discusses the potential impacts to the water environment and wastewater treatment facilities relevant to the Project site as a consequence of wastewater discharges from the construction, commissioning, operational and decommissioning phases of the Project. With specific reference to the marine environment, this section also considers the potential impacts associated with surface water run-off and accidental spillage associated with the proposed storage and loading / unloading activities at the Port area.

11.2 BASELINE CONDITIONS

11.2.1 INTRODUCTION

This section presents an overview of the baseline water quality desktop study conducted for the Project. The study reviewed available relevant literature in order to gather information about the regional surface and marine water quality. Groundwater resources are addressed in Section 7 Terrestrial Environment.

The Ras Al Khair Industrial City has been designed to accommodate a number of industrial facilities, including aluminium, phosphate processing facilities and other support plants, therefore studies undertaken for these facilities represent the primary source of information with regards baseline water quality and systems. The literature reviewed included the following:

- Feasibility Study Pre-Works of Umm Wu’al Project, Ma’aden Phosphate Company (SOFRECO, 2012);
- Seawater Sampling Results (2012) as commissioned by Ma’aden Phosphate Company;
- Environmental Baseline Study for proposed Ras Al Khair Port Project (Gulf Consult, 2011);
- Thermal Plume Dispersion Modelling, Ma’aden Phosphate Company (ERM, 2009);
- Ma’aden Aluminium Project, Environmental Impact Assessment (GHD, 2005) and Supplementary Environmental Impact Assessment Study (WHGME, 2010) for the Raz Az Zawr Aluminium Project;

11.2.2 SURFACE WATER

As a consequence of the Regional climatic conditions, there are no natural permanent or semi-permanent surface water bodies within or adjacent to the project site. A number of retention, evaporation and Irrigation Ponds are present, integrated into the existing site’s surface water and wastewater treatment network. Previous Environmental Impact Assessment (EIA) studies, including the Ma’aden Phosphate Project Supplementary EIA by GHD (2008) and the Ma’aden Aluminium Project Supplementary EIA by WHGME (2010) suggest that temporary ponding of surface water does occur in response to rainfall events. This is particularly prevalent in the coastal Sabka areas of the Ras Al Khair peninsula where ponded water can remain for several days or weeks depending on the duration of the rainfall event, the saturation of the soil and the height of the groundwater (WHGME, 2010). Areas of surface water may also form where there are active excavation works, where the high groundwater level is exposed.

Wastewater treated in the existing Sanitary Treatment Plant (STP) is discharged to a High Density Polyethylene (HDPE) lined Irrigation Pond (6,000 m$^3$). The normal flow of treated sanitary wastewater expected from the STP is 7m$^3$/hr under normal conditions, and 8.58m$^3$/hr under maximum conditions, over a 24 hour period. The Irrigation Pond also receives
neutralised wastewater from the existing Ammonia Plant and boiler blow down from the existing SAP and PDP auxiliary boiler. On compliance with RCER-2010 irrigation standards (Table 3D, RCER 2010 Volume I), this water is used for irrigation of the MPC complex. During winter when less water is required for landscaping, excess irrigation water overflows to the Evaporation Pond.

The Evaporation Pond is a HDPE lined open area pond which has been designed to accommodate treated SAP wash down water from the pH adjustment skid. The capacity of this pond is approximately 10,400m³, but the build-up of sludge periodically reduces this. A regular maintenance regime is in place to remove sludge from the pond which is pumped into a road tanker and transported to a Royal Commission (RC) licensed waste facility in Jubail.

A third pond, the Storm Water Retention Pond, receives storm water runoff from across the existing MPC facilities. This is located some distance from the other ponds, south of the existing administrative buildings. The Retention Pond ties-in to the RC sewer network to allow storm water to be discharged from site.

As reported in Section 8 Biological Resources, there is potential for bird species to utilise these ponds, but there are currently no records of this. The ecological value of the existing ponds is deemed to be very low, as they are purely managed as integral elements of the surface water and wastewater treatment networks. The nearest body of surface water that is considered to represent a sensitive environmental receptor to the site is the marine environment of the Gulf coast.

11.2.3 MARINE WATER

This section summarises the findings of previous studies that assessed elements of the marine environment adjacent to the project area. These include the Raz Az Zawr [Ras Al Khair] Aluminum Plant study by GHD in 2004, the Ras Al Khair Port Basin study by Gulf Consult in 2011, and the seawater sampling study conducted by Ma’aden Phosphate Company in 2012. As a consequence of the interaction between water quality and sediment quality, relevant sediment monitoring is also discussed.

The marine environment adjacent to the peninsular is typical of that found in the South Western region of the Gulf. The intertidal and subtidal areas are dominated by muds, sands and rock interspersed with areas of mangrove, seagrass and coral reef habitat. These habitats provide ideal spawning, nursery and foraging areas for a wide variety of invertebrate, fish and reptile species. The intertidal areas are also known to support a diverse array of birds, including internationally important migratory wading bird populations which overwinter in the Gulf during the Northern Hemisphere’s winter.

The quality and extent of these habitats along this section of coast varies depending on the existence and nature of any coastal development. Mangroves have not recorded around the peninsula, but areas of seagrass and live coral have been recorded offshore. The high average water temperatures and salinities preclude most coral species from establishing sustainable communities in the Gulf, but a few of the more tolerant species have adapted to the extreme conditions. Extreme coral bleaching events have resulted in a mosaic of dead and live coral across many of the reefs (GHD, 2005).

Although activities related to the construction, commissioning, operation and decommissioning of the storage, loading and unloading activities proposed at the port do not encroach on the marine environment, they will need to be planned / executed so as to minimise their potential for direct and indirect impact on the sensitive marine receptors outlined above.

Raz Az Zawr [Ras Al Khair] Aluminum Plant Marine Survey, GHD 2005

GHD undertook marine water quality and sediment sampling in 2004 to gather baseline data which facilitated impact assessment in the subsequent EIAs for the Aluminium and Phosphate projects (e.g. GHD, 2005, 2008; WHGME, 2010).

The water quality programme included physicochemical, chemical and bacteriological elements. Physicochemical parameters were measured at 16 beach sites around the RAK
The results of physiochemical monitoring are summarised in Table 11-1 below. All the measurements met with the RCER-2010 Ambient Water Quality Criteria for Coastal Waters, and were within the expected range for the Region and time of year.

**Table 11-1: Summary of the Physicochemical Measurements Recorded at Ras Al Khair (GHD, 2005)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>RAK Beach</th>
<th>RAK Reefs</th>
<th>RAK Dredge Channel (Proposed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Median</td>
<td>Max</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>26.17</td>
<td>28.71</td>
<td>30.00</td>
</tr>
<tr>
<td></td>
<td>27.27</td>
<td>27.29</td>
<td>27.33</td>
</tr>
<tr>
<td>Conductivity (mS/cm)</td>
<td>55.00</td>
<td>61.30</td>
<td>65.60</td>
</tr>
<tr>
<td></td>
<td>59.20</td>
<td>59.25</td>
<td>59.30</td>
</tr>
<tr>
<td>Salinity (ppt)</td>
<td>36.39</td>
<td>41.16</td>
<td>44.45</td>
</tr>
<tr>
<td></td>
<td>39.61</td>
<td>39.63</td>
<td>39.66</td>
</tr>
<tr>
<td>Dissolved Oxygen (% saturation)</td>
<td>4.30</td>
<td>5.40</td>
<td>5.70</td>
</tr>
<tr>
<td></td>
<td>5.00</td>
<td>5.10</td>
<td>5.10</td>
</tr>
<tr>
<td>pH</td>
<td>7.77</td>
<td>7.87</td>
<td>8.41</td>
</tr>
<tr>
<td></td>
<td>7.99</td>
<td>8.02</td>
<td>8.10</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>0.40</td>
<td>1.60</td>
<td>113.80</td>
</tr>
<tr>
<td></td>
<td>- 0.60</td>
<td>- 0.30</td>
<td>0.60</td>
</tr>
</tbody>
</table>

Water samples for chemical and bacterial analysis were collected from 11 locations along the beach frontage, and near to the proposed locations of the cooling water intakes and outfalls (now operational) between 12th and 17th of May 2004 (refer to Figure 11-1). The results of the water sample analyses are summarised in Table 11-2.
Figure 11-1: Water Sample Locations from the Arabian Gulf Coast north of the Project Site (Chemical and Biological Analysis) (GHD, 2005)
Table 11-2: Water Quality Analysis at Ras Al Khair – samples dated between 12th and 17th of May 2004 (GHD, 2005)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Unit</th>
<th>DL</th>
<th>Site WQ 1</th>
<th>Site WQ 2</th>
<th>Site WQ 3</th>
<th>Site WQ 4</th>
<th>Site WQ 5</th>
<th>Site WQ 6</th>
<th>Site WQ 7</th>
<th>Site WQ 8</th>
<th>Site WQ 9</th>
<th>Site WQ 10</th>
<th>Site WQ 11</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Metals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td>mg/L</td>
<td>0.1</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Arsenic</td>
<td>mg/L</td>
<td>0.001</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Cadmium</td>
<td>mg/L</td>
<td>0.005</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Cobalt</td>
<td>mg/L</td>
<td>0.005</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Chromium</td>
<td>mg/L</td>
<td>0.02</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Copper</td>
<td>mg/L</td>
<td>0.01</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Iron</td>
<td>mg/L</td>
<td>0.05</td>
<td>0.11</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Manganese</td>
<td>mg/L</td>
<td>0.01</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Nickel</td>
<td>mg/L</td>
<td>0.01</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Lead</td>
<td>mg/L</td>
<td>0.05</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Antimony</td>
<td>mg/L</td>
<td>0.05</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Zinc</td>
<td>mg/L</td>
<td>0.01</td>
<td>0.01, 0.01, 0.01</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Mercury</td>
<td>mg/L</td>
<td>0.001</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td><strong>Coliforms</strong></td>
<td>CFU</td>
<td></td>
<td>1</td>
<td>ND</td>
<td>4</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>--</td>
<td>ND</td>
<td>ND</td>
<td>39</td>
<td>ND</td>
</tr>
<tr>
<td>Total Coliform</td>
<td>CFU</td>
<td>1</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>--</td>
<td>ND</td>
<td>ND</td>
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<td>ND</td>
</tr>
<tr>
<td>Faecal</td>
<td>CFU</td>
<td>1</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>--</td>
<td>ND</td>
<td>ND</td>
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<td>ND</td>
</tr>
<tr>
<td>Enterococci</td>
<td>CFU</td>
<td>1</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>--</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td><strong>Total petroleum hydrocarbons (TPH)</strong></td>
<td>µg/L</td>
<td>0.001</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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<td>ND</td>
<td>1.389</td>
<td>ND</td>
</tr>
<tr>
<td>C5-C10</td>
<td>µg/L</td>
<td>0.25</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>C11-C28</td>
<td>µg/L</td>
<td>2</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>t-C28</td>
<td>µg/L</td>
<td>0.001</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Benzene, toluene, ethylbenzene &amp; xylene</td>
<td>BTEX</td>
<td>µg/L</td>
<td>0.001</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Polyaromatic hydrocarbons</td>
<td>PAH</td>
<td>µg/L</td>
<td>0.5</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
</tbody>
</table>

Notes: DL – Detection Limit / ND – not detected

Overall, the chemical and bacteriological analysis results were below the limits detailed in the RCER 2010 Ambient Water Quality Criteria for Coastal Waters. Low levels of zinc (Zn) were recorded at all sites, and iron (Fe) was recorded at sites 1 (0.11 mg/L) and 10 (0.21 mg/L). The zinc concentrations observed (0.01mg/L - 0.03mg/L) were considered elevated background conditions and indicative of a moderately disturbed environment (GHD, 2005). The absence of discrete discharges containing zinc near the site, and the broad spatial distribution in terms of the results, suggested that the source of the zinc contamination within the marine environment may be the result of atmospheric deposition associated with industrial facilities located in the region.

In terms of TPH analysis, the results for all fractions were at non-detectable levels at all sites, except for C5-C10 (light gasoline fraction) at sampling site 10 (1.389 µg/L). In the absence of obvious discharges, possible explanations for this result include contamination from the hydrocarbon pollution legacy that remains in the region from the first Gulf War (GHD, 2005), or more likely from offshore oil production or incidental discharges from passing vessels (Literathy et al., 2002).

In addition to the water samples, sediment samples were obtained and analysed to assess baseline concentrations of TPH. Samples were collected at 10 sites along the beach frontage of the project site between 12th and 17th of May 2004 (exact locations are not provided within Gulf Consult (2005), but assumed to be located at or adjacent to the water sampling locations WQ1 – WQ10). The results of analysis are summarised in Table 11-3.
The results of the TPH analysis indicate that the sediments sampled were heavily contaminated with the heavy TPH fraction (>C28). The results concur with previous studies and confirm the notion that a contamination legacy resulting from oil pollution from the first Gulf War still remains (SAPC, 2005; GHD, 2008).

Marine sediments are known to act as sinks for many marine pollutants, including petroleum hydrocarbons and other oil derived chemical compounds. These are known to be widely distributed within the sediments of the Arabian Gulf region (Literathy, 2002). An arbitrary classification system of oil derived pollution levels in sediments based on hydrocarbon content was developed for the Arabian Gulf (Literathy, 2002). The classification system is as follows:

- Unpolluted - 10 – 15 mg/kg hydrocarbon content
- Slightly polluted - 15 – 50 mg/kg hydrocarbon content
- Moderately polluted - 50 – 200 mg/kg hydrocarbon content
- Heavily polluted - > 200 mg/kg hydrocarbon content

Literathy (2002) found moderate to heavy contamination in seven areas in the North and Southern parts of the Arabian Gulf. Diesel and heavy fraction hydrocarbons (> C 23- oils and greases) were found at high levels in the sediments, whilst the lighter fraction hydrocarbon compounds (C6-C9) contributed very little to sediment loading. It was suggested that the probable sources for these high levels of pollution included offshore and onshore oil production facilities, industrial effluents from onshore industry, tanker ballast water and oil spills (Literathy, 2002).

Ras Al Khair Port Thermal Plume Dispersion Modelling, ERM 2009

Ma’aden Phosphate Company commissioned a thermal plume dispersion modelling study to assess a number of scenarios for a thermal discharge in the vicinity of the Ras Al Khair Port area. Detailed 3-dimensional (3-D) hydrodynamic modelling was undertaken of four discharge scenarios using a thermal plume discharge of 125,000 m³ per hour at a constant temperature of 6 or 8 °C above typical summer and winter conditions.

As was expected, the output of the modelling indicated that maximum water temperature and the probability of temperature increases changed with season and discharge temperature. In addition, a preliminary evaluation of potential sedimentation rates in the harbour area showed that there would be minimal erosion and accretion for a 50 micron sediment particle size (ERM, 2009).
Ras Al Khair Port Baseline Study, Gulf Consult 2011

The purpose of the study was to establish baseline data for water quality and sediment quality within the port basin area. The sampling programme entailed collection of physiochemical data and sediment samples at 12 sites located at 500m intervals within the port basin area (refer to Figure 11-2). The insitu physiochemical data are summarized in Table 11-4 below. All of the measurements recorded were below the limits detailed in the RCER 2010 Ambient Water Quality Criteria for Coastal Waters and were within the range expected for the region and time of year.

Figure 11-2: Water and Sediment Sampling Locations (Ras Al Khair Port Baseline Study, Gulf Consult 2011)
### Table 11-4: Physiochemical Measurements from Ras Al Khair Port, 2011

<table>
<thead>
<tr>
<th>Parameter</th>
<th>DL</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>S6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity (NTU)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Temp °C</td>
<td>32.6</td>
<td>32.8</td>
<td>32.9</td>
<td>32.9</td>
<td>35.1</td>
<td>32.8</td>
<td></td>
</tr>
<tr>
<td>Conductivity ms/cm</td>
<td>64.5</td>
<td>64.3</td>
<td>64.3</td>
<td>64.7</td>
<td>64.4</td>
<td>63.7</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>7.6</td>
<td>7.5</td>
<td>7.5</td>
<td>7.5</td>
<td>7.5</td>
<td>7.9</td>
<td>7.9</td>
</tr>
<tr>
<td>Dissolved oxygen mg/l</td>
<td>4.5</td>
<td>4.2</td>
<td>4.2</td>
<td>4.2</td>
<td>4.2</td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>Chlorine residual mg/l</td>
<td>0.02</td>
<td>0.03</td>
<td>0.04</td>
<td>0.03</td>
<td>0.03</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Oil and grease Total mg/l</td>
<td>&lt;1.4</td>
<td>&lt;1.4</td>
<td>&lt;1.4</td>
<td>&lt;1.4</td>
<td>&lt;1.4</td>
<td>&lt;1.4</td>
<td></td>
</tr>
<tr>
<td>VOCs µg/L</td>
<td>10 µg/L</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&lt;10</td>
</tr>
</tbody>
</table>

### Parameter

| Turbidity (NTU) | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Temp °C         | 32.5| 32.6| 32.1| 32.2| 32.3| 32.6| 32.6|
| Conductivity ms/cm | 63.8| 63.9| 64.3| 63.8| 63.9| 63.8| 63.8|
| pH              | 8.1 | 8.2 | 8.2 | 8.2 | 8.2 | 8.2 | 8.2 |
| Dissolved oxygen mg/l | 4.7 | 4.8 | 4.8 | 4.7 | 4.7 | 5.0 |
| Chlorine residual Total mg/l | 0.03 | 0.04 | 0.05 | 0.02 | 0.03 | 0.02 |
| Oil and grease Total mg/l | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 | <1.4 |
| VOCs µg/L       | 10 µg/L | <10 | <10 | <10 | <10 | <10 | <10 |

The results of the sediment analysis showed there to be negligible levels of oil/grease and volatile organic compound (VOCs). The results of the heavy metal analysis are detailed in Table 11-5 below. The results indicated high levels of Chromium (Cr), and elevated levels of Cadmium (Cd) and Lead (Pb) contamination, although the source of this contamination was unconfirmed. The report suggested that the regular dredging activity in the area may be linked to contaminant mobilisation and availability, but did not provide a potential source for the original contamination.

### Table 11-5: Heavy Metal Concentrations in Sediments (Gulf Consult, 2011)

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>DL</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic, mg/Kg</td>
<td>0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Cadmium, mg/Kg</td>
<td>0.1</td>
<td>0.3</td>
<td>0.28</td>
<td>0.16</td>
<td>0.19</td>
<td>0.17</td>
<td>0.23</td>
<td>0.2</td>
</tr>
<tr>
<td>Chromium, mg/Kg</td>
<td>0.1</td>
<td>22.04</td>
<td>20.31</td>
<td>4.59</td>
<td>5.62</td>
<td>7.01</td>
<td>25.08</td>
<td>22.31</td>
</tr>
<tr>
<td>Mercury, mg/Kg</td>
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<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Lead, mg/Kg</td>
<td>0.1</td>
<td>1.26</td>
<td>1.16</td>
<td>0.57</td>
<td>0.62</td>
<td>0.71</td>
<td>1.31</td>
<td>1.39</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>DL</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic, mg/Kg</td>
<td>0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Cadmium, mg/Kg</td>
<td>0.1</td>
<td>0.48</td>
<td>0.51</td>
<td>0.25</td>
<td>0.47</td>
<td>0.27</td>
<td>0.29</td>
<td>0.13</td>
</tr>
<tr>
<td>Chromium, mg/Kg</td>
<td>0.1</td>
<td>37.55</td>
<td>34.56</td>
<td>23.14</td>
<td>35.46</td>
<td>20.14</td>
<td>21.48</td>
<td>11.24</td>
</tr>
<tr>
<td>Mercury, mg/Kg</td>
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<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Lead, mg/Kg</td>
<td>0.1</td>
<td>2.97</td>
<td>3.12</td>
<td>1.35</td>
<td>2.89</td>
<td>1.11</td>
<td>1.54</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Notes: DL – Detection Limit
Ma’aden Phosphate Company Seawater Sampling, 2012

As part of an operational environmental monitoring programme, Ma’aden Phosphate Company conducted water quality sampling at 5 locations adjacent to the existing facility, including the:

- Power and Utilities Return Water (PAU)
- Ammonia Plant Return Water (AMP)
- SAP Return Water (SAP)
- Seawater After Channel (SAC #1)
- Seawater After Channel (SAC #2)

The results of the analysis are detailed in Table 11-6. All results were within the maximum allowable limits for direct discharge to coastal waters (RCER 2010), although both of the seawater channel samples failed to meet the RCER 2010 Ambient Coastal Water Quality limit for turbidity.

The heavy metals analysis results are detailed in Table 11-7. All of the samples were compliant with the RCER 2010 direct discharge limits, although 4 sites (PAU, AMP, SAP and SAC #1) failed to meet the ambient coastal water criteria for aluminium.
### Table 11-6: Seawater Sampling (2012) Results Compared with RC Ambient Water Quality Criteria (Table 3A RCER 2010) and Water Quality Standards for Direct Discharge to Coastal Waters (Table 3C RCER 2010)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MDL</th>
<th>Unit</th>
<th>PAU Sample 1</th>
<th>AMP Sample 2</th>
<th>SAP Sample 3</th>
<th>Seawater After Channel Sample 4</th>
<th>Sample 5</th>
<th>Table 3A RCER 2010 Ambient Coastal Water Quality Max Red Sea &amp; Arabian Gulf</th>
<th>Table 3C RCER 2010 Direct Discharge to Coastal Waters Max Allowable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>0.1</td>
<td>°C</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>5</td>
<td>75 Jubail</td>
</tr>
<tr>
<td>Turbidity</td>
<td>0.1</td>
<td>NTU</td>
<td>2.14</td>
<td>4.18</td>
<td>4.48</td>
<td>5.16</td>
<td>5.42</td>
<td>8.12</td>
<td>8.12</td>
</tr>
<tr>
<td>Total Suspended Solids</td>
<td>&lt;1</td>
<td>mg/L</td>
<td>1.33</td>
<td>2</td>
<td>2.67</td>
<td>1.33</td>
<td>5</td>
<td>7.8 – 8.5</td>
<td>6-9</td>
</tr>
<tr>
<td>pH</td>
<td>8.11</td>
<td>pH</td>
<td>8.06</td>
<td>8.06</td>
<td>8.12</td>
<td>8.12</td>
<td>8.12</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Cyanide</td>
<td>0.01</td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Fluoride</td>
<td>0.002</td>
<td>mg/L</td>
<td>0.34</td>
<td>0.33</td>
<td>0.39</td>
<td>0.31</td>
<td>0.41</td>
<td>1.5</td>
<td>25</td>
</tr>
<tr>
<td>Nitrate as N</td>
<td>0.02</td>
<td>mg/L</td>
<td>0.31</td>
<td>0.39</td>
<td>0.36</td>
<td>0.61</td>
<td>0.42</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Total Ammonia as N</td>
<td>0.03</td>
<td>mg/L</td>
<td>0.03</td>
<td>0.23</td>
<td>0.2</td>
<td>0.03</td>
<td>0.06</td>
<td>1.2</td>
<td>3.0</td>
</tr>
<tr>
<td>Hydrogen Sulfide</td>
<td>0.02</td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Total Organic Carbon</td>
<td>0.25</td>
<td>mg/L</td>
<td>3.82</td>
<td>3.31</td>
<td>3.27</td>
<td>2.86</td>
<td>2.85</td>
<td>10</td>
<td>75</td>
</tr>
<tr>
<td>Floating Particles</td>
<td>1.0</td>
<td>mg/L</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
<td>1</td>
<td>1 Nil</td>
</tr>
<tr>
<td>BOD</td>
<td>2.0</td>
<td>mg/L</td>
<td>4.1</td>
<td>4.1</td>
<td>3.94</td>
<td>4.12</td>
<td>4.35</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>COD</td>
<td>2.0</td>
<td>mg/L</td>
<td>14.2</td>
<td>14.3</td>
<td>15.69</td>
<td>13.9</td>
<td>14.39</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Chlorinated carbons</td>
<td>--</td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.01</td>
<td>0.5</td>
</tr>
<tr>
<td>Chlorine Residual</td>
<td>0.02</td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.05</td>
<td>0.3</td>
</tr>
<tr>
<td>Chromium (Hexavalent)</td>
<td>0.02</td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Oil &amp; Grease</td>
<td>1</td>
<td>mg/L</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
<td>&lt;1.0</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Oxygen Dissolved</td>
<td>0.1</td>
<td>mg/L</td>
<td>7.88</td>
<td>7.68</td>
<td>7.69</td>
<td>7.84</td>
<td>7.77</td>
<td>5 (min)</td>
<td>2.0</td>
</tr>
<tr>
<td>Phenols</td>
<td>0.01</td>
<td>mg/L</td>
<td>0.07</td>
<td>0.12</td>
<td>0.06</td>
<td>0.07</td>
<td>0.09</td>
<td>0.12</td>
<td>1</td>
</tr>
<tr>
<td>Phosphorus Total as P</td>
<td>0.01</td>
<td>mg/L</td>
<td>0.093</td>
<td>0.185</td>
<td>0.13</td>
<td>0.149</td>
<td>0.175</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Salinity</td>
<td>0.1</td>
<td>g/L</td>
<td>39.4</td>
<td>39.4</td>
<td>39.1</td>
<td>39.1</td>
<td>40.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Kjeldahl Nitrogen</td>
<td>0.2</td>
<td>mg/L</td>
<td>0.34</td>
<td>0.62</td>
<td>0.56</td>
<td>0.43</td>
<td>0.48</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>PAH Total</td>
<td>0.0003</td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Total Coliform Count</td>
<td>1</td>
<td>CFU/100mL</td>
<td>ND</td>
<td>4</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>54</td>
<td>2400 MPN/100ml</td>
</tr>
</tbody>
</table>

Notes: For detailed assessments of the quality coastal shellfish harvesting and recreational waters, the units quoted for measuring coliforms; CFU (colony forming unit) and MPN (most probably number) of CFUs in a given sample volume are not generally directly comparable as the former is a definitive value, where the latter is an estimate of probability. However, at for this assessment, the CFU value provides a good indication of compliance with the MPN standard.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>MDL</th>
<th>Unit</th>
<th>PAU Sample 1</th>
<th>AMP Sample 2</th>
<th>SAP Sample 3</th>
<th>Seawater After Channel</th>
<th>Sample 4</th>
<th>Sample 5</th>
<th>Table 3A RCER 2010 Ambient Coastal Water Quality Max Red Sea &amp; Arabian Gulf</th>
<th>Table 3C RCER 2010 Direct Discharge to Coastal Waters Max Allowable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium (Al)</td>
<td>0.0001</td>
<td>mg/L</td>
<td>0.0849</td>
<td>0.053</td>
<td>0.0535</td>
<td>0.0538</td>
<td>0.0486</td>
<td>0.05</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Arsenic (As)</td>
<td>0.0001</td>
<td>mg/L</td>
<td>0.0014</td>
<td>0.0014</td>
<td>0.0013</td>
<td>0.0015</td>
<td>0.0016</td>
<td>0.05</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Barium (Ba)</td>
<td>0.0001</td>
<td>mg/L</td>
<td>0.008</td>
<td>0.0092</td>
<td>0.0099</td>
<td>0.0105</td>
<td>0.0128</td>
<td>1</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Cadmium (Cd)</td>
<td>0.0001</td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.005</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Chromium (Cr)</td>
<td>0.0001</td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.1</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Cobalt (Co)</td>
<td>0.0001</td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.05</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>0.0001</td>
<td>mg/L</td>
<td>0.0017</td>
<td>0.0027</td>
<td>0.0019</td>
<td>0.002</td>
<td>0.002</td>
<td>0.015</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>0.0001</td>
<td>mg/L</td>
<td>0.0449</td>
<td>0.0466</td>
<td>0.0879</td>
<td>0.0374</td>
<td>0.0422</td>
<td>1</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>0.0001</td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.01</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>0.0001</td>
<td>mg/L</td>
<td>0.0053</td>
<td>0.0074</td>
<td>0.0024</td>
<td>ND</td>
<td>ND</td>
<td>0.05</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Mercury (Hg)</td>
<td>0.0001</td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.0001</td>
<td>0.005</td>
<td></td>
</tr>
<tr>
<td>Nickel (Ni)</td>
<td>0.0001</td>
<td>mg/L</td>
<td>0.0013</td>
<td>0.0015</td>
<td>0.0013</td>
<td>0.0011</td>
<td>0.0009</td>
<td>0.1</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>0.0001</td>
<td>mg/L</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>0.1</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
11.2.4 OVERALL BASELINE CONDITIONS

The water quality of the adjacent marine environment is of a relatively good quality, although there are indications that low level hydrocarbon pollution incidents do occur, most probably as a result of unlicensed ballast water and fuel discharges from commercial vessels in the area.

The wider area also suffers from a legacy of hydrocarbon pollution from the first Gulf War. This pollution exists within the sediments, and when disturbed, for example during dredging or other activities that result in the mobilisation of the sediment, this can pose a threat to the surrounding water quality. The level of contamination in the sediments appears to vary spatially, with the highly impacted areas probably reflecting the prevailing depositional / accumulation patterns within the area.

Although no natural, permanent surface water bodies are present in the project area, storm water ditches and channels flood during periods of heavy rainfall. If utilised as part of the surface water drainage system for the new Project, these will provide a direct pathway to the marine environment for any contamination discharged.

11.3 IMPACT ASSESSMENT

11.3.1 INTRODUCTION

Activities will be undertaken during the construction, commissioning, operational and decommissioning phases of the project that have the potential to impact the quality of the surface water resources on/or adjacent to the Project site. Anticipated discharges associated with these activities during each of these phases, together with the potential impacts are assessed in the section.

The potential significance of any predicted impacts has been assessed with reference to the methodology presented in Section 5 Impact Assessment Methodology.

11.3.2 CONSTRUCTION PHASE

The following construction-related activities have the potential to impact upon water environment and / or wastewater treatment facilities relevant to the Project site:

- Equipment wash water and concrete preparation;
- Storm water run-off;
- Delivery of oversized equipped via shipping channels; and
- Sanitary wastewater discharge.

Potential unmitigated impacts on water quality due to the activities listed above are summarised in Table 11-8 and discussed in the following text.

Table 11-8: Construction Phase Impact Assessment

<table>
<thead>
<tr>
<th>Factor</th>
<th>WQ1</th>
<th>WQ2</th>
<th>WQ3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Frequency</td>
<td>Infrequent</td>
<td>Rare</td>
<td>Rare</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Likely</td>
<td>Unlikely</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Duration</td>
<td>Short</td>
<td>Short</td>
<td>Short</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
<td>Direct</td>
<td>Indirect</td>
</tr>
<tr>
<td>Significance</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>
11.3.2.1 DEGRADATION OF COASTAL WATER QUALITY DUE TO CONSTRUCTION-RELATED SURFACE WATER RUNOFF / ACCIDENTAL SPILLS

Temporary site drainage systems will be designed and constructed at each development plot to collect uncontaminated surface water. Site ground levels at the construction areas will be sloped so that a gradient is formed to direct surface water to construction collection pits/channels at the site perimeters. Uncontaminated surface water collected will be directed to RC perimeter storm water ditches and the existing surface water Retention Pond until the new Retention Pond is constructed and available for use.

Drainage from car and truck parking areas and any maintenance or fuelling areas has the potential to adversely impact receiving water if not contained, collected by a separate system and treated via an oily water drainage systems.

Construction plant and equipment will require wash down during the construction phase to help reduce dust emissions and cement truck washdown. Wash water resulting from these activities may be contaminated and if discharged without treatment has the potential to increase the pH and suspended solids levels in any receiving water body.

Similarly, hazardous substances used, stored and transported on site during the construction phase have the potential to impact the water environment if a pathway is present/created. Accidental release of such substances to the surface water drainage system or at the Port’s edge can pose a significant risk to the water environment.

Impact WQ1 – Medium Significance

11.3.2.2 DEGRADATION OF COASTAL WATER QUALITY DUE TO CONSTRUCTION-RELATED SHIPPING

King Abdul Aziz Port in Dammam will be used for the import of some construction equipment and materials, however where oversized equipment cannot travel inland to the Project site from Dammam, barges will operate from Dammam Port to Ras Al Khair Port. As these loads are expected to be large inert materials such as structural steel, tank materials, and modular components of the new facilities, no significant marine environmental impact generated by direct spills to sea in the unloading of barges or during transportation of the construction equipment is foreseen.

Dredging works are not anticipated for this transport as existing shipping lanes can be used.

The Port is currently operated by the Saudi Ports Authority (SEAPA) and regulated in part by the RC which is responsible for controlling pollution associated with the development and operation of the industrial city. Any ship movements will therefore be required to comply with RCER-2010 clause 3.10 and the standards outlined in Table E with regards ballast water in addition to Port Authority requirements.

The likelihood of a pollution event associated with the additional movement of shipping vessels for oversized equipment during the construction phase of this project is considered to be low. However, if a fuel spill occurred, the magnitude of this impact is predicted to be medium in nature.

In accordance with the requirements of the IFC Environmental, Health and Safety Guidelines for Ports, Harbours and Terminals (IFC, 2007), the International Convention for the Prevention of Pollution from Ships (MARPOL) and national legislation, SEAPA as the Port operator, will provide appropriate ‘collection, storage and transfer and/or treatment services and facilities of sufficient capacity and type for all wastewater generated by vessels at the port’ (IFC, 2007).

Impact WQ2 – Low Significance

11.3.2.3 IMPACT OF CONTAMINATED WATER ON WASTEWATER SYSTEMS - CONSTRUCTION

No significant impacts on the existing wastewater system are expected as the existing STP and associated Irrigation Pond have sufficient capacity and control measures to manage this wastewater stream during the construction phase.
Depending on the construction area location, sanitary wastewater produced will be collected and either piped/pumped (ammonia plant area) to the existing central STP or collected and transported via tanker to the STP (all other areas).

The use of tankers to transport sanitary wastewater to the STP introduces the potential for contamination of surface water (via the drainage system) from leaks of overflowing tanks, or from spillages during transfer of wastewater from the collection tanks. The significance of such an impact is not predicted to be high as this would be a rare occurrence of very short duration. Contamination of the surface water system with untreated sanitary wastewater would be restricted to the surface water Retention Pond at which point water can be prevented from discharge to sea.

Potentially contaminated wastewaters may also arise from construction activities such as, but not limited to, concrete washes (high alkaline), wheel washes (high sediments), and other equipment/vehicle cleaning activities (potentially containing detergents). This wastewater will not be allowed to infiltrate groundwater or be discharged to the storm water system. All construction wastewaters will be contained, stored and disposed of as per RCER-2010.

**Impact WQ3 – Low Significance**

11.3.2.4 IMPACT OF DEWATERING ACTIVITIES – DISCHARGE TO SEA

Due to the shallow depth to groundwater on the Project site, construction activities are likely to involve dewatering of excavations. Subsequent discharge of this water to the sea may be adopted as a disposal route. As reported in Section 7 – *Terrestrial Environment*, based on the available information, the water currently exceeds the quality criteria for direct discharge for a number of determinants and therefore has the potential to negatively impact on the coastal waters and associated sensitive ecological receptors. This impact is considered to be of high significance.

As this impact is captured within Section 7 of this ESIA (Impact TE3), it is not recorded further within this Section.

11.3.3 COMMISSIONING PHASE

The main activities during the pre-commissioning and commissioning phase which may potentially impact water quality will be the hydrotesting of pipelines and tanks, and the flushing and cleaning of pipelines.

Potential unmitigated impacts on water quality and wastewater treatment due to these activities are summarised in Table 11-9 and discussed in the following text.

**Table 11-9: Commissioning Phase Impact Assessment**

<table>
<thead>
<tr>
<th>Factor</th>
<th>WQ4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
<td>Medium</td>
</tr>
<tr>
<td>Frequency</td>
<td>Infrequent</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Likely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
</tr>
<tr>
<td>Duration</td>
<td>Short</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Medium</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Medium</td>
</tr>
</tbody>
</table>

Hydrotesting of pipelines, tanks and vessels will be conducted using fresh (desalinated) process water in order to meet quality criteria needed for this activity and to avoid corrosion damage to the equipment prior to start-up. In particular, tanks filled to a preset level, will be required to maintain this load state for a certain period of time before being drained.
The water used during hydro-testing has the potential to collect some contaminants from the pipes, such as oils or chemicals used to treat the pipes or tanks, as well as sediments. The need for chemical treatment of this water (e.g. biocides and corrosion inhibitors) will be determined by the FEED / EPC Contractor as this will depend on the water analysis and the duration the water is required to remain in the pipelines or tanks.

The volume of water to be used during hydrotesting activities is not available at this stage, but due to the number of proposed storage tanks and extent of proposed pipe systems, a large volume is anticipated (e.g. the capacity of the storage tanks within the Materials Storage and Handling Area is estimated to be over 63,000 m$^3$). Discharge of hydrotest wastewater is not permitted to sea or to the Irrigation Pond if analysis fails to determine compliance with RC standards. The available capacity of the existing Evaporation Pond has yet to be confirmed, but it is unlikely that this will be able to accept the full volume of hydrotest water in a condensed time period.

If phased discharges to the Evaporation Pond are deemed feasible, this can be used for evaporation, sediment settlement and biocide degradation (if used). This pond does not connect to any downstream drainage points and therefore impacts to the surface water system or marine environmental are negligible. The sludge from the pond is currently pumped into a road tanker and transported to a RC licensed waste facility in Jubail.

Use of the Evaporation Pond may adversely influence its use by other users on site and reduce its capacity to respond to an emergency situation within the MPC Complex.

As an alternative to the use of the Evaporation Pond, once the new wastewater sumps/tanks have been hydrotested, these may be used to hold hydrotest water while water quality analysis is conducted to determine its suitability for discharge to the Retention Pond. Premature release of this water to the Retention Pond has potential to adversely impact on the quality of the water stored here.

Pre-treatment of the cooling tower prior to operation is also important to reduce fouling and corrosion. Construction-related debris and oil films present as a result of equipment fabrication will need to be removed by flushing the system with water and cleaning fluids (generally alkaline) Also, corrosion inhibitors associated with passivation of the metal surfaces throughout the cooling system may be collected in cleaning / start-up water discharges which will have an increased pH. This wastewater stream has the potential to impact on receiving water bodies if adequate water quality control measures are not implemented.

Wastewater failing to achieve irrigation and/or discharge standards will be transported to the Jubail Industrial Wastewater Treatment Plant (subject to meeting RCER-2010 pre-treatment standards).

**Impact WQ4 – Medium Significance**

11.3.4 OPERATIONAL PHASE

The new facilities have been designed to minimise the use and discharge of water, thereby reducing the requirements for wastewater treatment and the impacts associated with land-based or marine discharges.

Section 4 *Detailed Description and Layout of the Proposed Development* details the wastewater streams expected during the operational phase the Project and these are summarised below.

The potential operational wastewater discharges (direct and indirect) to coastal water can be summarised as:

- Demineralisation Plant regeneration water (or alternatively to the Irrigation Pond);
- Cooling tower blowdown;
- Cooling water closed loop drain down from Ammonia Plant (infrequent); and
• Surface water run-off or accidental spillage associated with storage and loading / unloading activities at the Port.

Wastewater systems which may be utilised to manage operational wastewater include:

• Existing Sanitary Wastewater Treatment Plant (on-site).
• New Ammonia Plant Evaporation Pond:
  • MDEA washing and scrubber blowdown.
• Existing Irrigation Pond:
  • Treated process area storm water, oily water and fire water complying with irrigation standards;
  • Demineralisation Plant regeneration water (or alternatively to sea); and
  • Treated sanitary wastewater.
• Off-site Industrial Wastewater Facility (e.g. Jubail):
  • Treated process area storm water, oily water and fire water which does not comply with irrigation standards; and
  • Central laboratory waste streams (as per existing arrangements).

Non-contaminated storm water will be collected in an appropriately designed surface water system and will be either used in the treatment of process area storm water and demineralised water regeneration effluents, or discharged via the clean storm water network to the new HDPE-lined Retention Pond and RC storm water ditch network. The risk of contamination from the clean surface water is considered to be negligible and therefore not assessed further.

Potential unmitigated impacts on water quality due to the above activities are summarised in Table 11-10 and discussed in the following text.

### Table 11-10: Operational Phase Impacts Assessment

<table>
<thead>
<tr>
<th>Factor</th>
<th>WQ5</th>
<th>WQ6</th>
<th>WQ7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Frequency</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Unlikely</td>
<td>Unlikely</td>
<td>Likely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
<td>Local</td>
<td>Local</td>
</tr>
<tr>
<td>Duration</td>
<td>Short</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
<td>Negative</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
</tr>
</tbody>
</table>

11.3.4.1 DEGRADATION OF COASTAL WATER QUALITY DUE TO DIRECT DISCHARGES

**Sea Water Closed Looped Cooling Tower System Blowdown**

To manage the concentration of dissolved solids in the cooling tower water, a portion of the water is drawn off / blown-down and discharged. It is proposed that approximately 1,500m³/hour blowdown wastewater will be collected and discharged to the Gulf via the existing cooling water sea water return stream. As cooling tower blowdown water is non-contact cooling water, it is generally of good quality with slightly elevated dissolved solid levels and an elevated temperature. However, due its salinity and concentrated mineral characteristics, it is not suitable for irrigation purposes.
The chemical characteristics of this water will be required to meet the standards as detailed in RCER 2010 (Table 3C) prior to discharge in the cooling water return stream. In addition, and in accordance with RCER 2010, Ma’aden will implement monitoring programmes for biological components (weekly) and Legionella bacteria (monthly) for the tower circulating and effluent water as well as any wastewater settled in the basin of the tower during turnaround time.

As a consequence of the relatively low volume of blowdown water anticipated during the operational phase and the large dilution factor within the existing cooling water return (blowdown water equates to approximately 1.24% of the existing cooling water return of 120,596 m³/hr), it was concluded that modelling the impact on the existing thermal plume would not be necessary. The dilution factor involved with the variance discharge is so great, that any potential impact will be of a low significance.

**Closed Loop Cooling Water System Drain Down**

Closed loop fresh cooling water will need to be collected from various coolers in the system (with a complete system draining for any maintenance/cleaning events). This water is generally of high quality (demineralised water) but may include some concentrations of corrosion inhibitors.

The volume and method of collection and treatment of the drawdown liquor will be confirmed by the FEED / EPC Contractor, but at present this is proposed as a series of drain sumps to collect the water from various coolers with provision for either disposal or pumping back to a buffer storage (for reuse). Discharge to sea (or disposal to a treatment facility) is unlikely and will only be permitted if the RCER-2010 standards are met and therefore the magnitude of impact on the coastal waters is considered to be low.

**Impact WQ5 – Low Significance**

11.3.4.2 DEGRADATION OF COASTAL WATER QUALITY DUE TO ACCIDENTAL SPILLS / RUNOFF

The liquid product (ammonia, PPA and MGA) loading area at the Port will be constructed as a contained impervious area with a dedicated drainage system to a sump. In the event of a spill, the contents of the sump will be transferred offsite via tanker for treatment and disposal.

Although rare in the Project area, extreme coastal weather conditions can disrupt the planned movement of the liquid loading arms and their discharge points on the ship, presenting a risk of spillage. However similar bunded loading areas will be provided by the ships and therefore spill to the sea at the berth is unlikely.

In the event of a spill from the ammonia loading arm, ammonia released will likely become gaseous before reaching the ground / drainage system, however this presents a significant occupational health and safety issue requiring appropriate mitigation/management (refer to Section 12 Health and Safety Aspects).

Potash is an alkaline material and if spilled in large quantities into the Gulf, it may have localised impacts on the pH of the marine water. Such spillage of potash however is unlikely to occur as the material will be transferred from ship directly overland to a conveyor and storage building. Section 6 Air Quality and Meteorology did not identify significant fugitive dust emissions from this activity, therefore the likelihood of significant impacts associated with windblown material is considered to be very low.

SEAPA (and/or other designated port operators) will provide spill prevention, control and emergency response procedures covering accidental events at the Port. This will include the identification of areas of the port sensitive to spills and releases of hazardous materials and responsibilities for managing and implementing such procedures. As the Port extension will be commissioned to service the increase in ship traffic resulting from the Project, SEAPA’s procedures will soon expand where necessary to support the proposed loading/unloading activities. Lack of appropriate consultation with SEAPA may reduce the effectiveness of Project-specific procedures and as such increase the risk of spills to the marine environment.

Firewater is likely to contain pollutants toxic to marine life if discharged to sea. However, the potential for runoff of firewater to the coast is considered to be low as this will be collected from the process and port areas by the contaminated surface water system and drained.
through a series of channels to sumps. If monitoring concludes this water does not achieve the RCER-2010 irrigation standards, the contaminated water will be transported by tanker off-site to an appropriate industrial waste water treatment plant (e.g. at Jubail Industrial City).

Overall, the potential for spills and/or contaminated surface water from the port area to discharge to the coastal waters is considered unlikely, however these activities will take place regularly throughout the Project life and the magnitude of such an impact if it is realised is assessed as ‘medium’.

Impact WQ6 – Medium Significance

11.3.4.3 IMPACT OF CONTAMINATED WATER ON WASTEWATER SYSTEMS - OPERATIONS

In the absence of an industrial wastewater facility at Ras Al Khair, process area water collected within the contaminated water drainage system (which may include fire water) that does not meet irrigation standards will be tankered offsite for treatment at the Jubail Industrial Wastewater Treatment Plant. The volume of this water is not known at this stage of the design, but due to the arid conditions of the Project location, this water source will primarily be associated with wash-down activities and emergencies, and therefore infrequent.

Similarly, treated oily water which does not meet the RCER irrigation standards will require alternative reuse/disposal methods.

In accordance with RCER-2010, the proposed Project design includes for storage capacity of 72 hours of normal plant effluent flow to meet emergencies with pumping facility. Underground pits are proposed for this purpose.

Any wastewater directed to an RC Industrial Wastewater Treatment Plant is required to meet the pre-treatment standards specified in Tables 3B and 3B-1 of RCER-2010. In the event that wastewater does not meet the pre-treatment standards, treatment and final disposal must be arranged at waste facility approved by the RC.

The collection and treatment of central laboratory wastewater associated with the extension of this facility has yet to be confirmed, but is expected to be managed by the existing drainage and treatment system. The existing laboratory waste stream is captured, and pH buffered prior to being tankered off site for treatment.

The MGA and Raffinate pipelines from the Materials Storage and Handling Facility to the DAP/NPK Plant require cleaning by flushing process water from the storage area to the DAP/NPK Plant. There is no impact on wastewater systems as this waste stream will be directed to the waste tanks inside DAP/NPK for reuse in the process.

It is understood that contaminated water associated with the existing MPC facilities which cannot be treated effectively on site to achieve the RCER-2010 irrigation standards is accepted by Jubail Industrial Wastewater Treatment Plant for treatment and disposal/reuse. As the characteristics of this type of wastewater will be similar to that of the proposed Project facilities, adverse impacts on the wastewater facility are unlikely.

An alternative system for collection and treatment of MDEA washing liquor and scrubber blowdown wastewater (to that of an evaporation pond) will be established by the FEED / EPC Contractor for the Ammonia Plant following the consideration of Best Available Techniques. It is therefore unlikely that this wastewater stream will significantly impact on wastewater systems.

The wastewater collection and treatment system proposed at the demineralisation plant (pH adjustment using sulphuric acid or caustic soda) will be designed so that this waste stream can be directed to the Irrigation Pond for reuse. However, as this wastewater is a saline stream, similar in composition to the seawater return of the existing Ammonia Plant, the regeneration water may be discharged to the seawater return header if authorised by the RC. No significant impacts are anticipated as its reuse or discharge will be in accordance with RC standards.

With regards sanitary wastewater, no significant impacts on the existing wastewater system are expected as the existing Sanitary Treatment Plant and associated Irrigation Pond have
sufficient capacity and control measures to manage this wastewater stream. In the event of Plant failure, there is not link between the associated utilities (including the Irrigation Pond) and the surface water system and therefore no discharge of untreated wastewater will be directed to sea.

**Impact WQ7 – Low Significance**

### 11.3.5 DECOMMISSIONING PHASE

**Table 11-11: Decommissioning Phase Impact Assessment**

<table>
<thead>
<tr>
<th>Factor</th>
<th>WQ8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
<td>Medium</td>
</tr>
<tr>
<td>Frequency</td>
<td>Rare</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
</tr>
<tr>
<td>Duration</td>
<td>Short</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Low</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
</tr>
</tbody>
</table>

The following decommissioning activities have the potential to impact on surface water or wastewater treatment facilities if conducted:

- Removal/infill of the construction Retention Pond;
- Dismantling of storage and loading/unloading facilities at the Port and the Materials Storage and Handling Facility; and
- Flushing/cleaning of loading/unloading equipment and storage tanks.

Due the proposed plans for development of the Ras Al Khair Industrial City, the removal/infill of the Retention Pond is considered unlikely as this can service other clean stormwater systems in the area. Also, although the high value equipment (e.g. ammonia loading arm) may be dismantled from the Port, the Port itself will remain operational (with plans for expansion).

Flushing/cleaning of loading/unloading and storage equipment has potential for more significant impacts to those of the commissioning phase as residual process chemicals will be present within the equipment. However, although the Ras Al Khair Industrial City does not currently include an industrial wastewater treatment facility, this is included in future development plans and is therefore likely to be available within the design life of the proposed Project (25 years).

**Impact WQ8 – Low Significance**
11.4 MITIGATION AND RECOMMENDATIONS

11.4.1 OVERVIEW

Implementation of mitigation will be required during the construction, commissioning, operational and decommissioning phases of the facility to minimise potential negative impacts on the quality of water resources on the project site and adjacent areas. Mitigation can include a combination of facility design, management procedures and monitoring arrangements. The following text discusses the predicted impacts and suggested mitigation measures for the activities previously identified for the different phases of the project.

The following underlying mitigation principals are proposed for all phases of the Project:

- A surface water protection plan will be developed as part of the Environmental Monitoring and Management Plan and shall be implemented by all site contractors;
- All discharges will be licensed and meet the relevant RC standards;
- There will be no direct discharge to sea without prior authorisation from the RC;
- Sanitary wastewater will remain segregated from other wastewaters and will be collected and discharged to the existing onsite STP for treatment;
- Clean storm water run-off will be collected and managed via the new onsite Retention Pond once operational to allow the precipitation of suspended solids prior to discharge;
- Monitoring of water quality will be undertaken in accordance with any requirements specified in the RC Environmental Permit to Construct.
### 11.4.2 CONSTRUCTION PHASE MITIGATION AND RECOMMENDATIONS

#### 11.4.2.1 CONSTRUCTION PHASE IMPACTS AND MITIGATION – WATER QUALITY MANAGEMENT

<table>
<thead>
<tr>
<th>ID Code</th>
<th>Impact</th>
<th>Potential Significance</th>
<th>Mitigation Measure</th>
<th>Significance after Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>WO1</td>
<td>Degradation of Coastal Water Quality Due to Construction-Related Surface Water Runoff / Accidental Spills</td>
<td>Medium</td>
<td>• Prior to commencing construction activities, consultation with SEAPA shall take place to agree consultation and engagement procedures going forward relating to activities at the port.</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• The EPC Contractor shall develop, implement and maintain a construction phase Environmental Emergency Response Plan (EERP) and a Construction Environmental Management Plan (CEMP) will be developed to be cognisant of SEAPA’s existing and developing procedures for Ras Al Khair Port as well as requirements of the RC. This shall include a surface water protection plan.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Surface water management systems must be appropriately designed to maintain separate collection, treatment and disposal routes for contaminated water, oily water and uncontaminated surface water.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Designated refuelling and vehicle maintenance areas will be constructed. These will comprise bunded and sealed areas and all scheduled refuelling and maintenance of construction and transportation vehicles will be undertaken within these designated areas.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Hazardous material storage tanks, including for fuels, will be located within bunded and hard surfaced areas with adequate capacity for the volume of hazardous materials stored within.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• An adequate quantity of drip trays and spill kits will be provided to contain and recover potential releases of hazardous substances.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Washing-out of concrete delivery, mixing and pouring plant and equipment will be undertaken in a designated impervious area and all wash water shall be contained for subsequent treatment and re-use and / or disposal to an approved location.</td>
<td></td>
</tr>
</tbody>
</table>
11.4.2.2 CONSTRUCTION PHASE RECOMMENDATIONS – WATER QUALITY MANAGEMENT

The EPC Contractor shall develop, implement and maintain the construction phase EERP and CEMP as supporting documents to the Environmental Management and Monitoring Plan (Appendix A of this ESIA). These plans will detail responsibilities and procedures for environmental and emergency response management during construction, including:

- Minimum technical standard of construction plant;
- Competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency;
- Spill control procedures;
- Procedures to be implemented following an accidental release of hazardous substances, e.g. during refuelling, including details of measures to be adopted to stop, contain as far as practical on site, and clean up spills, and to inform the relevant authorities in the event that a spill migrates (or occurs) off-site so that appropriate regional plans can be activated;
- Availability of pumps and spill mitigation materials such as absorbent granules to contain and recover hazardous substances releases;
- Management and inspection of vehicles/sub-contractors used to transfer sanitary wastewater from collection tanks. These must be fit for purpose and operated by trained members of staff;
- Minimisation of water use, where possible; and
- Schedule for regular audits of construction activities to assess and report on the ongoing effectiveness of measures employed.

Potentially contaminated wastewater arising from construction activities such as, but not limited to, concrete washes (high alkaline), wheel washes (high sediments), and other equipment/vehicle cleaning activities (potentially containing detergents) is not permitted to infiltrate groundwater or be discharged to the storm water system. All construction wastewaters shall be contained, stored and disposed of as per RCER-2010.
### 11.4.3 COMMISSIONING PHASE MITIGATION

<table>
<thead>
<tr>
<th>ID Code</th>
<th>Impact</th>
<th>Potential Significance</th>
<th>Mitigation Measure</th>
<th>Significance after Mitigation</th>
</tr>
</thead>
</table>
| WQ4     | Impact of hydrotest and cleaning/flushing water on wastewater management systems | Medium                 | • Prior to pre-commissioning / commissioning, procedures outlining the proposed management, analysis, treatment and discharge/disposal methods and locations for hydrotest water, including justification for any chemical additives, shall be outlined in the Environmental Management and Monitoring Plan.  
• The EPC Contractor shall liaise with MPC to confirm available capacity of the existing surface water ponds to accept the calculated volume of water requiring disposal.  
• The volume of water to be used shall be minimised through careful planning of the hydrotest sequence and water reuse.  
• The EPC Contractor shall control the flow rate of discharge of hydrotest water to the receiving water body (to be determined following water quality analysis in accordance with RCER-2010) to avoid overloading the receiving system/s.  
• The EERP developed during the construction phase shall be updated as appropriate to include for the management of hydrotest water and the use of the existing surface water ponds in the event of an emergency. | Low             |
### 11.4.4 OPERATIONAL PHASE MITIGATION AND RECOMMENDATIONS

#### 11.4.4.1 OPERATIONAL PHASE IMPACTS AND MITIGATION – WATER QUALITY MANAGEMENT

<table>
<thead>
<tr>
<th>ID Code</th>
<th>Impact</th>
<th>Potential Significance</th>
<th>Mitigation Measure</th>
<th>Significance after Mitigation</th>
</tr>
</thead>
</table>
| WQ6     | Degradation of Coastal Water Quality Due to Accidental Spills / Runoff | Medium                 | • The EMMP and EERP shall be developed to acknowledge port operational and incident management plans in consultation with SEAPA (and other port operators as required).  
• All staff shall be competently trained and response teams established.  
• Designated contained areas for loading the liquid products shall be defined and equipped with appropriate collection systems to contain any spills on land.  
• If proximity detection systems are not available to safely detect if marine loading arms are moving beyond safe operating limits, constant manual monitoring during product loading may be implemented to detect the motion of the loading arm and initiate shutdown procedures if required. Occupational health and safety procedures must be followed at all times during such monitoring. The proposed method of monitoring shall be agreed with the RC and SEAPA as appropriate.  
• Minimal drop distances for unloading potash shall be employed.  
• Provide an adequate quantity of drip trays and spill kits to contain and recover potential releases of hazardous substances. | Low                          |
11.4.4.2 OPERATIONAL PHASE RECOMMENDATIONS – WATER QUALITY MANAGEMENT

- Ma’aden and the Operator will maintain an appropriate level of engagement with SEAPA to ensure emergency response procedures relating to port activities are aligned.

- Ma’aden shall develop, implement, audit and maintain a Project EMMP and EERP. These plans will detail responsibilities and procedures for environmental management and environmental emergency response during operation of the facility. Of specific reference to water quality management, these plans should consider the following:
  - Routine plant inspection and maintenance schedules and procedures;
  - Procedures for implementing appropriate water quality detection instrumentation and monitoring and reporting the quality and volumes of process and discharges waters to enable compliance monitoring (in accordance with the RC Environmental Permit to Operate Regulations, RCER-2010 Volume II);
  - Details of surface water quality monitoring prior to the discharge of collected wastewater to the irrigation and Retention Ponds;
  - Procedures for the treatment of any wastewater onsite (e.g. oil separation) and also for the transfer of contaminated wastewater offsite;
  - Details of monitoring of dissolved solids to optimise discharge of cooling tower blowdown water;
  - Competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency (including accidental releases of hazardous substances);
  - Procedures to be implemented following an accidental release of hazardous substances, including details of containment and recovery measures to be applied; and
  - Procedures for co-ordinating site staff actions in emergency situations with off site stakeholders / regulators.

- Adequate pumps and spill mitigation materials such as absorbent materials should be available at all times on site to contain and recover hazardous substances releases.

- Training should be provided for staff, sub-contractors and suppliers on the use of spill mitigation materials and equipment and procedures, in the event of an emergency (including accidental releases of hazardous substances).

- Process and discharge waters are to be monitored to ensure monitoring requirements as required in the Royal Commission Environmental Permit to Operate (EPO) Regulations, RCER-2010 Volume II.

11.4.5 DECOMMISSIONING PHASE RECOMMENDATIONS

Prior to decommissioning, the assigned contractor/s will prepare detailed decommissioning plans to detail the procedures to be adopted for the safe decommissioning of the facility’s tanks, pipelines, buildings and infrastructure. Ma’aden shall incorporate such plans to the overall Project EMMP to provide adequate detail for sound, and sustainable site decommissioning.

Following decommissioning and demolition of the facility, a survey of the surface water quality at the site shall be completed to confirm that the presence and operation of the facility has not led to an unacceptable deterioration of the quality of surface water. Should contamination be identified that could have been caused by the facility, a specific remedial plan will be developed to define the extent of contamination and remedial measures to be implemented.
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12.0 SOCIO-ECONOMIC ASPECTS

12.1 INTRODUCTION

This Section includes a general description of the socio-economic characteristics on a national, regional and local level including demographics, economic activity, infrastructure, and education which are then assessed through a review of existing published information. Potential impacts on the socio-economic and cultural aspects are evaluated for each phase of the Project.

Whilst investigating the feasibility of phosphate mining and export projects in the northern and eastern regions of Saudi Arabia, Ma’aden representatives have previously liaised with various stakeholders directly as well as commissioned a number of studies/reports for which socio-economic assessments were undertaken prior to the construction of the existing industrial facilities at Ras Al Khair Industrial City. At that time, relevant measures were taken to mitigate potential impacts of the construction and operation of these facilities on sensitive receptors.

Ma’aden’s corporate policy requires the assessment of its projects’ impacts on the social environment and therefore this current study has been completed with reference to the guidelines established by Ma’aden and set forth in the document titled Social Impact Assessment (SIA) Guidelines and Minimum Requirements (Ma’aden, June 2012).

In keeping with Ma’aden’s commitment to stakeholder participation, a Stakeholder Engagement Plan has been prepared for implementation during the life of the Umm Wu’al Phosphate Project (refer to Appendix C). This Stakeholder Engagement Plan outlines the approach to be taken in supporting the communications and engagement objectives, processes and deliverables required to support successful delivery of the Umm Wu’al Phosphate Project.

Ma’aden has adopted the International Council on Mining and Metals (ICMM) Sustainable Development Framework as the basis for its corporate management philosophy. The following framework principles adopted relate specifically to socio-economic factors:

- ICMM Principle 3: Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities;
- ICMM Principle 9: Contribute to the social, economic and institutional development of the communities in which we operate; and
- ICMM Principle 10: Implement effective and transparent engagement, communication and independently verified reporting arrangement with our stakeholders.

As published in their Corporate Brochure, Ma’aden is committed to Corporate Social Responsibility (CSR) allowing them “to contribute positively to the well being of our people, the environment, economy and society”. Ma’aden’s commitment to CSR focuses on the four pillars; ethics, environment, community commitment and employee commitment.

12.2 METHODOLOGY

Previous studies commissioned in the Project area have been reviewed for the purpose of the assessment of socio-economic aspects relevant to Ras Al Khair.

Consultation in the Ras Al Khair area was undertaken in 2004 by GHD Consulting on behalf of Ma’aden as part of the environmental and social baseline surveys completed in the framework of the Al Jalamid Project (reported in SAPC, 2005).

A Community Impact Assessment undertaken by Environmental Consulting Bureau in 2006 for the Al Jalamid Project (reported in SOFRECO – TECHNIP, 2012) included consultation in the vicinity of both the Umm Wu’al (Al Jalamid) and Ras Al Khair (Ras Az Zawr) areas. The main objective of this Community Impact Assessment was to identify community concerns and potential adverse impacts to the local communities due to the proposed project activities. Consulted parties included:

- Key Government agencies for Al Jalamid and Ras Al Khair areas;
• Bedouin communities of Al Jalamid and Ras Al Khair;
• The Coast Guard at Ras Al Khair;
• Soldiers at Ras Al Khair.

The Community Impact Assessment (2006) reports that ‘during the consultation, no specific concerns were raised against the proposed project by either government agencies or by the people interviewed’.

The relevant information documented within the above noted studies has been updated throughout the following sections to account for changes that have taken place subsequent to these studies, including the construction of other industrial operations within the Ras Al Khair peninsula. Site visits conducted by WHGME in January 2013, as well as a review of Environmental Impact Assessments for more recent projects in the RAK Industrial Facility were used to update the original findings where appropriate.

Ma’aden representatives are liaising directly with the Royal Commission, the Saudi Railway Authority and the Port Authority with regards to Project elements at Ras Al Khair. Overall, Ma’aden have reported encouraging feedback from stakeholders for the Umm Wu’al Phosphate Project as this is seen as a positive opportunity for employment of local men and women as well as local business/community enhancement.

12.3 BASELINE CONDITIONS

12.3.1 INTRODUCTION

The following sub-sections provide background information on the economic and socio-cultural situation in the KSA as a whole, as well as locally in the vicinity of the Project site. The national level information helps to provide a context indicating the importance of the proposed Project for the region, as well as the entire Kingdom. Section 12.4 then outlines the impact assessment and relevant mitigation measures.

12.3.2 NATIONAL SOCIAL BACKGROUND

Saudi Arabia, home to Islam’s two holiest shrines in Mecca and Medina, is the birthplace of Islam. In 1932 Abdul Aziz bin Saud founded the modern Saudi state. According to the 1992 Basic Law, one of the founder’s male descendants must rule the kingdom. The current king, Abdullah bin Abdulaziz Al Saud, ascended to the throne in 2005.

The Saudi Economy

Saudi Arabia had an agriculture-based economy with a largely nomadic population until oil was discovered in the 1930s. It was not until the oil crisis of the 1970s that the country’s economy began to grow rapidly. The Kingdom possesses approximately one-fifth of the world’s proven petroleum reserves and is the world’s largest exporter of oil. The KSA plays a leading role in the Organisation for Petroleum Exporting Countries (OPEC). The petroleum sector accounts for approximately 80% of budget revenues, 45% of GDP, and 90% of export earnings (CIA World Factbook, 28 February 2013). Historically, the economy has been controlled primarily by the government, but Saudi Arabia is now encouraging private sector growth in order to diversify its economy and to employ more Saudi nationals. Saudi Arabia acceded to the World Trade Organisation in 2005, to attract foreign investment and to help to diversify the economy.

The Saudi economy employs nearly six million foreign workers, particularly in the oil and service sectors. The Government is increasing spending on job training and education, and also infrastructure development and government salaries (as well as encouraging more women to join the workforce), to help reduce the current Saudi unemployment rate, which reached 12.1% in 2012. The King Abdullah University of Science and Technology, the Kingdom’s first co-educational university, which opened in 2009, is a key example of the long-term investment in education for employment.
National Economic Activity

The Kingdom’s ambitious diversification programme is aimed at expanding the existing manufacturing base into areas including logistics and transport, technology, medicine and finance. As indicated above, the Saudi government has made it a priority to diversify the industrial sector to reduce dependence on oil extraction and refinement. This strategy is laid out in the Ninth National Development Plan (2010-2014). The Saudi Arabian General Investment Authority (SAGIA), responsible for managing the investment environment in the Kingdom, initiated a '10 x 10' diversification programme to help place Saudi Arabia among the world’s top ten competitive investment destinations. The programme involves the establishment of Economic Cities (ECs); four of which are currently at development stage: the King Abdullah Economic City situated north of Jeddah, the Knowledge Economic City in Madinah, the Prince Abdulaziz bin Mousaed Economic City in Hail, and the Jizan Economic City that will be located south of Jeddah. The programme is expected to create more than a million jobs within the next 15-20 years, creating opportunities for Saudi nationals.

Other steps to diversify the economy have also been taken through the development of the Yanbu and Jubail Industrial Cities, situated on the Red Sea and the Arabian Gulf (approximately 60 km from Ras Al Khair) respectively. The cities use natural gas and natural gas liquids, as well as other refined products from the nation’s oil industry, to manufacture products that in turn supply non-oil related industries.

Population and Demographics

The population of Saudi Arabia is recorded as exceeding 27 million, nearly 19 million of whom are Saudi nationals (2010 population census). Up until the 1960s, most of the population was nomadic or semi-nomadic, but the recent rapid economic growth has resulted in more than 95% of the population now being settled. As of 2011, urbanisation had reached 85% and some cities and oases have densities of more than 1,000 people per square kilometre.

The population has a large proportion of youths with a median age of 25.3 as recorded in the 2010 Census. The total fertility rate reported for 2012 is 2.26 children born per woman (CIA, 2013). This is a dramatic reduction from 1990 when the fertility rate was 6 children born per woman (World Bank, 2009). Child and infant mortality rates are relatively low for the Middle Eastern region as a whole, but are high compared to the rest of the Gulf Cooperation Council. According to the Saudi Arabia Central Department of Statistics and Information (CDSI), the 2012 total population growth rate including non-nationals was 2.9%, but the population growth rate for Saudi nationals was 2.21% (note that detailed population figures have yet to be released for this year).

Table 12-1: Key KSA National Demographic Statistics

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2008</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saudi males</td>
<td>8,287,370</td>
<td>Not reported</td>
<td>9,525,178*</td>
</tr>
<tr>
<td>Saudi females</td>
<td>8,239,970</td>
<td></td>
<td>9,448,437*</td>
</tr>
<tr>
<td>Non-nationals</td>
<td>6,150,922</td>
<td></td>
<td>8,589,817*</td>
</tr>
<tr>
<td>Saudi Labour Force</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(15 years and over)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total males</td>
<td>2,708,760</td>
<td>3,274,356</td>
<td>3,750,781</td>
</tr>
<tr>
<td>Total females</td>
<td>429,323</td>
<td>482,313</td>
<td>646,590</td>
</tr>
<tr>
<td>Total</td>
<td>3,138,083</td>
<td>3,756,669</td>
<td>4,397,371</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(% of population)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saudi males</td>
<td>8.4</td>
<td>6.8</td>
<td>6.1</td>
</tr>
<tr>
<td>Saudi females</td>
<td>24.4</td>
<td>26.9</td>
<td>35.7</td>
</tr>
<tr>
<td>Total Saudi Population</td>
<td>11.0</td>
<td>10</td>
<td>12.1</td>
</tr>
<tr>
<td>Total population</td>
<td>5.8</td>
<td>5.2</td>
<td>5.5</td>
</tr>
<tr>
<td>Total males</td>
<td>4.5</td>
<td>3.6</td>
<td>2.7</td>
</tr>
<tr>
<td>Total females</td>
<td>13.4</td>
<td>14.5</td>
<td>21.3</td>
</tr>
</tbody>
</table>

Source: Saudi Arabia Central Department of Statistics and Information, 28 February 2013
*According to 2010 Census
Employment Profile

The KSA has relied upon a large non-national workforce, currently totalling almost 6 million foreign workers. The diversification efforts discussed in previous sections are largely aimed at employing Saudi nationals and reducing the unemployment rate among its citizens. As referred to above, new universities, such as the King Abudallah University of Science and Technology will enable the large Saudi youth population to develop the educational and technical skills required of the private sector.

Economic activity for women in the Kingdom is low, with an unemployment rate of 26.9% among Saudi nationals in 2008 increasing to 35.7% in 2012. A 2009 World Bank report estimated that 70% of working women were expatriate female workers and many of those expatriates were employed in jobs that Saudi women could perform: retail, manufacturing and services. This report also showed that Saudi female labour force participation was concentrated in the education sector. Unemployment levels among women are much higher than those for men, as indicated in the table above. In 2012 there were 1.7 million unemployed women, almost half of whom had a university education.

National Education

When the Kingdom of Saudi Arabia was established in 1932, very few people had access to education. By 1951, the Kingdom had 226 schools, and currently there are approximately 25,000 schools. The Ministry of Education was created in 1954 and the Ministry of Higher Education in 1975. The first university, which is currently known as King Saud University, was established in 1957 in Riyadh, and now there are 24 public and 8 private universities, with more planned. The educational system is now open to all citizens and students are provided with free education, books and health services.

In addition to founding new universities, King Abdullah in 2005 also implemented a government scholarship programme that provides tuition and living expenses for young Saudi nationals to attend Western universities in countries such as Canada, the United States, the United Kingdom, Australia, New Zealand, France, Germany and Switzerland.

Education of girls in Saudi Arabia has expanded exponentially in recent decades. In 1964 the first government school for girls opened. Nowadays, more than half of the population of Saudi schools and universities is made up of females.

Religion and Culture

The Kingdom of Saudi Arabia is an Islamic theocratic monarchy. Islam is the official religion of the Kingdom and it is required by law that all Saudi citizens are Muslims. The Government does not legally recognise or protect freedom of religion. The public practice of non-Muslim religions is prohibited, which is enforced by the Saudi Mutaween, or Committee for the Propagation of Virtue and the Prevention of Vice (CPVP). According to a Pew Forum report (2009), approximately 97% of the total population is Muslims. Of these, 85-90% are Sunni Muslims, while 10-15% are Shia Muslims.

Saudi Arabia’s culture is Arab and Islam, and features historical rituals and folk culture. The Kingdom’s culture has been influenced by its Islamic heritage, its Bedouin traditions, and its role as an historic trade centre.

The Kingdom is the birthplace of the Islamic religion. Salafism, or Wahabbism, is the predominant form of Islam practiced in Saudi Arabia today. Cultural and religious highlights of the year include the holy month of Ramadan and the Hajj (pilgrimage) season. During the holy month of Ramadan, Muslims fast from dawn to dusk. In the Hajj season, millions of Muslim pilgrims from around the world make their way to Mecca.

The traditional and strict cultural values are enforced by the religious police, or CPVP. Alcoholic beverages and pork products are prohibited. Further, women are currently not allowed to drive a car. Conservative dress is enforced and unrelated males and females are not permitted to socialise.
12.3.3 LOCAL BASELINE INFORMATION

The Ras Al Khair peninsula and surrounding areas are very sparsely populated and have limited commercial, community and government facilities outside the Royal Commission’s Industrial City. The surrounding land is owned by the Government and there are no private landowners, tribal lands or permanent settlement in the Industrial City. However, as reported in Section 4 Detailed Description and Layout of the Proposed Development, the Royal Commission is developing a master plan for the future development of the Ras Al Khair Industrial City which may see the City extents expand across the peninsula.

In 2003, design and construction activities for a phosphate plant, an aluminium plant and a power plant were initiated on the Ras Al Khair Peninsula. A port facility has also recently been developed in addition to a major east-west railway transport link established for connection to western Saudi Arabia. This rail link will serve as a source area for much of the raw materials coming to Ras Al Khair. Figure 12-1 illustrates the existing land use in the vicinity of the Ras Al Khair Industrial Complex.

Local Population and Infrastructure

At Ras Al Khair there are no permanent settlements, villages or townships. The only major activities at present are those associated with the development of the Industrial Facility, the Saline Water Conversion Corporation (SWCC) and the Manifa oilfield development programme (approximately 30 km to the north of the Project site).

Previously up to 16 Bedouin encampments of temporary or semi-permanent nature were observed in the immediate vicinity of the proposed project area, but prior to the construction of the existing industry facilities, the semi-permanent encampments were relocated from the area (GHD, 2008).

A small Coast Guard Listening Post was located centrally on the Peninsula. Buildings from the listening post still exist, but it is unclear whether it is currently operational.

A Housing Complex is being constructed adjacent to the existing Complex (approximately 8 km from the Project site) to house the single workers (bachelor village) in the vicinity of the Ras Al Khair industrial facility. Community facilities and public services, such as health care, water supply, sewerage facilities, waste management and power supply are being developed at Ras Al Khair to serve the influx of population working at the Ras Al Khair Industrial City.
Figure 12-1: Facilities around the Ma'aden Phosphate Company Site and inside the Ras Al Khair Industrial Complex.
A radio transmission facility is maintained by the Saudi Ministry of Culture and Information at the eastern end of the Ras Al Khair Peninsula, approximately 12 km from the proposed Project site.

Early studies record Manifa as a small fishing village supporting a small fishing fleet (8 trawlers), processing and handling plant in earlier studies. However, this village is also undergoing extensive development by Saudi Aramco as part of the Manifa Oilfield development which is expected to commence oil production in 2013. The Manifa area will be a large industrial area serving oil and gas needs for Saudi Arabia over the next decades.

Although most recent population figures are unavailable for the area, numbers will have increased significantly with the ongoing development of the Ras Al Khair Industrial City. Workers, planners, regulators, owners, support companies, etc. are all setting up encampments at Ras Al Khair.

The closest sizeable civilian population centre is Nuayriyah which lies approximately 68 km to the west of the peninsula (93 km by road) and has a population of 26,470, made up of 19,885 Saudi nationals and 6,585 non–Saudis (according to the 2010 census). Nuairiyah is located on a major link road from Ar Riyadh to Kuwait and Jubail to Jordan and supports large agricultural areas in the immediate vicinity and neighbouring regions.

Based on the above, ‘Affected Communities’ are considered to be limited to those associated with the Ma’aden Housing Complex and the temporary camps located on the Ras Al Khair peninsula.

Local Employment
The Ras Al Khair Industrial City is the primary source of employment in the area. Employment statistics specific to Ras Al Khair however are not currently available from the Government. Estimated operational employment numbers for the existing industrial facilities are as follows:

- Ma’aden Phosphate Company: Approximately 1,000 (direct hires excluding contractors); and
- Ma’aden Aluminium Company: Approximately 3,000 (Source: WHGME, 2010)

Additionally, construction works associated with the Aluminium facility and expansion of the Port (China Harbour) are currently employing temporary staff in the immediate area.

The radio transmission station facilities may source some employees locally; however, it is considered that more senior staff are likely to come from the major centres nearby.

Local Recreation
The area of the Industrial City was previously used during the winter months for recreational camping; however, such activities are no longer permitted due to the security level of the industrial areas which are now fenced and guarded. The peninsula is located adjacent to the marine boundaries of the Jubail Marine Wildlife Sanctuary, which is located to the south of the Industrial Complex. Fishing and other marine recreational activities can be organised from Jubail and ports to the south.

Local Economy
The new developments at Ras Al Khair, including the power station, the aluminium plant and the existing and proposed phosphate facilities are all opening up the local economy for this area. The social systems in the region are expected to change markedly with the ongoing development, and will in all likelihood only mature in the next ten years. With the increased influx of workers and facilities, a large support community is expanding to service this area. The local economy is clearly one of growth, with massive employment opportunities to those in the few local communities.

Table 12-2 below summarises the approximate income of unskilled, semi-skilled and skilled workers expected at the proposed Project based on Ma’aden’s corporate HR policy.
Local Cultural and Archaeological Heritage

Extensive traversing of the Project area prior to development of the Industrial City in 2003 and 2004 failed to identify any sites of cultural or archaeological significance (SAPC, 2005).

12.3.4 COMMUNITY CONSULTATION – RAS AL KHAIR

Due to the location and industrial nature of the Project area, community consultation was not considered appropriate to the proposed Industrial Complex at Ras Al Khair. Findings of the previous community consultations undertaken prior to the construction of the existing Ma’aden facilities adjacent to the proposed Project site are summarised Table 12-3 below. This included consultations and interview sessions with representatives from Bedouin families who used project lands for grazing prior to development, as well as interviews with the Coast Guard and soldiers. The interviews helped to determine whether interested stakeholders had concerns about development in the project area. These consultations served to also acquire important socio-economic data on the nomadic communities, such as income sources, health care and educational facilities.

<table>
<thead>
<tr>
<th>No.</th>
<th>Government Agency Rep./ Community Resident</th>
<th>Concerns Raised about the Project</th>
<th>Baseline Information / Data Provided</th>
<th>Other Comments and Suggestions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mr Abd-AlAziz Mutery, National Guard Officer (Amplifier Station) Living in Nuayriyah 32 years old</td>
<td>None</td>
<td>No private landowners, tribal lands or families or settlements in the area. Non-Saudi shepherds pass through the area during the grazing season (December to March).</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>Mr Ibrahim Al-Harby (Coast Guard Officer) Living in Nuayriyah 36 years old</td>
<td>None</td>
<td>No commercial or recreational fishing industry exists in the area. The area is used for some recreational purposes (temporary camping on the shorelines -only in good weather). No educational or health care institution exists.</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>Mr Bin Aboud Al-Mansoury 75 years old (Bedouin Family Representative)</td>
<td>None</td>
<td>He has lived in the area for over 40 years. His family consists of 20 members (includes the shepherds). Main source of income is from the livestock (around 200 sheep and 100 camels). Annual income</td>
<td>The proposed facility should implement appropriate technologies to avoid any health effects from</td>
</tr>
</tbody>
</table>

Table 12-2: Salaries of Saudi and Expatriate Workers

<table>
<thead>
<tr>
<th>Category</th>
<th>Nationality</th>
<th>Yearly Salary Years (US $/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skilled</td>
<td>Saudi</td>
<td>92,050</td>
</tr>
<tr>
<td></td>
<td>Eastern Expatriate</td>
<td>71,388</td>
</tr>
<tr>
<td>Semi-skilled</td>
<td>Saudi</td>
<td>63,091</td>
</tr>
<tr>
<td></td>
<td>Eastern Expatriate</td>
<td>45,664</td>
</tr>
<tr>
<td>Unskilled</td>
<td>Saudi</td>
<td>43,927</td>
</tr>
<tr>
<td></td>
<td>Eastern Expatriate</td>
<td>31,220</td>
</tr>
<tr>
<td>No.</td>
<td>Government Agency Rep./ Community Resident</td>
<td>Concerns Raised about the Project</td>
</tr>
<tr>
<td>-----</td>
<td>------------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>4</td>
<td>Mr Seif Hamad Al Mansoury, 65 years old</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Willing to relocate to another area if required.</td>
</tr>
<tr>
<td>5</td>
<td>Foreign Shepherds (8 candidates)</td>
<td>None</td>
</tr>
</tbody>
</table>


Bedouin no longer use the Project area following commencement of the construction and operation of the existing industrial facilities at Ras Al Khair. The buildings of the Coast Guard listening post remain inside the Industrial City, but it is believed that the post itself is being relocated to another area in the near future.
12.4 IMPACT ASSESSMENT

12.4.1 INTRODUCTION

As indicated by the summary of baseline conditions, the extent of sensitive social receptors in the vicinity of the Project site is limited, however typical concerns for the development of a new industrial project are considered to include:

- Community health, safety and security (IFC Performance Standard 4);
- Land acquisition and involuntary re-settlement (IFC Performance Standard 5);
- Effects on indigenous people and communities (IFC Performance Standard 7);
- Degradation of cultural heritage (IFC Performance Standard 8).

The applicability of IFC Performance Standard 2 – ‘Labour and working conditions’ is outlined in Section 15 Health and Safety Aspects in which the potential impacts of the proposed Project on workers and community health are considered as well as proposing measures to manage and monitor them.

There is also the potential for positive effects on the local economy as a result of the construction and operation of the Project.

12.4.2 CONSTRUCTION

Potential impacts from construction of an industrial facility were identified. These impacts are summarised in Table 12-4 and discussed in the sections below.

<table>
<thead>
<tr>
<th>Factor</th>
<th>SE01</th>
<th>SE02</th>
<th>SE03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Continuous</td>
<td>Infrequent</td>
<td>Continuous</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Likely</td>
<td>Unlikely</td>
<td>Likely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
<td>Local</td>
<td>Regional</td>
</tr>
<tr>
<td>Duration</td>
<td>Short</td>
<td>Short</td>
<td>Short</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
<td>Negative</td>
<td>Positive</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
</tr>
</tbody>
</table>

As the ‘Affected Communities’ relevant to the Project at Ras Al Khair are considered to be limited to those associated with the Ma’aden Housing Complex and the temporary camps located on the Ras Al Khair peninsula, i.e. ‘the workforce’, the Construction Management and associated Health and Safety Plans will be relevant for the management of social aspects. It is a contract requirement for the EPC Contractors to produce such Plans which will be progressively updated to reflect the transition requirements as the Project moves through its different stages. Information from these Plans are required to be incorporated into the Health, Safety, Security and Environment (HSSE) Plan for the area, which will also address aspects such as traffic management, access and egress, etc. This is addressed further in Section 15 Health and Safety Aspects.

12.4.2.1 COMMUNITY HEALTH, SAFETY AND SECURITY - CONSTRUCTION

Due to the proposed working hours, it is unlikely that members of the construction phase workforce will reside in the nearest community centre (Nuayriyah – approximately 68 km west), and no construction-related activities are expected to take place in the vicinity of this community. Therefore the construction works are unlikely to increase community exposure to risks and
impacts. Any potential impacts on ‘communities’ is limited to the existing Ma’aden Housing Complex and temporary camps located on the Ras Al Khair peninsula.

The health, safety and security of resident workers at these areas may be affected by increased vehicle movements (including the transport of hazardous materials) and temporary structures / site arrangements. However, due to the industrial nature of the Project location and existing security arrangements, traffic and pedestrian access points and routes around and across the Project area will afford protection to existing ‘communities’ of workers. Adverse impacts may arise if construction management arrangements are not co-ordinated appropriately with those in existence.

At present, basic community facilities, such as health care, water supply, sewerage, waste management, and power supply are present and expanding at Ras Al Khair. These are a direct result of the Industrial City and service the associated work force. The construction activities and associated population increase will not degrade natural resources currently utilised by communities or cause significant impacts on local ‘community’ services and infrastructure such as water supplies as these works will utilise existing infrastructure with sufficient supply capacity (refer to Section 14 Utilities Infrastructure and Usage). If such impacts do occur, these will be infrequent and of low magnitude.

With regards to safety and security, the influx of temporary and permanent construction workers into the Project area is not considered to result in significant impacts as the KSA in general is conservative and committed to practicing Islamic principles and traditions, the expatriate work force particularly those who are new and are not residents of the KSA will be informed on religious and cultural sensitivities on arrival into the country.

This influx also has the potential to expose existing resident workers to diseases. This potential impact is assessed within Section 15 Health and Safety Aspects.

Exposure to dusts and particulate matter from construction activities is addressed within Section 8 Air Quality and Meteorology and Section 15 Health and Safety Aspects.

**Impact SE01 – Low Significance**

12.4.2.2 LAND ACQUISITION AND INVOLUNTARY RESETTLEMENT - CONSTRUCTION

Ma’aden has secured appropriate site allocation of the Project site within the Industrial City from the Royal Commission. The Royal Commission maintains responsibility for environmental management and controlling pollution associated with the development and operation within the City and there are no private landowners.

Based on the above, forceful land acquisition and involuntary resettlement is not expected as a consequence of the proposed Project.

12.4.2.3 EFFECTS ON INDIGENOUS PEOPLE AND COMMUNITIES - CONSTRUCTION

IFC Performance Standard No 7 recognises indigenous peoples as “social groups with identities that are distinct from mainstream groups in national societies” who are “particularly vulnerable if their lands and resources are transformed, encroached upon, or significantly degraded”. Due to the location and scope of the Project and the fact that there are no tribal communities or settlements within the Project area, this Standard is considered to be of limited relevance and as such no negative effects on indigenous people and communities are expected from the proposed project.

12.4.2.4 DEGRADATION OF CULTURAL HERITAGE - CONSTRUCTION

The IFC Performance Standard No 8 identifies cultural heritage sites as either tangible (e.g. sites of archaeological, historical, or cultural value) or intangible (e.g. sites of cultural knowledge, innovations, practices embodying traditional lifestyles). No archaeological or cultural heritage sites are reported to exist in the Project area and as such adverse impacts on archaeological or cultural heritage is not a principle concern. Similarly, intangibles such as cultural knowledge and traditional practices of Bedouins will not be compromised as a consequence of the proposed Project as all grazing activity is already external to the industrial facility.
Impact SE02 – Low Significance

12.4.2.5 IMPACT ON LOCAL ECONOMY - CONSTRUCTION

The construction phase of the Project will provide a large positive impact on the local economy, through employment opportunities and acquisition of in-Kingdom sub-contracts, material and equipment supplies.

Impact SE03 – Medium (Positive) Significance

12.4.3 OPERATIONS

Potential impacts from the operational phase of the Project were identified. These impacts are summarised in Table 12-5 and are discussed below.

Table 12-5: Summary of Construction Phase Impacts Assessment

<table>
<thead>
<tr>
<th>Factor</th>
<th>SE04</th>
<th>SE05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Continuous</td>
<td>Continuous</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Unlikely</td>
<td>Likely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
<td>Regional</td>
</tr>
<tr>
<td>Duration</td>
<td>Medium</td>
<td>Long</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
<td>Positive</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>Medium</td>
</tr>
</tbody>
</table>

12.4.3.1 COMMUNITY HEALTH, SAFETY AND SECURITY - OPERATION

Similarly to the construction phase workforce, it is unlikely that many of the operational workforce will reside in the nearest community centre, Nuayriyah, which is located approximately 98km by road. Housing facilities are expected to be provided at Ras Al Khair peninsula for this Project (as an extension to the existing facilities). However, the Royal Commission has communicated early plans for a Ras Al Khair Industrial City Community to be located east of Nuayriyah to support future development plans for the Industrial City itself.

The potential impacts identified for the construction phase are also possible during the operation of the Project but at a lesser scale due to the reduced number of staff, i.e. increased vehicle numbers, strain on community facilities / services and influx of workers.

Security and traffic arrangements required for Industrial City are a requirement of the Royal Commission and will be enforced at all times, therefore reducing the likelihood of significant impacts on the work force community present in nearby areas.

Community facilities are being constructed as the Industrial City develops, advancing from its previous non-existent state. Services provided to the Ras Al Khair communities are associated exclusively with the Industrial City which will provide sufficient supply capacity (refer to Section 14 Utilities Infrastructure and Usage).

As with the construction phase, the influx of operational workers has the potential introduce communicable diseases which can be transmitted within community areas. However, this is considered less likely as the workforce will be significantly less than that of the construction phase and in accordance with the national policy of Saudization, a large portion of the workforce will comprise Saudi nationals. Refer to Section 15 Health and Safety Aspects for further assessment details of working conditions.
Overall, the existing resident workforce is unlikely to be significantly impacted by the operational phase; however, exposure to a number of hazards at community areas may occur in exceptional circumstances.

**Impact SE04 – Low Significance**

12.4.3.2 IMPACT ON LOCAL ECONOMY - OPERATION

The operational phase of the Project will significantly contribute to the economy through employment opportunities, increased availability of services, enhancement of a significantly underdeveloped area of Saudi Arabia as well as exports and procurement.

As a result of extensive development in the KSA, and particularly in the Eastern Province, communities in the region (Saudi nationals and expatriates) may be affected by potentially higher incomes (mainly for government and select private sector employees), increased cost of living and access to additional community facilities and opportunities, etc.

It is estimated that 284 Saudi citizens will initially be hired to operate the Project facilities (SOFRECO – TECHNIP, 2012). This number will increase as the Saudization policy takes effect and more Saudi citizens are trained in the required skills.

**Impact SE05 – Medium (Positive) Significance**

12.4.4 DECOMMISSIONING

*Table 12-6: Summary of Decommissioning Phase Impacts Assessment*

<table>
<thead>
<tr>
<th>Factor</th>
<th>SE06</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>Rare</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Likely</td>
</tr>
<tr>
<td>Extent</td>
<td>Regional</td>
</tr>
<tr>
<td>Duration</td>
<td>Short</td>
</tr>
<tr>
<td>Magnitude</td>
<td>Medium</td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
</tr>
</tbody>
</table>

Closure and decommissioning activities will have similar impacts to those identified for the construction phase.

In addition, a reduction in economic activity is also likely to result. As it is also likely that the Project will promote direct, indirect and induced economic opportunities at a regional level, there is potential for impacts upon the wider economy following decommissioning of the facility.

However, economic growth over the duration of Project may have led to the creation of an economy in the local and provincial area, which although linked, may not be entirely reliant on the Project. Such growth is also likely to be maintained by the other industry developments currently proposed for the Ras Al Khair peninsula.

**Impact SE06 – Low Significance**
12.5 RECOMMENDATIONS

Socio-economic impacts from the proposed Project will be largely positive given that the new development will create jobs in the region and opportunities for local and regional businesses to provide goods and services to Ma’aden, its contractors and its workers.

Potential negative impacts of medium or high significance are not anticipated to occur as a consequence of the Project construction, operation or decommissioning phases.

Implementation of the following measures is recommended to manage the potential impacts identified as being of low significance and maintain good management practices.

12.5.1 CONSTRUCTION AND OPERATION PHASE RECOMMENDATIONS

- Employ local resources: Local employees with skills to suit the required roles should be selected where available. Also, local companies should be contracted to supply construction goods and services wherever feasible.

- Prior to engagement of the local employees, a comprehensive training matrix can be produced to reflect the training needs of the personnel involved. This matrix should then be monitored and updated accordingly to ensure that the appropriate skill sets are transferred effectively.

- A grievance mechanism should be developed and maintained so that the resident worker ‘communities’ have a means of communicating any concerns regarding the facility’s construction or operation to project management.

- Induction training should be provided to all foreign workers and non-Muslim workers on the local culture and practices that are acceptable and unacceptable. In addition, camp management procedures will be established to minimise interactions and possible tensions with the local communities.

- Ma’aden should work closely with the contractors and Royal Commission to develop hazard prevention programmes (e.g. road traffic accidents during construction stage). In addition, safety training such as road safety training should be provided to workers and material suppliers should be provided with information on delivery routes and speed limits. Further information is provided in Section 13 Traffic and Transport, Section 15 Health and Safety Aspects and also in Appendix B Environmental Emergency Response Plan.

- Although the discovery of archaeological features or artefacts is considered unlikely, it is recommended that EPC contractors include a protocol to be followed in the event of a discovery of archaeological features or artefacts. This would include contact details for the appropriate representatives at Saudi Commission for Tourism and Antiquities, Ma’aden, Royal Commission and/or other relevant stakeholders who can document and preserve the findings if necessary.

12.5.2 DECOMMISSIONING PHASE RECOMMENDATIONS

- Where possible, encourage and support the use of local and provincial suppliers of goods and services by the wider Ras Al Khair Industrial City development.

- Seek to support employment in the region and within other Ma’aden projects following decommissioning of the Project facilities.
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13.0 TRAFFIC AND TRANSPORT INFRASTRUCTURE

13.1 INTRODUCTION

The purpose of this Section is to describe the existing infrastructure and transport system and assess the potential impacts of the Project on the usage and demands on roads, railway, ports and airports.

13.2 BASELINE CONDITIONS

13.2.1 INTRODUCTION

The Kingdom of Saudi Arabia is a large landmass covering 80% of the Arabian Peninsula and measuring 2,250,000 km². In the past the emphasis has been on road and air links, however, recent government initiatives are focussing on extending the existing rail network (SAMIRAD, 2013a).

The baseline conditions for traffic and transport infrastructure have been determined through a desktop review of relevant literature in order to gather information about the Saudi transport infrastructure at the national and regional level. Information collated for local conditions is supported with findings of a local traffic survey conducted in March 2013 at the Ras Al Khair Project site.

13.2.2 NATIONAL AND REGIONAL BACKGROUND

Roads

The Ministry of Transport is responsible for the design, build and maintenance of roads within the Kingdom as well as the co-ordination of all surface transport including rail. Due to large-scale development of industry and agriculture, and the rapid development of urban centres, the road network has been significantly improved over the last 40 years.

The Central Department of Statistics and Information (CDSI) Statistical Yearbook 47 (for year 2011) states that the road network in Saudi Arabia has a total length of 195,974 km for 2011, comprising 59,143 km of asphalt paved roads and 136,831 km of agricultural roads (CDSI 2011). The total road length for the Eastern Province was reported as 3,680 km. The government of Saudi Arabia continues to undertake development projects to extend the road network coverage with the Ministry of Transport reporting that a length of over 22,000 km of highways is currently under construction (MOT 2013a).

The Saudi Public Transport Company (SAPTCO) was established in 1979 to provide public bus transport services across Saudi Arabia. SAPTCO has terminals in most of the Kingdom's major cities and connects 600 cities, towns and villages (SAPTCO, 2013). Daily international trips by road are scheduled to Kuwait, Bahrain, Qatar, United Arab Emirates, Yemen, Egypt, Jordan, Syria, Sudan and Lebanon.

The number of passengers served by SAPTCO in 2008 was approximately 6.9 million passengers travelling between cities, and about 11.9 million passengers using the service inside cities, including about 5.5 million passengers for the purpose of Hajj (pilgrimage) and Umrah, while 0.6 million passengers used the service for international trips (MEP, 2009). SAPTCO do not operate at Ras Al Khair.

Road access to Ras Al Khair

The main road access point from the Ras Al Khair Industrial City to the rest of Saudi Arabia is via the dual carriageway ‘Route 7950’ which traverses the Ras Al Khair peninsula from east to west. Route 7950 connects at its most western point to Route 95, a primary road which traverses the Eastern Province from north to south and provides connections to other main central and western routes.
The list below shows the approximate distance by road from the Ras Al Khair Industrial City to some of the major cities and industrial centres of Saudi Arabia:

- Al Jubail 134 km via Route 95
- Dammam 200 km via Route 95
- Riyadh 576 km via Route 40
- Turaif 1,168 km via Route 85
- Mecca 1,448 km via Route 40
- Jeddah 1,530 km via Route 40

**Rail**

Saudi Railways Organisation (SRO) operates the rail network of Saudi Arabia with a total length of approximately 1,380 km (SRO, 2013a). The existing network, which consists primarily of a single track, standard-gauge line, extends from King Abdul Aziz Port in Dammam and the City of Dammam itself (southeast of the Project site) to Riyadh with connections to Abqaiq, Hofuf, Haradh, Al-Tawdhihiyah and Al-Kharj. The main rail network currently operated by SRO is as follows:

- 449 km passenger line connecting Riyadh to Dammam through Al-Ahsa and Abqaiq;
- 556 km cargo line starting at King Abdul Aziz Port in Dammam and ending in Riyadh, passing by Al-Ahsa, Abqaiq, Al-Kharj, Haradh and Al-Tawdhihiyah;
- 373 km branch lines connecting some industrial and agricultural sites.

The Saudi Railway Master Plan 2010-2040 is a development strategy which outlines the expansion of the existing network to be implemented in three phases and include a total of 19 individual railway lines and a total length of 9,990 km (SRO, 2013b). The three stages are outlined as follows:

- First Level Projects (high priority): development stage 1 from 2010 – 2025 approximate length: 5,500 km.
- Second Level Projects (medium priority): development stage 2 from 2026 – 2033 approximate length: 3,000 km.
- Third Level Projects (minor priority): development stage 3 from 2034 – 2040 approximate length: 1,400 km.

The railway network specified in development Stage 1 contains the following railway projects, some of which already exist or are in implementation (refer to Figure 13-1):

- The planned “Saudi Railway Landbridge” (West Bridger Rail Project) between Riyadh and Jeddah and between Dammam and Jubail which has now received approval. The connection between Dammam and Jubail is due for completion in 2016.
- The North-South Railway between the northern regions, Ras Al Khair/Jubail and the capital Riyadh, including the connection to the proposed ESCWA - railway network in Jordan via Al Haditha. The 1392 km 'Mineral Route' section of the NSR was opened in May 2011 and carries phosphate concentrate from the Ma’aden mine at Al Jalamid to Ras Al Khair port on the Gulf coast (Railway Gazette International 2013).
- Double line upgrade of the existing railway lines between Dammam and Riyadh.
- Connections to the proposed GCC - railway network, with lines between Batha (UAE) Border - Hofuf and Jubail - Ras Al Khair - Kuwait Border, as well to Qatar and Bahrain.
Figure 13-1: Railways of Saudi Arabia
Ports

Saudi Arabia has several large modern ports that are operated by the Saudi Ports Authority (SEAPA). These ports play a significant role in the transport of petroleum products and other industrial goods. SEAPA operates the following nine major ports located on both the Red Sea and Arabian Gulf coasts (SEAPA 2013a):

- Red Sea:
  - Dhiba Port;
  - Yanbu Commercial Port;
  - King Fahd Industrial Port Yanbu;
  - Jeddah Islamic Port;
  - Jizan Port;

- Arabian Gulf:
  - King AbdulAziz Port Dammam;
  - Jubail Commercial Port;
  - King Fahd Industrial Port Jubail; and
  - Ras Al Khair Industrial Port.

Construction work at Ras Al Khair Port commenced in 2008 (China's Harbor Engineering and Contracting Co Ltd) and port facilities were operational in 2011. The Port is currently reported to serve more than 80 different industrial projects in the region and has plans for expansion up to 50 berths by 2030.

King Abdul Aziz Port Dammam is the main gateway through which cargo enters the Eastern and Central Provinces of the Kingdom. It is strategically placed to service the requirements of the oil industry, the continuous development of Riyadh, the capital, and the major provincial cities in the Eastern and Central Provinces (SEAPA, 2013a). This Port currently operates from 39 berths with capacity of 0.5 million TEU export and import (year 2011), with plans to double this capacity. Capacity of Jubail port was reported as 93,000 TEU export and import in 2011.

Airports

Air travel is the preferred method of travel within the Kingdom due to the distances separating the main cities. Saudi Arabian Airlines (SAUDIA) is the national carrier. All major airlines in the world offer services in and out of the Saudi Arabia. The air transport network comprises 26 airports, including four international, six regional and 16 domestic airports (MEP, 2009). Table 13-1 lists the Saudi Arabian airports currently operational within 400 km of the Ras Al Khair peninsula.

Table 13-1: Eastern Province Airports (International, Domestic and Saudi Aramco)

<table>
<thead>
<tr>
<th>City Served</th>
<th>Province</th>
<th>Airport Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>International Airports</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dammam</td>
<td>Eastern</td>
<td>King Fahd International Airport</td>
</tr>
<tr>
<td>Riyadh</td>
<td>Riyadh</td>
<td>King Khalid International Airport</td>
</tr>
<tr>
<td><strong>Domestic Airports</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Al-Hofuf, Al-Ahsa</td>
<td>Eastern</td>
<td>Al-Ahsa Domestic Airport</td>
</tr>
<tr>
<td>Hafar Al-Batin (KKMC)</td>
<td>Eastern</td>
<td>Hafar Al-Batin Domestic Airport</td>
</tr>
<tr>
<td>Qaisumah, Hafar Al-Batin</td>
<td>Eastern</td>
<td>Qaisumah Domestic Airport</td>
</tr>
<tr>
<td><strong>Saudi Aramco Airports</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tanajib</td>
<td>Eastern</td>
<td>Tanajib Airport</td>
</tr>
<tr>
<td>Abu Ali, Jubail</td>
<td>Eastern</td>
<td>Abu Ali Airport</td>
</tr>
<tr>
<td>Jubail</td>
<td>Eastern</td>
<td>Jubail Airport</td>
</tr>
<tr>
<td>Khafji</td>
<td>Eastern</td>
<td>Khafji Airport</td>
</tr>
<tr>
<td>Ras Al-Mishab</td>
<td>Eastern</td>
<td>Ras Al-Mishab Airport</td>
</tr>
<tr>
<td>Haradh</td>
<td>Eastern</td>
<td>Haradh Airport</td>
</tr>
</tbody>
</table>
13.2.3 LOCAL BACKGROUND

Road

Ras Al Khair Industrial City has a modern high capacity road network built to international standards as part of the development of the Ras Al Khair peninsula in the last decade. These networks are specifically designed for industrial traffic and are integrated with the national Saudi Arabian road network as described in Section 13.2.2. The Industrial City network is owned and managed by the Royal Commission. These roads are currently used by the existing operations such as the Ma’aden Phosphate Company (MPC) and the Ma’aden Aluminium Company (MAC). One of the main sources of road traffic to the Ras Al Khair industrial complex currently is the transport of molten sulphur by tanker from Berri Gas Plant at Jubail, which represents around 200-300 HGVs per day. This activity is however likely to change to port and rail transport as the rail network develops in the area. The Ras Al Khair Industrial City is also currently undergoing major development including plans for the construction of a 2,350 MW Power and Desalination Plant to the northwest of the Project site which will also increase the road traffic on the peninsula.

A local traffic survey was conducted to provide information on the quantities and types of vehicles accessing the Ras Al Khair industrial complex. Traffic counts were conducted at a predefined location (27°31’10.69"N, 49°11’11.80"E) which was identified to represent the main access point for road traffic accessing the Project site (refer to Figure 13-2).

Figure 13-2: Traffic Survey Location, 2013

Traffic counts were conducted over the following survey periods:

- Saturday 9th March 2013 (06:00 – 09:00, 15:00 – 18:00); and
- Sunday 10th March 2013 (09:00 – 13:00, 18:00 – 21:00).

Survey findings are reported as Scenario A or B:

1. **Scenario A** - Movement of vehicles from a south to north direction, i.e. access towards the Ras Al Khair industrial complex from Route 7950; and
2. **Scenario B** - Movement of vehicles from north to south, i.e. access from the Ras Al Khair industrial complex towards Route 7950.

The survey was conducted over two weekdays to understand a typical operating day. Results of the traffic survey are shown in Table 13-2 and Table 13-3.
### Table 13-2: Ras Al Khair Traffic Survey Results for Saturday 9th March 2013

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Weather</th>
<th>Period</th>
<th>Cars</th>
<th>Trucks</th>
<th>Buses</th>
<th>Other</th>
<th>Total Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Clear</td>
<td>Clear</td>
<td>06:00 - 07:00</td>
<td>72</td>
<td>16</td>
<td>20</td>
<td>0</td>
<td>108</td>
</tr>
<tr>
<td>B Clear</td>
<td>Clear</td>
<td>06:00 - 07:00</td>
<td>44</td>
<td>26</td>
<td>10</td>
<td>0</td>
<td>80</td>
</tr>
<tr>
<td>A Clear</td>
<td>Clear</td>
<td>07:00 - 08:00</td>
<td>217</td>
<td>35</td>
<td>20</td>
<td>3</td>
<td>275</td>
</tr>
<tr>
<td>B Clear</td>
<td>Clear</td>
<td>07:00 - 08:00</td>
<td>71</td>
<td>18</td>
<td>23</td>
<td>2</td>
<td>114</td>
</tr>
<tr>
<td>A Clear</td>
<td>Clear</td>
<td>08:00 - 09:00</td>
<td>196</td>
<td>19</td>
<td>9</td>
<td>0</td>
<td>224</td>
</tr>
<tr>
<td>B Clear</td>
<td>Clear</td>
<td>08:00 - 09:00</td>
<td>50</td>
<td>43</td>
<td>10</td>
<td>0</td>
<td>103</td>
</tr>
<tr>
<td>A Dusty</td>
<td>Dusty</td>
<td>15:00 - 16:00</td>
<td>48</td>
<td>43</td>
<td>6</td>
<td>0</td>
<td>97</td>
</tr>
<tr>
<td>B Dusty</td>
<td>Dusty</td>
<td>15:00 - 16:00</td>
<td>276</td>
<td>18</td>
<td>8</td>
<td>0</td>
<td>302</td>
</tr>
<tr>
<td>A Dusty</td>
<td>Dusty</td>
<td>16:00 - 17:00</td>
<td>37</td>
<td>4</td>
<td>9</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>B Dusty</td>
<td>Dusty</td>
<td>16:00 - 17:00</td>
<td>201</td>
<td>13</td>
<td>31</td>
<td>0</td>
<td>245</td>
</tr>
<tr>
<td>A Clear</td>
<td>Clear</td>
<td>17:00 - 18:00</td>
<td>33</td>
<td>14</td>
<td>12</td>
<td>0</td>
<td>59</td>
</tr>
<tr>
<td>B Clear</td>
<td>Clear</td>
<td>17:00 - 18:00</td>
<td>107</td>
<td>14</td>
<td>7</td>
<td>0</td>
<td>128</td>
</tr>
</tbody>
</table>

Total Vehicles Counted: 1352
Average Vehicles Per Hour: 112.7
Percentage Vehicle Type (%): 75.7

The maximum number of vehicles (per hour) observed in the morning of 9th March was 275 travelling from a south to north direction (Scenario A) between 7:00 - 8:00. The maximum in the afternoon was 302 travelling from north to south (Scenario B) between 15:00 - 18:00. The pattern of car and bus movements conveys the daily ‘commute’ of the existing workforce between accommodation facilities and the existing industrial facilities and operational construction sites.

The percentage split between the types of vehicle showed that cars were the dominant vehicle type, accounting for 76% of the total number of vehicles. It is estimated that each bus can transport 50 people.

### Table 13-3: Ras Al Khair Traffic Survey Results for Sunday 10th March 2013

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Weather</th>
<th>Period</th>
<th>Cars</th>
<th>Trucks</th>
<th>Buses</th>
<th>Other</th>
<th>Total Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Clear</td>
<td>Clear</td>
<td>09:00 - 10:00</td>
<td>71</td>
<td>41</td>
<td>2</td>
<td>0</td>
<td>114</td>
</tr>
<tr>
<td>B Clear</td>
<td>Clear</td>
<td>09:00 - 10:00</td>
<td>83</td>
<td>41</td>
<td>2</td>
<td>0</td>
<td>126</td>
</tr>
<tr>
<td>A Dusty</td>
<td>Dusty</td>
<td>10:00 - 11:00</td>
<td>96</td>
<td>43</td>
<td>9</td>
<td>0</td>
<td>148</td>
</tr>
<tr>
<td>B Dusty</td>
<td>Dusty</td>
<td>10:00 - 11:00</td>
<td>81</td>
<td>38</td>
<td>7</td>
<td>0</td>
<td>126</td>
</tr>
<tr>
<td>A Dusty</td>
<td>Dusty</td>
<td>11:00 - 12:00</td>
<td>110</td>
<td>23</td>
<td>12</td>
<td>0</td>
<td>145</td>
</tr>
<tr>
<td>B Dusty</td>
<td>Dusty</td>
<td>11:00 - 12:00</td>
<td>55</td>
<td>21</td>
<td>3</td>
<td>0</td>
<td>79</td>
</tr>
<tr>
<td>A Dusty</td>
<td>Dusty</td>
<td>12:00 - 13:00</td>
<td>121</td>
<td>19</td>
<td>1</td>
<td>0</td>
<td>141</td>
</tr>
<tr>
<td>B Dusty</td>
<td>Dusty</td>
<td>12:00 - 13:00</td>
<td>61</td>
<td>29</td>
<td>14</td>
<td>0</td>
<td>104</td>
</tr>
<tr>
<td>A Clear</td>
<td>Clear</td>
<td>18:00 - 19:00</td>
<td>88</td>
<td>18</td>
<td>16</td>
<td>1</td>
<td>123</td>
</tr>
<tr>
<td>B Clear</td>
<td>Clear</td>
<td>18:00 - 19:00</td>
<td>111</td>
<td>20</td>
<td>22</td>
<td>1</td>
<td>154</td>
</tr>
<tr>
<td>A Clear</td>
<td>Clear</td>
<td>19:00 - 20:00</td>
<td>27</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>34</td>
</tr>
<tr>
<td>B Clear</td>
<td>Clear</td>
<td>19:00 - 20:00</td>
<td>39</td>
<td>11</td>
<td>7</td>
<td>0</td>
<td>57</td>
</tr>
<tr>
<td>A Clear</td>
<td>Clear</td>
<td>20:00 - 21:00</td>
<td>24</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>32</td>
</tr>
<tr>
<td>B Clear</td>
<td>Clear</td>
<td>20:00 - 21:00</td>
<td>27</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>30</td>
</tr>
</tbody>
</table>

Total Vehicles Counted: 994
Average Vehicles Per Hour: 71.0
Percentage Vehicle Type (%): 70.3

The maximum number of vehicles (per hour) observed in the afternoon of 9th March was 302 travelling from north to south (Scenario B) between 15:00 - 18:00. The pattern of car and bus movements conveys the daily ‘commute’ of the existing workforce between accommodation facilities and the existing industrial facilities and operational construction sites.
The maximum number of vehicles (per hour) observed in the morning of 10th March was 148 travelling from a south to north direction (Scenario A) between 10:00 - 11:00. The maximum in the afternoon/evening was 154 travelling from north to south (Scenario B) between 18:00 - 19:00. Similar to the counts the previous day, car and bus movements correspond to peak working hours. The percentage split between the types of vehicle showed that cars were the dominant vehicle type with 70% of the total number of vehicles.

Overall the traffic survey identified that the numbers of vehicles operating during the morning hours travelling toward the Ras Al Khair industrial complex are greater than those travelling in the opposite direction, while in the afternoon the case is the opposite. In general the flow seems to be balanced in both directions with cars representing the dominant vehicle type.

**Rail**

The North-South Railway will be utilised by the Project for transfer of materials from the Umm Wu’al Mine and Waad Al Shamaal Phosphate Industrial Complex area to the Ras Al Khair Project site and vice versa. Refer to Section 4 Detailed Description and Layout of the Proposed Development for more details.

Under Royal Decree in 2006, the licence was granted to establish the Saudi Railway Company (SAR) to construct and operate the North-South Railway project and the related services and facilities. The main North-South Railway is currently a single track with passing loops and is intended for mixed passenger and freight use. Its total length from Ras Al Khair to the Jordanian border is approximately 2,400 km. The distance from Ras Al Khair to Al-Jalamid is approximately 1,500 km. A new branch line of approximately 135 km length will be required on this line from Al-Jalamid to the Umm Wu’al Mine and Waad Al Shamaal Phosphate Industrial Complex for project specific operations.

The operations of the existing Ma’aden Phosphate Company (MPC) facility at the Ras Al Khair require rail services to transport approximately 5 Mtpa of phosphate rock from the beneficiation process at Al Jalamid. This represents two trains per week transporting 160 wagons, approximately 160,000 tons. The other anticipated services that will also utilise the North-South Railway include:

- A passenger service between Al-Jawf and Al-Quaryyat to be operational by 2014 (SAR, 2013);
- The addition of sulphuric acid transfers for existing MPC operations;
- A Bauxite Transportation Service transferring 4 Mtpa of refinery feed bauxite ore from the Al-Baitha mine in Qassim province to the Ma’aden Aluminium Company (MAC) processing plant at Ras Al Khair (WHGME 2010);
- Transportation of bulk materials (such as caustic soda etc) to the mining sites in the Northern Province from Jubail /Dammam; and
- Other potential transfers between future mineral facilities and the industrial centres on the Gulf Coast.

The existing railway system serving the Ras Al Khair Industrial City includes a rail head with a large turning loop. A branch line to the north was recently constructed to serve sidings for sulphuric acid deliveries to the existing MPC facilities.

**Port**

The existing port at Ras Al Khair covers an area of 23 km² and consists of the following:

- Three 785 m long and 15m deep berths;
- One 121 m long and 6 m deep service berth, equipped with fenders, candles, reach stackers, ammonia loading arm, ladders and support yard;
- A 700 m diameter vessel turning basin;
- A 23 km long and 16 m deep approach channel (170 m breadth) and waves breaker;
Work is in progress on building berths 5 and 6.

As noted in Section 13.2.2, the Port currently serves more than 80 different industrial projects in the region and has plans for expansion up to 50 berths by 2030. Once berths 5 and 6 are completed, the Port is expected to handle approximately 895 metric tonnes of industrial products annually. The site of minerals to be exported through the port will amount to 4.34 million tonnes and imports will amount to approximately 0.66 million tonnes (SEAPA, 2013b).

13.3 IMPACT ASSESSMENT

13.3.1 INTRODUCTION

This Section describes the potential for impacts on the existing traffic and transport infrastructure as a result of the construction and operation of the proposed Ras Al Khair Industrial Complex. The significance of the potential impacts identified are characterised in accordance with the methodology described in Section 5 Impact Assessment Methodology.

Potential impacts relating to traffic and transport on other aspects of the environment are addressed in the relevant sections of this report as follows;

- Section 6 Air Quality and Meteorology;
- Section 9 Noise and Vibration;
- Section 11 Water Quality Management;
- Section 12 Socio-economic Aspects; and
- Section 15 Health and Safety Aspects.

Detailed information of the Project requirements for the construction and operation of the transport network is provided in Section 4 Detailed Description and Layout of the Proposed Development.

Saudi Arabian Railways (SAR) will be responsible for the design and delivery of all railway related works and will therefore undertake the necessary impact assessment / permitting for this infrastructure. The following assessment does however address the proposed rail sidings required to the East of the process area to link the proposed Materials Storage and Handling Area to the Port and also to the Umm Wu’al Mine and Waad Al Shamaal Phosphate Industrial Complex in the North.

SEAPA will provide the Port area and berths required for the proposed storage and loading/unloading activities. SEAPA will therefore undertake the necessary impact assessment / permitting for this infrastructure and associated maintenance such as dredging. The following assessment addresses potential impacts on traffic / transport related to the construction and operation of the proposed land-based storage and loading/unloading activities at the Port only.

Air travel will be used by both construction and operational staff from inside and outside of the Kingdom. Due to the large capacity of the airport network within Saudi Arabia, it is not considered that this Project will have any significant impacts on the operation of this infrastructure. Air travel is therefore excluded from the following impact assessment.

13.3.2 CONSTRUCTION

Construction of the Project facilities is to begin in the first quarter of 2014 and is due to be completed in the last quarter of 2016. At its peak, a maximum workforce of approximately 3,300 is expected to be required. The peak construction period is expected to extend over 24 months when all construction sites will be active. The workforce will be housed in an accommodation camp in close proximity to the Project site, which will provide all utilities and amenities required by the workers including accommodation, welfare and recreational facilities, healthcare services and religious requirements. The construction phase will have various transport requirements including the movement of personnel and the delivery of substantial quantities of construction materials and process equipment from in Kingdom and
other international sources. Based on this, the construction of the facility has the potential to impact upon the existing transport infrastructure. The predicted construction phase impacts are summarised in Table 13-4.

**Table 13-4: Construction Phase Impact Assessment**

<table>
<thead>
<tr>
<th>Scope of Impact</th>
<th>TI1</th>
<th>TI2</th>
<th>TI3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor Importance / Sensitivity</td>
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<td>Low</td>
</tr>
<tr>
<td>Frequency</td>
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<td>Rare</td>
<td>Frequent</td>
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<td>Likelihood</td>
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<td>Unlikely</td>
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</tr>
<tr>
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<td>Regional</td>
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</tr>
<tr>
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<tr>
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</tr>
<tr>
<td>Action</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

**Road**

The majority of the heavy materials and large pieces of equipment will be transported to the Project site via sea shipment (primarily Dammam) and HGV transfer. There will also be materials and equipment being transported from within Kingdom, predominately via roads. The prefabrication and modularisation of construction elements (such as concrete structures) increases the productivity on site but can result in the requirement to transport large structures by road using slow moving vehicles.

Volumes of daily traffic using the national and local roads in the vicinity of the Project site and the internal roads within the complex will increase temporarily during the construction phase as a result of the influx of construction workers requiring transportation to, from and around the site, as well as the delivery of construction materials and equipment. The existing operations of Ma’aden Phosphate Company (MPC) and other industrial facilities in the area will also be utilising this infrastructure throughout the construction period so there is a potential for traffic congestion in the absence of management plans.

Existing HGV traffic in and around Dammam is expected to be high due to its extensive land and marine based industry. Also, road activity between Dammam and Ras Al Khair will be influenced by activities at Jubail Industrial City which is position between the two areas. The current road network between Dammam and Ras Al Khair however offers two main routes: Route 613 Dammam – Jubail; and Route 95 Dammam – Ras Al Khair. Therefore traffic destined for Ras Al Khair from Dammam is unlikely to adversely impact on the capacity of the road network in and around Jubail.

Using estimates for the quantities of materials and equipment required for construction it is anticipated that approximately 20,000 HGVs will be required to deliver materials over the three year construction programme. This equates to approximately 125 HGV movements per week, or 21 per day (based on a 6 day working week). Peak construction periods will have higher daily HGV movements and if it is considered that peak construction extends for 24 months (worst case), representing 67% of the total construction period, then weekly and daily peak HGV movements can be estimated as 258 and 43 respectively (67% of 20,000 HGVs spread over 24 months).

Due to the industrial nature of the Project area and existing security arrangements, traffic access points and routes around and across the Project area will be restricted. Private cars will not be permitted without prior approval, and personnel vehicle access to the site is likely to be restricted to buses for transporting the workforce from accommodation camps to the work areas. Assuming each bus can transport 50 workers, a maximum of 66 bus trips will be...
required to transport the peak construction workforce of 3300 personnel. Due to the short distances between accommodation camps and the Project work areas, buses are however likely to make a number of trips to/from the construction areas reducing the number of buses on the road.

Overall it is anticipated that the peak construction phase will lead to an increase of approximately 324 daily movements (66 construction worker trips plus 258 HGV trips) in and out of the site (i.e. 648 single vehicle movements per day). This estimate is based on the unlikely event that the full workforce is active at one shift pattern. Adverse impacts may arise if construction traffic management arrangements are not co-ordinated appropriately with those already in existence.

The typical capacity of a high standard dual carriage way road with a speed limit of 60 to 90 km per hour is 2010 one-hourly flows in each direction (DMRB 1999). Using the data from the March 2013 local traffic survey and the projected additional traffic from the peak construction activities, the roads in and around the vicinity of the Ras Al Khair Industrial City will continue to operate within capacity. The additional vehicles are required for a temporary period during construction and therefore additional site-generated traffic is expected to create minimal impacts to the existing traffic operations near the site.

Each Engineering, Procurement and Construction (EPC) contractor is contractually required to develop, implement and maintain a construction phase Traffic and Transportation Management Plan to outline the management of transporting people, equipment and materials. To inform this Plan, each EPC is required to perform a traffic and logistics study to assess roads and determine access requirements via other modes of transport. On completion of this survey, construction lay down areas, dimensions of all road and jobsite clearance limitations will be identified.

**Impact TI1 - Low Significance.**

**Rail**

No significant impacts on rail infrastructure are anticipated during the construction phase as it is anticipated that materials and equipment will be transported via sea shipment or road transfer.

The construction of the rail sidings by SAR may coincide with Project-related construction activities at the Materials Storage and Handling Facility and therefore there is some potential for impacts on SAR construction traffic in the absence of appropriate consultation between EPC Contractors, SAR and Ma'aden.

Although not currently proposed, the North-South railway has potential to provide a transport link during the construction phase to transfer materials between Jubail and Ras Al Khair. Also, as noted in Section 13.2.2, the connection between Dammam and Jubail is due for completion in 2016, which may be able to serve some periods of the construction programme. The use of the railway for delivering materials and equipment during the construction phase would be beneficial in reducing HGV traffic. Any use of the railway for the delivery of construction materials should consider the timetable of the existing services using this line and ensure that there are no impacts from the impediment of the existing operations.

**Impact TI2 - Low Significance.**

**Port**

The majority of the specialist prefabricated items will be produced outside of Saudi Arabia and so will be shipped to a port for transfer to the site via road.

As Ras Al Khair Port does not currently have the required infrastructure to support the receipt of construction equipment and materials, it is currently proposed that Dammam Port will be utilised. However, in the instance that oversized equipment cannot travel inland, barges will operate from Dammam to Ras Al Khair Port via existing shipping channels. Prior approval of barge movements will be required from SEAPA which will dictate berthing locations and timings, therefore no significant impacts on port operations is expected.
Due to the current capacity of Dammam Port and its plans for expansion, no significant adverse impacts on the Port’s infrastructure are anticipated. However, the traffic and logistics study and Traffic and Transportation Management Plan to be developed by the EPC Contractor/s will confirm this.

Any transportation of materials and equipment from construction sites and production facilities within Kingdom (e.g. the west coast of Saudi Arabia) will be transferred via ship movements if feasible. Transfer of equipment from west coast ports (such as Jeddah, Yanbu) to an east coast port will significantly reduce the amount of materials which have to be transported across the country by road, therefore reducing the requirement for HGV movements. This has beneficial impacts due to the reduction in potential congestion issues and reduced carbon emissions.

**Impact TI3 - Low Significance.**

### 13.3.3 COMMISSIONING

The pre-commissioning and commissioning activities for the Project will require the presence of the EPC Contractor in addition to the operations staff to allow training etc. The total staff presence will be less than that estimated for the construction phase and therefore less transportation will be required (reducing the magnitude of any potential impacts). The pre-commissioning and commissioning period will commence straight after the construction works are finalised and is for a temporary period only. No significant adverse impacts on transport infrastructure over and above those identified for the construction phase are therefore anticipated.

### 13.3.4 OPERATIONS

Potential impacts of the operational phase of the Project on existing infrastructure have been assessed below and are summarised in Table 13-5.

**Table 13-5: Operational Phase Impact Assessment**

<table>
<thead>
<tr>
<th>Scope of Impact</th>
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<th>TI5</th>
</tr>
</thead>
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</tr>
<tr>
<td>Frequency</td>
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<td>Action</td>
<td>Direct</td>
<td>Direct</td>
</tr>
<tr>
<td>Significance</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

**Road**

The operational phase of the Project will require between an estimated 519 and 536 personnel working over three shifts. Project staff will reside in the specifically designed Ma’aden housing network located approximately 8 km to the south west of the Project site.

A large proportion of the operational workforce at the process plants are expected to be transported to/from work by bus (estimated to hold 50 people) as there are no significant parking facilities at these locations. Staff in the administration and laboratory buildings will have access to parking.

The peaks in traffic over a 24 hour period are expected around the time of the three shift changes (06:00-08:00, 14:00-16:00, 22:00-00:00). Assuming a worst case (i.e. all workers
using cars for each individual person) then the maximum number of vehicles would be approximately 179 (number of workers representing a complete shift) in one direction.

The majority of the raw materials required for the Project will arrive at the site via rail. There will however be some materials transported by HGVs from various sources to the Ras Al Khair industrial complex using the national and local road network. These materials are to be transported by HGV rather than by train as the rail network will not service the areas from which these materials are being sourced. The daily estimates for operational HGV movements associated with these raw materials are as follows:

- 9 HGVs for filler;
- 2 HGVs for urea;
- 1 HGV for coating oil;
- 30 HGVs for PPA (10% of supply from Umm Wu’al to Ras Al Khair); and
- 1 HGV for other miscellaneous materials (including various chemicals and auxiliary products, such as coating agent and defoamer).

The current estimate of demand requires the access of 43 HGVs per 24 hour period which equates to approximately one HGV every 30-35 minutes.

Using the maximum number of existing traffic movements recorded in the March 2013 survey (1785 trips) and the anticipated total volume of additional traffic as a worst case (401 trips (179 car return trips and 43 HGV trips)); the total traffic movement at the survey location is estimated to comprise 2,186 once the Project facilities are operational. This represents an increase of 22% of the current traffic movement and therefore significant negative impacts on the existing road network are not anticipated.

A new site access area (security entrance) will be installed at the Ras Al Khair industrial complex to reduce the congestion impacts caused by the extra demand in vehicles requiring access. This will allow more vehicles to access the site at any one time reducing the occurrence of trucks backing up at the entrance and exit of the site.

**Impact TI4 - Low Significance.**

**Rail**

During the operational phase, raw materials and products for export will be transported via the North-South Railway from the Umm Wu’al Mine and Waad Al Shamaal Phosphate Industrial Complex to the Ras Al Khair Industrial Complex. The assessment of the environmental and social impacts resulting from the construction and operation of the North-South Railway will be assessed by SAR is outside of this report.

Liquid handling systems associated with rail transport at Ras Al Khair are required for the following raw materials and products:

- MGA Raffinate Phosphoric Acid, 6,345 T/day (4190m$^3$), 2.094MTPA over 330days.
- MGA for Export, 950 T/day (550m$^3$) or 0.304MTPA over 320days.
- PPA for Export, 196 T/day (299m$^3$) or 0.065MTPA over 330days.
- Sulphuric Acid, 1380 T/day (745m$^3$) or 0.415MTPA over 300days.

The Project will require approximately two freight trains per day in each direction, every day of the year apart from a planned maintenance shutdown period of 28 days per annum. There will no rail exports of products produced at Ras Al Khair; these will be transported via conveyors and pipelines to the Port for export.

Rail sidings to meet Project demands are to be specially designed and constructed by SAR for the sole use of the Project operations. It is therefore anticipated that the operational phase of the Project will not adversely impact the existing rail transport infrastructure at Ras Al Khair.

**Impact TI5 - Low Significance.**
Ras Al Khair Port will be utilised for the import of potash as a raw material and for the export of products of the Ammonia and DAP/NPK Plants as well as the Umm Wu’al Mine and Waad Al Shamaal Phosphate Industrial Complex (PPA and MGA). The estimated numbers of ships to visit Ras Al Khair Port per year as part of the operational phase of the Project is expected to be approximately 228 ships per year. SEPA will design and construct the required berthing and manage the movements of ships to ensure that there are no significant impacts on the existing infrastructure. Access channels together with navigation aids will be developed in accordance with the requirements of the appropriate International Standards to accommodate the numbers and sizes of ships required.

The assessment of the environmental and social impacts resulting from the construction and maintenance of the proposed berths will be assessed by SEAPA outside of this report.

13.3.5 DECOMMISSIONING

The decommissioning of the Project facilities has the potential to impact local and national transport infrastructure in a similar way as during the construction period although both the workforce and time period will be less. The dismantling of the facility will require construction vehicles and heavy machinery to demolish the processing plants and other structures. HGVs will also be required to transport waste to the appropriate waste facilities. Rail infrastructure and ships may also be utilised to transport contaminated equipment over long distances from the site to specialist waste facilities within Kingdom and/or at specialist international facilities.

The continuing development of the Ras Al Khair peninsula, including its transportation infrastructure, is likely to influence the ability of this infrastructure to manage increased traffic movements associated with the decommissioning phase.

Updates to the traffic and logistics study and Traffic and Transportation Management Plan first developed for the construction phase will manage traffic related to decommissioning.

13.4 RECOMMENDATIONS

Potential negative impacts of medium or high significance on transport infrastructure are not anticipated to occur as a consequence of the Project commissioning, construction, operation or decommissioning phases.

Implementation of the following measures is recommended to manage the potential impacts identified as being of low significance and maintain good management practices. It is anticipated that this assessment can be built upon during detailed design when detailed Project requirements are realised.

13.4.1 CONSTRUCTION PHASE RECOMMENDATIONS

The EPC Traffic and Transportation Management Plan shall be prepared in consultation with Ma’aden Project Management Team and the RC prior to commencement of construction. This plan will detail as a minimum (but not limited to) the following:

- Responsibility and procedures for co-ordination and liaison with SEAPA, SAR and the Ministry of Transport as appropriate during construction;
- Identify any temporary re-routing of traffic, procedures for managing delivery transportation companies, e.g. to avoid peak traffic times when delivering bulk material and equipment;
- Procedures for staggering start and finish times where feasible to reduce peak traffic flows;
- Confirmation of capacity within the rail network and availability of trains to deliver materials required during construction;
- Confirmation of the capability for Ras Al Khair Industrial Port to accept equipment and materials required for construction;
Outcomes of traffic risk assessments undertaken;
Access routes for construction plant and materials;
Transport routes for the workforce (on arrival to and departure from the accommodation, and between accommodation and the work areas);
On-site traffic management;
Measures to segregate pedestrians from vehicle areas;
Training and awareness;
Measures to protect the local community where appropriate;
Schedule of audits of the management plan to confirm its ongoing effectiveness.

The Construction Environmental Management Plan which will be developed for the Project should consider the following:

No vehicles should leave the site with materials adhering to the wheels in a quantity which may result in its being deposited on the public highway, and creating nuisance, or hazard to vehicles. Suitable wheel washing equipment to avoid such problems should be installed if appropriate, operated and maintained on the site until the development is completed.

The use of locally won materials, such as sand and fill etc will be utilised wherever possible to reduce the requirement to import bulk materials from other locations reducing truck movements bringing this material from external locations.

Ma’aden will continue to engage with SAR and SEAPA as appropriate to manage construction-related interfaces.

13.4.2 OPERATION AND DECOMMISSIONING PHASE RECOMMENDATIONS

Ma’aden to develop, implement and maintain a Traffic and Transportation Management Plan appropriate for operational and decommissioning use. This should consider the following:

Responsibility and procedures for co-ordination and liaison with SEAPA, SAR and the Ministry of Transport during operation and decommissioning;
Confirmation of capacity within the rail / road / port network to manage materials to and from the site during operation and decommissioning;
Rail scheduling and operational procedures;
Access routes for operational vehicles and workforce transportation between Ma’aden accommodation and work areas;
On-site traffic management;
Measures to segregate pedestrians from vehicle areas;
Training and awareness in road safety; and
Measures to protect the local community where appropriate.
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14.0 UTILITIES INFRASTRUCTURE AND USAGE

14.1 INTRODUCTION

This Section outlines the existing utilities infrastructure and usage relevant to the Ras Al Khair Industrial City, specifically the existing Ma’aden Phosphate Company (MPC) complex with which a number of interactions are proposed as part of the Project. The utility requirements for the Project are described in order to identify and characterise potential impacts associated with increased demands on existing utility infrastructure including the provision of electricity, water supply, wastewater treatment, cooling systems, steam, instrument and plant air, and telecommunications.

The impact on waste facilities is discussed in Section 10 Waste Management and the impact on existing transport infrastructure is addressed in Section 13 Traffic and Transport Infrastructure.

14.2 BASELINE CONDITIONS

14.2.1 INTRODUCTION

The baseline conditions of the existing utilities infrastructure are described below. Further details specific to each of the processing plants and other facilities are provided in Section 4 Detailed Description and Layout of the Proposed Development. The existing MPC utilities infrastructure at Ras Al Khair became fully operational in May 2010.

14.2.2 POWER

Electrical Power Supply & Distribution

Electricity for the Kingdom of Saudi Arabia is provided by Saudi Electricity Company, which was the result of merging all electricity providers in April 2000. The company produces over 51,000 MW of power through a mixture of steam, gas, combined-cycle and solar facilities, and provides to 6.3 million customers (SEC, 2011). The Ras Al Khair Industrial City is connected to the SEC electrical power grid which has sufficient capacity to supply the existing MPC operations. The Saline Water Conversion Company (SWCC) is currently developing a 2,350 MW power and desalination plant to be located in the north-west of the Ras Al Khair Industrial City. This will supply power and water to the Ras Al Khair Industrial City and the SEC grid providing a further source of reliable power in the local area.

A substantial amount of electrical power for the existing MPC operations is however currently generated by the excess energy produced by the Sulphuric Acid Plants (SAP) and the existing Ammonia Plant. This is used to minimise the amount of power imported from the SEC grid. Three SAP trains supply steam to the Power and Desalination Plant (PDP), located in the north of the Ras Al Khair industrial complex, which produces a total of 129.4 MW from two steam turbine generators (each producing 64.7 MW). In addition a 22 MW steam turbine generator located in the existing Ammonia Plant utilises the excess energy produced from the ammonia waste heat boilers and auxiliary boiler to first power the Ammonia Plant itself before exporting the excess power (13 MW) to the grid. Power produced by MPC operations is combined with the imported power from the SEC power grid. Operations at the Port are currently powered from an electrical power network utilised by the Saudi Port Authority (SEAPA).

Natural Gas

Ras Al Khair Industrial City is currently supplied with natural gas from a cross country Saudi Aramco natural gas pipeline. There are currently two metering stations owned by Saudi Aramco located in the Ras Al Khair Industrial City. These metering systems supply the existing MPC operations, Ma’aden Aluminium Company (MAC) and SWCC. The metering availability of the older of the two stations is at full capacity with spare capacity identified in the new metering facility. A 12.5km DN 600 buried carbon steel natural gas pipeline connects the older of the metering stations to the existing MPC industrial complex which allows the distribution of natural gas initially to the Ammonia Plant and then across the other facilities. Natural gas is
used as a feed and fuel in the existing Ammonia Plant at high pressure, and also as a fuel for the SAP, PDP and Di-ammonium Phosphate (DAP) plants at a lower pressure.

At the tie-in to the existing MPC industrial complex there is a requirement for conditioning of the gas prior to its distribution.

Emergency Diesel Generators

The existing MPC operations are supplied with emergency power as required from Emergency Diesel Generators (EDG) located at each of the individual plant substations. Each EDG has an associated day tank which is filled by road tanker.

14.2.3 WATER SUPPLY

The climate of the Arabian Peninsular dictates that the majority of the water supply for the Kingdom is obtained from a mixture of non-renewable groundwater sources (62%), renewable groundwater sources (from the Arabian Shield) (30%), desalinated water (6%) and reclaimed wastewater (2%) (MEP, 2009).

Due to its coastal location, the main water resource for the Ras Al Khair Industrial City is the Arabian Gulf. Seawater is transferred through an inlet channel to the Power and Desalination Plant (PDP) located in the north of the MPC industrial complex. Within the existing MPC complex, water is currently treated and supplied as follows:

<table>
<thead>
<tr>
<th>Water Type</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process (service) water</td>
<td>Existing PDP.</td>
</tr>
<tr>
<td>Desalinated water</td>
<td>Existing PDP.</td>
</tr>
<tr>
<td>Demineralised (polished) water</td>
<td>Desalinated water supplied from the existing PDP which is polished in the demineralisation unit located within the existing Ammonia Plant.</td>
</tr>
<tr>
<td>Fire water</td>
<td>The fire water system utilises process (service) water supplied from the existing PDP.</td>
</tr>
<tr>
<td>Potable water</td>
<td>Process (service) water supplied from the existing PDP is re-mineralised in the potable water treatment facility.</td>
</tr>
<tr>
<td>Irrigation water</td>
<td>Extracted from the irrigation pond which receives treated effluent from the sanitary waste water treatment plant.</td>
</tr>
</tbody>
</table>

14.2.4 WASTEWATER TREATMENT

MPC currently operates a 240 m$^3$/day Sanitary Treatment Plant (STP) within its complex to treat sanitary waste from MPC facilities. Effluent is treated to a secondary level (BOD <10 mg/l, COD <40 mg/l) and is discharged to a HDPE lined Irrigation Pond. The normal flow of treated effluent expected from the STP is 7 m$^3$/hr under normal conditions, and 8.58 m$^3$/hr under maximum conditions, over a 24 hour period. The design of the open surface Irrigation Pond is sized for a 6,000 m$^3$ capacity. A set of five surface mechanical aerators are provided for odour control, continuously agitating the surface of the pond. The Irrigation Pond also receives neutralised wastewater from the existing Ammonia Plant and boiler blow down from the existing SAP and PDP auxiliary boiler. If the water within the Irrigation Pond meets the requirements outlined in Table 3D, RCER 2010 Volume I it is used for irrigation of the MPC complex using four pumps in two sets. The first set provides irrigation water to a sprinkler system in the administration area (which a rated flow of 8 m$^3$/hr, operating for a 10 hour period per day). The second set of pumps provide irrigation water for landscaping in the rest of the complex (these pumps are rated for 377 m$^3$/day). During winter however the quantity of water required for landscaping is reduced by half and so under such conditions excess irrigation water overflows to the Evaporation Pond.

The Evaporation Pond is a HDPE lined open area pond which has been designed to accommodate treated SAP wash down water from the pH adjustment skid. The surface area
of the pond is 6,500 m$^2$, having an operating depth of 1.6 m. Salts generated during the neutralisation of sulphuric acid with caustic soda are gradually transported along with the wash down water to the pond. These salts crystallise as the water evaporates from the pond leaving behind a sludge layer of salt and sand. The build up of this sludge gradually reduces the volume of the pond so a regular maintenance regime is in place to clean off all debris and sludge. The sludge is pumped into a road tanker and transported to a RC licensed waste facility in Jubail.

A third pond, the Storm Water Retention Pond, receives storm water runoff from across the existing MPC facilities. This is located some distance from the other ponds, south of the existing administrative buildings. The Retention Pond ties-in to the RC sewer network to allow storm water to be discharged from site.

14.2.5 COOLING SYSTEM

Seawater from the Arabian Gulf is supplied to the existing Ammonia Plant, SAPs and the PDP by a once-through sea water cooling system to act as a non-contact cooling agent. This system has a throughput of approximately 124,000 m$^3$/h. A portion of the seawater supply to the PDP is used as the feed for the production of desalinated water. The concentrated brine by-product from the PDP is discharged into the seawater return with the seawater used for cooling purposes. This mixing reduces the temperature of the cooling water and the concentration of the brine.

14.2.6 STEAM

The existing facilities at the MPC industrial complex are supplied with steam produced from the existing Ammonia Plant and SAPs.

14.2.7 INSTRUMENT AND PLANT AIR

The existing facilities at the MPC industrial complex are supplied with instrument and plant air produced from the existing Ammonia Plant. Common air compressors supply both instrument and plant air, however separate piping headers are used to distribute both grades of air to the facilities (highest supply priority is given to instrument air with plant air being shed in preference (in the event that low pressure is identified)).

14.2.8 TELECOMMUNICATION

Telecommunications in-Kingdom are provided by Saudi Telecommunications Company (STC). Fixed telephone lines stood at 4.63 million at the end of 2011 of which around 3.3 million (71%) were residential lines (CITC 2011). Mobile communications are provided by four main suppliers comprising Bravo, Mobily, STC and Zain regulated by Communication and Information Technology Commission. The total number of mobile subscriptions grew to around 53.7 million at the end of 2011, with a penetration rate of 188%. Prepaid subscriptions constitute the majority (over 87%) of all mobile subscriptions (CITC 2011). The Ras Al Khair industrial complex is currently connected to a STC landline which provides telecommunications across the site.

14.3 IMPACT ASSESSMENT

14.3.1 INTRODUCTION

This Section describes the Project requirements for utilities infrastructure. The impact of each of the required utilities is characterised and the impact assessed as per the methodology described in Section 5 Impact Assessment Methodology.

14.3.2 CONSTRUCTION PHASE IMPACTS ON UTILITIES

The construction phase requires utility services and infrastructure to support the construction works on site and to supply the temporary construction camps which house construction personnel. Construction camps will be equipped with the utilities and support services necessary to accommodate the workforce, such as water, electricity, air conditioning, laundry, canteens, recreational and medical services. In addition, the workforce will also require other services, such as health services (discussed in Section 15 Health and Safety Aspects).
internet and telecommunication demands. Any tie-ins with the existing services may have a potential impact on the existing uses. These impacts are summarised in Table 14-1, and discussed in the following sub-sections.

**Table 14-1: Construction Phase Impact Assessment – Utilities**

<table>
<thead>
<tr>
<th>Scope of Impact</th>
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<th>UI3</th>
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<tbody>
<tr>
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<td>Medium</td>
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</tr>
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**14.3.2.1 POWER SUPPLY**

Construction activities will require an electrical supply to power construction equipment and lighting. Where possible the construction works will utilise the power generated supply from the existing MPC / SEC grid. Remote working areas are not anticipated, but if tie-ins are not feasible, diesel powered portable generators will be used. The power requirements for the construction phase are not expected to have a significant impact on the existing MPC operations. Where tie-ins to the existing electrical grid are required there may be temporary outages to allow the tie-ins to be made however these are likely to be for short periods of time (max 3-4 hours). SEC’s existing infrastructure at the Project site provides security of electricity supply for the construction phase will be met comfortably. In the event of grid failure, emergency diesel generators will be used to maintain essential services (lighting etc).

**Impact UI1 – Low Significance.**

**14.3.2.2 WATER SUPPLY**

A constant supply of potable, service and fire water will be required during the construction phase for various uses including drinking, showers, emergency eye washes, concrete mixing, dust mitigation and fire extinguishing etc. The existing PDP has sufficient capacity to supply the likely requirements of the construction phase, and although there will be an associated energy cost with meeting the extra demand, the supply of water required for construction is not anticipated to have a significant impact on the existing MPC operations or utilities.

Where tie-ins to the existing water supply routes are applicable, construction supply will be managed so that it will not have an impact on the existing operations during this connection period. Where tie-ins are not feasible due to locations, potable water can be supplied by onsite potable water units.

Service water will also be supplied by the PDP during construction phase. The existing fire protection equipment and services will be used along with specific onsite protection as required.

Water required for the construction works will be stored at the construction site and construction camps. It is likely that the storage units will be supplied using road tankers. If at EPC stage, it is determined that the demand for water supply can not be met by the existing infrastructure at Ras Al Khair, water will be supplied (via road tanker) from other locations such as Jubail.

**Impact UI2 – Low Significance.**
14.3.2.3 WASTEWATER TREATMENT
Sanitary wastewater for the construction sites and camps will be collected in local storage tanks and is likely to be transported (via road tankers) to the existing STP. MPC have indicated that there is a sufficient capacity to meet the demands of the construction phase. No significant impacts on this infrastructure are anticipated.

*Impact UI3 – Low Significance.*

14.3.2.4 TELECOMMUNICATIONS
Temporary wireless telecommunications will be installed at the construction sites and camp, and maintained throughout the construction phase to allow communications to be made for co-ordinating the construction actives and for personal uses at the construction camps. These are not expected to directly tie-in to the existing telecommunications used by MPC and will be provided for by the EPC Contractor. No significant impacts are expected.

*Impact UI4 – Low Significance.*

14.3.3 PRE-COMMISSIONING & COMMISSIONING PHASE IMPACTS ON UTILITIES
Utilities infrastructure and supply is required during the pre-commissioning and commissioning phase to test the equipment and to start-up the processing units. The impacts of this use of utilities is summarised in Table 14-2 below. Further details of utility requirements for this phase are provided in Section 4 Detailed Description and Layout of the Proposed Development.

Table 14-2: Pre-Commissioning and Commissioning Phase Impact Assessment – Utilities

<table>
<thead>
<tr>
<th>Scope of Impact</th>
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During the pre-commissioning and commissioning phase electrical power from the existing MPC grid will be utilised before the Ammonia Plant becomes fully operational. Steam and Plant/Instrument Air will also be provided by MPC until the Ammonia Plant becomes operational. Water will be supplied as per the operational phase (see below). Water required for hydrotesting activities will be supplied via the existing PDP. The total quantity of water to be used during hydrotesting activities is not available at this stage, but the total quantity will be minimised through hydrotest water reuse, by transferring it from one tank to another. As the tanks have different volumes, careful planning in the hydrotest sequence will be implemented, which will consider the construction schedule, applicable engineering standards and Project specifications. MPC have confirmed that the existing utilities have sufficient capacity to meet the requirements of the Project during the commissioning phase. No significant impacts have been identified

*Impact UI5 – Low Significance.*
14.3.4 OPERATIONS PHASE IMPACTS ON UTILITIES

A description of the proposed utilities infrastructure is provided in Section 4 *Detailed Description and Layout of the Proposed Development*. Potential impacts of the operational phase of the Project on existing utilities have been assessed below and are summarised in Table 14-3.

**Table 14-3: Operational Phase Impact Assessment – Utilities**

<table>
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<tr>
<th>Scope of Impact</th>
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14.3.4.1 ELECTRICAL POWER SUPPLY

The anticipated electrical power demand for the Project during the operational phase is 83 MW for normal operation, and 86 MW for peak operation. The Ammonia Plant will however contain a 22 MW steam turbine generator which will utilise the excess energy produced by the waste heat boilers and the auxiliary boiler. This generator will first power the Ammonia Plant itself before exporting the excess (13 MW) to the grid. MPC have confirmed that the current spare capacity from the existing infrastructure is approximately 40 MW. To meet the remaining 24 MW Project demands (during peak operation), two new bays will be added to an existing 115kV substation. Following this expansion the demand requirements for the existing site and the Project requirements will be within capacity. The Project facilities at the port will tie into the Saudi Port Authority (SEAPA) network which will be expanded if required to accept this additional load. No significant impacts are therefore anticipated.

*Impact UI6 – Low Significance.*
14.3.4.2 NATURAL GAS SUPPLY

Natural gas is required mainly for use as a feed in the Ammonia Plant (to extract hydrogen for the ammonia synthesis reaction), but is also to fuel the Ammonia Plant and DAP/NPK plants. Natural gas will supply the ammonia flare pilots and the auxiliary boiler which runs continuously on minimal load for safety reasons to supply the Ammonia Plant with power during emergency situations. It will also fuel the drying process required in the DAP/NPK plants. A new DN 600 natural gas pipeline will be installed from the Saudi Aramco meter outside of the MPC industrial complex to connect into the new Ammonia Plant. This will then be distributed to the DAP/NPK plants for use. The new natural gas supply pipeline will tie into the existing supply to MPC operations for use across both existing and proposed Project facilities. The installation of a new separate supply pipeline will increase the overall supply reliability of natural gas to the MPC industrial complex having a beneficial impact to the existing MPC operations.

Impact UI7 - Low (Positive) Significance.

14.3.4.3 EMERGENCY DIESEL GENERATORS

Emergency Diesel Generators (EDGs) will be located at the Ammonia Plant, DAP/NPK plants and also at the proposed administration area to provide an emergency power source in the event of a loss of grid power for safe shutdown of the facilities. Each EDG will have an associated day tank which will be filled by road tankers. The EDG’s will not impact the operation of the existing power supply facilities and therefore no significant impacts are identified.

Impact UI8 - Low Significance.

14.3.4.4 WATER SUPPLY

The existing Power and Desalination Plant (PDP) within the MPC industrial complex will supply process (service) water to the proposed facilities. The Project requires a process water supply of approximately 101-141 m$^3$/hr normal flow with a peak demand of 180 m$^3$/hr. The existing PDP will also supply desalinated water to the proposed Ammonia Plant to allow the production of demineralised (polished) water for use as boiler feed water. This process requires approximately 200 m$^3$/hr normal flow with a peak demand of 208 m$^3$/hr. MPC have confirmed that the existing PDP has sufficient capacity to meet the process (service) and desalinated water demands of the Project, therefore no significant impacts are anticipated. An estimated 3.8 m$^3$/hr of potable water is required to meet the supply demands of the Project. The production of potable water from the existing PDP is currently limited as a large part of the production is already committed to a long-term supply to the Port. Therefore an increase in production of potable water will be required as part of the Project. This will involve a new potable water unit to remineralise the desalinated water. There is sufficient desalinated water available from the existing systems. Potable water will be derived from the remineralisation of desalinated water supplied from the existing PDP. A tie-in to the existing Ras Al Khair potable water distribution system will feed a new potable water storage tank (1,000m$^3$). This expansion of the existing potable water system will increase the reliability and availability of potable water to the existing system having a beneficial impact to users within the MPC industrial complex with a low significance.

The proposed Project fire water system will tie into the existing system at the MPC industrial complex with an extension to the existing ringmain. Firewater is supplied by process water from the existing PDP plant. MPC have confirmed that the existing system has sufficient supply capacity to cover the additional areas required for the Project. No significant impacts have been identified.

Overall the impact of the Project on the existing water supply utilities is considered to be of low significance. The Project will utilise spare capacity in the existing system and will increase the reliability and availability of the potable water supply system.

Impact UI9 - Low (Positive) Significance.
14.3.4.5 WASTEWATER TREATMENT

Sanitary wastewater will be collected at each of the processing plants and transferred to the existing STP operated by MPC. MPC have confirmed that the existing facility has sufficient capacity to meet the requirements of the Project. Anecdotal evidence from MPC operations personnel has informed that there may be beneficial impacts from an increase in sanitary wastewater due to minor operational issues occurring as a result of insufficient influent in current operations. The increase in treated effluent transferred to the Irrigation Pond will be used for irrigation purposes (subject to RCER 2010). Additional pumps will be used for this. The existing overflow to the Evaporation Pond can facilitate the management of any excess water in winter months.

A new storm water system will be constructed as part of the Project to collect uncontaminated rainwater and surface runoff from uncontaminated areas of the Project facilities. The Project storm water system will be separate from the existing MPC system and will be diverted and collected in a new HDPE-lined clean stormwater Retention Pond located south of the existing retention pond.

Contaminated water drainage systems for the proposed Project will be confined to each of the process and storage areas and managed via new infrastructure. Therefore no adverse impacts on the existing infrastructure are anticipated.

Impact UI10 - Low Significance

14.3.4.6 COOLING SYSTEM

A new cooling system and associated cooling tower is to be constructed to meet the demands of the Project, particularly that of the proposed Ammonia Plant. This will be a separate system from the existing cooling water system used by MPC; however a connection to the existing seawater return line will be required to supply approximately 4,000 m$^3$/hr for top-up water. Blowdown water from the proposed cooling system, with an estimated volume of 1,500 m$^3$/hr, will be returned to the seawater outlet only if it meets the requirements of Table 3C, RCER 2010, Vol I. The impacts on water quality are assessed in Section 11 Water Quality Management. No significant impacts on the existing cooling water system infrastructure are anticipated.

Impact UI11 - Low Significance.

14.3.4.7 STEAM

During the operational phase, steam supply for the Project will be provided by the proposed Ammonia Plant once it has been commissioned. Superheated low pressure steam produced as part of the ammonia synthesis process will supply the DAP/NPK plants, train unloading area (PPA, MGA, Sulphuric Acid from Umm Wu’al), storage, and Port facilities. This new header will run in parallel and tie-in into the existing low pressure steam header which receives its supply from the existing Ammonia Plant. This will benefit the existing steam system in providing a back-up supply to the existing system and vice versa. This is considered to have a beneficial impact to the both the existing and new MPC facilities of medium significance.

Impact UI12 - Medium (Positive) Significance.

14.3.4.8 INSTRUMENT AND PLANT AIR

During the operational phase, instrument and plant air supply for the Project will be provided by the proposed Ammonia Plant once it has been commissioned. This new system will run in parallel and tie-in into the existing system which receives its supply from the existing Ammonia Plant. This will benefit the existing air supply system in providing a back-up to the existing system and vice versa. This is considered to have a beneficial impact to the both the existing and new MPC facilities of low significance.

Impact UI13 - Low (Positive) Significance.
14.3.4.9 TELECOMMUNICATIONS

The Project telecommunication system will interface with the existing telecommunication system utilised by MPC to tie-in to the existing Saudi Telecommunication Company (STC) landline. The main equipment of the Ras Al Khair telecommunications system will be installed in the administration building and DAP/NPK control building. The main equipment for an integrated security system will be installed in the existing security control centre. It is not anticipated that there will be any significant impacts of the Project on the existing telecommunication system.

Impact UI14 - Low Significance.

14.3.5 DECOMMISSIONING PHASE IMPACTS ON UTILITIES

The impacts on utilities during the decommissioning phase are expected to be similar to the construction phase. Site staff will require the provision of an electrical and water supply for the construction camps and construction activities. Portable electrical generators are a potential source of electrical power and water can be supplied by road tanker if required. During the lifetime of the Project, the Ras Al Khair Industrial City is expected to see large amounts of growth and the development of utility infrastructure. Therefore no significant impacts are anticipated during this phase.

14.4 RECOMMENDATIONS

Potential negative impacts of medium or high significance on the utilities infrastructure are not anticipated to occur as a consequence of the Project commissioning, construction, operation or decommissioning phases. In all cases where supply from the existing utilities cannot meet the Project demands, new infrastructure will be installed to service the Project.

Implementation of the following measures is recommended to manage the potential impacts identified as being of low significance and maintain good management practices. It is anticipated that this assessment can be built upon during detailed design when detailed Project requirements are realised.

14.4.1 CONSTRUCTION PHASE & COMMISSIONING PHASE RECOMMENDATIONS

The construction phase Emergency Response Plan (EERP) and a Construction Environmental Management Plan (CEMP) to be developed as supporting documents to the Environmental Management and Monitoring Plan (Appendix A of this ESIA) will detail responsibilities and procedures for environmental and emergency response management during construction. These Plans should consider the following:

- The supply of utilities during emergency situations, such as loss of grid power or water supply.
- Ensure that utilities requirements for the Construction Phase and Commissioning Phase are detailed and communicated throughout the construction and commissioning period to the relevant utility suppliers to ensure the timely provision of Project demands.
- Prior to commencing construction activities, consultation with existing MPC operators should take place to agree the necessary consultation and engagement procedures going forward. For example, it will be necessary to ensure that any tie-ins to the existing MPC utilities are communicated and agreed with MPC in advance of any connection. Also, the appropriate timings for such tie-ins to MPC utilities should be agreed, e.g. during low periods of current usage.
- Ensure that good environmental practice is considered for the use of utilities infrastructure during all stages of Construction, including (but not limited to):
  - Minimising utility consumption, such as minimising wastage and unnecessary discharges;
  - Minimisation of the use of diesel generators; and
- Take advantage of the existing MPC utilities where feasible, particularly for water supply and waste water treatment to reduce the amount of water or waste water which requires transportation from/to external sources (such as Jubail).

- Schedule of audits to monitor and record how all utility usage, storage and discharges requirements are undertaken with consideration of RCER-2010.

14.4.2 OPERATION PHASE RECOMMENDATIONS

During the operational phase, the use of utilities and provision of utilities services should be monitored to ensure that there is no overloading of any system. It will be important for MPC divisions from both the existing and new facilities to communicate utility uses and requirements with each other (and other utility suppliers) during the operational phase to ensure that reliable supplies can be maintained throughout to minimise impacts on production.

Significant gains in utility reliability can be achieved through the distribution of utility services between both facilities during abnormal operations, e.g. the switch-off of one of the natural gas pipelines during potential maintenance operations or outages.

Ma’aden will be required to maintain an Emergency Response Plan (EERP) for the operational phase of the Project which should detail the use of utilities and alternative utilities supply’s for emergency situations.

Significant economic and environmental benefits can be achieved by minimising the use and consumption of utilities services. Direct savings can be realised by the reduction in energy consumption and water supply reduction which can be achieved through the minimisation of wastage and unnecessary uses. Ma’aden’s existing Environmental Management System (EMS) provides a systematic way of analysing operations from an environmental perspective and can be used to document achievable goals for energy reduction through specific practical energy saving measures. Maintenance of this efficient use of utilities reduces the requirement for importing of utilities services from outside of the Project.
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15 HEALTH AND SAFETY ASPECTS

15.1 INTRODUCTION

This Section presents and overview of international and national Health and Safety legislation and standards and provides information on regional and local health infrastructure. Baseline health data for the country as a whole and the region in which the project is located are evaluated for each phase of the Project to give an understanding and an overall picture of health issues and potential impacts in relation to Health and Safety.

The World Health Organisation (WHO) defines health as: "A state of complete physical, mental and social well-being, and not merely the absence of disease”. It also states that “good health is essential to human welfare and to sustained economic and social development”.

The maintenance of a good health status is promoted within the Qur’an. Hygiene is the prominent topic in Islam, and the Qur’an advises Muslims to uphold high standards of physical hygiene whenever possible. The Saudi Government gives the health sector a high priority so as to provide all Saudi citizens and residents with access to free and high standards of health care.

15.2 BASELINE CONDITIONS

15.2.1 LEGISLATIVE CONTEXT

15.2.1.1 LABOR LAW (2005)

Royal Decree No. M/51 Labor Law (2005) is the principal legislation defining the occupational health and safety rights of all workers within the Kingdom of Saudi Arabia (KSA). The law seeks to provide the guiding principles for workers rights in terms of pay, welfare, working hours and conditions and access to healthcare. The most relevant sections and articles relating to Health and Safety are detailed in Section 2 Policy, Legal and Administrative Framework.

15.2.1.2 ROYAL COMMISSION ENVIRONMENTAL REGULATIONS (RCER 2010)

RCER 2010 Volume I provides a series of standards for air quality, noise, water quality which comply with international guidance for public health.

RCER 2010 Volume-II, Section 1.3.1 states that Type I and II Facilities may be required to conduct a health risk assessment study on a case-by-case basis as part of the application for the Environmental Permit to Construct (EPC). The Royal Commission (RC) has not requested such an assessment for the Project to date. However, in accordance with Volume II Appendix C, the ESIA has considered potential health impacts in each Section where relevant. In addition, this Section Health and Safety Aspects provides the baseline relevant to Ras Al Khair using records and statistics obtained from health organisations, and outlines the impact assessment conducted for all phases of the project (construction; commissioning; operations; decommissioning).

RCER 2010 require the production of an Environmental Emergency Response Plan (EERP) to detail all Safety, Health and Environment (SHE) procedures, including those for Health Incidents. RCER 2010 Volume-II Appendix D the EERP Guidelines also states that "the facility shall have a proper medical facility to conduct periodic medical examination of employees”.

15.2.1.3 WORLD BANK

The World Bank (WB) has defined the principals for the Assessment of Health in EIA. Guidance is provided through the Environmental Assessment Sourcebook (2007) for the systematic integration of public health and safety concerns through early screening of proposed developments and implementation of appropriate measures to address risks during project preparation, implementation, and beyond.

Health aspects of particular interest are the potential risks associated with communicable and non-communicable diseases, accidents and injury, malnutrition (direct and indirect through land-use change), health infrastructure and the impact of the project on its capacity, integration into the project design, and monitoring of potential effects.
In addition, the World Bank has produced Environmental, Health and Safety (EHS) Guidelines (2007) which detail specific requirements for occupational and community health, safety and welfare. The document sets out the minimum requirements for compliance with international best practice, provides exposure limits for various groups in terms of noise, radiation etc., and details minimum expectations for the provision of welfare facilities on site, and in accommodation camps. The guidelines also detail recommendations for the protection of workers and the community against the transmission of diseases, including the provision screening and vaccination programmes.

The IFC performance standards (as described in Section 2 Policy, Legal and Administrative Framework) also highlight the importance of health and welfare in Environmental and Social Sustainability. The following performance standards are particularly relevant to this Section:

- IFC Performance Standard (IFCPS) 1 – Assessment and Management of Environmental and Social Risks and Impacts;
- IFCPS 2 – Labour and Working Conditions; and
- IFCPS 4 – Community Health, Safety and Security.

IFCPS 2 requires the adoption of human resources policies and procedures to provide workers with clear documented information as to their rights under National Labour Laws and any relevant collective agreements. These include their rights relating to working hours, wages, overtime, compensation, breaks, rest days, and any benefits including leave for illness, maternity leave, annual and statutory holidays etc.

Where accommodation is being provided, policies on the quality and management of the facilities should be implemented to ensure the provision of basic services which are defined as:

- Minimum space;
- Supply of water;
- Adequate sewage and waste disposal;
- Protection against heat, cold, damp, noise, fire, and disease carrying animals;
- Adequate sanitary and washing facilities;
- Cooking and storage facilities;
- Natural and artificial lighting; and
- Basic medical services where appropriate.

The accommodation should also not restrict workers’ freedom of movement or of association.

The IFC with the European Bank for Reconstruction and Development (EBRD) have published the guidance note: Worker’s Accommodation: Process and Standards (IFC 2009) with associated checklist which details the level of required facilities, layout and expectations for the provision of all workers accommodation both during construction and operation.

The performance standard also states the minimum expectations under Occupational Health & Safety for employees, third party contractors, and workers in the supply chain. The standard requires the implementation of policies and procedures to good international industry practices which minimise the risks to workers from hazards including physical, biological, chemical, radiological and specific threats to women. The procedures should include the identification of hazards, their prevention or protective measures, reporting and documentation of accidents, diseases and incidents, and emergency preparedness. Training of workers should also be undertaken.

Policies and procedures should also be developed and implemented for the management and monitoring of third party contractors and the primary supply chain, and incorporate these where appropriate into their contractual obligations.
IFCPS 4 has the following objectives:

- To anticipate and avoid adverse impacts on the health and safety of the affected community during the project from both routine and non-routine circumstances; and
- To ensure the safeguarding of personnel & property is carried out in accordance with relevant human rights principals and in a manner that avoids or minimises risks to the affected communities.

The implementation of the actions required to comply with this standard is managed through the ESMS outlined in IFCPS 1. The Standard requires the evaluation of the risks and impacts to the Health and Safety of any affected communities during construction, commissioning, operation and decommissioning. Measures to prevent, minimise and manage these risks in line with international best practise are required to be implemented, and any mitigation measures should be commensurate with the nature and magnitude of the impact. Importantly, the standards call for the avoidance of risks and impacts over minimisation and mitigation. The standard highlights the following aspects:

- Infrastructure and Equipment Design and Safety;
- Hazardous Materials Management and Safety;
- Ecosystem Services;
- Community Exposure to Disease; and
- Emergency Preparedness and Response.

The performance standard also provides guidance on the minimum requirements where security personnel are employed as part of the project (either directly or through contract). The requirements cover hiring, training, equipping, use of force, conduct towards affected communities, and monitoring. It also requires compliance with the United Nations (UN) Code of Conduct for Law Enforcement Officials, and the UN Basic Principles on the use of Force and Firearms by Law Enforcement Officials.

A grievance mechanism is also required to be provided for all parties.

15.2.1.4 MA’ADEN CORPORATE POLICY

Ma’aden published their commitment to corporate and social responsibility and presented the results of their work through their Annual Report. The corporate commitment is underpinned by four pillars:

- Health, Safety and Environment - including the development and implementation of related policies, standards, management systems and risk management;
- Commitment to Community - including the positive contribution to the communities in which it operates;
- Commitment to Employees - which provides a commitment to the overall wellbeing of their employees and their families; and
- Ethics - including the way in which the company is run, compliance with all regulations and legislation, and the governance of its employees conduct.

During 2011, the corporate Health and Safety team introduced the Safety Culture Improvement Plan to cover all Ma’aden sites and drive improvement in all safety aspects. The plan includes management involvement in the commitment to safety, provision of training and awareness programmes, internal audit procedures and safety recognition programmes.

The implementation of the plan included training for employees from all subsidiaries and headquarters on areas including:

- Creating a World Class Safety Culture;
- Defensive Driving; and
• Root Cause Analysis.

The plan also included practical approaches to help management at subsidiaries formulate strategies to lead the continued development of a safety culture, gain employees’ involvement through safety contact, and observation and measuring the success of safety initiatives. This led to an improvement of Overall Lost Time Injury Frequency Rate (LTIFR).

In 2011 Ma’aden’s commitment to Corporate Social Responsibility (CSR) has achieved several Health and Safety milestones including:

• All mega project safety milestones;
• Comprehensive management and training systems to international industry standards;
• Over SR28 million invested in employee training; and
• Construction of the medical clinic at the Al Amar Gold Mine located 195km southwest of Riyadh.

In particular the Ma’aden Phosphate Company (MPC) achieved:

• Over 15,000 hours in-house Environment, Health and Safety training for the MPC including 5,874 employees and contractors trained;
• 4,115,460 safe-man hours completed without Lost Time Injury;
• Awarded Ma’aden safety recognition award (Golden Award) for achieving more than one year without lost time injury;
• Achieved the 2011 LTIFR target rate of 0.41% and all Environmental Key Performance Indicators (KPIs);
• Participated and witnessed performance test of all plants, all stack emission’s within the plant design meeting the requirements of the RC; and
• Implementation of 70% of all required EHS Standards.

In addition, the MPC EHS Management System upgrade has set a target to clear all non-conforming items during 2012 and complete IMSEHS&Q and achieve ISO 9001, ISO 14001 and OHSAS 18001 certification.

MPC have also produced their Safety, Health, Environment and Quality (SHEQ) Policy which includes the following Health & Safety Objectives:

• Ensuring compliance with regulatory, legislative and corporate requirements (including OHSAS18001);
• Identifying and evaluating risks associated with company activities and documenting a programme to eliminate or reduce any hazards as far as reasonably practicable to prevent injury and ill health;
• Undertake frequent monitoring, audit and review of the SHEQ management system to ensure the system remains relevant and effective;
• Set Health and Safety performance objectives and monitor and assess results to promote continuous improvement;
• Provision of training, planning and communication tools to ensure personnel are aware and can competently carry out their SHEQ responsibilities;
• Satisfy the needs and expectations of the customer at all times by providing services and products that meet and exceed expectations and results; and
• Consult and communicate with employees and other interested parties on the value of an integrated SHEQ approach, and encourage full participation in the development of the management system in place.

The policy objectives underpin the company’s commitment to continuously improve their
Health and Safety performance in their operations.

15.2.2 NATIONAL HEALTH

The KSA has a population of >27 million with a population growth rate of 3.19%. The population is spread between 150 cities and >2000 villages, often located in remote areas. The provision of Health Services in KSA falls under the remit of the Ministry of Health (MoH). The MoH operates a three tier approach to healthcare provision:

- Primary: Health Centres;
- Secondary: General Hospitals; and
- Tertiary: Specialist Hospitals.

The MoH provides approximately 60% of Health Care Facilities, with the remainder being provided by other ministries with specific healthcare duties to discharge (e.g. Ministry of Defence, National Guard, Ministry of Interior, Ministry of Higher Education), with some private healthcare providers, and the King Faisal Specialist Hospital.

The MoH has published a ten year health care strategy (2009/10 to 2019) for KSA, to provide a patient centred healthcare service to meet “patients’ health needs in the right place at the right time”. The strategy provides for (and protects) the patients’ right to know and choose their health care treatment and provider, and is implemented through the MoH Integrated and Comprehensive National Healthcare Project.

The MoH report National and Regional healthcare statistics through the publication of the Health Statistics Year book (MoH 2009).

15.2.2.1 HEALTH CARE INFRASTRUCTURE

Table 15-1 below provides a summary of the health infrastructure within KSA.

Table 15-1: Summary of National Health infrastructure 2004 to 2009 (from Central Department of Statistics & Information in KSA)

<table>
<thead>
<tr>
<th>Year</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>Per 10,000 people</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number MoH Hospitals</td>
<td>213</td>
<td>218</td>
<td>225</td>
<td>231</td>
<td>244</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Number MoH Beds</td>
<td>30317</td>
<td>30617</td>
<td>31420</td>
<td>31720</td>
<td>33277</td>
<td>13.1</td>
<td></td>
</tr>
<tr>
<td>Number Physicians</td>
<td>18621</td>
<td>20219</td>
<td>21265</td>
<td>22643</td>
<td>24802</td>
<td>25832</td>
<td>10.2</td>
</tr>
<tr>
<td>Number Nurses</td>
<td>41356</td>
<td>42628</td>
<td>44395</td>
<td>51188</td>
<td>55429</td>
<td>63297</td>
<td>24.9</td>
</tr>
<tr>
<td>Number Pharmacists</td>
<td>1167</td>
<td>1123</td>
<td>1023</td>
<td>1301</td>
<td>1529</td>
<td>1654</td>
<td>0.65</td>
</tr>
<tr>
<td>Number Allied Health Personnel</td>
<td>21802</td>
<td>23116</td>
<td>25052</td>
<td>26657</td>
<td>28752</td>
<td>32360</td>
<td>12.8</td>
</tr>
<tr>
<td>Health Centers</td>
<td>1848</td>
<td>1905</td>
<td>1925</td>
<td>1925</td>
<td>1986</td>
<td>2037</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Approximately 22.6% of the physicians and 36.6% of the dentists are Saudi Nationals, of these, 25% are female. Saudi nationals comprise approximately 50% of the nursing workforce, with 75% of the pharmacists and 86% of the allied health personnel, 26% of the total allied personnel are female.

Each primary health care centre provides services to an average of 12456 people. There are dental clinics in 54% of the centres, with X-ray facilities in 31% and labs in 73%.
A comprehensive vaccination program over the last 20 years has been undertaken in KSA. The program has increased the proportion of babies vaccinated against measles, rubella and mumps during their first year of life from 93% to 98.2% in 2010. Vaccinations against diphtheria, whooping cough and tetanus, polio, and hepatitis B also achieved 98%, with 97.7% for tuberculosis (UNEP 2011).

The program has seen a corresponding decrease in mortality in under five’s with 19.5 deaths per thousand live births in 2010, an improvement of 55.7% since 1990. Infant mortality rate declined to 16.9 deaths per 63 thousand live births in 2010; an improvement of 50.3% since 1990.

A total of six cases of Meningococcal Meningitis were recorded in 2009, a reduction from 2008 levels. Other types of cerebrospinal meningitis, including pneumococcal and hemophilus influenza, with the incidence rate per 100,000 increasing to 1.32 in 2009 from 1.21 in 2008.

The total number of cases of tuberculosis (TB) in 2009 was 3949, with an incidence rate of 15.56/ 100,000; a decrease of 0.22/ 100,000 from 2008. However, there was a marked increase in case reporting and notification. 2009 also saw the implementation of a Health Education Program for TB.

Malaria is present across the KSA, however there is a wide regional variation in cases. Anti-Malaria programs have been in place since 1948, which include spraying, and transmission of Malaria has been stopped in the Eastern, Northern, and large cities in the western regions.

A total of 2393 cases of malaria were reported in 2009, half of which were in the Jazan region in the southwest corner of Saudi Arabia. 97.5% of all malaria cases in 2009 were from incoming foreign nationals.

Other diseases include Amoebic Dysentery, Typhoid, and Shigellosis. These have also largely seen a decrease in incidence rate between 2007 and 2009 (Table 15-2).

<table>
<thead>
<tr>
<th>Disease</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amoebic Dysentery</td>
<td>15.04</td>
<td>13.35</td>
<td>12.09</td>
</tr>
<tr>
<td>Typhoid and Paratyphoid</td>
<td>1.16</td>
<td>1.08</td>
<td>1.25</td>
</tr>
<tr>
<td>Shigellosis</td>
<td>0.64</td>
<td>0.76</td>
<td>0.47</td>
</tr>
<tr>
<td>Salmonella</td>
<td>7.81</td>
<td>5.21</td>
<td>5.41</td>
</tr>
<tr>
<td>Hepatitis A</td>
<td>5.7</td>
<td>6.8</td>
<td>5</td>
</tr>
<tr>
<td>Malta Fever</td>
<td></td>
<td>13.9</td>
<td>18.3</td>
</tr>
</tbody>
</table>

According to the World Health Organisation (WHO 2012), non-communicable disease account for 71% of all deaths in KSA, see Figure 15-1. Cardiovascular Disease accounts for the largest proportion at 42%, with other non-communicable diseases accounting for a further 12%.
15.2.2.4 OCCUPATIONAL HEALTH & ACCIDENTS

Occupational Health in KSA is aimed at the prevention, treatment and monitoring of work related injuries and diseases, especially in high risk industries such as metallic industries, petrochemical, plastic and textile industries. It also includes the prevention of and measurement of exposure to radioactive isotopes, especially in health facilities.

The General Organisation for Social Insurance (GOSI) for Saudi Arabia is responsible for the protection of workers, treating and compensating work injuries under the Occupational Hazards Branch (OHB), developing and updating schedules of occupational diseases in accordance with relevant international laws and legislation, and preparing the Annual Statistical Report on the occupational injuries in the KSA.

In 2009, the MoH states that 22.9% of occupational diseases were related to the metallic industry, with the food industry accounting for 16.5%. Upper respiratory tract diseases accounted for 27.1% of all the occupational diseases, with musculo-skeletal disorders and digestive diseases accounting for 21.3% and 15.7% respectively (Table 15-3).

A total of 937 work related injuries were reported in 2009, 16.2% occurred in the building material industry, closely followed by followed by ceramics and metallic industries with 16.1% and 14.6% respectively. 26% of the injuries were related to contusions, with open wounds and fractures accounting for 22.4% and 20.7% respectively see Figure 15-2.

There were a total of 44,316 deaths in 2009. Of these, Injuries and accidents accounted for 21% of deaths amongst non-saudis and 16.9% of Saudis. 39.9% of deaths for non-saudis, and 26.1% for Saudis were the result of ill-defined causes. However it is worth noting that this category includes the majority of those deaths which occur outside of the MoH hospitals.

Figure 15-1: Proportion of total deaths in KSA for all age groups (WHO 2012)
### Table 15-3: Occupational Health Diseases by Sector in 2007

<table>
<thead>
<tr>
<th>Disease</th>
<th>Metals</th>
<th>Building Materials</th>
<th>Ceramics &amp; Glass</th>
<th>Plastics &amp; Chemical</th>
<th>Paper &amp; Printing</th>
<th>Wood</th>
<th>Leather</th>
<th>Textile</th>
<th>Food</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anemia</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>ENT</td>
<td>9</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>9</td>
<td>35</td>
<td>22</td>
<td>14</td>
<td>16</td>
<td>6</td>
<td>121</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td>4</td>
<td>0</td>
<td>7</td>
<td>29</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>5</td>
<td>9</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td>Obstructive pulmonary disease</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>Urinary tract Infections</td>
<td>8</td>
<td>8</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>35</td>
</tr>
<tr>
<td>Eye disease</td>
<td>7</td>
<td>8</td>
<td>14</td>
<td>9</td>
<td>13</td>
<td>22</td>
<td>13</td>
<td>25</td>
<td>12</td>
<td>2</td>
<td>125</td>
</tr>
<tr>
<td>Digestive system diseases</td>
<td>96</td>
<td>12</td>
<td>19</td>
<td>18</td>
<td>17</td>
<td>13</td>
<td>12</td>
<td>17</td>
<td>25</td>
<td>18</td>
<td>188</td>
</tr>
<tr>
<td>Dermatitis</td>
<td>18</td>
<td>23</td>
<td>15</td>
<td>18</td>
<td>32</td>
<td>9</td>
<td>15</td>
<td>15</td>
<td>25</td>
<td>18</td>
<td>188</td>
</tr>
<tr>
<td>Musculoskeletal diseases</td>
<td>85</td>
<td>100</td>
<td>5</td>
<td>19</td>
<td>80</td>
<td>34</td>
<td>17</td>
<td>41</td>
<td>79</td>
<td>10</td>
<td>470</td>
</tr>
<tr>
<td>Upper respiratory tract diseases</td>
<td>210</td>
<td>36</td>
<td>33</td>
<td>12</td>
<td>49</td>
<td>15</td>
<td>28</td>
<td>75</td>
<td>130</td>
<td>10</td>
<td>598</td>
</tr>
<tr>
<td>Other Diseases</td>
<td>66</td>
<td>9</td>
<td>0</td>
<td>8</td>
<td>9</td>
<td>13</td>
<td>14</td>
<td>27</td>
<td>40</td>
<td>49</td>
<td>235</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>505</strong></td>
<td><strong>223</strong></td>
<td><strong>97</strong></td>
<td><strong>92</strong></td>
<td><strong>223</strong></td>
<td><strong>146</strong></td>
<td><strong>130</strong></td>
<td><strong>219</strong></td>
<td><strong>363</strong></td>
<td><strong>206</strong></td>
<td><strong>2204</strong></td>
</tr>
<tr>
<td>Number of Facilities</td>
<td>39</td>
<td>7</td>
<td>1</td>
<td>17</td>
<td>7</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>10</td>
<td>2</td>
<td>90</td>
</tr>
<tr>
<td>Number of Workers</td>
<td>2121</td>
<td>361</td>
<td>48</td>
<td>818</td>
<td>493</td>
<td>60</td>
<td>180</td>
<td>361</td>
<td>363</td>
<td>84</td>
<td>4889</td>
</tr>
</tbody>
</table>
The GOSI Annual Report for 2012 states that out of a total of 75,825 workplace injuries, 81.3% recovered without disability, 4.8% recovered but with disability, and 0.7% (557) injuries resulted in death. The remainder were under treatment. Of these injuries, 94.3% were to non-Saudis, however, GOSI state that the ratio of Saudi to non-Saudi workers injured is 1:4, and that non-Saudis typically undertake higher risk occupations. 48% of all workplace injuries occur in construction with trade accounting for 25.6% and manufacturing 15.7%. Plastics and Chemicals account for 10%.

Table 15-4 and Table 15-5 below detail the number of workplace injuries by industry sector and injury type, and injury cause respectively. Those of particular relevance to this assessment are construction and manufacturing. The leading causes of injuries in both construction and in manufacturing are falls (falling down or falls from height), and being struck by or against something. In both of these industry sectors, cuts and punctures, fractures and crushing injuries, and secondary contusions are the main types of injury. Twists, hernias and ruptures are relatively high in the construction sector, with infections relatively high in manufacturing.
Table 15-4: Work Place Injuries by Injury, Location and Industrial Sector in 2012 (GOSI Annual report 2012)

<table>
<thead>
<tr>
<th>Industry Sector</th>
<th>Infection</th>
<th>Amputation</th>
<th>Burns</th>
<th>Dislocation</th>
<th>Hernia &amp; Rupture</th>
<th>Cut &amp; puncture</th>
<th>Fracture &amp; Crush</th>
<th>Twist &amp; stretch</th>
<th>Secondary Contusion</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post &amp; Communications</td>
<td>98</td>
<td>8</td>
<td>23</td>
<td>6</td>
<td>50</td>
<td>286</td>
<td>237</td>
<td>90</td>
<td>593</td>
<td>126</td>
<td>1517</td>
</tr>
<tr>
<td>Trade</td>
<td>2190</td>
<td>77</td>
<td>352</td>
<td>71</td>
<td>320</td>
<td>4625</td>
<td>1582</td>
<td>1726</td>
<td>7528</td>
<td>914</td>
<td>19385</td>
</tr>
<tr>
<td>Construction</td>
<td>3480</td>
<td>166</td>
<td>560</td>
<td>162</td>
<td>1004</td>
<td>7612</td>
<td>4165</td>
<td>2743</td>
<td>12592</td>
<td>3883</td>
<td>36367</td>
</tr>
<tr>
<td>Mining &amp; Quarrying</td>
<td>64</td>
<td>7</td>
<td>47</td>
<td>10</td>
<td>33</td>
<td>219</td>
<td>139</td>
<td>79</td>
<td>287</td>
<td>100</td>
<td>985</td>
</tr>
<tr>
<td>Social Services</td>
<td>174</td>
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<td>48</td>
<td>8</td>
<td>71</td>
<td>371</td>
<td>214</td>
<td>137</td>
<td>518</td>
<td>238</td>
<td>1789</td>
</tr>
<tr>
<td>Agriculture &amp; fishing</td>
<td>48</td>
<td>15</td>
<td>18</td>
<td>6</td>
<td>16</td>
<td>107</td>
<td>105</td>
<td>22</td>
<td>201</td>
<td>70</td>
<td>608</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>1181</td>
<td>140</td>
<td>444</td>
<td>49</td>
<td>336</td>
<td>3373</td>
<td>1187</td>
<td>794</td>
<td>3078</td>
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<td>11921</td>
</tr>
<tr>
<td>Electricity &amp; Water</td>
<td>123</td>
<td>7</td>
<td>60</td>
<td>8</td>
<td>33</td>
<td>216</td>
<td>121</td>
<td>67</td>
<td>288</td>
<td>151</td>
<td>1074</td>
</tr>
<tr>
<td>Financing &amp; Real Estate</td>
<td>231</td>
<td>28</td>
<td>54</td>
<td>8</td>
<td>49</td>
<td>527</td>
<td>299</td>
<td>124</td>
<td>662</td>
<td>197</td>
<td>2179</td>
</tr>
<tr>
<td>Total</td>
<td>7589</td>
<td>458</td>
<td>1606</td>
<td>328</td>
<td>1912</td>
<td>17336</td>
<td>8049</td>
<td>5782</td>
<td>25747</td>
<td>7018</td>
<td>75825</td>
</tr>
</tbody>
</table>

**Project Name:**
UMM WU’AL PHOSPHATE PROJECT

**Ma’aden**
Saudi Arabian Mines Company
Table 15-5: Workplace Injuries by cause and Industrial Sector (GOSI 2012 Annual report)

<table>
<thead>
<tr>
<th>Industry Sector</th>
<th>Caught in</th>
<th>Struck by or against</th>
<th>Rubbed or abraded</th>
<th>Falling Down</th>
<th>Vehicle Accident</th>
<th>Body Reaction</th>
<th>Contact with Radiation or caustics</th>
<th>Contact with cold or heat</th>
<th>Stress</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post &amp; Communications</td>
<td>18</td>
<td>383</td>
<td>134</td>
<td>496</td>
<td>165</td>
<td>46</td>
<td>11</td>
<td>14</td>
<td>12</td>
<td>238</td>
<td>1517</td>
</tr>
<tr>
<td>Trade</td>
<td>103</td>
<td>4120</td>
<td>1498</td>
<td>4378</td>
<td>435</td>
<td>1046</td>
<td>78</td>
<td>221</td>
<td>819</td>
<td>6687</td>
<td>19385</td>
</tr>
<tr>
<td>Construction</td>
<td>324</td>
<td>11590</td>
<td>3779</td>
<td>10440</td>
<td>1264</td>
<td>1557</td>
<td>220</td>
<td>594</td>
<td>907</td>
<td>5692</td>
<td>36367</td>
</tr>
<tr>
<td>Mining &amp; Quarrying</td>
<td>32</td>
<td>295</td>
<td>139</td>
<td>214</td>
<td>85</td>
<td>37</td>
<td>13</td>
<td>32</td>
<td>36</td>
<td>102</td>
<td>985</td>
</tr>
<tr>
<td>Social Services</td>
<td>24</td>
<td>356</td>
<td>202</td>
<td>604</td>
<td>110</td>
<td>87</td>
<td>23</td>
<td>31</td>
<td>49</td>
<td>303</td>
<td>1789</td>
</tr>
<tr>
<td>Agriculture &amp; fishing</td>
<td>9</td>
<td>153</td>
<td>38</td>
<td>204</td>
<td>54</td>
<td>31</td>
<td>9</td>
<td>8</td>
<td>3</td>
<td>99</td>
<td>608</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>256</td>
<td>3414</td>
<td>1851</td>
<td>2464</td>
<td>373</td>
<td>556</td>
<td>183</td>
<td>325</td>
<td>181</td>
<td>2318</td>
<td>11921</td>
</tr>
<tr>
<td>Electricity &amp; Water</td>
<td>12</td>
<td>271</td>
<td>77</td>
<td>233</td>
<td>87</td>
<td>93</td>
<td>16</td>
<td>29</td>
<td>15</td>
<td>241</td>
<td>1074</td>
</tr>
<tr>
<td>Financing &amp; Real Estate</td>
<td>25</td>
<td>642</td>
<td>320</td>
<td>546</td>
<td>130</td>
<td>81</td>
<td>20</td>
<td>28</td>
<td>22</td>
<td>365</td>
<td>2179</td>
</tr>
<tr>
<td>Total</td>
<td>803</td>
<td>21224</td>
<td>8038</td>
<td>19579</td>
<td>2703</td>
<td>3534</td>
<td>573</td>
<td>1282</td>
<td>2044</td>
<td>16045</td>
<td>75825</td>
</tr>
</tbody>
</table>

Project Name: UMM WU’AL PHOSPHATE PROJECT
The Ministry of Interior publish statistics on Motor Vehicle Accidents (MVA) in Saudi Arabia. MVA incident rates are known to be high in the country in comparison to Western economies. In 2009, there were circa 78,000 reported incidents in KSA, approximately 10% of which resulted in injuries, and 920 deaths (1%). Figure 15-3 below shows MVA incidence rates (A), injuries (B) and deaths (C) between 2000 and 2009.

It can be seen that in 2008 and 2009 there was a marked increases in incident rates of MVA. The proportion of injuries per incident rose from a low of 4.8% to 10%, and deaths from 0.755% to 1.1%.

15.2.3 REGIONAL HEALTH

The Ras Al Khair Industrial Complex lies within the Eastern Region of KSA. Health Facilities in the region are predominantly provided by the MoH, although there are private health services readily available in the major cities. There are a total of 126 health centres in the region most...
of which are equipped with X-ray, laboratory or dental facilities. There are 19 hospitals, and 1820 physicians working in the region, with 5147 nurses see. Table 15-6 and Table 15-7 below.

**Table 15-6: Health Facilities in the Eastern Region (MOH 2009)**

<table>
<thead>
<tr>
<th>Type of Facility</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospitals</td>
<td>19</td>
</tr>
<tr>
<td>Health Centres</td>
<td></td>
</tr>
<tr>
<td>With Dental Clinics</td>
<td>74</td>
</tr>
<tr>
<td>With X-ray</td>
<td>34</td>
</tr>
<tr>
<td>With Laboratory</td>
<td>82</td>
</tr>
<tr>
<td>Dental centre</td>
<td>1</td>
</tr>
<tr>
<td>Health Centres (Control at Entry point)</td>
<td>7</td>
</tr>
<tr>
<td>TB Centre</td>
<td>1</td>
</tr>
<tr>
<td>Rehabilitation Centre</td>
<td>1</td>
</tr>
<tr>
<td>Central Laboratory Facility</td>
<td>1</td>
</tr>
<tr>
<td>Anti-smoking Clinics</td>
<td>2</td>
</tr>
<tr>
<td>Forensic Medicine</td>
<td>1</td>
</tr>
<tr>
<td>Total Number of Centres</td>
<td>126</td>
</tr>
</tbody>
</table>

**Table 15-7: Number of Health Personnel in the Eastern Region.**

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physicians</td>
<td>1820</td>
</tr>
<tr>
<td>Nurses</td>
<td>5147</td>
</tr>
<tr>
<td>Pharmacists</td>
<td>125</td>
</tr>
<tr>
<td>Allied Health Personnel</td>
<td>2579</td>
</tr>
<tr>
<td>Document Title</td>
<td>RAS AL KHAIR ESIA</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Ma’aden Doc Nº</td>
<td>MD-513-000-EN-RPT-0069</td>
</tr>
<tr>
<td>Jacobs Doc Nº</td>
<td>60-R400-WH/G.06f/0072</td>
</tr>
</tbody>
</table>

15.2.4 LOCAL HEALTH

There are very few medical facilities in the Ras Al Khair area. However, there is a medical facility at the existing Ma’aden ammonia plant close to the proposed development, and medical facilities at the adjacent aluminium plant.

The nearest hospitals are located in Jubail Industrial City approximately 50-60km to the South. The RC Hospital is located on the Western side of the Industrial City, close to its headquarters and provides a comprehensive suite of departments and facilities, including outpatients and intensive care, dentistry and emergency. The Jubail Central Hospital is a MoH facility in the centre of Jubail industrial City which also provides a comprehensive range of facilities.

15.3 HEALTH AND SAFETY IN CONSTRUCTION

The Ras Al Khair industrial complex will be developed over a 40 month programme. During this period the workforce is expected to comprise an average of 2500 workers rising to a peak of 3300, from a variety of backgrounds but mainly from Asia and neighbouring countries.

The EPC contractor will be required to operate in compliance with relevant laws and standards outlined in Section 15.2.1 Legislative Context and Section 2 Policy, Legal and Administrative Framework.

The workforce will be housed in the accommodation buildings close to the location of the works. It is anticipated that the existing camp facilities at Ras Al Khair Industrial City may be utilised as the activities associated with the adjacent Aluminium Facility reduce. Construction camps will be equipped with the utilities and support services necessary to accommodate the workforce, such as water, electricity, air conditioning, laundry, canteens, recreational and medical services.

Health screening will be carried out for the workforce. The implementation of this health screening, combined with access to on-side medical facilities will reduce the risk of health impacts to those with chronic conditions. A medical facility exists at the site however the capacity of this facility is not currently known and this will be expanded as part of the Project.

The EPC Contractor is required to establish, equip and staff a First Air facility at the site for providing First Aid treatment for their staff as well as subcontractor’s personnel and labours. The EPC Contractor will also establish an Emergency Medical Transportation Plan, taking into account the location and local road systems and constraints.

Facilities for medical services (expansion of the existing) will be provided at the accommodation medical facility to administer care to all injured personnel who require a level of treatment beyond the scope of normal first aid. The medical facilities include treatment and recovery rooms and will be manned by suitably qualified medical staff. Facilities/equipment to be provided shall include, but not be limited, to mobile digital x-ray, mobile ultra sound, slit lamp, blood analyser, ECG, defibrillator etc. Medical evacuation facilities shall be provided for more severe injuries.

15.4 HEALTH AND SAFETY IN DESIGN

Ma’aden corporate policies and procedures have been developed to ensure compliance with international best practise for compliance with OHSAS 18001 and ISO 9001 and ISO14001. This ensures the management system is fully compliant with IFCPS 1 and the WB/IFC General EHS Guidelines.

The Health and Safety of both employees and the local community has been considered as an integral part of the project design. The design process has included HAZID workshops and a series of detailed HSE assessments has been made for specific parts of the facility as part of the FEED (Front End Engineering Design) process.

Eliminating or reducing the risk of many of the potential operational Health and Safety impacts has been a central theme in the FEED stage, and it is therefore useful to incorporate a summary of this to avoid the assessment of an impact which will not be realised, or be substantially reduced. A summary of this work is provided below.
15.4.1 HSE DESIGN BASIS

A Design Basis has been developed for the project which defined the minimum standards for design Compliance. These included the KSA High Commission for Industrial Security (HCIS) Safety Directives (SAFs) and Security Directives (SECs); Ma’aden Engineering specifications and procedures; and the Saudi Building Code (SBC).

The hierarchy of controls required for the management of the Design HSE aspects and incorporated into this project are:

- Hazard Identification;
- Eliminate or Minimise Hazards by Design (inherently safer design);
- Hazard Prevention (reduction of likelihood);
- Hazard Detection (transmission of information to control point);
- Hazard Control (limitation of scale, intensity and duration); and
- Hazard Mitigation of Consequences (protection from effects).

The design basis identifies hazards associated with the materials and process, and sets out a suite of guiding principles under the above hierarchy of controls. Hazards identified include:

- **Material Hazards** - including fires and explosions from ignition of fluids or dust; injury from exposure to strong acids, metal corrosion from exposure to strong acids; creation of flammable and explosive hydrogen gas; and exposure to toxic fluids;

- **Chemical Corrosion** - identifies chemicals which could corrode metals on contact requiring special construction of containment systems, including: molten sulphur, sulphuric acid, phosphoric acid, and Caustic Soda;

- **Reaction Hazards** - including generation of explosive atmosphere from excess ammonia gas, toxic gases from urea decomposition release of ammonia from failure of granulator;

- **Operating Conditions** - including high temperature and high pressure conditions;

- **Plant and Equipment Hazards** - including structural failure of equipment, and impacts from external forces (e.g. dropped items and collisions); and

- **Work Hazards** - including human error, falls, manual handling. Exposure to chemicals and environmental factors (noise, temperature, radiation etc.), and traffic both on and off site.

An inventory of hazardous chemicals and materials is also included in the document, which also details the properties of the chemicals. Principles adopted as part of the hazard control process are summarised in Table 15-9.
### Table 15-9: Summary of Hazard Controls as detailed in the Design HSE: Design basis for FEED.

<table>
<thead>
<tr>
<th>HAZARD ELIMINATION</th>
<th>HAZARD DETECTION</th>
<th>HAZARD CONTROL</th>
<th>HAZARD MITIGATION</th>
<th>OCCUPATIONAL HSE</th>
</tr>
</thead>
</table>
| Early identification of hazards to ensure risks are reduced (ALARP) through changes to the design. | Provision of comprehensive fire & gas detection system. | Overpressure protection systems including:  
- Design compliance with Ma’aden Specification;  
- Equipment to withstand highest expected pressures in normal operation;  
- No reliance on instrumentation for detection/response initiation to overpressure relief/protection unless no practical alternative to reducing risks;  
- Containment of hazardous releases from overpressure relief devices; and  
- Provision of reliable and appropriate overpressure relief. | Provision of active fire protection in areas where there is potential for harm to personnel, damage to plant/equipment and/or risk of escalation. Design shall be in line with legislation and best practise. | First aid provision at site: Use of medical facilities at existing ammonia facility. Provision of safety showers in close proximity to sources of exposure and compliant with regulations. |
| Minimum manning during operation and maintenance including:  
- simple robust design;  
- specification of materials;  
- equipment & control systems;  
- optimisation of space; and  
- provision of remote monitoring equipment. | Design systems in line with legislative requirements & industry best practise. | Process Control Systems to include:  
- Display of normal plant operating parameters;  
- Generation of appropriate alarms;  
- Automatic shutdown of plant deemed operating abnormally;  
- Operator interface for monitoring and control;  
- Facilities for alarm and event logging;  
- Interface with fire & gas/ emergency shutdown functions;  
- Start up and sequencing;  
- Trend logging; and  
- HVAC fire damper monitoring & control. | Passive Fire Protection (PFP) to include:  
- Protection of structural supporting features from collapse (e.g. walkways);  
- Protection of critical equipment and supporting cabling;  
- Consideration of design life, maintenance, corrosion resistance and normal operational limits in the selection of materials;  
- Critical cabling in compliance with IEC 60331;  
- Diversity in cabling routing;  
- Fire risk hazards assessment study to be carried out to support PFP requirements; and  
- Fireproof ratings to be considered and compliant with Ma’aden specifications. | Exposure to Hazardous Chemicals:  
- Bulk handling of chemicals where appropriate;  
- Provision of adequate storage to comply with separation and segregation needs;  
- Avoidance of use of chemicals where possible;  
- Prohibition of use of human carcinogens (IARC Group 1) avoidance of those with high potential;  
- Provision of enclosed systems where possible;  
- Location of exhaust stacks and vents away from personnel and HVAC intakes. |
<table>
<thead>
<tr>
<th>HAZARD ELIMINATION</th>
<th>HAZARD DETECTION</th>
<th>HAZARD CONTROL</th>
<th>HAZARD MITIGATION</th>
<th>OCCUPATIONAL HSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leak minimisation through:</td>
<td>Implementation of continuous monitoring in areas where potential exists for flammable/toxic releases.</td>
<td>Provision of fail-safe Safety Instrumented System to detect &amp; inhibit unsafe conditions progressing to an &quot;event&quot; such as release of hazardous materials including:</td>
<td>Emergency Response to ensure personnel can reach a place of safety during any credible accident event. Specific requirements are detailed in separate sections below.</td>
<td>Noise &amp; Vibration:</td>
</tr>
<tr>
<td>• minimising process complexity;</td>
<td>• Emergency shutdown system (through isolation, segmentation), including alarms, warning, and return to safe conditions; and</td>
<td>• Optimisation of isolatable sections to minimise the inventory of materials which may be released during an &quot;event&quot;.</td>
<td>• Design to comply with KSA regulations for noise in occupational environment;</td>
<td></td>
</tr>
<tr>
<td>• reducing the number of joints;</td>
<td>• Use of welded joints;</td>
<td></td>
<td>• Provision of hearing protection for areas exceeding international limits (e.g. OSHA &amp; ANSI/ASSE);</td>
<td></td>
</tr>
<tr>
<td>• use of welded joints;</td>
<td>• Use of shut-in pressure systems;</td>
<td></td>
<td>• Noise controls integrated into design;</td>
<td></td>
</tr>
<tr>
<td>• corrosion resistant materials; and</td>
<td>• Use of corrosion resistant materials; and</td>
<td></td>
<td>• Segregation of high noise areas; and</td>
<td></td>
</tr>
<tr>
<td>• double containment storage.</td>
<td></td>
<td></td>
<td>• Segregation of low &amp; high noise areas.</td>
<td></td>
</tr>
<tr>
<td>Inventory Minimisation including:</td>
<td>Implementation of evacuation procedures.</td>
<td>Hazardous Drainage and Bunding to include:</td>
<td>Escape &amp; Evacuation Facilities including:</td>
<td>Thermal Environment:</td>
</tr>
<tr>
<td>• Elimination or minimisation of flammable &amp;/or toxic chemicals;</td>
<td></td>
<td>• Separation of hazardous and non-hazardous drains;</td>
<td>• Provision of escape routes;</td>
<td>• Location of exhaust stacks away from personnel;</td>
</tr>
<tr>
<td>• Simplification /minimisation of process equipment;</td>
<td></td>
<td>• Closed drains separated from open drainage systems;</td>
<td>• Training;</td>
<td>• Workshop areas to be vented (natural or non-natural);</td>
</tr>
<tr>
<td>• Optimisation of the molten sulphur &amp; phosphate storage facilities (inc. production rates, rail supply/ loading rates &amp; frequencies);</td>
<td></td>
<td>• Provision of surface drainage in areas with flammable liquids;</td>
<td>• Detailed emergency procedures;</td>
<td>• Adequate supply of drinking water provided at 24°C;</td>
</tr>
<tr>
<td>• Use of small isolatable inventories.</td>
<td></td>
<td>• Consideration of liquid release trajectories in design of bunding; and</td>
<td>• Provision of Safety equipment; and</td>
<td>• Shade from solar radiation for outdoor work areas; and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Controlled collection and disposal of flammable release and firewater.</td>
<td>• Provision of lifesaving equipment.</td>
<td>• Air conditioning for permanently manned areas.</td>
</tr>
<tr>
<td>Facilities layout including:</td>
<td>Process &amp; Utilities bunding and Drainage to be provide for:</td>
<td>Incident awareness including:</td>
<td>Hot Surfaces (&gt;65°C):</td>
<td></td>
</tr>
<tr>
<td>• Compliance with legislation ;</td>
<td>• Diesel storage and loading areas;</td>
<td>• PA systems;</td>
<td>• Elimination or minimisation of hot surfaces and equipment; and</td>
<td></td>
</tr>
<tr>
<td>• Segregation of normal &amp; hazardous areas;</td>
<td>• Power generation &amp; electrical transformer;</td>
<td>• Beacons for visual identification;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Maximising natural ventilation &amp;</td>
<td></td>
<td>• Alarm volumes; and</td>
<td>• Guards to be provided for</td>
<td></td>
</tr>
<tr>
<td>HAZARD ELIMINATION</td>
<td>HAZARD DETECTION</td>
<td>HAZARD CONTROL</td>
<td>HAZARD MITIGATION</td>
<td>OCCUPATIONAL HSE</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>blast overpressure venting;</td>
<td>• Process equipment (pumps etc.) including drip trays;</td>
<td>• Provision of different alarm tones for different response types.</td>
<td></td>
<td>protection where hot surfaces exist in preference to lagging.</td>
</tr>
<tr>
<td>• Maximise distances between ignition/toxic sources and location of flammable &amp; manned facilities;</td>
<td>• Oil/chemical laydown areas;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Consider conditions (e.g. prevailing wind) in dispersion of toxic/flammable materials, smoke &amp; gas;</td>
<td>• Workshop aprons;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Orientation of instrument connections to maximise protection from blasts;</td>
<td>• Roads;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Locate high potential ignition sources in well ventilation;</td>
<td>• Water &amp; Wastewater treatment units;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Maximise escape routes in the facility.</td>
<td>• Building roofs;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Vehicle washdown areas; and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Refuelling areas.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ignition Prevention including:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Appropriate rating of equipment;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Upwind location of ignition sources;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Provision of HVAC intakes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Roads and car parks outside of hazardous areas;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Combustion &amp; compressor locations outside of hazardous areas;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Enforcement of temporary equipment procedures;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Appropriate rating for all emergency shutdown equipment (including telecoms, alarms, etc.);</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Minimise hazardous areas (Zone1);</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Provision of HVAC systems; and</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Production of area classification plans showing release sources, ventilation type, zones, temperature class, &amp; process inventory data (e.g. flash point, pressure &amp; temp).</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Escape Facilities including:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Location around the working area perimeters;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Provision of escape routes for stretchers and personnel wearing breathing apparatus;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Ease of use of emergency doors (Accessibility, ease of use, single action, linked to escape route, ability to open even if locked from other side etc.);</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Design of ladders, walkways etc. in line with regulations;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Exclusion of laydown areas from escape routes with physical demarcation where appropriate; and</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Emergency Lighting (Supplied by the by the emergency switchboard, provision of battery back-up for escape routes, muster areas, and emergency service locations.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiation (ionising &amp; non-ionising):</td>
<td>• Ionising sources of radiation to be avoided;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Exposure to non-ionising sources to be eliminated or minimised and shall not exceed the prescribed limits;</td>
<td>• Exposure to man-made UV radiation to be eliminated;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Location of High Voltage switch rooms to be away from permanently manned areas; and</td>
<td>• Radiofrequency &amp; microwave hazards to be controlled at source through design, and layout of the plant.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### HAZARD ELIMINATION

**Electrical Protection including:**
- Low smoke & fume cables;
- Inclusion of protection (Surge, short circuit etc.) & current isolation;
- Protection of live parts (including inside cabinets etc);
- Isolation of faults to prevent escalation; and
- Provision of power bypass systems.

### HAZARD DETECTION

### HAZARD CONTROL

### HAZARD MITIGATION

**Muster Facilities:**
- Located within a designated refuge area. Primary location is the Administration Area;
- Able to accommodate maximum number of personnel during normal operations; and
- Design compliant with regulations and best Practise.

### OCCUPATIONAL HSE

**Command and control facilities design to (in the case of serious emergency):**
- Monitor Fire & Gas Alarms;
- Detect & monitor propagation of fire;
- Initiate emergency depressurisation of the facility;
- Monitor the running condition of firewater pumps; and
- Initiate fire fighting systems at selected locations (deluge).

**Explosion Prevention including:**
- Maximising natural ventilation through orientation of equipment, minimising confinement etc; and
- Reduce congestion & confinement through simplification of process, layout optimisation, provision of grated decks, etc.

**Mechanical Handling & Impact Prevention including:**
- Sufficient space for laydown areas;
- Provision of lifting aids;
- Provision of access platform areas;
- Location of equipment to prevent lifting over live plant; and
- Reduce vehicle access to site areas through segregation, provision of barriers, routing of pipelines etc.
15.4.2 HAZID AND HAZOP WORKSHOPS

A series of Hazard Identification (HAZID) reviews were carried out during the FEED stage of the project. Ten separate HAZID review sessions were carried out. The outcome from these reviews has been fed into the engineering design, and any outstanding actions included as part of the action list to be carried forward into the next phase of the project (detailed design & EPC).

The main objectives of this HAZID review were to:

- Identify the significant hazards and threats associated with design, operation and maintenance of all facilities within the FEED design scope of work associated with the Ras Al Khair industrial Complex Project;
- Identify appropriate hazard management measures (safeguards) required to eliminate hazards, reduce risks and protect against the identified hazards;
- Raise actions and assign responsibility for assessment/evaluation of any potential additional safeguards; and
- Achieve a common understanding of the all requirements towards achieving a safe design.

The scope of the HAZID studies covered the following units;

- NPK/DAP plant;
- All common utilities and Infrastructure facilities at Ras Al Kahir including:
  - Process water;
  - Potable water System;
  - Feed and Product Storage Tanks (includes molten sulphur buffer storage);
  - Material Handling (loading and unloading) facilities; and
  - RAK Port Storage facilities.

The review covers hazards associated with operations activities, however, those associated with construction activities that have been identified as relevant to design phase were considered. A HAZID session will be carried out on all units during the next phase of the project to address specific design hazards associated with construction, commissioning and maintenance activities.

Actions identified by the HAZID process addressed many of the issues raised in the Health & Safety Design basis, however, additional hazards were identified and are summarised below.

- **Climatic Extremes** – high ambient temperatures, dust & sand storms, flash flooding etc., and incorporate mitigation measures into the design in terms of equipment temperature ranges, suitability of materials, effect on HVAC systems, provision of PPE, damage to infrastructure and mitigation in the design, surface water drainage design etc;
- **Seismic activity** – Consideration of seismic event and tsunami;
- **Dust Control** – management of dust through damping down using treated process water to be included in the design;
- **Diseases** – including effect on promotion of diseases such as legionella from cooling towers, and diseases from contact with toxic materials. Assessment of design, layout and mitigation in compliance with relevant standards and best practise;
- **Working Hazards** – such as working at height etc. Provision of a site permit to work system, incorporation of training, and implementation of site safety procedures in line with Occupational Safety guidance;
- Medical evacuation facilities – consideration of the type of facilities required for evacuation to specialist facilities in the region;
- Noise – Noise levels at the site boundaries designed to be below required standards.
- Common Emergency Services – including fire, medical, police etc., for major emergency response. Consideration of resources available and impacts on the wider community and project requirements for incorporation into the design.
- Waste Disposal – consideration of the types, and means of disposal with a view to minimising volumes, and waste to landfill.

In addition to the HAZID review, HAZOP reviews are also planned which will identify specific hazards in relation to construction, commissioning and decommissioning, however the results of these were not available for inclusion as part of the ESIA.

The HAZISD/HAZOP studies carried out as part of the FEED for the NPK/DAP plant and common utilities and Infrastructure facilities at Ras Al Kahir have, were relevant, considered potential impacts from ammonia gas. However, the FEED for the Ammonia Plant has not been progressed at this stage. The HSE FEED for the Ammonia Plant will be subject to a detailed HAZID and HAZOP. These will consider and potential healths impact from Ammonia as a result of Ammonia production, use, storage and transfer.

15.4.3 SPECIFIC RISK ASSESSMENTS

Specific risk assessments have been undertaken as part of the design HSE process for hazards such as toxic chemicals, fire and explosion hazards, occupied buildings, and a further one will be undertaken on Health Risks associated with the facilities.

The risk assessments have been carried out in accordance with best practise procedures and the assessment is based on a risk matrix derived from the likelihood and severity of the potential impacts. Mitigation measures are then developed to minimise the risks through elimination/avoidance, reduction of risk at source, and finally protection.

Identified risks and mitigation are incorporated into the FEED design where appropriate, or detailed for inclusion in the detailed design.

15.5 IMPACT ASSESSMENT

15.5.1 INTRODUCTION

The following Section considers and assesses the potential impacts, both negative and positive, that the proposed Ras Al Khair industrial Complex may have upon the Health, Safety and Welfare of the workforce. Sensitive receptors for the local community have been identified as part of the Section 12 - Socio-economic Aspects.

Consideration has been given to impacts associated with the construction, operation and decommissioning stages of the Project. The impact assessment has been completed in accordance with the methodology outlined by Section 5 - Impact Assessment Methodology.

The Ras Al Khair industrial city is currently under construction, however, there are no local communities in the area. The nearest town is Nairiyah which lies approximately 68 km to the west of the peninsula, with a population of 26,470, of which approximately 75% are Saudi nationals. Nairiyah supports large agricultural areas in the immediate vicinity and neighbouring regions. There are no schools, hospitals or sensitive receptors in the vicinity, and the accommodation camps being developed at present are for single occupancy with no facilities for dependants.

Community impacts have therefore been scoped out of this assessment, and will focus on impacts on the workforce, including workforces in adjacent industries. The exception to this is for Traffic and Transport (Vehicle Accidents) which is a potentially significant risk for any local road users.
15.5.2 CONSTRUCTION

Potential sources of impacts during the construction phase include the following:

- Exposure to environmental factors (Air Quality, Noise, Water & Contamination);
- Impacts of increased vehicle movement;
- Occupational Health & Safety of Construction Workers (including accidents and injuries, and mental health); and
- Communicable and non-communicable diseases.

Potential impacts from construction of an industrial facility were identified. These impacts are summarised in Table 15-10 and discussed in the sections below.

Table 15-10: Summary Assessment of Health Impacts During Construction

<table>
<thead>
<tr>
<th>Factor</th>
<th>HS01a</th>
<th>HS01b</th>
<th>HS02</th>
<th>HS03</th>
<th>HS04</th>
<th>HS05a</th>
<th>HS05b</th>
<th>HS06</th>
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<td>High</td>
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<td>Frequent</td>
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<tr>
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<td>Likely</td>
<td>Unlikely</td>
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<td>Unlikely</td>
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<td>Local</td>
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<td>Long</td>
<td>Short</td>
<td>Short</td>
<td>Short</td>
<td>Short - Medium</td>
</tr>
<tr>
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<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
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<td>Negative</td>
<td>Negative</td>
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<td>Negative</td>
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<td>Low</td>
<td>Medium</td>
<td>Medium</td>
</tr>
</tbody>
</table>

15.5.2.1 CONSTRUCTION STAGE IMPACTS ON THE HEALTH OF THE WORKFORCE RELATED TO AIR QUALITY AND NOISE

Impacts on air quality during construction related to the use of mobile diesel plant, increase in traffic volumes, and an increase in dust particles. Increased exposure to NOx and SOx emissions from plant and vehicles can increase the sensitivity of individuals in vulnerable groups especially those diagnosed with chronic conditions such as Asthma. The EPC contractor will be required to implement a number of best practice measures during construction to reduce any potential impact to air quality see Section 2 – Air Quality & Meteorology. In addition the implementation of a comprehensive health screening for the workforce, combined with access to on-side medical facilities will reduce the risk of health impacts to those with chronic conditions. Exhaust emissions from on-site stationary engines and other operating equipment are considered insignificant, as these emissions generally are of low concentration and volume and are emitted from sources that are subject to maintenance programmes and are operated in compliance with HSES policies to protect on-site workers. The overall impact of air quality on workforce health (including workforces from adjacent facilities) is therefore considered to be low from air quality.

Construction noise and vibration from on-site plant and machinery, transportation, can adversely affect peoples’ quality of life. The health effects of noise and vibration during construction include hearing loss caused by exposure to noise at work which continues to be a significant occupational disease, and hand arm vibration exposure. Factors that contribute to the health effects are: the noise level, level and type of vibration, and the length of exposure (e.g. daily or over a period of years). Exposure to noise is more common and it can take years for a health effects to be realised. Management of construction noise will follow international best practise and will include consideration in the detailed design phases of changes in the
construction process, and plant to minimise noise impacts, organisation of the programme and workforce ensure rotation of staff, development of a comprehensive training programme and provision of PPE where required, and implementation of monitoring and health surveillance measures during construction. The implementation of these measures will reduce the impact to low significance.

**Impact HS01a (air quality) – Low significance**

**Impact HS01b (noise) – Low Significance**

15.5.2.2 CONSTRUCTION STAGE WATER IMPACTS ON WORKFORCE HEALTH

Potable water supply to the construction site will be provided via the existing water facilities and will be supplied to the required standards as defined by National Drinking Water Quality Standard for KSA (2012) and IFC Environmental Health, and Safety Guidelines for Water and Sanitation (2007), and therefore health risks to the workforce are considered negligible. Water will also be required for construction processes. The existing PDP has sufficient capacity to supply the likely requirements of the construction phase. It is unlikely that the volumes of water required will degrade the availability of supplies during the construction phase.

**Impact HS02 – Low Significance**

15.5.2.3 CONSTRUCTION STAGE CONTAMINATED SOILS ON WORKFORCE HEALTH

Given the baseline soil chemical quality data the site’s current potentially contaminative operations cannot currently be established. Given the industrial nature of the surrounding area, it is likely that contamination of the soils exists. For the purposes of this assessment on workforce health, a precautionary approach will be taken. Contamination in soils can impact on human health in a variety of ways, however, the impact will vary according to the type of pollutant and the method of exposure. Direct effects occur through contact with soil or inhalation of soil contaminants. Indirect effects can be seen through (for example) infiltration of soil contamination into water sources used for human consumption. The latter can affect communities far removed from the site of contamination. Chronic exposure to chromium, lead and other metals, petroleum, solvents, and many pesticide and herbicide formulations can be carcinogenic, cause congenital disorders, or can cause other chronic health conditions. Measures to protect the environment from pollution (either from contaminated soils and/or through accidental spillage etc) are detailed in Section 7 – Terrestrial Environment. These measures will mitigate contamination of any potential water sources. Construction methods to reduce dust (e.g. spraying), combined with a visual screening during construction works will reduce the potential for exposure to contaminated soils. At present, the potential impact on workforce health taking the precautionary approach is considered to be Medium adverse. This assumes the potential impact has long term impacts on a person’s health as a result of exposure (and is therefore of high magnitude), and that the exposure is likely to occur.

**Impact HS03 – Medium Significance**

15.5.2.4 CONSTRUCTION STAGE WASTE IMPACTS ON WORKFORCE HEALTH (LIQUID & SOLID)

A construction site Waste Management Plan will be developed and implemented for the Project and will be specific to the requirements during the Early Works and main Construction activities. The Plan will detail the types of waste and the mechanisms for storage and disposal (see Section 10 – Waste Management). Domestic, general and hazardous waste is required to be stored, collected and disposed of in according to National standards and procedures reducing any potential risks to the workforce. Construction waste water will take the form of two types: sanitary and general construction. Sanitary waste water will discharged to the exiting STP. Water is likely to be required for dust suppression measures. As all waste water will be contained and disposed of at a designated treatment works and treated to irrigation standards, the potential for increase of any water based diseases and/or vector borne diseases will be minimised and is considered to be low impact.

**Impact HS04 – Low Significance**
15.5.2.5 CONSTRUCTION STAGE TRAFFIC IMPACTS ON WORKFORCE AND COMMUNITY SAFETY

The impact of traffic and transport on air quality and subsequent potential impacts to health have been documented in Section 15.5.2.1. Traffic and transport details are presented in Section 13 – Traffic & Transport. This section identifies the potential impacts associated with physical movement of vehicles especially where they relate to MVAs. The national statistics for MVAs are detailed in Section 15.2.2.4. The GOSI annual Report suggests that 3.5% of all workplace injuries/accidents are caused by MVAs at least half of these are in the construction industry. Therefore, any increase in vehicle movements could have a profound impact on the safety of both the workforce and the local community.

The Ma’aden Mining Company through their Corporate Policy are committed to reducing MVAs and as such, all project personnel who are required to drive will be provided with defensive driver training. Safety processes will be implemented to reduce the need for driving.

During construction, it is likely that the workforce will be taken by bus from the accommodation camp to the construction site(s). However, the EPC Contractor will perform a Traffic and Logistics Study to assess roads and determine access requirements via other modes of transport. On completion of this survey, construction lay down areas, dimensions of all road and jobsite clearance limitations will be identified.

Much of the construction materials and plant will be delivered to the site by the existing road network. The use of the rail infrastructure will be considered as part of the EPC Contractor will Traffic and Logistics Study the use of the existing rail network could reduce the potential impact on accidents. Safety records and processes will form part of any supplier and contractor evaluation, ensuring the EHS guidelines are driven into all aspects of the project, reducing risks of MVAs in the supply chain. The likelihood of MVAs occurring to the workforce will therefore be considerably reduced.

Potential community safety issues relate to the increased risk of MVAs from other road users. Due to the industrial nature of the Project area and existing security arrangements, traffic access points and routes around and across the Project area will be restricted. Private cars will not be permitted without prior approval, and personnel vehicle access to the site is likely to be restricted to buses for transporting the workforce from accommodation camps to the work areas. The use of the railway would also significantly reduce vehicle movements. Given the extremely low presence of local residents the risks to pedestrians is considered to be very low. There does, however, remain a significant risk that the increase in traffic movements could further increase the risk of MVAs to other road users.

**Impact HS05a (Workforce Safety) – Low Significance**

**Impact HS05b (Community Safety) – Medium Significance**

15.5.2.6 CONSTRUCTION STAGE OCCUPATIONAL HSE IMPACTS ON THE WORKFORCE (ACCIDENT/ INJURY & DISEASE)

Many aspects related to occupational health (e.g. MVAs, environmental aspects,) have been assessed in Sections 15.5.2.1 to 15.5.2.5. This section will therefore consider general workforce accidents and injuries, diseases, and issues such as Mental Health and Stress. The national statistics for workforce accidents and injuries, diseases are detailed in Section 15.2.2.4. In summary accidents and injuries in the construction industry, account for approximately half of all workforce injuries (GOSI 2012).

Workplace accidents and injuries can be reduced through the implementation of international best practise in training, monitoring, HSE guidelines and practises. Injuries and accidents can be further reduced through the introduction of a programme which addresses culture and behaviours on site. Furthermore, Corporate Policy and engagement with staff, suppliers and contractors will have a major impact on the success of any safety practises implemented on site.

The Project will be implemented using processes and procedures designed to international best practise, and will seek accreditation to ISO 9001, ISO 14001 and OHSAS 18001.
certification. This will also be compliant with the IFC EHS General Guidelines (2007). The Ma’aden corporate commitment to Health and Safety has seen the Ma’aden Phosphate Company awarded their Golden Award for no lost-time injuries in 2011.

First aid services and Medical facilities will be provided on site during the main construction period. However, there are no local hospital facilities, the nearest being located in Jubail. Therefore, and serious injuries will be required to be transferred for a considerable distance, potentially increasing the risk to the health of the injured party through an increased delay in appropriate medical treatment, potentially increasing the severity of the injury/accident or condition (e.g. in cardio pulmonary diseases) and in extreme incidents causing death.

An Environmental Emergency Response Plan (EERP) will be developed as part of ESIA (see Appendix B) which will detail the response to severe injuries/accidents. The provision of fully trained medical staff and comprehensive medical facilities will reduce this risk to low, however, it is recommended that consideration is given to the evacuation of injured staff given the distances involved in transfer to a hospital facility.

Mental health & stress is also an important consideration for any workforce. The accommodation camp has been designed to provide high standard accommodation with recreational facilities, and access to on-site health care staff, all of which will contribute to a reduction in stress and improved mental health. Working hours, holidays, pay, grievance mechanisms etc., will also be implemented according to National Labor laws, ensuring the employment conditions are suitable and do not contribute to an increase in stress.

The baseline assessment suggests that the cases of many communicable diseases are relatively low, especially for cases of malaria which are primarily brought into the area through migration of workers. Transmission of such diseases amongst the construction workers themselves and transmission between the construction workers and the workforces from adjacent industries must both be considered.

The exact location, layout, and facilities will be determined in the next phases, however the construction workers are likely to be housed in shared accommodation with communal toilet and shower facilities. The close living quarters and communal kitchens could increase the spread of infectious diseases that may be present. The accommodation camps during construction will be designed to National Labor Law and in line with the guidance published in the IFC Workers Accommodation: Processes and Standards (IFC 2009). In addition, a comprehensive health screening programme for workers will be developed in compliance with KSA regulations.

It is anticipated that the incidence rate of a variety of commonly occurring infectious ailments and diseases, such as chickenpox, hepatitis, and diarrhoeal diseases will increase. However the implementation of a comprehensive health screening programme, compliance and implementation of international HSE standards and the World Bank EHS guidelines, provision of a medical facility with fully trained staff, and the introduction of a comprehensive information/training programme will reduce the significance of the potential impact.

Impacts HS06 – Medium Significance

15.6 COMMISSIONING AND OPERATIONS

As discussed in Section 15.4, the operational health, safety and welfare of the workforce and community has been integral to the design of the mine and process facility, and undertaken to internationally accepted standards. The operational workforce will be substantially lower than during construction, and will be housed in permanent accommodation with catering, recreational and sports facilities, and on-site medical and health facilities and nursing staff, with full compliance with the occupational health guidelines (IFC 2007) in the general EHS Guidance. All wastewatwr will be treated by the on-site treatment facilities connected through a sewer network, and a permanent potable water supply will be provided.

A full project description is provided in Section 3 - Detailed Description and Layout of the Proposed Development which describes the phases of operation, design of the plant and supply of materials, design of the loading and storage areas, and the recycling of all water on-
The operational assessment therefore considers only the residual impacts which have not been designed out, or minimised, and is limited in scope to:

- Air Quality & Dust;
- Traffic and Transport (including community effects);
- Occupational Health, Accidents and Incidents; and
- Communicable and Non-Communicable Diseases.

These potential impacts from the operational phase of the Project are summarised in Table 15-11 and are discussed below.

**Table 15-11: Summary of the Impact Assessment**

<table>
<thead>
<tr>
<th>Factor</th>
<th>HS07</th>
<th>HS08a</th>
<th>HS08b</th>
<th>HS10</th>
<th>HS10</th>
<th>HS11</th>
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</tr>
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</tr>
</tbody>
</table>

**15.6.1 OPERATIONAL STAGE AIR QUALITY IMPACTS ON THE WORKFORCE**

Impacts from air quality during operation relate to the emissions from plant and vehicles which can increase the sensitivity of individuals in vulnerable groups especially those diagnosed with chronic conditions such as Asthma. The implementation of a comprehensive health screening for the workforce, combined with access to on-site medical facilities will reduce the risk of health impacts to those with chronic conditions.

Traffic movements have the potential to adversely impact on the local air quality. The majority of materials will enter the site via train reducing the impact of traffic movements on air quality. Assuming a worst case (i.e. all workers using cars for each individual person) then the maximum number of vehicles would be approximately 179 (number of workers representing a complete shift) in one direction 536 per day in any single directions during operation, with an additional 24 truck movements per day time. Vehicles will enter the site from the main road.

The Ras Al Khair Industrial complex will be constructed adjacent to the existing industrial facilities. There is currently no ambient air monitoring in Ras Al Khair the existing air quality is based on available data from the air quality monitoring network at Jubail, which is approximately 65km to the southeast of Ras Al Khair. However, because this area is located approximately 15 km to the south-west of the Jubail industrial city and some distance form industrial development, it represents a conservative estimate of ambient background air concentrations in Saudi Arabia. This data shows that the area is achieving standards for SOx, and NOx. The results show that ambient PM10 concentrations are high due to local sand storm events PM10 (see Section 6 – Air Quality). The plant has been designed to comply with RC and international standards for air quality and emissions. Operation of the plant is unlikely to create further air quality degradation, however, consideration will be given in detailed design as to the impacts of the existing air quality in relation to maintenance of good health. A risk assessment will be undertaken which shall define the specific risks and mitigation, including
working hours, exposure limits, and use of PPE as required. A precautionary approach to the assessment has therefore been taken.

The overall impact of air quality on workforce health (including workforces from adjacent facilities) is therefore considered to be medium from air quality.

**Impact HS07 – Medium Significance**

15.6.2 OPERATIONAL STAGE TRAFFIC IMPACTS ON THE WORKFORCE AND COMMUNITY

Traffic and transport details are presented in Section 13 – Traffic & Transport. As highlighted in the baseline, MVAs are a major source of fatalities and injuries in KSA. The increase in road traffic therefore increases the risk of MVAs both to the workforce (including suppliers) and local road users. The workforce will likely be transported to site from the accommodation by bus, reducing the need for any driving, and this will be complemented through implementation of training and awareness programme (including where appropriate on-road defensive driver training). This will reduce the risk of both MVAs and also risk of injury resulting from an accident.

A traffic management plan will be implemented which will detail the rest requirements for driving over long distance (e.g. hauling), location of sensitive areas on the Ras Al Khair industrial complex (e.g. ammonia vaporiser), segregation of the work force from vehicle accessible area etc. Given the long distances and use of the road network, other road users will be more exposed to the potential for MVAs through the increased traffic generated on the roads. Awareness programmes for suppliers, contractors, could be included to reduce the risk of MVAs however, given the duration of the project and high incidence rate of MVAs the increase in traffic movements is likely to have a moderate impact on affected communities and other road users.

**Impact HS08a (Workforce) – Low Significance**

**Impact HS08b (Community) – Medium Significance**

15.6.3 OPERATIONAL STAGE ACCIDENT AND INJURY IMPACTS ON THE WORKFORCE

Many aspects related to occupational health have been considered as part of the Safety in Design Process (see Section 15.4), and the Ma’aden Phosphate company policy and implementation of this on their existing facilities has resulted in an exemplary safety performance in 2011. These international standards and systems (including lessons learned) in parallel with comprehensive on-site medical and welfare facilities, will be implemented on this project, and therefore the occupational health impacts in terms of accidents and injuries is considered to be low.

Mental health & stress is also an important consideration for any workforce. The accommodation camp will be designed to provide high standard accommodation with recreational and sports facilities, and access to on-site health care staff, all of which will contribute to a reduction in stress and improved mental health. Working hours, holidays, pay, grievance mechanisms etc., will also be implemented according to National Labor laws, ensuring the employment conditions are suitable (including factors such as climate) and do not contribute to an increase in stress.

The EERP will detail the communication and procedures associated with any major incidents (e.g. chemical spill, ammonia release). This plan will be developed throughout the detailed design phase and implemented on site using the policies and procedures outlined in Section 15.4. Operational stage impacts on the workforce are therefore considered to be low.

**Impact HS09 – Low Significance**

15.6.4 OPERATIONAL STAGE DISEASE IMPACTS

The risk of communicable diseases such as childhood diseases, HIV, Hepatitis etc, will still exist. The accommodation area forms part of the existing facilities, and comprehensive health screening and facilities being implemented on site for operations will further reduce the likelihood of the impact occurring. Sanitary and wastewater treatment and recycling on site ensures that a high standard of welfare facilities will be accessible to all on site. The
implementation of the site waste management plan will ensure all waste (domestic, industrial and hazardous) is stored in covered areas, according to best practice and will be removed from site on a frequent basis. This will reduce the risk of attracting potential vectors (e.g. rats) to the site. Existing standing water on site includes the irrigation ponds, which will be sufficient to accept treated waste water from the Project, and evaporation ponds. There will be a new surface water storage pond, however, this is unlikely to create a substantial increase in standing water areas. The existing ponds have not led to an increase in communicable water borne diseases since their commissioning within the existing workforce at adjacent facilities. Furthermore, it is understood that an increase of water entering the wastewater treatment plant will improve plant treatment performance. The operational impacts are therefore considered to be low.

**Impacts HS10 – Low Significance**

15.7 DECOMMISSIONING

Potential impacts from the decommissioning phase of the Project were identified. These impacts are summarised in Table 15-12 and are discussed below.

**Table 15-12: Summary of Health and Safety Impacts of Decommissioning**

<table>
<thead>
<tr>
<th>Factor</th>
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</tr>
<tr>
<td>Significance</td>
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<td>Medium</td>
</tr>
</tbody>
</table>

15.7.1 INTRODUCTION

Potential impacts from this phase of the project are both short term, resulting from decommissioning activities, and long term legacy issues resulting from materials and conditions left in place.

The accommodation areas will form part of the Industrial City and will therefore remain in service. Any infrastructure (e.g. utilities, health facilities, permanent roads, rail etc.) will all remain in-situ and will serve the growing community. The effects of this have been considered in the assessment above (through duration and magnitude of effect) and are, therefore, not considered in this section.

15.7.2 DECOMMISSIONING STAGE HEALTH & SAFETY IMPACTS ON THE WORKFORCE AND THE COMMUNITY

The impacts of decommissioning are likely to be similar to construction, with risks from chemicals, waste materials, accidents and injuries being the most likely to be realised. Decommissioning will be planned by developing, procedures, and any HSE requirements to ensure the project is decommissioned safely and effectively, using the correct PPE etc. The Emergency Response Plan will also detail response during decommissioning. The decommissioning impacts are therefore considered to be low.

A medium significance has been identified for the Community Impact. This is a precautionary assessment based on the potential long term effects any incident during decommissioning can
have on health for communities in and around the site. It is recognised that while there are no local communities present in and around the site at present, given the lifetime of the project communities surrounding the Ras Al Khair facilities will develop. Given the types of processes and chemicals being used, the magnitude of the impact should site restoration not be undertaken effectively could be moderately adverse. The implementation of a site restoration plan and post-project monitoring would reduce this potential impact to low.

**Impacts HS11a (Workforce) – Low Significance**

**Impacts HS11b (Community) – Medium Significance**

### 15.8 MITIGATION

#### 15.8.1 INTRODUCTION

The incorporation of Health and safety into the FEED stage has allowed much of the mitigation to be incorporated into the design, which has been effective in reducing the majority of the impacts to low adverse.

This section will detail the additional mitigation which is to be included as part of the detailed design and operational stages to reduce potential impacts further and/or realise further benefits.

A hierarchical approach to mitigation development has been adopted to manage impacts identified for the construction, commissioning, operational and decommissioning phases of the Project. This approach consists of three distinct stages:

- **Avoidance** – eliminate impacts wherever possible.
- **Minimise** – Reduce the effect of negative impacts that cannot be avoided.
- **Compensate** – Implement compensatory measures for remaining significant impacts.

Implementation of mitigation measures will be required during construction, commissioning, operation and decommissioning of the facility to minimise potential negative impacts of the activities on Health and Safety Aspects. The mitigation measures comprise a combination of management procedures and further assessments to be undertaken at detailed design and are described in the subsequent sections. The following text assesses the impacts predicted as being of medium to high significance against appropriate mitigation measures to predict the residual impact significance.

#### 15.8.2 CONSTRUCTION

#### 15.8.2.1 HEALTH & SAFETY IMPACTS AND MITIGATION – CONSTRUCTION PHASE

<table>
<thead>
<tr>
<th>ID Code</th>
<th>Impact</th>
<th>Potential Significance</th>
<th>Mitigation Measure</th>
<th>Significance after Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS03</td>
<td>Construction stage contaminated soils on workforce Health</td>
<td>Medium Adverse Significance</td>
<td>Ground investigations suggest some degree of soil contamination at the site. A soil sampling and analysis exercise is to be undertaken in the detailed design phase, with consideration of potential hazardous contaminants such as heavy metals. The results are to be used to undertake a detailed health risk assessment identifying the HSE process and methods to be employed on site during construction to protect the workforce.</td>
<td>Low</td>
</tr>
</tbody>
</table>
15.8.2.2 RECOMMENDATIONS – CONSTRUCTION PHASE

It is recommended that the EPC contractor conduct regular maintenance checks on mobile and fixed plant in relation to exhaust emissions. Any sandblasting activities required should be done in a controlled environment.

Training and awareness on issues such as defensive driving would be beneficial to the suppliers and contractors, given the high number of MVAs in KSA.

Safety performance, procedures and processes, and safety records should form part of any supplier evaluation.

15.8.3 COMMISSIONING, OPERATIONS & DECOMMISSIONING

15.8.3.1 HEALTH & SAFETY IMPACTS AND MITIGATION – COMMISSIONING, OPERATIONS & DECOMMISSIONING PHASES

<table>
<thead>
<tr>
<th>ID Code</th>
<th>Impact</th>
<th>Potential Significance</th>
<th>Mitigation Measure</th>
<th>Significance after Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS07</td>
<td>Air Quality impacts on the Workforce</td>
<td>Medium Adverse Significance</td>
<td>A risk assessment will be undertaken which shall define the specific risks and mitigation, including working hours, exposure limits, and use of PPE as required.</td>
<td>Low</td>
</tr>
<tr>
<td>HS08b</td>
<td>Operational stage traffic impacts on the Community</td>
<td>Medium Adverse Significance</td>
<td>A Traffic Management Plan will be implemented. Training and awareness on issues such as defensive driving will be provided to the workforce.</td>
<td>Low</td>
</tr>
</tbody>
</table>
15.8.3.2 RECOMMENDATIONS – COMMISSIONING, OPERATIONS & DECOMMISSIONING PHASES

Updates to the EERP should consider the following:

- Liaisons with the relevant authorities to ensure services are (a) available, and (b) have sufficient capacity to support the Project workforce and the anticipated nature of any health incidents / issues;
- Provision for evacuation to hospitals in Jubail for any incident types which the local medical facilities cannot treat (e.g. chemical, burns, fractures etc.) and which may be time critical;
- Given the distances involved in any transfer to Jubail, provision of fully training medical staff who can treat to a level which allows safe transfer of the patient to the hospital facilities either through air transport or road ambulance.

Training and awareness on issues such as defensive driving would be beneficial to the suppliers and contractors, given the high number of MVAs in KSA.

15.8.4 ACCIDENTAL EVENTS

The EERP (an outline of which is included in Appendix B) will detail the procedures and process to be followed to protect both the workforce and the local community from potential harm in the event of an incident. Development and implementation of the EERP is to include liaisons with the relevant authorities to ensure services are (a) available, and (b) have sufficient capacity to support the Project workforce and the anticipated nature of any health incidents / issues. Provision for evacuation to hospitals in Jubail is to also be included for incidents which the local medical facilities cannot treat (e.g. chemical, burns, fractures etc.), and which may be time critical. Given the distances involved in any transfer to Jubail, fully training medical staff will need to be able to treat to a level which allows safe transfer of the patient to the hospital facilities either through air transport or road ambulance.
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16.0 SUSTAINABLE DEVELOPMENT

16.1 INTRODUCTION

As a part of the Environmental and Social Impact Assessment (ESIA) Process, it is important that the sustainability of the proposed development is also evaluated against a range of recognised criteria, which requires consideration of economic, social and ecological processes as well as the optimisation of trade-offs between and across the three systems. The assessment of sustainability provided by this section has been undertaken by analysing how elements of sustainable development were integrated into the ESIA process, and into the design and planning of the Project itself. The sustainable development assessment is designed to ensure that the entire project lifecycle is taken into consideration.

16.2 SUSTAINABLE DEVELOPMENT CONTEXT

16.2.1 SUSTAINABLE DEVELOPMENT AS A POLICY CONCEPT

The modern concept of sustainable development emerged from a series of meetings and reports during the 1970s and 1980s. However, the most significant step in recognition of the concept of sustainable development came in 1987 when the UN-sponsored Brundtland Commission drafted *Our Common Future*, which detailed widespread concerns about poverty and the environment in different regions of the world. The report stated that whilst economic development cannot stop, it must change course to ensure that it fits within the ecological limits of the planet. The Brundtland Commission defined sustainable development as:

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

The Brundtland report also noted that; “Major unintended changes are occurring in the atmosphere, in soils, in waters, among plants and animals. Nature is bountiful but it is also fragile and finely balanced. There are thresholds that cannot be crossed without endangering the basic integrity of the system. Today we are close to many of those thresholds.”

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.

At the time of the Brundtland Commission, water sustainability and climate change were also identified as related/contributory issues, however these issues have since been acknowledged as serious global problems in their own right.

The Commission went on to outlined a series of "strategic imperatives," or "critical objectives," inherent in their concept of sustainable development. In response to the Commission’s report, the need to respond to the concept of sustainable development gained momentum in organisations around the world.

In 1992 the UN Conference on Environment and Development (also known as the ‘Earth Summit’) was held in Rio de Janeiro and attended by 172 of the world’s governments. The Earth Summit achieved a broad political consensus around the concept of sustainability as articulated in the adopted 27 principles Rio Declaration, which provided a framework for governments to improve environmental and economic condition around the world. The Summit also initiated Agenda 21, which introduced a comprehensive programme of action for global action in all areas of sustainable development. The establishment of the Millennium Development Goals (MDGs) at the Millennium Summit in 2000 continued the global movement towards the elimination of poverty and achievement of sustained development.
Since its inception four decades ago, the adoption of sustainable development principles has become factored into decision-making at all levels in government, public and private sector organisations throughout the world.

### 16.2.2 SUSTAINABLE DEVELOPMENT IN THE KINGDOM OF SAUDI ARABIA

Sustainable development is inherent in the principles of Islam, which hold that the protection, conservation and development of the environment and its natural resources are a mandatory duty to which every Muslim should be committed” (SOFRECO, 2012). In December 1994, the Kingdom of Saudi Arabia’s (KSA) Council of Ministers approved the Kingdom’s National Agenda 21 implementation plan to achieve sustainable development goals, formalising this inherent concept.

The KSA’s 9th National Development Plan (NDP) (2010-2014) has the overall theme of sustaining national development and supports an overarching goal of having KSA become: “A developed, thriving and prosperous economy, built on sustainable foundations. It will extend rewarding work opportunities to all citizens, will have a high-quality education and training system, provide excellent healthcare for all, and offer all necessary services to ensure welfare of all citizens; all while safeguarding social and religious values and preserving national heritage.”

The modern concept of sustainable development (environmental, social and economic factors) is also enshrined within the legislation and policies of the Presidency of Meteorology and Environment (PME) and Royal Commission (RC). Recognition of sustainable development is also evident in the policies, procedures and activities of other organisations within the Kingdom, such as the Ministry for Petroleum and Mineral Resources, Ma’aden and Saudi Aramco.

The Kingdom’s focus on diversification of industry, and expansion of the employment opportunities, is in keeping with the concept of sustainable development, and has increased focus on improving efficiency of resource use and taking advantage of green economy concepts.

### 16.2.3 IFC AND SUSTAINABLE DEVELOPMENT

The International Finance Corporation (IFC) considers multiple dimensions of sustainability in its approach to risk management with regards to decision-making on its investments. This is articulated through the Sustainability Framework, an integral part of the IFC’s strategic commitment to sustainable development.

The Sustainability Framework consists of the Policy on Environmental and Social Sustainability (IFC, 2012), which defines the IFC’s commitments to environmental and social sustainability, and the Performance Standards (IFC, 2012), which define a client’s responsibilities for managing the environmental and social risks associated with their project. This applies to all clients whose projects go through the IFC’s initial credit review process, and therefore the Sustainability Framework applies to Ma’aden in respect of the Ras Al Khair Industrial Complex (i.e. ‘the Project’).

### 16.2.4 THE PROJECT SUSTAINABLE DEVELOPMENT GOALS AND STANDARDS

Over and above adherence to national and international environmental and social standards, Ma’aden’s corporate policy incorporates the fundamental principles of the Islamic trust of stewardship towards the natural environment setting the context within which the project will be delivered:

- conservative exploitation of mineral process;
- protection of natural resources during operations; and
- reclamation and improvement of soil, air and water resources following the development of all operations.

Ma’aden is committed to Corporate Social Responsibility (CSR) allowing them “to contribute positively to the well-being of our people, the environment, economy and society”. In addition
to this overarching commitment, Ma’aden has adopted an HSE Policy which introduces accountability for progress towards sustainable development, a commitment to continual improvement in health, safety and environmental performance and a commitment to where appropriate, exceed legal requirements and national standards for environmental aspects and impacts. The policy also sets an ultimate objective of zero harm to people and the environment.

The Ma’aden Project Manual ‘Environment and Communities Assurance’ guide (MD-101-SMMPM-PM-EN-GUI-0001), applicable to all Ma’aden projects, states that Ma’aden has adopted the International Council on Mining and Metals (ICMM) Sustainable Development Framework as the basis for its corporate management philosophy with regards to sustainable development. In adopting the ICMM Sustainable Development Framework as the basis for its sustainability goals, Ma’aden has committed to “seek continual improvement in our performance and contribution to sustainable development so as to enhance shareholder value”.

Table 16-1 compares relevant inclusions of both the Ma’aden HSE Policy Statement and the ICMM Sustainable Development Framework to arrange and identify similarity between corresponding principles to be used as a basis for setting sustainable development goals for the project.

Table 16-1: Comparison of the Principles of the Ma’aden HSE Policy Statement and ICMM Sustainable Development Framework

<table>
<thead>
<tr>
<th>Ma’aden HSE Policy Statement</th>
<th>ICMM Sustainable Development Framework</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principles in relation to Governance</strong></td>
<td><strong>Implement and maintain ethical business practices and sound systems of corporate governance.</strong></td>
</tr>
<tr>
<td>Integrate HSE considerations into decision-making and business planning processes.</td>
<td><strong>Integrate sustainable development considerations within the corporate decision-making process.</strong></td>
</tr>
<tr>
<td><strong>Principles in relation to Risk Management</strong></td>
<td><strong>Implement risk management strategies based on valid data and sound science.</strong></td>
</tr>
<tr>
<td>Provide a working environment which is conducive to health and safety. Identify, assess and manage risk to employee and contractors and impacts on the environment, to a level which is as low as reasonable, achievable, social and economic factors taken into account. Develop a safe behaviour culture as a key component of duty-of-care and operate to the highest safety standards.</td>
<td><strong>Seek continual improvement of our health and safety performance.</strong></td>
</tr>
<tr>
<td><strong>Principles in relation to Performance Improvement</strong></td>
<td><strong>Seek continual improvement of our environmental performance.</strong></td>
</tr>
<tr>
<td>Set measure and review HSE performance targets, and objectives, benchmarking against best international practice. Provide resources to achieve our performance targets, and empower people to comply with this policy. Ensure that all employees contribute and take responsibility for their own and other’s health and safety, by reporting at-risk behaviour, hazardous conditions and environmental non-conformances, and taking the necessary preventative and mitigation action. Meet and, where appropriate, exceed all applicable HSE legal requirements, and national standards and international codes of practice for environmental aspects and impacts to which we subscribe. Maintain an HSE management system aligned with internationally recognised standards and leading industry practice.</td>
<td><strong>Seek continual improvement of our health and safety performance.</strong></td>
</tr>
<tr>
<td>Maintain an HSE management system aligned with internationally recognised standards and leading industry practice.</td>
<td><strong>Seek continual improvement of our environmental performance.</strong></td>
</tr>
</tbody>
</table>
Principles in relation to Natural Resource Conservation

- Prevent or minimise environmental pollution, conserve natural resources, minimise waste, progressively rehabilitate impacts, and value cultural heritage.
- Use cleaner energy and constantly improve the energy and material efficiency of operation.
- Contribute to conservation of biodiversity and integrated approaches to land use planning.
- Facilitate and encourage responsible product design, use, reuse, recycling and disposal of our products.

Principles in relation to Stakeholder Engagement

- Develop our people and assess their HSE competency.
- Communicate with, and engage employees, contractors, suppliers, government agencies, visitors and communities to share the responsibility for meeting this policy.
- Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities.
- Contribute to the social, economic and institutional development of the communities in which we operate.
- Implement effective and transparent engagement, communication and independently verified reporting arrangements with our stakeholders.

Using this comparison to determine the common principles contained within the Ma’aden HSE Policy Statement and ICMM Sustainable Development Framework, sustainable development goals throughout the project lifecycle, can be summarised as:

1. Incorporate environmental, social and economic considerations and principles into the decision-making process for the entire project lifecycle;
2. Identify risk with regards to environmental, social and economic impacts and implement measures to manage and mitigate risk;
3. Implement measures to ensure continual improvement in environmental, social and economic performance;
4. Implement measures to maximise conservation of natural resources and increase the efficiency of resource use; and
5. Ensure communication and engagement with stakeholders throughout the duration of the project and ensure the concerns of different stakeholders affected by the project are addressed.

The Ma’aden Communities and Assurance Guide requires sustainable development objectives and targets (KPIs) to cover environmental, community and economic factors and be in keeping with statutory and Ma’aden requirements, as well as industry best practice.

Sustainable development objectives and targets are to be established at the earliest possible stage in the project. The Environmental Design Basis developed for use during the FEED process provides the objectives and targets necessary to ensure the project is compliant. These, and the findings and recommendations of this ESIA should be used as the basis for assessing project performance with respect to environment and community aspects during the project’s lifecycle (engineering, procurement, construction, operation and decommissioning).

16.3 ASSESSING SUSTAINABLE DEVELOPMENT

Large industrial projects, such as the Ras Al Khair Industrial Complex, have the potential for significant negative impacts upon both the environment and the community in which they are constructed and operated. However, through suitable assessment, opportunities to manage and mitigate such impacts can be identified and incorporated at an early stage, leading to the incorporation of sustainable development considerations into the project lifecycle.

There is no single methodology for assessing the incorporation of sustainable development principles by a project. In the case of the Project, it is important that the assessment incorporates consideration of the sustainable development requirements of the project’s interested parties, namely the World Bank Group/International Finance Corporation (IFC) and the Royal Commission as well as the three core fundamentals of sustainable development (consideration of environmental, social and economic factors).
The assessment will consider the incorporation of sustainable development in the various chapters of the ESIA and the incorporation of sustainable development into the Project itself.

The sustainability assessment will assist in determining the extent to which sustainable development has been considered and incorporated into the ESIA process, which then in turn enables a more thorough assessment of sustainable development for the project.

16.3.1 SUSTAINABLE DEVELOPMENT ASSESSMENT METHODOLOGY

The ESIA itself has been prepared to address the environmental, social and economic requirements of the WB and IFC performance standards. Environmental, social and economic requirements as stipulated by the KSA and RC, as well as those of Ma’aden, have also been given due consideration in the preparation of the ESIA. Table 2-1 of Section 2 - Policy, Legal and Regulatory Framework, demonstrates how the ESIA addresses the performance standards, and thus the integration of sustainable development principles. Therefore the sustainable development assessment shall focus on the extent to which the project may be considered sustainable.

As identified and discussed above, the sustainability of a development can be judged in terms of the extent to which it meets the needs of the present, without impinging on the needs of future generations. The principles of intra-generational and inter-generational equity can be used to evaluate this on the basis of the temporal and spatial extent of the impacts.

Intra-generational equity is the principle of equity between different groups of people alive today. Similarly to inter-generational equity, intra-generational 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 (International Institute for Sustainable Development (IISD), 1997). Examples of intra-generational equity include identifying impacts that may affect different social groups and ensuring suitable mitigation exists and giving consideration to the comments made by members of the public with regards to the project and ESIA.

Inter-generational 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 (IISD, 1997). Examples of inter-generational equity include identifying ecosystems that may be affected by the development and assessing the risk of irreversible damage occurring to them and ensuring that an integrated assessment approach has been applied by the ESIA, weighing environmental, social and economic factors against one another.

Consideration is also given to global impacts for example climate change, loss of biodiversity, the depletion of natural resources and human rights.

The methodology employed for the sustainable development assessment of the project will consider the residual impacts identified within the ESIA of the Ras Al Khair Industrial Complex using the criteria of timescale and extent. The principles of intra-generational equity and inter-generational equity will be used to take account of the duration associated with each significant impact identified. The likely extent of the impact, in terms of geographical area, is also considered. Together these factors provide a means to evaluate the sustainability of the project.

The matrix presented as Figure 16-1 which has been developed using the principles of a risk assessment, and will be used to assess the sustainable development implications of the significant environmental, social and economic impacts of the Project.
Figure 16-1: Criteria for Sustainable Development Assessment

The following definitions provided in Table 16-2 apply to each of the criteria for the sustainable development assessment.

Table 16-2: Definitions for Sustainable Development Assessment

<table>
<thead>
<tr>
<th>Extent</th>
<th>Local</th>
<th>Regional</th>
<th>National</th>
<th>International</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>Within a 2km radius of the Ras Al Khair Industrial City</td>
<td>Outside of the local area, but within the Eastern Province of the KSA</td>
<td>Within the borders of the KSA</td>
<td>Outside of the borders of the KSA</td>
</tr>
<tr>
<td>Regional</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>International</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Timescale</th>
<th>Local</th>
<th>Regional</th>
<th>National</th>
<th>International</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short</td>
<td>Less than the life of the Project</td>
<td>Less than or equal to the operational lifetime of the project (25 years for Ras Al Khair Industrial Complex)</td>
<td>Greater than the lifetime of the project, but less than or equal to 100 years</td>
<td>Greater than 100 years</td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extended</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All residual environmental, social and economic impacts, regardless of significance, identified by the ESIA will be assessed against the sustainable development assessment criteria in order to give an indication of the sustainability of the project and plotted into the matrix illustrated in Figure 16-1.

Those impacts which are grouped towards the bottom left of the graph (i.e. shorter-term, localised impacts) can be considered to have a reduced impact on sustainable development (i.e. the project is more sustainable), whereas those residual impacts grouped towards the top right of the graph (i.e. longer-term, widespread impacts) can be considered to have a greater impact on sustainable development (i.e. the project is less sustainable). This approach is illustrated in Figure 16-2.
Figure 16-2: Diagrammatic representation of the classification of sustainable development impacts

Positive impacts identified by the ESIA will also be plotted to identify the positive impacts on sustainable development generated by the project. However, in the case of positive impacts, those grouped towards the top right can be considered more sustainable and those grouped towards the bottom left can be considered less sustainable.

16.4 SUSTAINABLE DEVELOPMENT ASSESSMENT OF THE PROJECT

The concept of sustainable development has been addressed during the “the design phase”. As discussed in Section 3, Consideration of Alternatives, the alternatives to the project considered environmental, social and economic factors. This ESIA and its associated studies, such as the air dispersion modelling and noise study, have been performed during the design phase. These studies evaluate the effects of the project from an environmental, social and economic perspective. 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. Through the consideration of environmental and social aspects in the various studies undertaken during FEED, the project is integrating some of the 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 Techniques (BAT) in the different process units. 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. For more detail on BAT, see Section 3 Consideration of Alternatives.

Throughout the ESIA, measures required to prevent, minimise or mitigate the identified impacts have been identified. These are also summarised within Section 18 Summary of Impacts and Mitigation Measures. Implementation of the proposed measures is anticipated to minimise, negative impacts and enhance positive impacts to maximise the sustainability of the project. The residual impacts identified throughout the ESIA have been classified in terms of their temporal and spatial extent. These are presented in the following tables, by reference to the impact Identification Code (ID Code). Colours used to indicate the significance of each residual impact are included within the key below each table. Table 16-3 considers the results of this classification for the negative residual impacts, and Table 16-4 does so for the positive impacts associated with the Project.
### Table 16-3– Sustainable Development Assessment, Negative Impacts

<table>
<thead>
<tr>
<th>TIMESCALE</th>
<th>Extended</th>
<th>Long</th>
<th>Medium</th>
<th>Short</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>TE4, TE6, TE8, TE9, TE10, TE12, TE13, HS03, HS07</td>
<td>E9, WQ6, AQ7, HS06, HS08b, HS11b</td>
<td>TE3, WQ1, WQ4, HS05b</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>E8</td>
<td></td>
</tr>
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<table>
<thead>
<tr>
<th>EXTENT</th>
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<th>Regional</th>
<th>National</th>
<th>International</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQ10</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Key:**
- Grey Text: Low Negative Residual Impact
- Orange Text: Medium Negative Residual Impact
- Red Text: High Negative Residual Impact

### Table 16-4– Sustainable Development Assessment, Positive Impacts

<table>
<thead>
<tr>
<th>TIMESCALE</th>
<th>Extended</th>
<th>Long</th>
<th>Medium</th>
<th>Short</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>TE11, UI7</td>
<td>SE5, UI9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>UI12, UI13</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>SE3</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>EXTENT</th>
<th>Local</th>
<th>Regional</th>
<th>National</th>
<th>International</th>
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<tbody>
<tr>
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</tbody>
</table>

**Key:**
- Grey Text: Low Positive Residual Impact
- Sky Blue Text: Medium Positive Residual Impact
- Blue Text: High Positive Residual Impact
The spatial and temporal classification of negative residual impacts identifies that the majority of residual negative impacts are localised to the Project area, and are of low significance. The duration of these local impacts extend from the short term to long term. The majority of these long term residual impacts are associated with Terrestrial Environmental and therefore have the potential to cause legacy issues in the soils or groundwater. The impact illustrated as being of high (negative) significance is associated with the estimated Ammonia Plant CO₂ emissions. As the FEED for this Plant has yet to be undertaken, it is not considered appropriate to reduce the impact significance following consideration of the proposed mitigation measures as these primarily relate to design features yet to be investigated. The majority of negative residual impacts from the Project affect environmental factors associated with the modern concept of sustainable development.

Table 16-3 indicates that the majority of the negative residual impacts affect ecological resources (Section 8 Biological Resources), the terrestrial environment (Section 7 Terrestrial Environment) and communities / employees (Section 15 Health and Safety Aspects) within the local area, over the operational lifetime of the Project. Potential residual impacts of low significance relating to water quality are of short duration.

The residual negative impacts that extend beyond the Project life are primarily associated with potential degradation of soils / groundwater which have a pathway to the marine environment.

Negative residual impacts have also been identified that are expected to extend up to 200km from the site, therefore impacting areas within the Eastern Province. The majority of the impacts with this extent are expected to be short, for traffic safety impacts on communities, but potential impacts on the marine environment associated with loading/unloading can potentially last for the Project lifespan is realised.

No negative residual impacts on a national or international level have been identified.

A number of positive impacts on sustainable development created by the Project have also been identified by the ESIA at a local and regional level. While there are fewer impacts in total, >50% of the positive residual impacts identified are of medium significance; some of which are expected to last beyond the Project lifetime, and extend beyond the local area of the Project. These positive residual impacts are primarily associated with economic, and social benefits as well as improvement / enhancement of local utility infrastructure or systems.

In reference to Table 16-3, the greatest impacts in terms of sustainable development come from impact E8 (potential impact from loading/unloading on the marine environment) and AQ10 (greenhouse gas emissions), although collectively, the large number of negative residual impacts in the local area over the short, medium and long-term provides a greater indication of the sustainability of the project.

Although a number of negative residual impacts have been identified from the Project ESIA, the majority are situated towards the bottom left half of the grid indicating an overall lower impact from a sustainable development perspective. Conversely, the positive impacts identified are predominantly situated in the centre of the grid, indicating an increased positive impact on sustainable development from the project.

As development of the Project progresses, the implementation of the mitigation proposed for the impacts identified by the ESIA, and associated recommendations, will reduce residual impacts and increase the sustainability of the Project. The implementation of the requirements of the ESIA and compliance with existing Ma’aden project processes, as detailed by the Environment and Communities Assurance Project Manual will support the overall promotion of sustainability within the Project. Features of this which support enhancement of sustainability include development of: the Environmental Management System (EMS); Sustainable Development Objectives and Targets; Environmental Management and Monitoring Plan (EMMP) etc. for the Project.

Ma’aden will use their existing project processes to further reduce the negative residual impacts identified by the ESIA and to develop and improve the Project’s positive sustainability performance.
16.4.1 THE PROJECT AND STAKEHOLDER ENGAGEMENT

Since one of the three core principles of sustainable development focuses on the social elements of projects, the role of stakeholder engagement to understand and manage social impacts is key. Section 12 Socio-Economic Aspects, and Appendix C Stakeholder Engagement Plan address to social element of sustainability in more detail. The ongoing implementation of the Stakeholder Engagement Plan will further support the Project in understanding and responding to the social dimension.

16.5 SUSTAINABILITY RECOMMENDATIONS

The sustainable development assessment identifies that although a number of positive and negative residual impacts are associated with the project, the categorisation of these indicate that the Project faces a common challenge in terms of sustainability. While there are a higher number of negative impacts, which primarily affect the environmental dimension of sustainability, there are counter positive impacts which though fewer in number are for the most part of greater magnitude and principally affect the economic and social dimensions as well as infrastructure enhancement. As with many projects there is a trade-off between negative impacts on the shorter term to the environment and positive, and sometimes longer term socio-economic impacts. The most significant impact to be addressed is that associated with the emission of greenhouse gas (CO\textsubscript{2}) from the Ammonia Plant.

The ESIA presents mitigation measures to reduce impacts to the residual impacts assessed within this section, however it also provides recommended good management practices which are in turn incorporated into the EMMP. Thus implementation of the EMMP, and the good management practices contained therein, has the potential to further address residual negative impacts, and improve on the sustainability of the Project.

On this basis the recommended areas of focus for the Project in terms of sustainability which should be assigned high priority, are:

- Application of existing Ma’aden project processes, specifically the Environmental and Communities Assurance Manual; and
- Establishment of objectives, targets and KPIs to monitor achievement of the goals established for the Project and progress towards sustainable development;
- Implementation of mitigations and recommended measures proposed within the ESIA, and the resultant EMMP and all procedures and action plans developed to support the EMMP; and
- Implementation of continuous improvements as identified by the Project’s Environmental Management System and associated monitoring, measurement, auditing.
# 17.0 CUMULATIVE IMPACTS ASSESSMENT ................................................................. 17-2

17.1 Introduction ........................................................................................................... 17-2
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17.0 CUMULATIVE IMPACTS ASSESSMENT

17.1 INTRODUCTION

This section assesses the cumulative impacts through consideration of the impacts of the Project and other future projects taking place in the vicinity which could affect the same social and environmental resources and receptors that can be expected to have a combined effect. The impact 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 in combination with other future planned projects in the area.

The International Finance Corporation (IFC) Performance Standard 1 Assessment and Management of Environmental and Social Risks and Impacts requires that environmental and social risks and impacts are identified in the context of a project’s area of influence, including “cumulative impacts that result from the incremental impact, on areas or resources used or directly impacted by the project, from other existing, planned or reasonably defined developments at the time the risks and impacts identification process is conducted.”

The IFC provides the following definition for cumulative impacts:

“Cumulative impacts are limited to those impacts generally recognised as important on the basis of scientific concerns and/or concerns from Affected Communities. Examples of cumulative impacts include: incremental contribution of gaseous emissions to an airshed; reduction of water flows in a watershed due to multiple withdrawals; increases in sediment loads to a watershed; interference with migratory routes or wildlife movement; or more traffic congestion and accidents due to increases in vehicular traffic on community roadways.”

The following cumulative impact assessment focuses on the potential impacts identified as high or medium significance prior to the consideration of mitigation in Sections 6 – 15 (and as summarised Section 18 Summary of Impacts and Mitigation). No significant residual Project-related impacts were identified by the impact assessment.

Table 17-1 summarises the potential impacts of high and medium significance identified prior to the consideration of mitigation in Sections 6 – 15. For each impact, the potential sensitive social or environmental resource / receptor is identified as well as those future developments which may result in cumulative impacts.
Table 17-1: Potential impacts of high and medium significance identified prior to the consideration of mitigation for the Ras Al Khair Industrial Complex (the Project) and the Potential for Cumulative Impacts associated with Future Development

<table>
<thead>
<tr>
<th>Sensitive Receptor</th>
<th>ID</th>
<th>Potential Impact (prior to mitigation)</th>
<th>Impact Importance</th>
<th>Effect</th>
<th>Project Phase</th>
<th>Potential for Cumulative Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air Quality and Meteorology</strong></td>
<td></td>
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</tr>
<tr>
<td>Ambient Air Quality</td>
<td>AQ7</td>
<td>Increase in Fluoride from Project operations combined with existing MPC facilities.</td>
<td>Scientific</td>
<td>Negative</td>
<td>Operation</td>
<td>Construction and operation of proposed future DAP expansion within and adjacent to the existing MPC Complex.</td>
</tr>
<tr>
<td>Ambient Air Quality</td>
<td>AQ10</td>
<td>Impact from Green House Gas (GHG) Emissions (specifically CO₂ emissions from the Ammonia Plant)</td>
<td>Scientific</td>
<td>Negative</td>
<td>Operation</td>
<td>The existing Ammonia Plant is estimated to emit over 1.5 million tonnes of CO₂ each year. The proposed Ammonia Plant is expected to be of similar design to the existing and therefore significantly increasing the emission of GHG from the Industrial Complex.</td>
</tr>
<tr>
<td><strong>Terrestrial Environment</strong></td>
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</tr>
<tr>
<td>Coastal Water Quality</td>
<td>TE3</td>
<td>Dewatering of excavations and discharge to sea</td>
<td>Scientific</td>
<td>Negative</td>
<td>Construction</td>
<td>Construction of proposed future industrial development across the Ras Al Khair peninsula; and Operation of Manifa oilfield development.</td>
</tr>
<tr>
<td>Groundwater &amp; Coastal Water</td>
<td>TE4,</td>
<td>Degradation of soil and groundwater quality due to accidental spills / leakage from plant infrastructure</td>
<td>Scientific</td>
<td>Negative</td>
<td>Commissioning, Construction, Operation, Decommissioning</td>
<td>Construction and operation of proposed future industrial development across the Ras Al Khair peninsula.</td>
</tr>
<tr>
<td>Quality</td>
<td>TE8,</td>
<td></td>
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<tr>
<td></td>
<td>TE12,</td>
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<td>TE13,</td>
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<td>TE6,</td>
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<td>TE9,</td>
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<td></td>
<td>TE10</td>
<td></td>
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</tr>
<tr>
<td><strong>Biological Resources</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Marine Fauna / Flora</td>
<td>E8</td>
<td>Potential impact from loading/unloading</td>
<td>Scientific</td>
<td>Negative</td>
<td>Operational</td>
<td>Construction and operation of Port expansion;</td>
</tr>
<tr>
<td>Marine and Terrestrial Fauna /</td>
<td>E9</td>
<td>Potential impact from contamination of natural environment</td>
<td>Scientific</td>
<td>Negative</td>
<td>Decommissioning</td>
<td>Construction and operation of Port expansion; and Operation of Manifa Oilfield.</td>
</tr>
<tr>
<td>Flora</td>
<td></td>
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<tr>
<td><strong>Water Quality Management</strong></td>
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</tr>
<tr>
<td>Sensitive Receptor</td>
<td>ID</td>
<td>Potential Impact (prior to mitigation)</td>
<td>Impact Importance</td>
<td>Effect</td>
<td>Project Phase</td>
<td>Potential for Cumulative Impact</td>
</tr>
<tr>
<td>-------------------</td>
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<td>----------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Coastal Water Quality</td>
<td>WQ1, WQ6</td>
<td>Degradation of Coastal Water Quality Due to Construction-Related Surface Water Runoff / Accidental Spills</td>
<td>Scientific Concern</td>
<td>Negative</td>
<td>Construction, Operation</td>
<td>Construction and operation of Port expansion; Operation of Manifa Oilfield.</td>
</tr>
<tr>
<td>Wastewater Management Systems</td>
<td>WQ4</td>
<td>Impact of hydrottest and cleaning/flushing water on wastewater management systems</td>
<td>Scientific Concern</td>
<td>Negative</td>
<td>Commissioning</td>
<td>Commissioning of proposed future industrial development across the Ras Al Khair peninsula; and Emergency situation within MPC complex requiring the full capacity of the wastewater management system.</td>
</tr>
<tr>
<td>Socio-Economic Aspects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local Economy</td>
<td>SE03, SE05</td>
<td>Impact on Local Economy</td>
<td>Affected Community</td>
<td>Positive</td>
<td>Construction and Operational</td>
<td>Construction and operation of proposed future industrial development across the Ras Al Khair peninsula; and Operation of Manifa oilfield development.</td>
</tr>
<tr>
<td>Utilities Infrastructure and Usage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steam</td>
<td>UI12</td>
<td>Benefits to the existing steam system in providing a back-up supply</td>
<td>Scientific Concern</td>
<td>Positive</td>
<td>Operational</td>
<td>Operation of DAP Production Expansion within the existing MPC Complex</td>
</tr>
<tr>
<td>Health and Safety Aspects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workforce</td>
<td>HS03</td>
<td>Construction stage contaminated soils on workforce health</td>
<td>Affected Community</td>
<td>Negative</td>
<td>Construction</td>
<td>Construction and operation of proposed future industrial development across the Ras Al Khair peninsula</td>
</tr>
<tr>
<td>Communities</td>
<td>HS05b, HS08b</td>
<td>Traffic impacts on workforce and community safety</td>
<td>Affected Community</td>
<td>Negative</td>
<td>Construction, Commissioning, Operational, Decommissioning</td>
<td></td>
</tr>
<tr>
<td>Workforce</td>
<td>HS06</td>
<td>Occupational HSE impacts on the workforce.</td>
<td>Affected Community</td>
<td>Negative</td>
<td>Construction</td>
<td></td>
</tr>
<tr>
<td>Workforce</td>
<td>HS07</td>
<td>Air Quality impacts on the Workforce</td>
<td>Affected Community</td>
<td>Negative</td>
<td>Commissioning, Operational, Decommissioning</td>
<td></td>
</tr>
<tr>
<td>Communities</td>
<td>HS11b</td>
<td>Decommissioning stage Health and Safety impacts on the Community</td>
<td>Affected Community</td>
<td>Negative</td>
<td>Commissioning, Operational, Decommissioning</td>
<td></td>
</tr>
</tbody>
</table>
17.2 FUTURE / PROPOSED PROJECTS

As introduced in Section 4 – *Detailed Description and Layout of the Proposed Development*, the Royal Commission has presented plans to develop Ras Al Khair Industrial City. The current area of under the jurisdiction of the Royal Commission (94 km²) is highlighted in *Figure 17-1*. The area highlighted to the east-southeast of the Phase I boundary represents the proposed extension to the Industrial City (Phase II), and the area to the northwest represents future expansion plans for the Port (inclusive of land reclamation and shipping lanes).

![Ras Al Khair Industrial Layout - Existing and Future (reproduced from RCJY, undated)](image)

*Figure 17-1: Ras Al Khair Industrial Layout – Existing and Future (reproduced from RCJY, undated)*

The primary, secondary and downstream industries currently within the industrial programme for Phase I of the Ras Al Khair Industrial City are as follows (RCJY, undated):

- Phosphate – primary and downstream;
- Aluminium – primary and downstream;
- Industrial minerals – primary;
- Steel plant - primary;
- Zinc / Copper Smelters – primary and downstream;
- Metals and fabrication - secondary;
- Energy goods and services - secondary; and
- ‘Offshore’ and ‘support’ clusters.

One phase of the Ma’aden Aluminium Company (MAC) development has been constructed southwest of the Project site comprising of an alumina refinery, aluminium smelter and...
aluminium rolling mill. Future phases are currently planned to the north and south of the existing facilities.

Ma’aden Phosphate Company are investigating the potential of expanding DAP production at Ras Al Khair to 2 million tonne/year DAP. The proposed location for additional production facilities and storage is within the existing MPC industrial complex (Phase I in Figure 17-1), immediately adjacent to the both the existing and proposed DAP/NPK facilities. Also, a plot for further expansion is currently identified south of the existing complex (Phase II in Figure 17-1).

China Harbor Engineering and Contracting Co Ltd are currently constructing two new berths (5 and 6) at Ras Al Khair Port, and are reported to be bidding for a third phase. There are reports plans for expansion up to 50 berths by 2030 (Global Times, 2013).

The Manifa off-shore oilfield development of which its land-based facilities are located approximately 20 km to the north of the Project site began oil production in April 2013. This oilfield is reported to be the world’s fifth-largest and its output will supply the Satorp refinery in Jubail as well as two others in the Western Region (Bloomberg, 2013). The design capacity of this oil field is reported to be 900,000 bpd (barrels per day). Dry-land rigs are linked by a 41 km of causeways with a number of elevated bridges designed to maintain natural water flow in the Manifa Bay (ORME, 2013).

17.3 CUMULATIVE IMPACT WITH OTHER PROJECTS

As the facilities are still to be developed, it not possible to quantify the potential impacts of the future developments summarised above, this assessment is largely qualitative. It is noted that there will inevitably be additional undocumented projects and that the proposals for development of the Industrial City are subject to change, or may not proceed as currently reported.

In accordance with IFC Performance Standard 1, the cumulative impact assessment focuses the key / important environmental and social attributes as established in the baseline for the site. The sensitivity of the current environment, and the proximity and sensitivity of receptors are central to cumulative assessment since cumulative impacts become more significant if the environment is already stressed.

The location of the proposed Project is unique in that a large portion of the Ras Al Khair peninsula is designated for industrial development under the supervision of the Royal Commission. Both existing and future utilities and transport infrastructure across the peninsula are therefore dedicated to this development. Also, as inferred by Section 12 Socio-Economic Aspects, ‘Affected Communities’ are considered to be limited to those associated with the Ma’aden Housing Complex and the temporary camps located on the Ras Al Khair peninsula.

The potential cumulative impacts are summarised in Table 17-2.
<table>
<thead>
<tr>
<th>Scope of Impact</th>
<th>CI1</th>
<th>CI2</th>
<th>CI3</th>
<th>CI4</th>
<th>CI5</th>
<th>CI6</th>
<th>CI7</th>
<th>CI8</th>
<th>CI9</th>
<th>CI10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Receptor</td>
<td></td>
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<tr>
<td>Importance /</td>
<td>Medium</td>
<td>Regional</td>
<td>Regional</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Sensitivity</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Frequency</td>
<td>Continuous</td>
<td>Infrequent</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Frequent</td>
<td>Infrequent</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
<td>Continuous</td>
</tr>
<tr>
<td>Likelihood</td>
<td>Likely</td>
<td>Unlikely</td>
<td>Unlikely</td>
<td>Unlikely</td>
<td>Likely</td>
<td>Likely</td>
<td>Likely</td>
<td>Likely</td>
<td>Unlikely</td>
<td>Unlikely</td>
</tr>
<tr>
<td>Extent</td>
<td>Local</td>
<td>Regional</td>
<td>Regional</td>
<td>Local</td>
<td>Local</td>
<td>Regional</td>
<td>Regional</td>
<td>Local</td>
<td>Local</td>
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</tr>
<tr>
<td>Duration</td>
<td>Long</td>
<td>Long</td>
<td>Long</td>
<td>Medium</td>
<td>Long</td>
<td>Short</td>
<td>Long</td>
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<tr>
<td>Magnitude</td>
<td>High</td>
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<td>Medium</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
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<td>Low</td>
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<td></td>
</tr>
<tr>
<td>Effect</td>
<td>Negative</td>
<td>Negative</td>
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<td>Negative</td>
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<td>Negative</td>
</tr>
<tr>
<td>Action</td>
<td>Direct</td>
<td>Indirect</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
<td>Direct</td>
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<tr>
<td>Significance</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
</tr>
</tbody>
</table>
17.3.1 AIR QUALITY & METEOROLOGY

The most significant impacts predicted for the Project are those related to the emission of Fluorides from the proposed DAP/NPK Plant in combination with existing levels, and the potential emission of significant volumes of CO₂ gas (primarily associated with the Ammonia Plant).

The further expansion of DAP/NPK production within and adjacent to the MPC Complex will contribute further to the ambient concentrations of Fluorides in the area with the potential for failure to achieve environmental standards.

Although Project CO₂ emissions represent only 0.33% of total CO₂ emissions in Saudi, estimated emissions would still represent an incrementally large contribution to GHG emission in the Project area. Therefore, GHG impacts associated with the proposed facility are considered to be of high significance.

**Impact CI – High Significance.**

17.3.2 TERRESTRIAL ENVIRONMENTS

Based on information available at the time of assessment, the groundwater quality within the MPC industrial complex currently exceeds the certain species from the RCER-2010 quality criteria for direct discharge to coastal water for a number of determinants. The project-related risks to coastal quality water (and associated sensitive ecological receptors) will be mitigated via analysis and pre-treatment of water prior to discharge to sea if required to achieve discharge standards.

Accidental spills, leakage from plant infrastructure and catastrophic failure of plant infrastructure associated with the proposed Project were all identified as posing a risk to both the groundwater and coastal water quality due to possible migration. The potential impacts of such activities on water quality will be mitigated through the use of bunded and hard surfaced areas with adequate capacity for the collection and/or storage of hazardous materials and therefore the residual impact is of low significance.

Future construction activities associated with the proposed future industrial development across the Ras Al Khair peninsula are likely to include dewatering activities with possible discharge to sea. The extents of the groundwater contamination identified for the Project site is unknown and therefore similar risks to coastal waters from direct discharge may be presented during the future development of the peninsula. As with the proposed Project mitigation, these future projects will be required to comply with RCER-2010 with regards coastal discharges and as such, no cumulative impacts are expected.

The operation of proposed future industrial development across the Ras Al Khair peninsula and the Manifa oilfield development has the potential to increase the risk of accidental spills, leakage from plant infrastructure and catastrophic failure of plant infrastructure. However, these exceptional circumstances are not considered to be significantly cumulative in nature, nor is the scale of potential impacts comparable. Such accidental incidents will be managed via legal instruments, e.g. those developments within the RC Industrial City will be managed via Environmental Emergency Response Plans (EERPs).

**Impact CI2 – Low Significance.**

17.3.3 BIOLOGICAL RESOURCES

**Terrestrial**

Decommissioning activities associated with the Project facilities were identified as having potential to degrade / contaminate the natural environment. The magnitude of this Project-specific impact is considered to be low as the facilities will be constructed within an existing industrial area that has been levelled as part of previous works to prepare the site for construction of the existing MPC facilities.

The future development and subsequent decommissioning of industry across the Ras Al Khair peninsula will significantly alter the existing natural environment outside of this area which is primarily ‘greenfield’. Based on the information available at the time of assessment, the value
of terrestrial biological resources, with the exception of avifauna, have been characterised as ‘Local’ which is defined as ‘areas of semi-natural vegetation or habitat considered to appreciably enrich the habitat resource within the context of the site and surrounding area. Sustainable populations of uncommon or declining species’. The value of avifauna was characterised as ‘International’ due to the extensive list of bird species recorded in Ras Al Khair, but primarily on the potential for the Socotra cormorant to be present. The Socotra cormorant is listed as Vulnerable on the IUCN Red List (2012) on account of population declines. This species has a restricted distribution and breeding colonies are restricted to off-shore islands.

Future developments in the area have the potential to disturb / damage biological resources in ‘greenfield’ area. However, this is not considered to be a cumulative impact as the Project facilities will not be developed on ‘greenfield’ areas.

**No Cumulative Impact.**

**Marine**

The loading and unloading of hazardous materials was identified as having potential to impact the marine environment should there be a spillage. The value of this receptor was characterised as ‘Regional’ which is defined as ‘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’.

With the planned expansion of Ras Al Khair Port (from 6 to 50 berths by 2030) and the presence of the Manifa oilfield, the risks of marine pollution incidents will increase particularly due to the dispersal mechanisms of the marine environment which can distribute pollutants to valuable sites off-shore (i.e. coral islands).

Although the implementation of mitigation measures similar to those required for the Project across all future berths will reduce the magnitude of impacts associated with hazardous material spills, however the operation of 50 industrial-related berths in addition the Manifa oilfield is likely increase the overall probability of a pollutant event in this coastal area.

The proposed Project loading and unloading activities will operate from just 3 of the total future 50 berths proposed, and residual impacts of the proposed Project loading and unloading activities have been identified as low significance. The potential impact on marine biological resources is therefore not considered to be significantly cumulative in nature, nor is the scale of these potential impacts considered to be comparable.

**Impact CI3 - Low Significance.**

17.3.4 NOISE

Baseline noise measurements taken at the proposed Ras Al-Khair Project site boundary line do not currently exceed the RCER-2010 standard and IFC (2007) guidelines, and based on the information available at the time of assessment, it is considered unlikely that noise levels attributable to the proposed Project development would exceed the quoted standard and guideline values at the Project site boundary or at the nearest human receptors (temporary construction camps).

The assessment concluded that there would be a negligible noise impact at the Ma’aden Housing (approximately 8 km south-west of the Project site) attributable to the development, the baseline levels at this location currently exceed the quoted standard and guideline values. Therefore, although the propose Project does not impact on this receptor, it has the potential to become increasingly sensitive in the presence of future development at Ras Al Khair.

The proposed Project will contribute to noise levels within the MPC industrial complex, but not significantly at the location of sensitive receptors.

**Impact CI4 - Low Significance.**
17.3.5 WASTE MANAGEMENT

Significant volumes of waste are not anticipated to be produced by the Proposed Project. Following the implementation of the waste hierarchy, any waste requiring disposal will be managed by existing facilities in Jubail in accordance with RCER-2010 requirements. No sensitive social or environmental resources/receptors have been identified for this aspect and therefore no significant cumulative impacts are predicted.

The capacity of Jubail to accept additional volumes of waste associated with future developments will need to be assessed as part of the master planning for the Industrial City, which is likely to include a new waste management facility tailored to the future industry needs.

*Impact CI5 - Low Significance.*

17.3.6 WATER QUALITY MANAGEMENT

The potential for cumulative impacts for this aspect associated with accidental spills to the marine environment is similar to that identified for marine biological resources (refer to Section 17.3.3).

The potential (medium) significant impact associated with the management of water from hydrotesting of pipelines and tanks, and the flushing and cleaning of pipelines from the commissioning phase of the Project relates to the sensitivity of the receiving wastewater system. For the proposed Project, this system involves the existing evaporation pond within the MPC complex (which is not utilised by other industries external to the MPC Complex) and Jubail Industrial Wastewater Treatment Plant. The use of these systems will only be required in the event that this water does not achieve water quality standards required of RCER-2010 (irrigation or coastal discharge). This is a temporary impact, but one that requires proactive consideration for emergency situations within the MPC Complex. This will be achieved through the Project Environmental Management and Monitoring Plan and the Environmental Emergency Response Plan in consultation with the existing MPC facility managers.

This consultation should extend to the operators of the proposed DAP expansion facilities to be located within the MPC complex if these plans are realised.

*Impact CI6 - Medium Significance.*

17.3.7 SOCIO-ECONOMIC ASPECTS

Section 12 *Socio-economic Aspects* identified the potential for positive impacts socio-economic aspects as a consequence of the Project in terms of job creation, economic development, and knowledge and skills enhancement. The wider Ras Al Khair Industrial City Development is envisaged to enhance this significant level of economic development, and provide a wider range of community services and infrastructure available primarily to the associated workforce communities.

As outlined above, the ‘Affected Communities’ associated with the Project are considered to be limited to those associated with the Ma’aden Housing Complex and the temporary camps located on the Ras Al Khair peninsula. However, the operational phase of the Project in conjunction with that of the proposed future development at Ras Al Khair will significantly contribute to the wider economy through employment opportunities, increased availability of services, enhancement of a significantly underdeveloped area of Saudi Arabia as well as exports and procurement.

*Impact CI7 - Medium Significance.*

17.3.8 TRAFFIC AND TRANSPORT INFRASTRUCTURE

The closest sizable population centre is Nuayriyah which lies approximately 68 km to the west of the peninsula (93 km by road). Nuairiyah is located on a major link road from Riyadh to Kuwait and Jubail to Jordan. The main road access point from the Ras Al Khair Industrial City to the rest of Saudi Arabia is via the dual carriageway ‘Route 7950’ which traverses the Ras Al Khair peninsula from east to west. This road dedicated to the existing industry on the peninsula and therefore not considered as a ‘community roadway’. The closest ‘community
roadway’ is Route 95 located approximately 30 km from the Project site where Route 7950
connects at its most western point. This is a primary road which traverses the Eastern
Province from north to south and provides connections to other main central and western
routes.

The potential for traffic congestion and accidents due to increases in vehicular traffic on
community roadways is possible during the development and operation of the Ras Al Khair
Industrial Complex and expansion/operation of the Manifa Oilfield facilities, as well as their
connections with Jubail and Dammam.

The assessment of the propose Project elements did not identify significant residual impacts
on road or rail transport infrastructure due to sufficient carrying capacity. However,
cumulatively the development of the Ras Al Khair Industrial City has potential to adversely
impact the capacity and safety of the existing infrastructure if not managed. Infrastructure
investment on the peninsula will expand the current network to meet the needs of the future
developments, but there is a need for up-to-date traffic studies and management plans to help
inform infrastructure investment at Government level.

**Impact CI8 - Medium Significance.**

17.3.9 UTILITIES INFRASTRUCTURE AND USAGE

No significant residual adverse impacts on utilities were identified for the Project development
as where existing infrastructure cannot provide sufficient capacity / supply, this will be
provided for by the Project development itself. Both the existing and proposed MPC facilities
will benefit from the extension to the existing steam system via the provision of a supply back-
up. This beneficial impact may extend to the future DAP expansion, but this is not considered
to be significant.

**Impact CI9 – Low (positive) Significance.**

17.3.10 COMMUNITY AND EMPLOYEE HEALTH

The impacts of the Project on community and employee health are outlined in Section 15
Health and Safety Aspects. This section establishes that while there are potential risks to
employee health, these are adequately addressed through appropriate management controls
and procedures. The distance of the Project to the nearest sensitive receptor community,
means that low impacts are identified for communities.

With the development of Ras Al Khair Industrial City, it can be expected that the influx of
people, and the increasing industrial activity may present cumulative air quality issues, and
therefore health impacts in both employees and the wider community. Furthermore the
development of the industrial zones brings these impacts closer to the communities to the
west of the peninsula. These impacts can be readily managed, however, and are not
considered to be cumulative impacts of note.

**Impact CI10 - Medium Significance.**

17.4 CONCLUSIONS

While the predicted impacts of the proposed Ras Al Khair Industrial Complex Project is
predicted to be acceptable in line with the standards or expectations of the regulator, the
cumulative impact assessment identifies a number of areas where cumulative impacts from
the Project, and the proposed development of Ras Al Khair Industrial City and Manifa Oilfield,
can be expected. The aspects for which the most significant cumulative impacts can be
expected are:

- Air Quality – Negative;
- Water Quality Management – Negative;
- Traffic and Transport Infrastructure – Negative;
- Community and Employee Health and Safety – Negative; and
- Socio-Economic Aspects – Positive.
The true nature and scale of these cumulative impacts cannot be quantified given the conceptual stage of the development of the Industrial City. Prior to construction activities, individual industrial or infrastructure projects developed within the City in the future will be required to apply for an Environmental Permit to Construct (EPC) from the Royal Commission. As with the proposed Project, this will require the completion of an environmental impact assessment which will include a cumulative impact assessment.

Mitigation for the cumulative impacts identified above include:

- Maintenance of emission standards;
- Ambient air/water quality monitoring;
- Traffic studies and management plans; and
- Ongoing effective and integrated planning of the City and all included projects.

Of paramount importance is the continuous assessment of the environmental “headroom”, so as not to overload the carrying capacity of the area.

As a key stakeholder in the Ras Al Khair Industrial City development, Ma’aden shall consider and make available this ESIA for use in cumulative impact assessments of future developments of the Industrial City, and shall liaise with the Royal Commission, the Saudi Port Authority and Saudi Railway Authority as appropriate to support collaborative and multi-stakeholder solutions for cumulative impacts.
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18.0 SUMMARY OF POTENTIAL IMPACTS AND MITIGATION ............................... 18-2

*Table 18-1: Summary of Environmental Impacts and Mitigation* ........................ 18-3

### Summary of Potential Impacts and Mitigation

<table>
<thead>
<tr>
<th>Document Title</th>
<th>RAS AL KHAIR ESIA</th>
<th>Revision</th>
<th>A03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ma’aden Doc Nº.</td>
<td>MD-513-000-HS-EN-RPT-0069</td>
<td>Page</td>
<td>18-1</td>
</tr>
<tr>
<td>Jacobs Doc Nº.</td>
<td>60-R400-WH/G.06f/0072</td>
<td>Date</td>
<td>August 2013</td>
</tr>
</tbody>
</table>
18.0 SUMMARY OF POTENTIAL IMPACTS AND MITIGATION

The environmental and social impacts identified within Sections 6-17 of this ESIA pertain to the construction, commissioning, operation and decommissioning of the Project. In accordance with Section 5 Impact Assessment Methodology, two types of mitigation measures are identified through this ESIA Report in order to alleviate or manage the potential impacts identified:

- Type 1: Measures to be taken to manage potential impacts considered to be of medium or high significance. Following application of these measures, residual impacts are expected to be lower.
- Type 2: Recommended measures that could be taken to manage impacts classified as low/insignificant. These measures can be considered as good management practices.

Mitigation measures identified to respond to impacts of high or medium significance, are incorporated into the These measures are augmented within the EMMP with the recommended measures, which represent good management practices addressing impacts of low significance, and / or providing for sound environmental management.

Table 18-1 summarises the high and medium impacts identified throughout this ESIA, and the corresponding mitigation measures. These mitigations are incorporated into the Environmental Management and Monitoring Plan (EMMP) provided in Appendix A. Recommended measures identified in Sections 6 to 17, augment the mitigation measures within the EMMP, thereby addressing impacts of low significance, and providing a plan for robust and best practice environmental and social management.
<table>
<thead>
<tr>
<th>ID Code</th>
<th>Impact (1)</th>
<th>Impact Phase</th>
<th>Potential Significance (2)</th>
<th>Mitigation Measure (3)</th>
<th>Mitigation Phase</th>
<th>Significance after Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQ7</td>
<td>Increase in Fluorides from Project operations combined with existing MPC facilities</td>
<td>X</td>
<td>Medium</td>
<td>• Ma'aden shall consider and make this ESIA available for use in cumulative impact assessments of future developments of the Industrial City.</td>
<td>X</td>
<td>Low</td>
</tr>
<tr>
<td>AQ10</td>
<td>Impacts from Green House Gas Emissions</td>
<td>X</td>
<td>High</td>
<td>The FEED Contractor shall document a full BAT analysis to demonstrate that best available techniques are used to capture CO₂ emissions. This process would include expansion on the alternatives discussed in Section 3 Consideration of Alternatives including: • Investigate design options for reducing greenhouse gas emissions. This assessment should consider other options for the capture and use of CO₂. • Reduce CO₂ emissions during the design period where possible using the Best Available Technologies (BAT). • Record BAT assessment findings. • The Operator shall conduct annual quantification and reporting (as appropriate for Category B Projects) in accordance with the guiding principles of the Equator Principles / International Finance Corporation.</td>
<td>X</td>
<td>High</td>
</tr>
<tr>
<td>TE3</td>
<td>Dewatering of excavations and discharge to sea</td>
<td>X</td>
<td>High</td>
<td>• Analysis and pre-treatment of water prior to discharge to achieve discharge standards.</td>
<td>X</td>
<td>Low</td>
</tr>
<tr>
<td>TE4</td>
<td>Degradation of soil and groundwater quality due to accidental spills</td>
<td>X</td>
<td>Medium</td>
<td>• Contractor to construct designated refuelling and vehicle maintenance areas. • Hazardous materials storage to be within bunded area with adequate capacity for volumes stored. • Absorvents and secondary containment to contain and recover potential release of hazardous materials. • Dedicated area for wash out following concrete delivery. • Prior to construction, the EPC contractor shall conduct an investigation of the soil and groundwater quality at the site - to include the construction of permanent groundwater monitoring wells where required • Develop/Implement Emergency Response (EERP) and Construction Environmental Management (CEMP) plans. • The EPC Contractor shall develop, implement and maintain a construction phase Environmental Emergency Response Plan (EERP) and a Construction Environmental Management Plan (CEMP) that will include a spill response/control plan</td>
<td>X</td>
<td>Low</td>
</tr>
<tr>
<td>TE6</td>
<td>Accidental leaks during pipe connections</td>
<td>X</td>
<td>High</td>
<td>• EPC Contractor to identify process hazards and appropriate control measures. • EPC Contractor to review and update EERP and CEMP to reflect changing project stages. • Adequate supply of absorbents will be available to contain and recover potential release of hazardous materials.</td>
<td>X</td>
<td>Low</td>
</tr>
<tr>
<td>TE8</td>
<td>Degradation of soil and groundwater quality due to accidental spills</td>
<td>X</td>
<td>Medium</td>
<td>• Hazardous materials storage to be within bunded area with adequate capacity for volumes stored.</td>
<td>X</td>
<td>Low</td>
</tr>
<tr>
<td>TE9</td>
<td>Degradation of soil and groundwater quality due to leakage from plant infrastructure</td>
<td>X</td>
<td>High</td>
<td>• Absorvents and secondary containment to contain and recover potential release of hazardous materials.</td>
<td>X</td>
<td>Low</td>
</tr>
<tr>
<td>TE10</td>
<td>Degradation of soil and groundwater due to catastrophic failure of plant infrastructure</td>
<td>X</td>
<td>Medium</td>
<td>• EPC Contractor to identify process hazards and appropriate control measures. • Revise, implement and audit a Project Environmental Management and Monitoring Plan (EMMP) and an Environmental Emergency Response Plan (EERP), including details of a spill response/control plan.</td>
<td>X</td>
<td>Low</td>
</tr>
<tr>
<td>ID Code</td>
<td>Impact (1)</td>
<td>Impact Phase</td>
<td>Potential Significance (2)</td>
<td>Mitigation Measure (3)</td>
<td>Mitigation Phase</td>
<td>Significance after Mitigation</td>
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</tr>
<tr>
<td>TE12</td>
<td>Accidental spills during tank and pipe drain-down and decommissioning</td>
<td>X</td>
<td>High</td>
<td>• Adequate supply of absorbents will be available to contain and recover potential release of hazardous materials. &lt;br&gt;• Revise, implement and audit EMMP and EERP as appropriate.</td>
<td>X</td>
<td>Low</td>
</tr>
<tr>
<td>TE13</td>
<td>Degradation of soil and groundwater quality due to accidental spills</td>
<td>X</td>
<td>Medium</td>
<td>• Designated refuelling and vehicle maintenance areas to be constructed. &lt;br&gt;• Hazardous materials storage to be within bunded area with adequate capacity for volumes stored. &lt;br&gt;• An adequate quantity of absorbents will be available to contain and recover potential releases of hazardous substances. &lt;br&gt;• Revise, implement and audit EMMP and EERP as appropriate.</td>
<td>X</td>
<td>Low</td>
</tr>
<tr>
<td>E8</td>
<td>Potential impact from loading/unloading on marine environment</td>
<td>X</td>
<td>High</td>
<td>• Ensure adequate maintenance of jetty storage facilities, including checking for release of materials. &lt;br&gt;• Ensure training of staff to ensure competency in operation of loading/unloading equipment. &lt;br&gt;• Incorporation of procedures for spill events to the EERP / EMMP as appropriate. &lt;br&gt;• Ensure regular maintenance of loading/unloading equipment.</td>
<td>X</td>
<td>Low</td>
</tr>
<tr>
<td>E9</td>
<td>Potential impact from contamination on biological resources</td>
<td>X</td>
<td>Medium</td>
<td>• Decommissioning Plan to be developed shall identify all possible sources of contamination and outline appropriate control and disposal measures that protect the natural environment.</td>
<td>X</td>
<td>Low</td>
</tr>
</tbody>
</table>

### Biological Resources

No impacts of ‘medium’ or ‘high’ significance have been identified.

### Noise and Vibration

No impacts of ‘medium’ or ‘high’ significance have been identified.

### Waste Management

No impacts of ‘medium’ or ‘high’ significance have been identified.

### Water Quality Management

<table>
<thead>
<tr>
<th>ID Code</th>
<th>Impact (1)</th>
<th>Impact Phase</th>
<th>Potential Significance (2)</th>
<th>Mitigation Measure (3)</th>
<th>Mitigation Phase</th>
<th>Significance after Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>WQ1</td>
<td>Degradation of coastal water quality due to construction related surface water run-off/accidental spills</td>
<td>X</td>
<td>Medium</td>
<td>• EPC Contractor to develop, implement and maintain a construction phase EERP and CEMP to include a surface water protection plan. This is to be cognisant of SEAPA's existing and developing procedures for Ras Al Khair Port as well as requirements of the RC. &lt;br&gt;• Surface water management systems to be designed to maintain separate collection, treatment and disposal for contaminated and uncontaminated water. &lt;br&gt;• Designated vehicle refuelling and maintenance areas to be established. &lt;br&gt;• Hazardous materials storage to be within bunded area with adequate capacity for volumes stored. &lt;br&gt;• Absorbents and secondary containment to contain and recover potential release of hazardous materials. &lt;br&gt;• Dedicated area for wash out following concrete delivery.</td>
<td>X</td>
<td>Low</td>
</tr>
<tr>
<td>ID Code</td>
<td>Impact (1)</td>
<td>Impact Phase</td>
<td>Potential Significance (2)</td>
<td>Mitigation Measure (3)</td>
<td>Mitigation Phase</td>
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<td></td>
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<td></td>
<td>Prior to pre-commissioning / commissioning, procedures outlining the proposed management, analysis, treatment and discharge/disposal methods and locations for hydrotest water, including justification for any chemical additives, will be outlined in the EMMP.</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>WQ4</td>
<td>Commissioning related impacts</td>
<td>X</td>
<td>Medium</td>
<td>• The Contractor will liaise with MPC to confirm available capacity of the existing surface water ponds to accept the calculated volume of water requiring disposal.</td>
<td></td>
<td>Low</td>
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<tr>
<td></td>
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<td>• The volume of water to be used will be minimised through careful planning of the hydrotest sequence and water reuse.</td>
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<tr>
<td></td>
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<td></td>
<td>• The Contractor shall control the rate of discharge of hydrotest water to the receiving water body to avoid overloading the receiving system.</td>
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<td>Low</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• The EERP developed during the construction phase will be updated as appropriate to include for the management of hydrotest water and the use of the existing surface water ponds in the event of an emergency.</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>WQ6</td>
<td>Degradation of coastal water quality due to accidental spills/run-off</td>
<td>X</td>
<td>Medium</td>
<td>• The EMMP and EERP shall be developed to acknowledge port operational and incident management plans in consultation with SEAPA (and other port operators as required).</td>
<td></td>
<td>Low</td>
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<tr>
<td></td>
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<td></td>
<td>• All staff shall be competently trained and response teams established.</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Designated contained areas for loading the liquid products shall be defined and equipped with appropriate collection systems to contain any spills on land.</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td>• If proximity detection systems are not available to safely detect if marine loading arms are moving beyond safe operating limits, constant manual monitoring during product loading may be implemented to detect the motion of the loading arm and initiate shutdown procedures if required. Occupational health and safety procedures must be followed at all times during such monitoring. The proposed method of monitoring shall be agreed with the RC and SEAPA as appropriate.</td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Minimal drop distances for unloading potash shall be employed.</td>
<td></td>
<td>Low</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Provide an adequate quantity of drip trays and spill kits to contain and recover potential releases of hazardous substances.</td>
<td></td>
<td>Low</td>
</tr>
</tbody>
</table>

**Socio-Economic Aspects**

SE3 Impact on local economy - construction | X | Medium+ | Positive impact - no mitigation required. |

SE5 Impact on local economy - operation | X | Medium+ | Positive impact - no mitigation required. |

**Traffic and Transport Infrastructure**

No impacts of 'medium' or 'high' significance have been identified.

**Utilities Infrastructure and Usage**

UI12 Steam | X | Medium+ | Positive impact - no mitigation required. |

**Health and Safety Aspects**

HS03 Construction stage contaminated soils on workforce Health | X | Medium | Ground investigations suggest some degree of soil contamination at the site. Therefore a soil sampling and analysis exercise is to be undertaken in the detailed design phase, with consideration of potential hazardous contaminants such as heavy metals. |                | Low                         |
<p>|         |            |              |                           | The results of the soil sampling are to be used to undertake a detailed health risk assessment identifying the HSE process and methods to be employed on site during construction to protect the workforce. |                | Low                         |
| HS05b   | Construction stage traffic impacts on Significance on Community | X | Medium | Training and awareness on issues such as defensive driving will be provided to the workforce. |                | Low                         |</p>
<table>
<thead>
<tr>
<th>ID Code</th>
<th>Impact (1)</th>
<th>Impact Phase</th>
<th>Potential Significance (2)</th>
<th>Mitigation Measure (3)</th>
<th>Mitigation Phase</th>
<th>Significance after Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS06</td>
<td>Construction stage occupational HSE impacts on the Workforce (accident/ injury &amp; Disease)</td>
<td>X</td>
<td>Medium</td>
<td>• Early engagement with local service providers to assess the capacity of the region to absorb any potential issues is to be undertaken, and this will inform the design and staffing of the facilities to ensure local services are not adversely affected. This consultation is to include all emergency services to ensure agreement is reached on the most effective mechanisms to deal with any major incident, including any evacuation to hospitals in Jubail Industrial City.</td>
<td>X</td>
<td>Low</td>
</tr>
<tr>
<td>HS07</td>
<td>Air Quality impacts on the Workforce</td>
<td>X</td>
<td>Medium</td>
<td>• A risk assessment will be undertaken which shall define the specific risks and mitigation, including working hours, exposure limits, and use of PPE as required.</td>
<td>X</td>
<td>Low</td>
</tr>
<tr>
<td>HS08b</td>
<td>Operational stage traffic impacts on the Community</td>
<td>X</td>
<td>Medium</td>
<td>• Training and awareness on issues such as defensive driving will be provided to the workforce.</td>
<td>X</td>
<td>Low</td>
</tr>
<tr>
<td>HS11b</td>
<td>Decommissioning stage Health and Safety impacts on the Community</td>
<td>X</td>
<td>Medium</td>
<td>• Decommissioning will be planned by developing, procedures, and any HSE requirements to ensure the project is decommissioned safely and effectively, using the correct PPE etc in line with RC requirements and intended future use.</td>
<td>X</td>
<td>Low</td>
</tr>
</tbody>
</table>

Notes:
(1): Only impacts categorised as ‘medium’ or ‘high’ significance are included for mitigation (unless otherwise indicated in the corresponding section of the ESIA report).
(2): The factors used to determine the significance of a potential impact are defined in Section 4 Impact Assessment Methodology and tabulated for each impact in the corresponding section of the ESIA report.
(3): Measures to be taken to manage potential impacts considered to be of medium or high significance.

Cs: Construction Phase
Cm: Commissioning Phase
Op: Operations Phase
Dc: Decommissioning Phase / Closure
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### 19.0 ABBREVIATIONS & ACRONYMS

#### 19.1 ABBREVIATIONS & ACRONYMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAQS</td>
<td>Ambient Air Quality Standards</td>
</tr>
<tr>
<td>AP</td>
<td>Action Plan</td>
</tr>
<tr>
<td>BAT</td>
<td>Best Available Techniques</td>
</tr>
<tr>
<td>BFW</td>
<td>Boiler Feed Water</td>
</tr>
<tr>
<td>BREFs</td>
<td>BAT reference documents</td>
</tr>
<tr>
<td>CDSI</td>
<td>Central Department of Statistics &amp; Information</td>
</tr>
<tr>
<td>CEMP</td>
<td>Construction Environmental Management Plan</td>
</tr>
<tr>
<td>CITES</td>
<td>Convention on International Trade in Endangered Species of Wild Fauna and Flora</td>
</tr>
<tr>
<td>CMP</td>
<td>Commissioning Management Plan</td>
</tr>
<tr>
<td>CO</td>
<td>Carbon Monoxide</td>
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<td>µSv/yr</td>
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<td>Am³</td>
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<td>Bq/kg</td>
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<td>Lₐ</td>
<td>Level (sound pressure) - A weighting</td>
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<td>mg/l</td>
<td>miligrams per litre</td>
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<td>Mtpa</td>
<td>Million metric tonnes per annum</td>
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<td>MW</td>
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<td>Mega Watts of electrical output</td>
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<td>ppm</td>
<td>parts per million</td>
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20.2 DETAILED DESCRIPTION AND LAYOUT OF THE PROPOSED DEVELOPMENT

- SOFRECO – TECHNIP. 2012. Feasibility Study Pre-works Umm Wu’al Project.

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20.8 WASTE MANAGEMENT


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20.13 HEALTH AND SAFETY ASPECTS

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• IFC (2009), Workers Accommodation: Processes and Standards

20.14 CUMULATIVE IMPACT ASSESSMENT

  http://www.who.int/nmh/countries/sau_en.pdf


DEPARTMENT: SAFETY AND ENVIRONMENTAL
REPORT NO: 60-R400-WH/G.06F/0072 (APPENDIX A)
REPORT TITLE: RAS AL KHAIR
ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT (ESIA)
APPENDIX A – ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

PROJECT REFERENCE
PROJECT NO: 60-R400-WH
PROJECT LOCATION: SAUDI ARABIA
PROJECT TITLE: UMM WU’AL PHOSPHATE PROJEJECT
CLIENT: MA’ADEN (SAUDI ARABIAN MINING COMPANY)
CLIENT PROJECT NO: 2-115-12-12-2-2
CLIENT DOCUMENT NO: MD-513-0000-HS-EN-RPT-0069 (APPENDIX A)

PM Authorisation: Andy Dodd

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- [x] For Information
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A1.0 INTRODUCTION

This Environmental Management and Monitoring Plan (EMMP) summarises the development of a plan to monitor the implementation of the proposed mitigation measures during the life of the Project. It translates the findings and recommendations of the ESIA process into a set of procedures and plans for implementation on the ground level. The EMMP identifies those parties responsible for implementing the mitigation measures and recommendations identified and seeks to integrate with existing documents including corporate and site specific management policies. The EMMP includes an outline of environmental plans, and staffing and training recommendations.

The EMMP will continue to be developed in accordance with the following regulations and guidance to address and manage the environmental aspects and predicted impacts related to the Project:

- KSA Labor Law (2005);
- IFC (2007), Environmental, Health and Safety (EHS) Guidelines, General EHS Guidelines;
- IFC (2007), Environmental, Health and Safety (EHS) Guidelines, Large Volumes Inorganic Compounds Manufacturing and Coal Tar Distillation;
- IFC (2007), Environmental, Health and Safety (EHS) Guidelines, Phosphate Fertilizer Plants;
- IFC (2007), Environmental, Health and Safety (EHS) Guidelines, Nitrogenous fertilizer Production and
- IFC (2012), Performance Standards on Environmental and Social Sustainability.

A summary of relevant legislation is provided in Attachment 1.

A1.1 MA’ADEN ENVIRONMENTAL POLICY

Ma’aden undertake through partnerships with environmental experts and using the latest technologies to reduce the impact of their operations on the environment. They are committed to:

- pursue the goal of no harm to people
- protect the environment
- use material and energy efficiently to provide our products and services
- develop energy resources, products and services consistent with these aims
- share openly information on our environmental performance
- play a leading role in promoting the best practice in our industry
- manage environmental matters as any other critical business activity
- promote a culture in which all MPC employees share this commitment.

Ma’aden’s Environmental Policy Statement is provided In Attachment 2.
Ma’aden have published their commitment to corporate and social responsibility and present the results of their work through the Annual Report. The corporate commitment is underpinned by four pillars:

- **Health, Safety and Environment**: including the development and implementation of related policies, standards, management systems and risk management.
- **Commitment to Community**: including the positive contribution to the communities in which it operates.
- **Commitment to Employees**: which provides a commitment to the overall wellbeing of their employees and their families.
- **Ethics**: including the way in which the company is run, compliance with all regulations and legislation, and the governance of employees conduct.

During 2011, the corporate Health and Safety team introduced the Safety Culture Improvement Plan to cover all Ma’aden sites and drive improvement in all safety aspects. The plan includes management involvement in the commitment to safety, provision of training and awareness programmes, internal audit procedures and safety recognition programmes.

The implementation of the plan included training for employees from all subsidiaries and Headquarters on areas including:

- Creating a World Class Safety Culture;
- Defensive Driving; and
- Root Cause Analysis

In 2011 Ma’aden’s commitments to CSR has achieved several health and safety milestones including:

- All Mega project safety milestones;
- Comprehensive management and training systems to international industry standards;
- Over SR 28 million invested in employee training; and
- Construction of the Al-Amar Medical Clinic

In particular the Ma’aden Phosphate Company achieved:

- Over 15,000 hours in-house Environment, Health and Safety training for the Ma’aden Phosphate Company (MPC) including 5,874 employees and contractors trained;
- 4,115,460 Safe-man hours completed without Lost Time Injury
- Awarded Ma’aden safety recognition award (Golden Award) for achieving more than one year without lost time injury
- Achieved the 2011 LTIFR target rate of 0.41% and all Environment KPIs.
- Participated and witnessed performance test of all plants, all stack emission’s within the plant design meeting the requirements of the Royal Commission for Jubail and Yanbu.
- Implementation of 70% of all required EHS Standards.

In addition, the MPC EHS Management System upgrade has set a target to clear all non-conforming items during 2012 and complete IMSEHS& Q and achieve ISO 9001, ISO 14001 and OHSAS 18001 certification.
Ma’aden Phosphate company have also produced their Safety, Health, Environment and Quality (SHEQ) Policy which includes the following Objectives:

- Ensuring compliance with regulatory, legislative and corporate requirements (including OHSAS18001).
- Identifying and evaluating risks associated with company activities and documenting a programme to eliminate or reduce any hazards as far as reasonably practicable to prevent injury and ill health.
- Undertake frequent monitoring, audit and review of the SHEQ management system to ensure the system remains relevant and effective.
- Set Health and Safety performance objectives and monitor and assess results to promote continuous improvement.
- Provision of training, planning and communication tools to ensure personnel are aware and can competently carry out their SHEQ responsibilities.
- Satisfy the needs and expectations of the customer at all times by providing services and products that meet and exceed expectations and results.
- Consult and communicate with employees and other interested parties on the value of an integrated SHEQ approach, and encourage full participation in the development of the management system in place.

The policy objectives underpin the company’s commitment to continuously improve their Health, Safety and environmental performance in their operations.

The EMMP is consistent with the current design, which will be further developed over the life of the project. It has therefore been prepared as a dynamic document that will be reviewed and amended to a final EMMP for operation of the project.

A1.2 PURPOSE AND SCOPE OF THE ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

The EMMP builds upon the mitigation measures and recommendations identified by the ESIA to provide a tool to address and manage the environmental aspects and impacts related to the Project development at Ras Al Khair by outlining the environmental management responsibilities, statutory obligations, incident management and corrective action procedures, complaint handling responsibilities, auditing requirements and training programmes.

This EMMP is designed to help facilitate and manage the identified environmental aspects and impacts of the proposed development as it develops from detailed design through to the construction, commissioning, operation and decommissioning phases of the Project.

This document provides the outline or draft structure of the EMMP framework that will be further developed over the life of the project. The EMMP for the operation phase of the Project will be developed during detail design and the EPC Contractors will develop a detailed EMMP for the construction phase for approval by Ma’aden prior to implementation.

The EMMP shall be used in conjunction with the actions plans, such as the Waste Management Plan, which require development to address specific project-related risks and impacts and will guide the implementation of the Project so that it is undertaken in a safe, cost effective, planned and environmentally responsible manner.

This EMMP takes account of the measures and transposes them into actions that are applicable to the various phases of the Project. Guidance and instruction provided by this EMMP aims to reduce the risk of adverse effects to both the environment and those involved in the Project. The commitments recommended within the ESIA are provided in Attachment 4.
EPC Contractors will be required to draw on the requirements of this EMMP and incorporate these into the Construction Environmental Management Plan.

A1.3 OBJECTIVES

The primary objectives of this EMMP are to provide an environmental management manual for use by management and staff involved in the Project and to provide information to regulatory authorities regarding the environmental management practices that will be implemented throughout the life of the project.

The EMMP has the following main objectives:

• To provide a framework that facilitates Project compliance with environmental policy commitments and regulation through documentation of the mitigation measures that will be applied during the construction, commissioning and operational phases of the Project;
• To define the environmental plan required to implement the various mitigation measures and recommendations outlined in the ESIA;
• To identify the monitoring programmes that will be implemented to verify and manage predicted effects and confirm performance of mitigation measures;
• To describe resources that will be made available to implement the recommendations of the EIA including staffing and training requirements; and
• To manage environmental risk through training, audit and review.

A2.0 PROJECT DESCRIPTION

A2.1 PROJECT OVERVIEW

The proposed Ma’aden Umm Wu’al Phosphate Project will be based on two sites; the Umm Wu’al Mine and Waad Al Shamaal Phosphate Industrial Complex in the Northern Borders Province, which includes an open cast mine, beneficiation plant and a number of acid producing plants to process the extracted ore; and an industrial complex at Ras Al Khair Industrial City, which includes an Ammonia production plant, a Diammonium Phosphate (DAP)/Nitro Phosphate Potash (NPK) plant and materials storage and handling facilities. The design life for the Ras Al Khair Industrial Complex is 25 years.

The proposed Ammonia Plant will be a stand-alone plant, with its own facilities and is designed to produce 1.1 Mt/year of Liquid Ammonia from Natural Gas which will be stored in adjacent tanks for access by the DAP/NPK Plant. It is anticipated that the Project will also produce quantities of ammonia not required in the production process, which can be exported and sold domestically.

The DAP/NPK Plant will produce ammonium phosphate based granular fertilisers (DAP 2.2 MTPY and NPK 766 MTPY) which will be sold primarily into the international markets.

This EMMP has been developed for the the Ras Al Khair Industrial complex, hereafter known as “the Project”. The Umm Wu’al mine and Waad Al Shamaal facilities are the subject of a separate EMMP.

A2.2 LOCATION AND SITE DESCRIPTION

The proposed Project will be located within the Ras Al Khair Industrial City, which lies on a peninsula of land on the south-western Arabian Gulf coast within the Eastern Province of Saudi Arabia. The Industrial City is located approximately 80 km north of Jubail Industrial City.

The Ras Al Khair Industrial City includes its own industrial port and is connected to the mine site at Umm Wu’al by railway. The Industrial City is also accessible by a 27km road linked to the Abu Hadriyah highway. The closest sizable population centre Nuayriyah which lies
approximately 68 km to the west of the peninsula (93 km by road) and has a population of 26,470 (according to the 2010 census). Nuairiyah is located on a major link road from Riyadh to Kuwait and Jubail to Jordan. Figures A1 and A2 illustrate the site location and surrounding land use.

![Map of Umm Wu’al Phosphate Project Sites](image)

**Figure A-1: Location of the Umm Wu’al Phosphate Project Sites**

Existing infrastructure and utilities within the Industrial City are expanding following the construction of MPC’s existing fertiliser complex. Also, Ma’aden Aluminium Company (MAC) is currently constructing alumina and aluminium production facilities southwest of the Project site comprising of an alumina refinery, aluminium smelter and aluminium rolling mill.
Figure A-2: Site Location - Ras Al Khair Industrial City, the MPC Proposed Industrial Complex and Surrounding Industries / Land Use

The majority of the Project components will be located within the existing operational plot of MPC which already includes various facilities that can support the Project operations. These include:

- A number of administrative and miscellaneous warehousing buildings/facilities;
- Road layout and utility networks (including gas, electricity and water);
- On-site sanitary wastewater treatment plant with sufficient capacity to support the new development; and
- Irrigation Pond.

There is currently no industrial wastewater treatment facility at Ras Al Khair, but it is understood that treatment plant with capacity of 25,000 m$^3$/day is planned for the Industrial City. A new surface water Retention Pond will be constructed as part of the development.

A2.3 PROJECT FACILITIES

The main components of the project include the following:

- Process Area – Ammonia Production plant; Ammonia Storage tanks; Cooling Tower; DAP/NPK Production Units; DAP/NPK Raw Materials and Storage Warehouses; Office and Maintenance Area; and Roadways
• Materials Storage and Handling Facility: Storage Area and Tank Farm and handling facilities; and Rail infrastructure.
• Ras Al Khair Port - Loading/Unloading and Storage Facilities.

A2.4 PROJECT SCHEDULE AND WORKFORCE

The current project schedule is outlined below:

- Royal Commission Review of PAP and ESIA - Jul 2013 to Jan 2014 (estimated)
- Commencement of Detailed Engineering - Ammonia: Jul 2013
  Others: Aug 2013
- Construction including Pre-commissioning - Ammonia: Jan 2014 to Jul 2016
  Others: Aug 2014 to Dec 2016
- Commissioning - Ammonia: Sept 2016 to Dec 2016
  Others: Jan 2017 Apr 2017
- Facility Ready For Start Up - Ammonia: Jan 2017
  Others: May 2017

During the construction phase, the workforce is estimated to average 2,100 workers reaching a maximum of 3,260 workers. Construction work week will be 10 hours per day for 6 days per week. A temporary accommodation camp will be located close to the construction area and the workers will be transported by dedicated bus.

During the operation phase, the industrial complex operations staffing is estimated to be between 519 and 536. Table A1 details the anticipated operational personnel for the first 20 years of the proposed facilities at Ras Al Khair. The anticipated shift schedules are as follows:

- Morning shift (07:00 – 15:00): 6 days on, 1 day off;
- Evening shift (15:00 – 23:00): 6 days on, 1 day off;
- Night shift (23:00 – 07:00): 6 days on, 1 day off.

The number of personnel on site during operation is provided in Table A1 below:

Table A1: Breakdown of Operational Personnel for the Project

<table>
<thead>
<tr>
<th>Number of Personnel</th>
<th>Years 2017 - 2020</th>
<th>Years 2021 - 2023</th>
<th>Years 2024 - 2033</th>
<th>Years 2034 - 2037</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEO Saudi</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>VP Saudi</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Manager Saudi</td>
<td>11</td>
<td>14</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>Manager NS</td>
<td>6</td>
<td>16</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Supervisor Saudi</td>
<td>84</td>
<td>80</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Supervisor NS - Western</td>
<td>9</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Supervisor NS - Eastern</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Skilled Saudi</td>
<td>167</td>
<td>146</td>
<td>146</td>
<td>146</td>
</tr>
<tr>
<td>Skilled NS - Eastern</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Semiskilled Saudi</td>
<td>86</td>
<td>94</td>
<td>94</td>
<td>94</td>
</tr>
<tr>
<td>Semiskilled NS - Eastern</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unskilled Saudi</td>
<td>103</td>
<td>113</td>
<td>113</td>
<td>113</td>
</tr>
<tr>
<td>Unskilled NS - Eastern</td>
<td>37</td>
<td>33</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>536</strong></td>
<td><strong>532</strong></td>
<td><strong>519</strong></td>
<td><strong>522</strong></td>
</tr>
</tbody>
</table>
A2.5 CONSTRUCTION PHASE

A Construction Execution Plan will be developed by the EPC Contractor. This will include details on the preliminary construction plan and schedule for each work package; road access, construction seasons, construction labour availability and camp requirements are assessed and factored into the plan. A basic constructability review of the process plant and ancillary facilities will be included in the preliminary plan.

A Health, Safety, Security and Environment (HSSE) Plan for the area, which will also address aspects such as traffic management, access and egress, etc.

A conceptual project execution plan and general construction contracting strategy will be developed to:

- identify construction services requirements;
- complete contractor and labour resource survey;
- prepare the Project schedule, including the financing period, basic and detailed engineering, and procurement, construction and commissioning phases.

A2.6 CONSTRUCTION AREAS

The construction works will be undertaken in close proximity to the current operating equipment and storage, notably the existing Ammonia Plant. Potential hazards include gas leakage. This arrangement has occurred previously and, with the required controls, coordination and interfaces, a safe and productive construction phase can be achieved.

Construction of the new plant areas and associated facilities will need to consider a number of factors, including:

- Minimising impact of construction operations on existing operations, including production schedules;
- Location of construction offices and material laydown areas;
- Movement of construction vehicles on site;
- Security – maintaining security of existing site as well as construction areas; and
- The need to undertake construction activities in close proximity to existing (live) plant.

There is space available within the existing low security zone, in the southern half of the plot for construction offices and material laydown areas. This area can be utilised on the understanding that existing operations are not interrupted or impacted on in any way.

Additional lay down areas located adjacent to each of the main new plant areas (Ammonia, DAP/NPK and Material Storage and Handling Facility) may be required to minimise transportation of materials and plant, and minimise crossings of the existing site roads and high security zone. A number of temporary access locations may also be required.

Parts of the existing plant may need to be shut down to allow certain construction activities to take place, for example a temporary shutdown of DAP filling/discharging from storage tanks whilst tie-in to existing product pipelines takes place. Construction operations will have to be sequenced to suit existing site operations and shutdowns in order to avoid any unnecessary impact.

A2.7 CONSTRUCTION ACTIVITIES

Initial construction works are likely to include the following:

- Geotechnical investigations;
- Site preparation (site clearance etc.);
- Relocation / demolition of any buried infrastructure;
• Earthworks;
• Provision of site drainage;
• Set up temporary site facilities and camp infrastructure;
• Allocate work areas and install temporary security fencing; and
• Identification, arrangement and distribution of utilities, fuels etc required.

As the groundwater level at Ras Al Khair is less than 4 mbgl, dewatering is also likely to be required.

It is anticipated that the existing camp facilities at Ras Al Khair Industrial City will be utilised as the activities associated with the adjacent Aluminium Facility reduce. Construction camps will be equipped with the utilities and support services necessary to accommodate the workforce, such as water, electricity, air conditioning, laundry, canteens, recreational and medical services.

The construction works will be performed in many areas at the same time to meet the tight schedule. This will result in large movements of personnel and materials throughout the Industrial City. The construction execution is to be performed using the existing road system for access, and the requirement for significant integration with normal operational activities.

Ras Al Khair Port does not currently have the required infrastructure to support transport of equipment and materials, it is anticipated that Damman Port will be utilised. However, in the instance that oversized equipment cannot travel inland, barges will operate from Damman to Ras Al Khair Port (dredging works are not anticipated for this transport).

A2.8 PRE-COMMISSIONING & COMMISSIONING PHASE

The RCER-2010 require that a valid Environmental Permit to Operate (EPO) is obtained from the RC prior to any process commissioning.

A Commissioning Management Plan (CMP) will be prepared for the Project. The purpose of this plan is to define the strategy and resources required to commission the Project facilities and define the responsibilities of all parties during commissioning activities to ensure they are undertaken in a safe, organised and efficient manner.

The CMP sets out the requirement for the commissioning team to ensure that:

• all commissioning work is carried out safely;
• all commissioning work complies with environmental requirements;
• all commissioning work respects the needs of the local community;
• all commissioning works meets the clients requirements; and
• all commissioning work complies with the PMC policies and procedures.

The CMP will determine the definitive turnover sequence for the process plants. The CMP will need to be developed in outline soon after the mobilisation of the EPC Contractors to allow the sequencing to be incorporated into the Level III/IV overall Project work schedules.

In line with normal industry practice, there is expected to be a move from work package-based construction to operable system-based construction and commissioning activities during the final phases of the construction period, and this will need to be communicated via the Project schedule.

The PMC Lead Planner will produce the overall consolidated commissioning schedule with sufficient detail to enable the commissioning process for all of the Project facilities to be
coordinated and completed within the Project timescales. Each stakeholder will have the opportunity to contribute to the commissioning schedule prior to its final agreement. Commissioning managers from each EPC and the PMC will be responsible for the coordination of the commissioning activities and for compliance with safe working practices. During the commissioning process for the plants, regular meetings will be held to ensure the communication process is maintained and that the appropriate knowledge transfer takes place across operable systems and facilities, and also between the EPC Contractors.

Main activities and sequence of operations during the pre-commissioning and commissioning phase include:

- Hydrotesting of pipelines and tanks;
- Flushing & cleaning of pipelines;
- System dry-out;
- Inerting;
- Systematic conformity check of equipment;
- Static, de-energized test of equipment;
- Preliminary check;
- Functional check;
- Operational test;
- Pre-Start-up activities.

Hydrotesting of pipelines, tanks, and vessels will be conducted using fresh (desalinated) water in order to meet quality criteria needed for this activity using the existing seawater desalination system at Ras Al Khair Industrial Complex.

Discharge of hydrotest wastewater is likely to be routed to the existing evaporation pond and analysed to determine compliance with irrigation and/or coastal water discharge standards. The rate of discharge will be controlled in order to avoid overloading the receiving system. Wastewater failing to achieve such standards will be tankered off-site the Jubail industrial wastewater treatment plant for treatment.

### A2.9 OPERATIONAL PHASE

The Ammonia Plant will be designed for producing anhydrous ammonia with daily and annual capacities of 3,300 MT/D and 1,089,000 MTPY respectively. Bulk of ammonia will be used as a raw material to produce DAP, and the balance is planned to be exported from Ras Al Khair Port.

The combined DAP units (3No. trains) will be designed to yield 2,228,094 MTPY of DAP 18-46-0 grade. The NPK unit (1No. train) will be designed to yield 766,920 MTPY of NPK 15-15-15 grade. Both products will be exported from Ras Al Khair Port.

The Design Life for the Ras Al Khair Industrial Complex is 25 years.

### A2.9.1 AMMONIA PLANT

The Ammonia Plant is a stand-alone plant, with its own facilities and is designed to produce Liquid Ammonia from Natural Gas. It is comprised of the following sections: Natural Gas Desulphurisation and Compression, Steam Reforming, CO Conversion, CO₂ Removal, Methanation and Ammonia Synthesis. Secondary plant objectives include Waste Heat Recovery, Ammonia Refrigeration and Purge Gas & Hydrogen Recovery.

The main raw materials to be used for ammonia production are natural gas, process air and desalinated water. In addition, a number of catalysts are used in the process.
The existing MPC Desalination Plant will provide both desalination and process water to the Ammonia Plant.

The raw material types and the processes in which they are used for ammonia production are summarised in Table A2 below.

### Table A2: Raw Materials for Ammonia Production

<table>
<thead>
<tr>
<th>Raw Material/Feedstock</th>
<th>Process</th>
<th>Delivery &amp; Storage Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>Fuel: primary reformer, package (auxiliary) boiler, start-up heater, flare / pilot burner; and Feedstock</td>
<td>Pipe Supplied by Saudi Aramco</td>
</tr>
<tr>
<td>Desalinated and process water</td>
<td>Desalinated Water is used as feed to the Demineralised Water Unit (make-up water). Process (Service) Water can also be provided as required by the new Ammonia Plant outside normal operation. Recycling of condensates will minimise the consumption of desalinated water as make up water.</td>
<td>Pipe from existing MPC Power and Desalination Plant storage.</td>
</tr>
<tr>
<td>Seawater return water</td>
<td>Cooling Tower make up (blowdown and evaporation losses)</td>
<td>Seawater return headers of the existing plants.</td>
</tr>
<tr>
<td>Catalysts</td>
<td>Natural Gas Desulphurisation (Hydrogenation); Natural Gas Desulphurisation; CO Conversion; Methanation; Ammonia Synthesis; and CO₂ Removal</td>
<td>Pipe from existing MPC Power and Desalination Plant storage.</td>
</tr>
<tr>
<td>Antifoam agent</td>
<td>CO₂ Removal</td>
<td>Road Supplied by specialist providers</td>
</tr>
<tr>
<td>Oxygen scavenger</td>
<td>Boiler Feed Water Treatment: May be required during start-up or upset plant conditions</td>
<td></td>
</tr>
<tr>
<td>Chemical agent for pH control</td>
<td>Boiler Feed Water Treatment: PH control</td>
<td></td>
</tr>
<tr>
<td>Corrosion inhibitor</td>
<td>Chemicals for Circulating Cooling Water</td>
<td></td>
</tr>
<tr>
<td>Biocide</td>
<td>Chemicals for Circulating Cooling Water</td>
<td></td>
</tr>
<tr>
<td>Sodium Hydroxide (50%)</td>
<td>Water treatment (demineralisation plant, polishing unit, neutralisation)</td>
<td>Rail tanker-Storage Tank at Materials Storage and Handling Facility – Pipe to Plant</td>
</tr>
<tr>
<td>Sulphuric acid (98%)</td>
<td>Water treatment (demineralisation plant, polishing unit, neutralisation); Regeneration of ion exchangers</td>
<td></td>
</tr>
<tr>
<td>Resin</td>
<td>Water treatment (condensate polishing – demineralisation plant and polishing unit)</td>
<td>Road Supplied by specialist providers</td>
</tr>
</tbody>
</table>

Interconnections are required to integrate the new Ammonia Plant facilities with the existing MPC facilities. Interconnects include but not limited to:

- Electrical distribution including above and below ground routings as appropriate;
- Instrumentation distribution including above and below ground routings as appropriate;
- Water supply and return for cooling water, supply of process water, potable water, and firewater;
- Interconnecting (off-plot) piperracks;
- Interconnecting (off-plot) roads including main access routes to/from new plant;
- Storm-water drainage for new (off plot) roads;
• Connections (where applicable) for contaminated drainage and sanitary systems to existing treatment facilities. Due to levels of new plant areas and existing system, sanitary system may require lift station; and
• Industrial waste water is to be consolidated and stored locally within each plot area for tanker removal where appropriate.

Desalinated and potable will be supplied by the existing Power and Desalination Plant via new pumps and storage tank. Three storage tanks of 30,000 m$^3$ capacity are available for fire and process water as part of existing facilities. Existing firewater pumps and process water pumps may also be utilised. The current design of the existing fire water system at MPC is based on a maximum flow of 740m$^3$/h.

All process units will be designed on the basis of recycling all condensate generated in the plant and its utilities. Recycling of condensates will minimise the consumption of desalinated water as make up water.

The Ammonia Plant will be self-sufficient. The steam is generated by the ammonia production process will drive the synthesis gas compressor and the refrigeration compressor. An additional turbine provides the power to the Ammonia Plant.

Electrical power will be supplied by common grid during plant start-up. Additional power generation shall be completed inside Ammonia Plant. Emergency power will be supplied by a diesel generator for a safety shut down in case of total power failure. A dedicated diesel storage tank will be provided for the new emergency power diesel generator. This will be supplied by road tanker. Natural gas will fuel the auxiliary boiler.

Utilities that are to be supplied to the new Ammonia Plant by the existing MPC facilities at the Ras-Al-Khair site include:
• The existing sea water supply/return headers to the MPC Plants to supply make-up water to the new Ammonia Plant’s Sea Water Closed Loop Cooling Water System. Similarly, the cooling tower blow down is to be discharged to the sea water return line of the existing MPC Ammonia Plant.
• The existing PDP to supply Desalinated Water and Potable Water to the new Ammonia Plant. Process (Service) Water can also be provide as required by the new Ammonia Plant outside normal operation.
• The existing MPC fire water system facilities are to be evaluated to verify that they are adequate to supply the required fire water for the new Ammonia Plant.

The following is a summary of the utilities which can be exported by the new Ammonia Plant:
• The new Ammonia Plant will produce a surplus of steam, therefore the MP and LP steam headers will be designed with suitable tie-ins to supply the steam required for new DAP & NPK plants and new material handling areas.
• The new Ammonia Plant will include a facility to produce instrument and process air for its own consumption. In addition, it will also export Instrument and Plant Air to new DAP & NPK plants and new material handling areas.

The effluent treatment and disposal system will be divided into the following sections:
• Chemical and oily water sewer system;
• Demineralised water regeneration effluents;
• Non-contaminated storm water drainage system; and
• Sanitary sewer system

Each sewer system will be designed and constructed independent of each other and no mixing of effluents shall occur at any time.
Treatment methods for waste streams will be defined by the EPC Contractor following consideration of Best Available Techniques.

A2.9.2 NITRO PHOSPHATE POTASH (NPK) AND DI-AMMONIUM PHOSPHATE (DAP) PLANTS

The DAP / NPK complex will consist of four (4) granulation units arranged in pairs. One pair will consist of two (2) DAP units in one common building (DAP 1 and DAP 2) and the other pair will consist of one (1) NPK and one (1) DAP unit (DAP 3).

The DAP unit will be designed with an on stream factor of 330 days per year and 22 hours operation per day, and the NPK unit will be designed with an on stream factor of 332 days per year and 22 hours operation per day.

The main raw materials are concentrated phosphoric acid, liquid anhydrous ammonia, 98.5% sulphuric acid, urea, potassium chloride and filler.

Key Project components proposed for the DAP/NPK Plant are outlined in Table A3 below.

Raw materials for the DAP/NPK process will be stored in the Materials Storage and Handling Facility and at the Port (Potash) before transport to the process plants. A fleet of road trucks will transport the Potash from a storage facility at the Port for storage adjacent to the process plant.

One common raw material belt conveyor will be provided for the building housing DAP 1 and DAP 2 and a separate common raw material belt conveyor will be provided for the building housing DAP 3 and NPK.

Liquid raw materials will be pumped from the Materials Storage and Handling Facility to local storage within the DAP/NPK plant and also from the Ammonia Plant storage tanks.

The raw material types and the processes in which they are used for DAP/NPK production are summarised in Table A4 below.

<table>
<thead>
<tr>
<th>Table A3: Key Project Components Associated with the DAP/NPK Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Process Unit Area</strong></td>
</tr>
</tbody>
</table>
| DAP and NPK process plants | Off-site and Maintenance Area:  
- O&M workshop and outdoor paved storage yard;  
- Electrical substation (maintenance);  
- Road Weighbridge House;  
- Diesel generator building;  
- Fuel storage area;  
- Fire fighting water storage tanks; and  
- Potable/process water tank. | Two-storey admin building including first aid/medical centre and rescue/fire fighting |
| 2No. DAP/NPK product storage buildings (warehouses) and associated conveyors between production units and towards Port storage sheds. | Administration Area:  
- Electrical Substation (admin)  
- Additional car parking and road access within administration area | Two-storey central laboratory |
| 1 No. raw material storage building | | Two-storey training centre |
| Maintenance, stores and operation building | Facility Rail Workers House and Cafeteria |
| Storage tanks with bund walls for secondary containment | Sanitary block building |
| Road access | | |
| Waste water pits | | |
| Contaminated water drainage systems for paved areas within process units | | |
Table A4: Raw Materials for DAP / NPK Production

<table>
<thead>
<tr>
<th>Raw Material/Feedstock</th>
<th>Process</th>
<th>Delivery &amp; Storage Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filler</td>
<td>DAP and NPK Plants</td>
<td>Truck – Process Area storage building. Sourced within KSA</td>
</tr>
<tr>
<td>Urea</td>
<td>NPK Plant</td>
<td>Truck – Process Area storage building. Sourced within KSA</td>
</tr>
<tr>
<td>Potassium Chloride (K2O; potash)</td>
<td>NPK Plant</td>
<td>Ship – truck - Port storage building - conveyors - Plant</td>
</tr>
<tr>
<td>Phosphoric Acid (P2O5) and Raffinate</td>
<td>Scrubbing; Pre-neutraliser Reactor.</td>
<td>Rail tanker-Storage Tank at Materials Storage and Handling Facility – Pipe to Plant</td>
</tr>
<tr>
<td>Sulphuric Acid</td>
<td>Pre-neutraliser Reactor; Granulation Pre-scrubber Tank; and Tailgas Scrubber</td>
<td>Rail tanker-Storage Tank at Materials Storage and Handling Facility – Pipe to Plant</td>
</tr>
<tr>
<td>Liquid Ammonia</td>
<td>Preneutraliser Reactor; Granulation; Ammonia vaporisation.</td>
<td>Pipe from storage tanks within Ammonia Plant battery limit</td>
</tr>
<tr>
<td>Colouring and Coating Agents</td>
<td>Final product conditioning</td>
<td>Truck – Storage Tank at Materials Storage and Handling Facility – Pipe to Plant Sourced within KSA</td>
</tr>
<tr>
<td>Coating Oil</td>
<td>Final product conditioning</td>
<td>Truck – Storage Tank at Materials Storage and Handling Facility – Pipe to Plant Sourced within KSA</td>
</tr>
<tr>
<td>Anti-foam Agent</td>
<td>Scrubbers; Preneutraliser / pipe reactor tank.</td>
<td>Truck – Storage Tank at Materials Storage and Handling Facility – Pipe to Plant.</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>Fuel to dryer burner</td>
<td>Pipe Supplied by Saudi Aramco</td>
</tr>
<tr>
<td>Process Water</td>
<td>Preneutraliser Reactor (reaction of ammonia vapour and phosphoric acid); Scrubbing (removal of both dust and volatiles); Prescrubber and Scrubber tanks; and Tailgas Scrubber.</td>
<td>Pipe from existing MPC Power and Desalination Plant storage.</td>
</tr>
<tr>
<td>Medium Pressure Steam</td>
<td>Granulation</td>
<td>Ammonia Plant (by desuperheating and demineralised water (start-up) and recovered condensate during normal operation</td>
</tr>
<tr>
<td>Low Pressure Steam</td>
<td>Preneutraliser and product coating (coating oil dosing pumps – LP steam jacketed pipes and spray nozzle)</td>
<td>Ammonia Plant (expanded MP steam)</td>
</tr>
<tr>
<td>Instrument Air</td>
<td></td>
<td>Ammonia Plant</td>
</tr>
</tbody>
</table>

All process equipment in the plant operates under a small negative pressure in order to prevent the escape of unreacted ammonia, other gases and dust from the process.

Most of the dust is removed and returned to the process as recycle via the recycle conveyor.

A complete dedusting system will be implemented to avoid a dusty environment within the production building.

Water consumption during operations is expected to average 2781 m³/day process water; 56 m³/day Potable Water; and 4.2 m³/day Demineralised water.

Power will be supplied via the Ammonia HV Main Switchboard. A new Port Substation will also be provided to supply all electrical loads associated with the new ship loading and offloading.
facilities. The EPC Contractor will be responsible for liaising with the Port Authority to obtain power supplies to this substation from the existing port power infrastructure.

LV Emergency Diesel Generators at each Substation will be installed to supply the area’s emergency power requirements and maintain essential auxiliary power supply in case of complete blackout. These generators are not capable of black starting the plants. A local diesel fuel oil tank will provide 48 hours of continuous full load operation when full.

Power supply to the process plants and facilities will also be outsourced from the Saudi Electricity Company (SEC).

There will be no liquid effluent from the process. All liquid effluents will be collected in the sumps / waste water tanks and recycled to the process. Condensate recovery at Ras Al Khair will take place within the Ammonia Plant.

Potentially contaminated stormwater/firewater will be collected from the process areas and drained through a series of channels to a sump. If monitoring concludes this water does not achieve the RCER-2010 irrigation standards, the contaminated water will be transported by tanker off-site to an appropriate industrial waste water treatment plant (e.g. at Jubail Industrial City).

A2.9.3 MATERIALS STORAGE AND HANDLING FACILITY

Railway sidings with a Materials Storage and Handling Facility is proposed in the south-east corner of the Project site to facilitate the use of MGA + Raffinate and sulphuric acid and the export of MGA and PPA which are produced at the Umm Wu’al mine site. These materials will be transported to the area by rail, but smaller volumes of other materials will arrive via road tankers. The Materials Storage and Handling Facilities Area will comprise the following key components:

- Storage tanks;
- Bund walls and containment for accidental spillage from product tankage;
- Electrical Substation (handling/storage);
- Road access within storage area and tank farm;
- Contaminated water drainage systems for paved areas within storage areas and separate storm water drainage system for roads;
- Rail tanker unloading facilities; and
- Rail infrastructure (sidings, shelter and other SAR facilities).

Rail unloading facilities will be provided at Ras Al Khair to enable for the transfer of the MGA+Raffinate, sulphuric Acid, MGA for export, and PPA from rail wagons to storage tanks. Liquids for unloading will be discharged by gravity to underground tanks placed in reinforced concrete sumps. Suitable fire-fighting and spillage control systems will be designed and implemented.

The MGA Tank wagons are likely to require high pressure water washing to remove settled material every third trip and a suitably designed system is required to include a pumped wastewater return system directed to the MGA pump sump. All flushings will be used in the DAP/NPK process.

Potentially contaminated stormwater/firewater will be collected from this area and drained to a sump for transport to an off-site treatment facility.

A2.9.4 RAIL AND ROAD INFRASTRUCTURE

The required sidings at Ras Al Khair will be provided by SAR to service the Ras Al Khair Industrial Complex. The Ras Al Khair sidings will be located outside the Ma’aden site.
boundary to the east. This EMMP is concerned only with the facilities at the Ras Al Khair Industrial Complex and connections to Ras Al Khair Port.

SAR extension works will extend to the Project site boundary on its eastern side, and with SAR agreement, the EPC Contractor will construct (on their lands) the offloading infrastructure below track sub base level including reinforced concrete pits and steel pumping sumps for offloaded liquids with associated facilities including service ducts. New rail sidings are required on the Eastern side of the plot to link the Materials Storage and Handling Area to the Port and to the Umm Wu’al site in the North.

A transport corridor from the process plant area to the Port exists and is interconnected with existing roads owned and operated by the SEAPA.

The EPC Contractor will determine vehicle movements during the construction and operation of the facility and roads will be designed to Royal Commission and Ma’aden Roadworks specification.

A2.9.5 RAS AL KHAIR PORT DEVELOPMENT

It is anticipated that the Saudi Ports Authority (SEAPA) will allocate three berths at Ras Al Khair Port to Ma’aden for the Project, comprising two dry berths for export of bulk NPK/DAP and import of Potash and one berth dedicated to liquid export i.e., Ammonia, PPA and MGA. The construction and on-going maintenance (e.g. dredging) of these berths will be the responsibility of the SEAPA.

The Project elements proposed at the Port include the following aspects:

- Three export storage sheds for DAP & NPK with a minimum of 465,000 tonnes total capacity. A reclaimer and recovery conveyor will be provided in each shed.
- Import storage shed for Potash.
- A Ship un-loader (grab type) for off-loading Potash imports.
- Material handling conveyor to transport imported Potash from quay-side to storage area and from storage area to truck loading area.
- Material handling conveyor(s) to transport DAP & NPK product from the process plant to the Port storage and then from the Port storage area to ship).
- Mechanical Bulk Ship Loaders
- A PPA transfer pipeline and a separate MGA transfer pipeline from the Materials Storage and Handling Facility to the PPA and MGA Export Loading Arms in the Port.
- Ammonia loading arm to ship.
- Substation, control and workshop buildings.
- Service corridor from the process plant to the Port and road connections with SEAPA and RC provided roads.
- Emergency diesel generator (rating of 1000 kVA) in a weather proof noise enclosure.

No storage of Ammonia is intended in the Port area, and it is anticipated that all other material imports and exports will be via other ports and therefore no other handling/storage facilities in addition to DAP/NPK and Potash are required at the Ras Al Khair Port.

A2.9.6 SANITARY AND UNCONTAMINATED STORM WATER MANAGEMENT

Sanitary wastewater produced in the Ammonia Plant will be collected in sanitary collection pit and then pumped to the existing central sanitary treatment plant. Sanitary waste generated within the DAP/NPK process areas and will be diverted into local sumps for buildings that are
located within the process units and then collected by tanker and taken to the sanitary treatment plant. Sanitary waste from the administration area will be pumped from the local sump to the sanitary treatment plant.

Sanitary waste water will be treated to meet the RCER, 2010 irrigation water quality standards and is therefore routed to the Irrigation Pond. The water will be used for irrigation purposes at the Industrial Complex.

Rainwater will be collected from the roofs of buildings and directed into an underground pipe and trench system to perimeter ditches. Channels and gullies will be provided to convey the uncontaminated surface water from all roads and hard standing areas which are not part of the process areas. Drainage from car and truck parking areas will be discharged via oil separators with storm water by-passes to the perimeter ditches.

Clean storm water runoff in the Ammonia area will discharge into the contaminated water system. Outside the Ammonia Plant, the clean storm water drainage will collect storm water runoff from the new development areas excluding process and storage areas where the storm water runoff could potentially be contaminated. The collected clean storm water runoff will then be pumped to a new HDPE-lined clean storm water retention pond located south of the existing retention pond. Areas at risk of hydrocarbon pollution, for example car park areas, maintenance areas and fuel storage areas will drain through an oil interceptor prior to discharge to the clean storm water system.

A3.0 STATUTORY ENVIRONMENTAL REGULATIONS

The Site Manager shall ensure compliance with all applicable Regulations and Guidelines, and shall ensure that new regulations are monitored and implemented as applicable and required.

The proposed Project will be located entirely within the Ras Al Khair Mineral Industrial City which is under the jurisdiction of the Royal Commission (RC) for Jubail and Yanbu. Therefore, the primary regulations applicable to this project are provided by the RC Environmental Regulations (RCER) 2010 to control substances emitted, discharged or deposited, and noise generated within the industrial cities. The current RCER-2010 comprise the following:

- Volume I: Regulation and Standards - which includes all regulations, standards and guidelines required to operate an industrial facility in a manner which protects the environment and public health;
- Volume II: Consolidated Permit Program - which sets out the steps to be followed to obtain the necessary “Environmental Permit to Construct and the “Environmental Permit to Operate” from the RC in order to construct and operate industrial and other facilities within the industrial cities; and
- Volume III: Penalty System - which sets out the penalty system in event of non-compliance.

In addition, and where relevant, the Project must adhere to the requirements of the World Bank Group, specifically the IFC’s World Bank Group Environmental, Health, and Safety Guidelines (EHS Guidelines) as well as the Equator Principles.

These EHS Guidelines provide technical reference documents with general and industry-specific examples of Good International Industry Practice and are used by the IFC as a technical source of information during project appraisal activities. The following Guidelines are of relevance to the Project:

- General Environmental, Health, and Safety Guidelines, April 30, 2007;
The Equator Principles, established in June 2003, and subsequently reviewed in 2006 and 2013, is a risk framework for identifying, assessing, and managing environmental and social risks in project finance transactions. This framework is based on the IFC Performance Standards and the World Bank Group EHS Guidelines. Equator Principles Financial Institutions (EPFIs) have adopted the Equator Principles in order to ensure that the Projects financed are developed in a manner that is socially responsible and reflects sound environmental management practices. The principles comprise a set of ten broad principles that are underpinned by the environmental and social policies, standards and guidance of the IFC. The Equator Principles are as follows:

1. Principle 1: Review and Categorisation;
2. Principle 2: Environmental and Social Assessment;
3. Principle 3: Applicable Environmental and Social Standards;
5. Principle 5: Stakeholder Engagement;
6. Principle 6: Grievance Mechanism;
8. Principle 8: Covenants;
9. Principle 9: Independent Monitoring and Reporting; and

As directed in the RCER-2010 Volume I section 1.5, in the event that the RCER do not specify a standard relevant to the project site, then the project shall use for reference other recognised regulations as a basis for technical justification in the following order:

1. Saudi National / Presidency for Meteorology & Environment (PME);
2. The U.S. Environmental Protection Agency (US EPA);
3. U.S. State environmental rules and guidelines;
4. European Union (EU) members environmental rules and guidelines; and
5. Other internationally recognised and accepted regulatory bodies.

The IFC requires that when host country regulations differ from the levels and measures presented in the IFC Environmental, Health, and Safety Guidelines, projects are expected to achieve whichever is more stringent.

A summary of relevant legislation is provided in Attachment 1.
A4.0 ROLES AND RESPONSIBILITIES

The Contractor(s), in consultation with the Client, is required to define the roles of the Construction Team, with specific reference to roles and responsibilities as they relate to the environmental management of their specific tasks. Anticipated responsibilities for the Construction Manager have been included below.

This section of the EMMP should be amended to reflect any additional information obtained following the FEED phase of the programme.

A4.1 THE CLIENT

The Client’s role (inclusive of a Project Management Team) includes but is not limited to the following:

- Outlining their environmental requirements for the project pursuant with company policy, standards and procedures and providing copies of these;
- Advising of any changes to their environmental requirements especially those that may influence planning and permitting activities;
- Specifying any relevant site specific targets, impacts or mitigation measures (over and above RCER 2010 and Ma’aden requirements known to the Construction Team) to be incorporated into permit applications;
- Providing information to enable the Project to meet its environmental objectives;
- Reviewing and approving deliverables and subsequently submitting these to the relevant authorities as appropriate, e.g. compliance reports and environmental performance reports;
- Accountable for overall delivery and compliance with regulatory requirements including the RC conditions of approval;
- Review and approve the Construction EMMP;
- Review and approve the Construction Manager’s induction and training programme and monitor implementation;
- Attend Health, Safety & Environmental Management meetings as required;
- Train supervisors / managers to maintain communication of the provisions of the EMMP to all employees to conduct their work in a sustainable manner and adhere to the environmental requirements outlined in the EMMP; and
- Developing and operating a plant in accordance with relevant environmental regulations and commitments made within the ESIA and EMMP.

A4.2 THE CONSTRUCTION/OPERATIONAL MANAGER

The Construction/Operational Manager is responsible for overall delivery of the project, including day to day activities on site, and performance of all activities and disciplines.

The duties and responsibilities of the Construction Manager shall include, but not be limited to, the following:

- The implementation and performance of the Site HSE Plan;
- The implementation of the Construction Execution Plan;
- Input into the planning of the Site temporary facilities, and Site management of the establishment of these facilities
- Input into the scheduling of the mobilisation (and subsequent de-mobilisation) of the Construction Supervision team;
Input into the development of the Construction Schedule;

Monitoring Site Industrial Relations and providing feedback to the Construction Director;

The co-ordination of the Construction Supervision team and Construction Subcontractors within his area;

Monitoring the subcontractors compliance with their Quality and Inspection and Test Plans;

The Site co-ordination and performance of all Construction subcontractors;

Monitoring Subcontractors performance against their approved Contract programme and the overall Construction schedule, and providing feedback to the Jacobs Construction Director and the Site Team;

Chairing the weekly/monthly Jacobs Subcontractors Progress Meetings as agreed with the Construction Director;

Liaison with Site Engineering for the resolution of Site Technical Queries;

The preparation, and initial for agreement of Site Instructions in accordance with the Project applicable T&C’s and C&C Procedures;

Monitoring of construction costs against approved budgets for the portions defined by the Construction Director. Identifying and reporting any changes or potential changes to the work that could have an impact on construction costs and/or schedule. Initiating corrective action as instructed by the Site Manager;

Input into the Construction Weekly and Monthly Reports; and

Maintain a Daily Diary and monitor the upkeep of the Construction Supervisors daily logs.

A4.3 THE ENVIRONMENTAL MANAGER

The environmental manager will report to the construction manager and Health and Safety Manager. Responsibilities include (but are not limited to):

Develop, implement and adhere to a Construction EMMP, to be approved by Health, Safety and Environment Manager.

Obtain all relevant statutory and non-statutory licences that are the responsibility of the Contractor for the construction phase;

Coordinate and manage training of all staff prior to the commencement of commissioning and construction activities including coordination with the Health, Safety & Environment Manager to train personnel in their respective project aspects;

Ensure that all subcontractors are aware of their environmental management responsibilities;

Manage day-to-day implementation of this EMMP;

Undertake audits of all sub-contractors in accordance with the Construction EMMP;

Manage all monitoring in accordance with the Construction EMMP;

Establish environmental and social considerations during construction including environmental constraints on the project;

Report directly and promptly to the Health, Safety & Environment Manager on all environmental and occupational health and safety matters including incidents, non-conformances;

Conduct site inspections to ensure environmental management measures are effectively in place;
• Liaise with the Health, Safety & Environment Manager on and respond pro-actively to requests and instructions;
• Construct individual facilities in compliance with the Clients Environmental Policy and in accordance with relevant construction regulations, standards and best practice guidelines; and
• Consideration of environmental and sustainability credentials in the procurement of materials, equipment and additional services (liaising with the HSE Manager and Client as appropriate).
• Ensure stakeholder consultation is conducted in alignment with the Stakeholder Engagement Plan, liaising with client as appropriate.
• Identification of key stakeholders and the messages that need to be communicated;
• Interactive development of mitigation proposals;
• Consultation with regulatory bodies including the informal and formal permission and consent process;
• Evaluation and selection of, and working with Sub – Contractors to ensure management of environmental issues on the project;
• Environmental considerations in working methods for all construction activities;
• Liaison/consultation with local authorities and the local communities.

A5.0  COMMUNICATION

For the successful implementation of the EMMP, it is essential that all persons working for, or on behalf of, the Project who have responsibility to undertake work activities that have the potential to cause significant environmental impacts, including those arising from the design process are:
• Aware of this EMMP and associated Management and monitoring plans.
• Aware of the relevant environmental regulations and guidelines, as outlined in Attachment 1 and detailed in the ESIA;
• Aware of the details and commitments outlined in the relevant permits and approvals; and
• Appropriately trained and competent to fulfil their roles within the Project

Effective co-ordination and liaison on project activities is paramount to the successful implementation of the EEMP. The project management team should be committed to ensuring all issues requiring liaison and co-ordination are identified, and a responsible person (e.g. Project Manager) with the required skills and experience should be appointed to resolve and co-ordinate.

The Construction/Operational Project Manager is responsible for monitoring on a weekly/monthly basis all communications between team members and other parties, and for ensuring that all matters relevant to the project are communicated to team members as quickly as possible.

The Contractor Project Manager will be responsible for implementing internal communication on site.

Communications can be divided into internal communications, such as communications within the project team and design team and those that are considered external communications, such as communications between the project team and other interested parties that may include regulators, contractors, the local community and local businesses.
A5.1 INTERNAL COMMUNICATION

Environmental information will predominantly be communicated by ensuring that all relevant parties have a copy of the EEMP and associated plans and/or ensure all relevant parties have access to it. The Contractor Environmental Manager will keep a register of all issued copies of the Plans and will circulate any amendments to copy-holders.

The Project Management Team will develop additional means of communication wherever necessary which may comprise meetings between disciplines, presentations, workshops, and training where applicable.

A register of all appropriate internal environmental communication will be compiled and a process will be implemented to allow all actions to be dealt with accordingly. All relevant internal communications will be stored for the duration of the project and should be made available for audit on a monthly basis.

A5.2 EXTERNAL COMMUNICATION

An environmental communications register will be used to track incoming and outgoing external environmental communications and will include defined responsibilities and timescales for responding to communications.

The following measures should be undertaken as a minimum to ensure that all relevant parties are kept informed about the works during implementation:

- Stakeholders and the Local Community should be informed of and provided information on the Works Programme. This can take the form of meetings, letters etc., as appropriate.
- Notice boards should be erected, as appropriate, at the perimeter of the site to inform local residents, businesses and commuters about the progress of the works and of upcoming construction activities;
- Contact details, including physical address and telephone numbers should also be placed on the notice boards for general public enquiries and complaints;
- Where communities are likely to be subject to significant impacts or disturbance during construction then consultation should be undertaken with those likely to be affected to explain the nature and timing of the works.

A5.3 EXTERNAL COMPLAINTS PROCEDURE

An external complaints procedure will be developed to respond to any complaints that are received by the project during the construction works. This will be a documented system to respond to complaints received by letter, by telephone or in person. All complainants will receive an appropriate response within a defined period. Ma’aden will suitably consider each justified complaint, developing mitigation measures if necessary and altering the site environmental method statement, in discussion with the Contractor Project Manager.

A complaints register will be kept by the Construction/Operations Project Manager and made available during any audits and inspections as required. The register will contain all the justified complaints that have been received (including summaries of complaints received orally), a copy of the response sent to the complainant and a summary of how the complaint was responded to (e.g. the imposition of a further mitigation measure), if relevant.

A6.0 INDUCTION AND TRAINING

For the successful implementation of the EEMP, it is essential that all persons working for, or on behalf of, the project who have responsibility to undertake work activities (that have the potential to cause significant environmental impacts) are appropriately trained and are competent to fulfill their designated roles within the project.
The Construction/Operations Project Manager in consultation with the Environmental Manager will be responsible for ensuring all personnel working onsite have received an initial site induction. Records of induction will be maintained in a Training Register. They take ultimate responsibility for identifying all environmental training needs and ensuring that all key staff and personnel responsible for environmental management working on the project are competent.

As part of the commitment to achieving effective management of the environment, awareness training will be provided to all appropriate Project Management and site personnel.

The primary focus of such training will be to ensure that all team members understand the key environmental issues and requirements associated with the project works. This will ensure that all key staff and personnel working on the project are sufficiently aware of the environmental issues associated with the project, and understand the importance of compliance with Environmental Management documents. Training will generally include briefing on environmental issues of concern as part of Induction Training and Toolbox Talks, and cover general and specific environmental responsibilities with respect to:

As a minimum such environmental awareness training should inform all applicable staff of the following:

- The overall functionality of the EWCEMP which should be based on Ma’aden Corporate requirements and ISO140001 compliant;
- The importance of conformance with the environmental policy and procedures and with the requirements of Environmental Management documents (e.g. risk of prosecution, requirements to discharge planning conditions etc);
- Roles and responsibilities in achieving conformance with the environmental policy and procedures and with the requirements of environmental documents, including emergency preparedness and response training;
- The potential consequences of departures from specified operating procedures.
- General site issues;
- Traffic and access;
- Reporting procedures and reporting accountabilities.
- Relevant environmental legislation;
- Environmental responsibilities;
- Environmental aspects and potential impacts, including:
  - Air quality, including dust and odour;
  - Noise and vibration;
  - Protected species/areas;
  - Waste disposal and recycling;
  - Soils and geology;
  - Water quality;
  - Hydrogeology.
- Housekeeping requirements;
- Pollution prevention; and
- Incident management and use of the Environmental Emergency Response Plan (EERP).
The HSE Manager will also be responsible for training on hazards, risks, and emergency response connected to the EMMP.

Job specific training including competency assessment shall also be provided to staff carrying out activities with environmental implications such as waste or hazardous materials handling and disposal operations. This will be developed following a detailed training needs analyses.

Environmental awareness among site personnel should also be promoted through media such as notice boards and newsletters. All site personnel will be made aware of the structure and individuals by which environmental issues are managed.

A7.0 AUDIT, CORRECTIVE ACTION AND REPORTING

The environmental performance of the Project will be monitored and evaluated by carrying out regular environmental audits/inspections of the project. The information from these reviews will be documented in an audit report passed to the Ma’aden Project Management Team for action in the event of non-compliance.

Environmental audits will be conducted based on Ma’aden Corporate and ISO14001 requirements to evaluate the actual environmental performance of the project. The audit frequency will vary according to the environmental impact, legislative requirements and the auditor’s assessment of the project team’s competence.

Audits will be undertaken throughout the construction phase on a weekly/monthly basis by the Ma’aden Environmental Manager and will focus on the following aspects of performance:

- Management system verification;
- Site arrangements, working conditions and site behaviour are not damaging nor posing risk to the environment;
- Relevant consents and permissions have been obtained; and,
- Work is being performed in accordance with the relevant environmental policies, objectives, management system requirements, licenses and consents, specifications and approved EWCEMP and Method Statements as applicable.

A7.1 NON CONFORMANCE, CORRECTIVE AND PREVENTATIVE ACTION

Non-conformances will be defined as one or more of the following:

- There is evidence of a serious failure or breakdown of a process or system;
- Lack of a procedure defining a particular process or activity, which, is required by a standard, legislation or EEMP and associated plans;
- Evidence of a lack of awareness or compliance with the requirements of an existing procedure, EEMP and/or method statement;
- A one off contravention of the requirements of a procedure or rule
- Potential damage to the environment;
- Evidence of, or the potential for breach of, environmental legislation.

In accordance with Ma’aden Corporate Policy and ISO 14001, preventive action should occur either to prevent re-occurrence and/or to prevent potential non-conformities in the future. A project non-conformance, corrective and preventative action procedure form should be compiled in the event of a non-conformance. This details how the project will identify, handle and investigate non-conformances; will take action to mitigate any adverse impacts caused; and will be used for initiating and completing corrective and preventative action.
The Ma'aden and Construction/Operations Management Teams will be responsible for ensuring that all non-conformances are appropriately investigated and for ensuring that the appropriate corrective actions are developed and implemented.

The Construction/Operations Project Management Team will report all significant environmental non-conformances to Project Management Team. Agreed actions arising from any non-conformances raised by the site inspection/audit will be completed within an agreed timescale, monitored through to completion and in line with the requirements of the procedures.

A register will be kept by both the Ma'aden Environmental Manager and the contractor Project Manager of all non-conformances that will include, but not be limited to, a copy of the non-conformance report, a summary of the ensuing investigation and details of the proposed corrective action and evidence of its implementation.

A7.2 REPORTING

A report on each aspect-specific environmental audit on a monthly basis will be produced. Each of the aspect-specific environmental audits will result in the completion of a separate audit report, which will highlight:

- Any environmental legislative non-conformities;
- Any non-compliance to environmental method statement;
- Any required improvement;
- Any training requirements; and
- Any other issue of concern identified by the audit.

Any environmental or social issue of significance identified during the audit, even if not related to the specific topic covered, will be highlighted as part of the audit report.

A8.0 ASSOCIATED MONITORING AND MANAGEMENT PLANS

Attachment 4 provides the Environmental Management and Monitoring Implementation Plans for the various the mitigation proposals described in the ESIA. These plans will be updated as the project proceeds through detailed design, and should be supplemented with all good practices as recommend throughout the ESIA.

The EMMP will be supported by a series of management plans. An outline of the recommended plans are given in the following sections. These will be developed through the project and updated accordingly.

It should be noted that these are recommended plans based on the current phase of the project and other plans should be developed as appropriate.

A8.1 CONSTRUCTION ENVIRONMENTAL MANAGEMENT PLAN

The EPC Contractor shall develop, implement and maintain a construction and commissioning phase Environmental Emergency Response Plan (EERP) (see Appendix B of the ESIA) and Construction Environmental Management Plan (CEMP) as supporting documents to this Environmental Management and Monitoring Plan (EMMP).

The plans will detail responsibilities and procedures for environmental management during construction, including (but not limited to):

- Minimum technical standard of construction plant;
• Competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency (including accidental releases of hazardous substances);
• A dust management strategy to reduce dust emissions from construction activities. This will include dust suppression of haul routes and covering loads on construction vehicles;
• Speed restrictions to reduce dust emissions from construction vehicles;
• Site clearance procedures that allow species to move away before clearance, rather than being trapped within the construction area;
• Stockpile management systems and associated procedures to reduce dust emissions and run-off from temporary material stockpiles;
• A construction site waste management plan and erosion and pollution prevention measures to reduce the risk of contaminants entering the natural environment;
• Identification and control of water discharges, to ensure the drainage capacity of the location, and to minimise erosion potential.
• Procedures to be implemented following an accidental release of hazardous substances, e.g. during refuelling, including details of containment and recovery measures to be applied; and
• Availability of pumps and spill mitigation materials such as absorbent granules to contain and recover hazardous substances releases.

The plan should also consider the following recommendations included in the ESIA

• Identify job opportunities during construction available to the local workforce, and promote engagement of the local population in the construction phase. Ma'aden may consider committing to a Saudization percentage for the construction phase.
• Provision of training during the construction phase, to increase local knowledge of the construction industry, and to advance training in skills required for the operation of the project.
• An assessment of the medical facilities required to support construction activities. Early engagement with local service providers to assess the capacity of the region to absorb any potential issues should be undertaken. This consultation should include all emergency services to ensure agreement is reached on the most effective mechanisms to deal with any major incident, including any evacuation to hospitals in Jubail.
• The support to suppliers and contractors through the expansion of driver awareness training can be continued throughout the operational stage, to reduce the risk of potential MVAs from the increase in traffic and transport.

The contractor will undertake regular audits of the above management plans to confirm their on-going effectiveness.

A8.2 SITE WASTE MANAGEMENT PLAN

The Contractor to develop a Site Waste Management Plan to identify in more detail anticipated wastes, and their quantities, and undertake waste planning for treatment and disposal. This will be prepared and implemented by the Contractor before the production of any waste material.

The scope of the WMP should cover the activities undertaken by contractors during the construction phase of the development. The management of waste on site will be undertaken in accordance with the Waste Management Hierarchy. This hierarchy outlines that waste
prevention and minimisation are the first priority in managing wastes, followed by waste reuse and recycling. Disposal of waste will only be considered as a last resort.

The purpose of the WMP is to facilitate the appropriate management of waste that will arise during the construction of the development. The plan will ensure that appropriate procedures are developed to prevent and/or reduce waste production, maximise recycling and minimise the potential adverse impacts associated with waste handling and disposal.

Suitably qualified and accredited sub-contractors will be used during the removal and transportation of hazardous materials. All records for the transportation and disposal of hazardous waste will be maintained (and kept available for random inspection) on site.

A8.3 TRAFFIC MANAGEMENT PLAN

The EPC Contractor shall develop, and implement and maintain a construction phase Traffic and Transportation Management Plan, for approval by Ma’aden Project Management Team prior to commencement of construction. This plan will detail as a minimum (but not limited to) the following:

- Responsibility and procedures for co-ordination and liaison with SAR and the Ministry of Transport during construction and operation;
- Confirmation of capacity within the rail network and availability of trains to deliver materials required;
- Rail scheduling and operational procedures;
- Outcomes of traffic risk assessments undertaken;
- Access routes for construction plant and materials;
- Transport routes for the workforce (on arrival to/departure from the accommodation, and from the accommodation to the work areas);
- On-site traffic management during operations;
- Measures to segregate the pedestrian from vehicle areas;
- Training and awareness in road safety; and
- Measures to protect the local community where appropriate.

The contractor will undertake regular audits of the management plan to confirm their ongoing effectiveness.

In accordance with the IFC EHS general guidelines vehicles will not access the public highway wherever possible. No vehicles shall leave the site with materials adhering to the wheels in a quantity which may result in its being deposited on the public highway, and creating nuisance, or hazard to vehicles. Suitable wheel washing equipment to avoid such problems shall be installed if appropriate, operated and maintained on the site until the development is completed.

A8.4 AIR QUALITY AND DUST MONITORING AND MANAGEMENT PLAN

This plan will detail the methods for assessing the ambient air quality conditions prior to construction and operations. It will also detail the location and frequency of monitoring around the site boundary and at specific areas of the project which might give rise to significant air quality or dust impact to the workforce. The plan will consider the requirements of the RCER 2010 regulations.

The operator will undertake regular audits of the plan to confirm its on-going effectiveness and provide monthly reporting to the Ma’aden project management team for supply to the RC.

The plan should consider (but is not limited to) the following:
• Appropriate maintenance of important mitigation equipment such as scrubbers etc.;
• Emissions from mobile sources
• Dust suppression measures, including wetting, location and orientation of stockpiles, etc.
• Management of dust from crushing activities
• On-going assessment of carbon and greenhouse gas emissions
• Emissions monitoring and reporting to relevant authorities;
• Competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency (including accidental releases of hazardous substances)

Testing for all relevant point source emissions should be in line with RC requirements (Volume 1 section 2.5) and should include the following:
• Analytical data – pollutants, moisture content etc.;
• Physical Data – flow rate, temperature, pressure etc.;
• Process operating conditions at the time of testing;
• One example calculation for each method;
• Emission results with raw data in the same form as the standards in RCER 2010 Table 2B; and
• Details of calibration.

All point sources listed in Table 2D of the RCER regulations should be subjected to continuous monitoring. Each qualifying emission must be monitored individually, and monitoring programme and data must be available for inspection at all times.

Sampling and analytical methods should be carried out in accordance with the most recent edition of the USEPA methodologies for the sampling and analysis of point source and fugitive air emissions.

Reporting should be undertaken monthly to Ma’aden Project management team for supply to the RC. This should include:
• All measurements;
• All performance evaluations;
• Verification of Calibration and maintenance checks;
• Manufacturers recommended maintenance and calibration frequencies
• Occurrences and durations of start-ups, shutdowns etc.;
• Details of the periods when the continuous monitoring is inoperative
• Type of fuel used with specification and consumption where appropriate and to be supplied upon request
• Vendor manual with technical and calibration specifications.
• Monitoring period
• All monitoring data with statistical analysis (including ave, min, max, and standard deviation)
• Number of exceedences with explanations
Records of monitoring data and the occurrence and duration of any start up, shutdown or malfunction, performance test, evaluation, calibration, adjustment and maintenance of the monitoring system, should be retained by the operator for at least 3 years and made available to the RC upon request.

### A8.5 NOISE & VIBRATION MANAGEMENT PLAN

The EPC contractor shall develop and noise and vibration management plan detailing measures to control noise and vibration emissions during construction and operation. This will include (but is not limited to):

- Details of the noise monitoring programme and procedures for its implementation.
- Monitoring of noise at the site boundary to determine compliance with applicable standards and guidelines and assess the need for mitigation.
- Results of the updated noise modelling.
- Use of temporary sound-proof enclosures and anti-vibration measures shall be employed to reduce noise levels on site, in keeping with the results of the updated noise and vibration model.
- Maintenance procedures of all equipment in place to minimise noise from equipment.

The construction/operations manager operator will undertake regular audits of the above management plans to confirm their on-going effectiveness.

Prior to decommissioning / closure Ma’aden shall evaluate potential noise and vibration sources associated with planned decommissioning activities, and establish measures to ensure these activities comply with the necessary noise guidelines at the sensitive receptors.

### A8.6 SURFACE AND GROUNDWATER PROTECTION PLAN

A surface and groundwater management plan will be developed according to RCER 2010 requirements to include:

- Details of the testing frequency and for all water and wastewater management systems (including groundwater monitoring)
- Minimum technical standard of construction plant;
- Competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency;
- Spill control procedures;
- Procedures to be implemented following an accidental release of hazardous substances, e.g. during refuelling, including details of measures to be adopted to stop, contain as far as practicable on site, and clean up spills, and to inform the relevant authorities in the event that a spill migrates (or occurs) off-site so that appropriate regional plans can be activated; and
- Availability of pumps and spill mitigation materials such as absorbent granules to contain and recover hazardous substances releases.
- Detail procedures to ensure that vehicles used to empty septic tanks are fit for purpose and operated by trained members of staff to prevent spillage.
- Detailed method statements and Construction details for designated refuelling and vehicle maintenance areas. These will comprise bunded and sealed areas and all scheduled refuelling and maintenance of construction and transportation vehicles will be undertaken within these designated area(s).
• Ensure hazardous material storage tanks, including for fuels, are located within bunded and hard surfaced areas with adequate capacity for the volume of hazardous materials stored within.

• Provide an adequate quantity of drip trays and spill kits will be provided to contain and recover potential releases of hazardous substances.

• Ensure washing-out of concrete delivery, mixing and pouring plant and equipment shall be undertaken in a designated area and all wash water shall be contained for subsequent treatment and re-use and/or discharge.

The EPC Contractor shall maximise water re-use in construction and commissioning.

The EPC Contractor will undertake a programme of surface and groundwater water monitoring across the site to establish the current conditions, and continue monitoring to ensure water quality adheres to the required quality criteria as detailed by RCER 2010 and any requirements associated with the RC permit to construct and/or operate. Long term trends should also be assessed using the results.

The EPC Contractor shall undertake appropriate studies to locate an appropriate discharge point for clean hydrotest water to ensure sufficient drainage capacity is available. The EPC Contractor shall control the flow rate of discharge in accordance with the drainage capacity and any other conditions applied by the RC.

The contractor will undertake regular audits of the above management plans to confirm their ongoing effectiveness.

A9.0 KEY PERFORMANCE INDICATORS (KPI)

Ma’aden shall implement a monitoring and reporting strategy for the in the form of KPIs. These can be grouped into four main categories:

• Resource use - water, gas, raw materials
• Emissions to land – industrial waste (hazardous and non-hazardous)
• Emissions to air – Nitrogen oxide, sulphur dioxide, hydrogen fluoride, greenhouse gases
• Emissions to water – nutrients and inorganic pollutants, heat

Example KPIs from the current RAK Operations are provided in figure A2 below. The KPIs will be developed through detailed design and implemented for both Construction and Operation.
**Ammonia Plant**

<table>
<thead>
<tr>
<th>EHS Key Performance Metric</th>
<th>Definition-Guidance (To ensure consistency &amp; understanding)</th>
<th>Target</th>
<th>Primary Performance Outcome</th>
<th>Reporting Responsibility</th>
<th>Report Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reportable Smoking Flares</td>
<td>&gt;5 minutes within any 2 hour period (Incident Report required)</td>
<td>4 events per month</td>
<td>Compliance</td>
<td>Shift Supervisor</td>
<td>Monthly</td>
</tr>
<tr>
<td>Conversion Efficiency of Natural Gas to ammonia</td>
<td>Conversion of 29 MBTU/t</td>
<td>80% of the time during normal operations</td>
<td>Resource Conservation</td>
<td>Plant Manager</td>
<td>Monthly</td>
</tr>
<tr>
<td>Wastewater from the Ammonia Plant WWTP (oily water)</td>
<td>Compliance with the irrigation water quality standard</td>
<td>100%</td>
<td>Compliance</td>
<td>Shift Supervisor</td>
<td>Monthly</td>
</tr>
</tbody>
</table>

**Diammonium Phosphate Plant (DAP)**

<table>
<thead>
<tr>
<th>EHS Key Performance Metric</th>
<th>Definition-Guidance (To ensure consistency &amp; understanding)</th>
<th>Target</th>
<th>Primary Performance Outcome</th>
<th>Reporting Responsibility</th>
<th>Report Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH₃ and HF Emissions</td>
<td>Particulate Matter: 50 mg/Nm³, NH₃: 50 mg/Nm³, HF: 5 mg/Nm³</td>
<td>100% during normal operations</td>
<td>Compliance</td>
<td>Shift Supervisor</td>
<td>Monthly</td>
</tr>
</tbody>
</table>

**Power and Utilities**

<table>
<thead>
<tr>
<th>EHS Key Performance Metric</th>
<th>Definition-Guidance (To ensure consistency &amp; understanding)</th>
<th>Target</th>
<th>Primary Performance Outcome</th>
<th>Reporting Responsibility</th>
<th>Report Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling Water</td>
<td>Increase in return water temperature may have an impact on the marine environment</td>
<td>90% of the time: delta T has to be &lt; 10 deg C</td>
<td>Compliance</td>
<td>Shift Supervisor</td>
<td>Monthly</td>
</tr>
<tr>
<td>Irrigation Water Quality</td>
<td>Non compliance may have an impact on the plants or on the health.</td>
<td>Residual Chlorine, TSS and BOD</td>
<td>Compliance</td>
<td>Shift Supervisor</td>
<td>Weekly</td>
</tr>
</tbody>
</table>

*Figure A2: Example KPIs from the current RAK facility (to be adapted for use in the proposed facility).*
Examples of applicable socio-economic KPIs can include:

- percentage of suppliers employment from the local workforce;
- percentage of construction workforce from within the local or provincial area;
- percentage of operational workforce from within the local or provincial area;
- number of students / school leavers in receipt of Ma’aden sponsored vocational training; and
- percentage of operational workforce trained with transferable industry skills.

A10.0 ENVIRONMENTAL MONITORING & MANAGEMENT IMPLEMENTATION PLANS

The Implementation Plans outlined in Attachment 4 provide a detailed list of the environmental recommendations and mitigation identified in the ESIA for implementation on site at each phase of the Project. The Implementation Plans are live documents and shall be developed throughout the Project lifetime to ensure the project delivers to the required standards and objectives.

The Implementation Plans, where appropriate, include assumptions that have been made in the development of the ESIA assessment where non-compliance with these assumptions may change the overall assessment (e.g. air quality, noise and mobile plant etc.). Recommendations and/or actions identified in the ESIA to deliver positive/beneficial impacts are also identified.

The Implementation Plans shall be revised to include any recommendations or conditions from the RC and/or lending institution upon authorisation of the project. They shall also include any conditions relating to environmental protection, enhancement monitoring or management associated with any permits or permissions from other statutory authorities as the project progresses.

A11.0 EMMR CONCLUSIONS

This EMMR has been developed based on the current known design of the project and associated Environmental and Social Impact Assessment of the Project.

The successful delivery of the EMMR is dependent upon:

- Effective project communications, both internal and external;
- Comprehensive and on-going environmental awareness training for all staff tailored to their role;
- Engagement of Environmental Engineers in all stages of the project to design out potential environmental issues and design in effective mitigation and management procedures.
- Development of comprehensive management plans and method statements for specific environmental issues (e.g. air quality etc.); and
- Rigorous on-site management of environmental issues and compliance with the site rules;

This EMMR shall be reviewed and updated throughout the lifetime of the Project to incorporate design and legislative changes, and changes in the environmental objectives of Ma’aden.
## ATTACHMENT 1 – RELEVANT LEGISLATION

<table>
<thead>
<tr>
<th>Reference Number</th>
<th>Legislation/ Guidance</th>
<th>Applicable Section</th>
<th>Summary of relevant environmental aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air Quality and Dust</strong></td>
<td>A01 Royal Commission Environmental Regulations 2010, Volume I</td>
<td>Section 2</td>
<td>Regulation and Standards - includes all regulations, standards and guidelines required to operate an industrial facility in a manner which protects the environment and public health.</td>
</tr>
<tr>
<td></td>
<td>A02 Royal Commission Environmental Regulations 2010, Volume II</td>
<td>All</td>
<td>Consolidated Permit Program - sets out the steps to be followed to obtain the necessary &quot;Environmental Permit to Construct and the &quot;Environmental Permit to Operate&quot; from the RC in order to construct and operate industrial and other facilities within the industrial cities.</td>
</tr>
<tr>
<td></td>
<td>A03 Royal Commission Environmental Regulations 2010, Volume III</td>
<td>All</td>
<td>Penalty System - sets out the penalty system in event of non-compliance.</td>
</tr>
<tr>
<td></td>
<td>A04 IFC Performance Standard 3: Resource Efficiency and Pollution Prevention</td>
<td>All</td>
<td>Guiding Principles for the management of emissions and prevention of pollution.</td>
</tr>
<tr>
<td></td>
<td>A05 IFC General EHS Guidelines (2007)</td>
<td>Section 1.1</td>
<td>Ambient Air Standards and standards for emissions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 2.4</td>
<td>Air Quality Standards for Occupational Health</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 4.1</td>
<td>Guidelines for Construction Air Quality Management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 4.2</td>
<td>Guidelines for Construction Dust Management (Occupational Health)</td>
</tr>
<tr>
<td></td>
<td>A06 Equator Principle 2: Environmental and Social Assessment.</td>
<td>All</td>
<td>Guiding Principles for environmental assessment</td>
</tr>
<tr>
<td></td>
<td>A07 Equator Principle 10: Reporting and Transparency</td>
<td>All</td>
<td>Guiding Principles for the communication of environmental assessment findings and operational greenhouse gas emissions (as appropriate for Category B projects)</td>
</tr>
<tr>
<td><strong>Noise and Vibration</strong></td>
<td>B01 Royal Commission Environmental Regulations 2010, Volume I</td>
<td>Section 7</td>
<td>Regulation and Standards - includes all regulations, standards and guidelines required to operate an industrial facility in a manner which protects the environment and public health.</td>
</tr>
</tbody>
</table>
### Reference Number | Legislation/ Guidance | Applicable Section | Summary of relevant environmental aspects
--- | --- | --- | ---
B02 | Royal Commission Environmental Regulations 2010, Volume II | All | Consolidated Permit Program - sets out the steps to be followed to obtain the necessary “Environmental Permit to Construct and the “Environmental Permit to Operate” from the RC in order to construct and operate industrial and other facilities within the industrial cities.
B03 | Royal Commission Environmental Regulations 2010, Volume III | All | Penalty System - sets out the penalty system in event of non-compliance.
B05 | BS 5228:2009 Part 1 | All | Guidelines for Construction Noise and mitigation
B06 | BS 5228:2009 Part 2 | All | Guidelines for Construction vibration and mitigation

#### Water Management

<table>
<thead>
<tr>
<th>Reference Number</th>
<th>Legislation/ Guidance</th>
<th>Applicable Section</th>
<th>Summary of relevant environmental aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>C01</td>
<td>Royal Commission Environmental Regulations 2010, Volume I</td>
<td>Section 3</td>
<td>Includes all regulations, standards and guidelines required to operate an industrial facility in a manner which protects the environment and public health.</td>
</tr>
<tr>
<td>C02</td>
<td>Royal Commission Environmental Regulations 2010, Volume II</td>
<td>All</td>
<td>Consolidated Permit Program - sets out the steps to be followed to obtain the necessary “Environmental Permit to Construct and the “Environmental Permit to Operate” from the RC in order to construct and operate industrial and other facilities within the industrial cities.</td>
</tr>
<tr>
<td>C03</td>
<td>Royal Commission Environmental Regulations 2010, Volume III</td>
<td>All</td>
<td>Penalty System - sets out the penalty system in event of non-compliance.</td>
</tr>
<tr>
<td>C04</td>
<td>IFC Performance Standard 3: Resource Efficiency and Pollution Prevention</td>
<td>All</td>
<td>Guiding Principles for the management of water and prevention of pollutions.</td>
</tr>
<tr>
<td>C05</td>
<td>IFC General EHS Guidelines (2007)</td>
<td>Section 1.3</td>
<td>Guidelines and standards for wastewater treatment and water quality management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 1.4</td>
<td>Guidelines and standards for the recycling and re-use of water.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 2.1</td>
<td>Guidelines for the supply of potable water, and water provision under occupation Health.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 3.1</td>
<td>Guidelines on the protection of water quality and quantity for the Community</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 4.1</td>
<td>Guidelines for the management of wastewater during construction.</td>
</tr>
<tr>
<td>Reference Number</td>
<td>Legislation/ Guidance</td>
<td>Applicable Section</td>
<td>Summary of relevant environmental aspects</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------------</td>
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<td>------------------------------------------</td>
</tr>
<tr>
<td><strong>Contaminated Land</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D01</td>
<td>Royal Commission Environmental Regulations 2010, Volume I</td>
<td>Section 5</td>
<td>Includes all regulations, standards and guidelines required to operate an industrial facility in a manner which protects the environment and public health.</td>
</tr>
<tr>
<td>D02</td>
<td>Royal Commission Environmental Regulations 2010, Volume II</td>
<td>All</td>
<td>Consolidated Permit Program - sets out the steps to be followed to obtain the necessary “Environmental Permit to Construct and the “Environmental Permit to Operate” from the RC in order to construct and operate industrial and other facilities within the industrial cities. Also the groundwater monitoring regulations.</td>
</tr>
<tr>
<td>D03</td>
<td>Royal Commission Environmental Regulations 2010, Volume III</td>
<td>All</td>
<td>Penalty System - sets out the penalty system in event of non-compliance.</td>
</tr>
<tr>
<td>D04</td>
<td>IFC General EHS Guidelines (2007)</td>
<td>Section 1.5</td>
<td>Guidelines and standards for the management of hazardous materials onsite (including pollution prevention)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 1.6</td>
<td>Guidelines for the management of small quantities of hazardous materials (e.g. oils, batteries etc)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 1.8</td>
<td>Management of Contaminated Land (principals and guidelines)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 2.4</td>
<td>Management of hazardous materials (storage and use) for Occupational Health</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 4.1</td>
<td>Construction management of contaminated land and use of hazardous materials.</td>
</tr>
<tr>
<td><strong>Ecological Management</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E01</td>
<td>IFC Performance Standard 3: Resource Efficiency and Pollution Prevention</td>
<td>All</td>
<td>Guiding Principles for the management of resources and prevention of pollution.</td>
</tr>
<tr>
<td>E02</td>
<td>IFC Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources</td>
<td>All</td>
<td>Guiding Principles for the protection and management of biodiversity, habitats, and ecosystem services</td>
</tr>
<tr>
<td>E03</td>
<td>KSA Royal Decree M/22 (1406)</td>
<td>All</td>
<td>Framework for the establishment of the Saudi Wildlife Authority</td>
</tr>
<tr>
<td>E04</td>
<td>KSA royal Decree M/12 (1415)</td>
<td>All</td>
<td>Provides legislation for the development of a system of protected areas, and regulations for the continued protection of wildlife and habitats.</td>
</tr>
<tr>
<td>Reference Number</td>
<td>Legislation/ Guidance</td>
<td>Applicable Section</td>
<td>Summary of relevant environmental aspects</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------------------------------------------------------------------</td>
<td>--------------------</td>
<td>-------------------------------------------</td>
</tr>
</tbody>
</table>

**Waste Management**

| F01              | Royal Commission Environmental Regulations 2010, Volume I                              | Section 5          | Includes all regulations, standards and guidelines required to operate an industrial facility in a manner which protects the environment and public health. |
| F02              | Royal Commission Environmental Regulations 2010, Volume II                             | All                | Consolidated Permit Program - sets out the steps to be followed to obtain the necessary “Environmental Permit to Construct and the “Environmental Permit to Operate” from the RC in order to construct and operate industrial and other facilities within the industrial cities. |
| F03              | Royal Commission Environmental Regulations 2010, Volume III                            | All                | Penalty System - sets out the penalty system in event of non-compliance. |
| F04              | IFC General EHS Guidelines (2007)                                                     | Section 1.5         | Guidelines and standards for the management of hazardous materials |
|                  |                                                                                        | Section 1.6         | Guidelines and standards for the management of waste on site (including waste minimisation, storage and transport) |
|                  |                                                                                        | Section 3.5         | Guidelines for the protection of community health from transport of hazardous waste |
|                  |                                                                                        | Section 3.7         | Emergency Preparedness |
|                  |                                                                                        | Section 4.          | Construction management of waste, hazardous waste and occupational HSE. |
| F05              | IFC Performance Standard 3: Resource Efficiency and Pollution Prevention               | All                | Guiding Principles for the management of resources and prevention of pollution (including management of hazardous materials). |

**General legislation**

<p>| G01              | Royal Commission Environmental Regulations 2010, Volume I, II and III                 | All                | Provides definitions and general guidance on minimising impacts |
| G02              | IFC Performance Standard 1: Assessment and management of Environmental and Social risks and impacts | All | Provides general guidance on the processes and procedures for the assessment and management of environmental impacts including stakeholder consultation |</p>
<table>
<thead>
<tr>
<th>Reference Number</th>
<th>Legislation/ Guidance</th>
<th>Applicable Section</th>
<th>Summary of relevant environmental aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>G03</td>
<td>IFC Performance Standard 2; Labour and Working conditions</td>
<td>All</td>
<td>Provides definitions and general guidance on minimum standards for employment of workforce</td>
</tr>
<tr>
<td>G04</td>
<td>IFC Performance Standard 4; Community Health Safety and Security.</td>
<td>All</td>
<td>Provides definitions and general guidance on managing impacts on the local community including degradation of ecosystem services and emergency response.</td>
</tr>
<tr>
<td>G05</td>
<td>World Bank Environmental Assessment Sourcebook Update: Environmental Management Plans</td>
<td>All</td>
<td>Provides guidelines on the production, contents and implementation of environmental management plans</td>
</tr>
<tr>
<td>G06</td>
<td>World Bank Environmental Assessment Sourcebook Update: Public Consultation in the EA process: A Strategic Approach</td>
<td>All</td>
<td>Provides guidelines on the engagement of the local community and stakeholders</td>
</tr>
<tr>
<td>G07</td>
<td>IFC/EBRD: Workers’ accommodation: processes and standards. A guidance note by IFC and the EBRD</td>
<td>All</td>
<td>Guidance on the standards and requirements on the provision of workforce accommodation</td>
</tr>
<tr>
<td>G08</td>
<td>IFC General EHS Guidelines (2007)</td>
<td>Section 2.2 Section 4.2</td>
<td>Guidelines for the provision of HSE training and Awareness, traffic management and safety</td>
</tr>
<tr>
<td>G09</td>
<td>KSA Labor Law (2005)</td>
<td>All</td>
<td>Defines the working conditions and minimum welfare required for employment of all people within KSA</td>
</tr>
<tr>
<td>G10</td>
<td>ICMM Sustainable Development Framework (2012)</td>
<td>All</td>
<td>Defines the 10 overarching principles for ensuring sustainable development on mining projects.</td>
</tr>
<tr>
<td>G11</td>
<td>KSA 9th Development Framework</td>
<td>All</td>
<td>Outlines the development programme to ensuring sustainable economic growth in KSA.</td>
</tr>
<tr>
<td>G12</td>
<td>IFC Performance Standard 8: Cultural Heritage</td>
<td>All</td>
<td>Provides guidelines on identification of cultural heritage and outlines guiding principles for its’ protection</td>
</tr>
<tr>
<td>G13</td>
<td>IFC Performance Standards 1 - 8</td>
<td>All</td>
<td>Designed to help avoid, mitigate, and manage risks and impacts as a means of doing business in a sustainable way.</td>
</tr>
<tr>
<td>G14</td>
<td>Equator Principles 1 - 10</td>
<td>All</td>
<td>Based on the IFC Performance Standards, the Equator Principles provide a risk framework for identifying, assessing, and managing environmental and social risks in project finance transactions.</td>
</tr>
</tbody>
</table>
ATTACHMENT 2 – MA’ADEN CORPORATE ENVIRONMENTAL POLICY

Ma’aden Phosphate Company

Environmental Policy Statement

As the largest producer of phosphate fertilizers in Saudi Arabia, Maaden Phosphate Company (MPC) recognizes the critical role it plays in the management of health and safety at work and protection of the environment as a whole. MPC is committed to achieving and maintaining excellence in all aspects of its operations. Naturally, excellence in our environmental management is integral to the way we do business, and further reflects our accountability concerning active stewardship and progress towards sustainable development.

This policy provides the foundation for our company’s overriding commitment not only to protecting our environment but also to continually improve our environmental performance in our operations in Ras Al Khair and in Jalamid.

To achieve this, we are committed to:

- Meet and, where appropriate, exceed applicable environmental regulations, standards, guidance and codes of practice;
- Prevent or minimize environmental pollution, conserve natural resources and raw materials, minimize waste, and value cultural heritage;
- Use processes, practices, materials, products, substances or energy that avoid or minimize the creation of pollutants and waste and reduce the overall risk to the environment or human health;
- Provide a working environment which promotes and encourages environmental performance;
- Identify and implement pollution prevention options to minimize pollutants or waste generation through recycling, treatment and other measures needed to meet environmental goals, including areas not subject to regulations;
- Encourage reporting of all environmental incidents and investigate them to prevent their reoccurrence;
- Integrate environmental considerations into decision-making and business planning processes;
- Provide resources to achieve our performance targets and empower people to comply with this policy;
- Identify and assess environmental risks and ensure that wherever possible, risks and hazards are eliminated, combated or minimized;
- Set measures and review our environmental performance targets and objectives, benchmarking against best international standards;
- Maintain an environmental management system aligned with internationally recognized standards and leading industry practice;
- Provide appropriate training, sufficient information, instruction, training and supervision for employees to enable them to carry out their tasks competently and safely;
- Ensure that all employees contribute and take responsibility for their own and others health and safety by reporting at-risk behavior, hazardous conditions and environmental non-conformances, and taking the necessary preventive and mitigation action;
- Communicate with, and engage employees, contractors, suppliers, government agencies and visitors to share the responsibility for meeting this policy;
- Share our environmental experiences with the community and promote environmental awareness in the communities surrounding our facilities.

Our environmental performance is measured through a number of means such as self, internal and external auditing to confirm and improve our performance against the requirements of this policy.

This policy will be reviewed periodically to remain fully relevant to the needs of our stakeholders and will be communicated to everyone who is associated with us and publicly through our website.

Abdulaziz Al-Harbi
President
December 2010
Ras Al Khair Proposed Industrial Complex Layout - Process Area Layout

Project Name:
UMM WU'AL PHOSPHATE PROJECT
Ras Al Khair Proposed Industrial Complex Layout – Port Loading / Unloading Area Layout
### ATTACHMENT 4 - ENVIRONMENTAL MONITORING AND MANAGEMENT IMPLEMENTATION PLANS

The following Implementation Plans provide a detailed list of the environmental mitigations and recommendations identified in the ESIA for implementation on site at each phase of the Project. The Implementation Plans are live documents and shall be developed throughout the Project lifetime to ensure the project delivers to the required standards and objectives. The ESIA should be referred to for further detail on the various impacts and mitigation measures identified. The Implementation Plans shall be revised to include any conditions or recommendations from the Royal Commission and/or lending institution upon authorisation of the Project. They shall also include any conditions relating to environmental protection, enhancement monitoring or management associated with any permits or permissions from other statutory authorities as the Project progresses.

### DETAILED DESIGN IMPLEMENTATION PLAN

The Detailed Design Phase Implementation Plan provides a list of actions to be undertaken during the detailed design phase of the Project in order to mitigate impacts identified through the ESIA for each phase of the Project. Actioning this Implementation Plan supports compliance with regulatory requirements and the mitigation of impacts in latter phases of the Project.

<table>
<thead>
<tr>
<th>Impact ID</th>
<th>Impact Description</th>
<th>Action</th>
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<th>Further information</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>Sustainable Development</td>
<td>Continue to identify potential sustainability benefits through detailed design, specifically opportunities in line with Ma'aden corporate policy including: · Prevent or minimise environmental pollution, conserve natural resources, minimise waste, progressively rehabilitate impacts, and value cultural heritage. · Use cleaner energy and constantly improve the energy and material efficiency of operation. · Application of existing Ma'aden project processes, specifically the Environmental and Communities Assurance Manual · Establishment of objectives, targets and KPIs to monitor achievement of goals established for the Project and progress towards sustainable development; · Implementation of mitigation and recommended measures proposed within the ESIA, and the resultant EMMP and all procedures and plans developed to support the EMMP; and · Implementation of continuous improvements as identified by Ma'aden's Environmental Management System and associated monitoring, measurement, auditing.</td>
<td>Ma'aden</td>
<td>ESIA Section 16 G01; G10; G11</td>
</tr>
<tr>
<td>N/A</td>
<td>Equator Principles and IFC Performance Standards</td>
<td>The project commitments outlined in Tables 2-1 and 2-2 of the ESIA Section 2 Policy, Legal and Administrative Framework will be implemented / monitoring / reviewed as appropriate during the life of the project.</td>
<td>Ma'aden</td>
<td>ESIA Section 2, Ma'aden corporate policies and procedures G13, G14</td>
</tr>
<tr>
<td>N/A</td>
<td>Best Available Techniques</td>
<td>Contractors to assess and document BAT throughout Detailed Design in consultation with Ma'aden as appropriate.</td>
<td>Contractor, Ma'aden</td>
<td>ESIA Section 3, Ma'aden corporate policies and procedures G01</td>
</tr>
<tr>
<td>N/A</td>
<td>Communications and Training</td>
<td>Develop / implement / maintain a Stakeholder Engagement Plan (a framework of which is provided in Appendix C of the ESIA) including a grievance mechanism.</td>
<td>Ma'aden</td>
<td>Ma'aden corporate policies and procedures; ESIA Appendix C G02, G06</td>
</tr>
<tr>
<td><strong>Air Quality and Meteorology</strong></td>
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<tr>
<td>AQ3 – 10</td>
<td>Operational emission of NOx, CO, SO2, PM10, NH3, HF, Fugitive Emissions, GHG</td>
<td>Ensure compliance with the standards outlined within the ESIA, specifically RCER-2010, Volume I, Section 2: Air Environment through detailed design.</td>
<td>Contractor; Ma'aden</td>
<td>ESIA Section 2 and Section 6 A01, A02, A05</td>
</tr>
<tr>
<td>AQ7</td>
<td>Fluorides</td>
<td>Ma'aden shall consider and make available this ESIA for use in cumulative impact assessments of future developments of the Industrial City.</td>
<td>Contractor; Ma'aden</td>
<td>ESIA Section 6.3.4 A01, A02</td>
</tr>
<tr>
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</table>
| AQ10      | Operational Greenhouse Gas (GHG) Emissions – Ammonia Plant                          | Document a full BAT analysis to demonstrate that best available techniques are used to capture CO\textsubscript{2} emissions. This process is to include expansion on the alternatives discussed in Section 3 Consideration of Alternatives including the following:  
• Investigate design options for reducing greenhouse gas emissions and consider other options for the capture and use of CO\textsubscript{2}.  
• Reduce CO\textsubscript{2} emissions during the design period where possible using BAT.  
• Record BAT assessment findings. | FEED Contractor; EPC Contractor; Ma’aden | ESIA Section 6.3.4  
A04, A05, A06, A07 |
| NV1 – 7   | Operational Noise                                                                  | Ensure compliance with the standards outlined within the ESIA, specifically RCER-2010, Volume I, Section 9: Noise through detailed design.                                                             | Contractor; Ma’aden                                  | ESIA Section 2 and Section 9  
B01, B02, B04 |
| WQ7       | Impact of Contaminated Water on Wastewater Systems                                  | The FEED / EPC Contractor for the cooling tower should consult with Contractors for other Packages to consider options for the reuse of uncontaminated stormwater to treat process area storm water and/or demineralised water regeneration effluents. Ma’aden to facilitate this as required. | Contractor; Ma’aden                                  | ESIA Section 11  
C01 |
| HS06      | Occupational HSE impacts on the Workforce (accident/injury & disease)              | Undertake early engagement with local service providers to assess the capacity of the region to absorb any potential issues. This will inform the design and staffing of the facilities to ensure local services are not adversely affected.  
This consultation shall include all emergency services to ensure agreement is reached on the most effective mechanisms to deal with any major incident, including any evacuation to hospitals in Jubail Industrial City. | Contractor                                          | ESIA Section 15  
G01, G08, G09 |
## Construction Implementation Plan

<table>
<thead>
<tr>
<th>Impact ID</th>
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</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>General Project Wide</td>
<td>Management of Construction Impacts</td>
<td>Develop and implement a Construction Environmental Management Plan (CEMP)</td>
</tr>
<tr>
<td>N/A</td>
<td>Sustainable Development</td>
<td></td>
<td>Continue to identify potential sustainability benefits through construction, specifically opportunities in line with Ma'aden corporate policy including:</td>
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<td>• Prevent or minimise environmental pollution, conserve natural resources, minimise waste, progressively rehabilitate impacts, and value cultural heritage.</td>
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<td>• Use cleaner energy and constantly improve the energy and material efficiency of operation.</td>
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<td>• Application of existing Ma'aden project processes, specifically the Environmental and Communities Assurance Manual.</td>
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<td>• Establishment of objectives, targets and KPIs to monitor achievement of goals established for the Project and progress towards sustainable development;</td>
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<td>• Implementation of mitigation and recommended measures proposed within the ESIA, and the resultant EMMP and all procedures and plans developed to support the EMMP; and</td>
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<td></td>
<td>• Implementation of continuous improvements as identified by Ma'aden’s Environmental Management System and associated monitoring, measurement, auditing.</td>
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<tr>
<td>N/A</td>
<td>Equator Principles and IFC Performance Standards</td>
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<td>The project commitments outlined in Tables 2-1 and 2-2 of the ESIA Section 2 Policy, Legal and Administrative Framework will be implemented / monitoring / reviewed as appropriate during the life of the project.</td>
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<td>N/A</td>
<td>Communications and Training</td>
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<td>Develop / implement / maintain a Stakeholder Engagement Plan (a framework of which is provided in Appendix C of the ESIA) including a grievance mechanism.</td>
</tr>
<tr>
<td>AQ1</td>
<td>Air Quality</td>
<td>Construction Dust Emissions</td>
<td>Development and implementation of the CEMP to consider measures such as:</td>
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<td>• During transport, covering all dust generating stockpiled materials with a suitable weighted tarpaulin;</td>
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<td>• Establishment of pedestrian routes within the construction area to be used by workers;</td>
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<td>• Minimise the amount of materials stockpiled as far as is practicable, with any required stockpiles aligned parallel to the prevailing wind direction;</td>
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<td></td>
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<td>• Covering of any exposed soils in heavily trafficked areas such as roads or carparks with gravel or crushed stone to reduce wind blown dust generation;</td>
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<td>• A reduced construction site speed limit to prevent the generation of large dust clouds from vehicles;</td>
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<td>• Subject to water availability and the time of the year, surface spraying of road surfaces with water and a soil binding agent;</td>
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<td>• Periodic grading of any uneven surfaces that arise on construction traffic routes.</td>
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<td>Prior to commencement of construction activities, development of an Air Quality &amp; Dust Monitoring Plan should be considered as part of the CEMP to ensure appropriate on-site mitigation measures are implemented.</td>
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</table>
### Terrestrial Environment

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>TE1</td>
<td>Loss of soil resource during construction</td>
<td>Soils should be stored and reused on site as part of the Project design.</td>
<td>Contractor</td>
</tr>
<tr>
<td>TE3</td>
<td>Dewatering of Excavations and Discharge to Sea during construction</td>
<td>Analysis and pre-treatment of water prior to discharge to sea, if required, to achieve RCER-2010 discharge standards.</td>
<td>Contractor</td>
</tr>
<tr>
<td>TE4</td>
<td>Degradation of soil and groundwater quality due to accidental spills during construction</td>
<td>The EPC Contractor shall develop, implement and maintain a construction phase EERP and CEMP, including: • Minimum technical standard of construction plant; • Competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency (including accidental releases of hazardous substances); • Procedures to be implemented following an accidental release of hazardous substances, e.g. during refuelling, including details of measures to be adopted to stop, contain as far as practicable on site, and clean up spills, and to inform the relevant authorities in the event that a spill migrates (or occurs) off-site so that appropriate regional plans can be activated; and • Availability of pumps and spill mitigation materials such as absorbent granules to contain and recover hazardous substances releases. Prior to construction of the facility, the EPC Contractor shall conduct an investigation of the soil and groundwater (using existing well data where available) quality at the site shall be completed to complement the current understanding of the local conditions and to enable the evaluation of the potential impact of the presence and operation of the facility on the terrestrial environment over the lifetime of the Project. This shall include the construction of permanent groundwater monitoring wells where required. The project Proponent shall prepare and submit a Permit Application for authorisation to construct groundwater monitoring wells (PA-W9) in accordance with RCER-2010 Volume II. Regular audits of the implemented management plans should be undertaken to confirm their ongoing effectiveness.</td>
<td>Contractor</td>
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</tbody>
</table>

### Biological Resources

<table>
<thead>
<tr>
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<tr>
<td>E1 - 4</td>
<td>Impact on Flora and Fauna</td>
<td>Updates to the construction phase EERP and CEMP should consider the following: • Include an overview of the ecological value and sensitivity of the Project area in contractor’s Site Induction. This should include guidance on species identification and actions to take if encountered within Project area; • Restrict clearance works to minimum requisite area; • Restrict vehicle movements to defined haul / access routes to minimise risk of wildlife collisions with vehicles; • Enforce speed limits on and around the Project area. Anti-nesting devices should be installed to deter birds (birds have previously been found stuck in vents).</td>
<td>Contractor</td>
</tr>
</tbody>
</table>
## Noise and Vibration

**NV1** Noise Impacts on Off-Site Sensitive Receptors

All construction works to comply with international standards for construction noise (e.g. BS 5228: 2009 - "Code of practice for noise and vibration control on construction and open sites"). Reduced noise limits to be adhered to where night time construction is being undertaken.

Vehicle Movements to be reduced as far as practicable.

- Undertake a noise and vibration assessment to identify the specific need for noise mitigation and ensure compliance with applicable standards. Noise and Vibration Plan to be developed prior to commencing construction activities. The Noise and Vibration Management Plan to detail measures to control noise and vibration emissions during construction and detail the monitoring to be undertaken. Development and implementation of the Plan should consider the following:
  - Details of the noise monitoring programme and procedures for its implementation;
  - Monitoring of noise to determine compliance with applicable standards and guidelines and assess the need for mitigation;
  - Results of the updated noise modelling (where applicable);
  - Use of temporary sound-proof enclosures and anti-vibration measures shall be employed if required to reduce noise levels on site, in keeping with the results of the updated noise and vibration model;
  - Maintenance procedures of all equipment in place to minimise noise from equipment;
  - Programme and scope of regular audits of the management plan to confirm its on-going effectiveness;
  - Effective silencing of equipment where possible and compliance with any stated requirements of Ma'aden and the RC where appropriate;
  - Adherence to reduced noise limits where night time construction is proposed;
  - Vehicle Movements to be reduced as far as practicable;
  - Construction activities to comply with British Standards for Vibration;
  - Ensure that plant and equipment that is used intermittently will be shut down or throttled down to a minimum between work periods;
  - Ensure that plant and equipment are maintained and lubricated as per the manufacturer’s instructions to avoid friction noise etc.

**NV2** Vibration Impacts on Off-site Sensitive Receptors

**Waste Management**

**WM1** Generation of Inert, Non-Hazardous and Hazardous Wastes

A Waste Management Plan for defining how waste materials will be stored, handled and disposed of for the Construction Phase should be developed as a supporting document to the Environmental Management and Monitoring Plan (EMMP). The Construction Waste Management Plan shall be continually monitored and re-evaluated to ensure the effectiveness of the plan is maintained. This Plan should consider the following:

- All hazardous, non-hazardous, municipal and inert wastes to be stored, handled, transported, recycled, treated and disposed of as per RCER-2010.
- Transportation regulations (particularly those relating to hazardous materials) published by the Ministry of Transportation shall be complied with.
- A RC approved manifest to be prepared before any transportation of hazardous / non-hazardous wastes from site.

**WM2** Environmental Degradation due to Incorrect Storage / Spillage

- Minimise onsite waste storage times as much as practical (no longer than 180 days as per RCER-2010), and control access to stored wastes;
- Hazardous substances (including wastes) to be stored in appropriate containers, in appropriately bunded and impervious
## Impact ID | Impact Description | Action | Responsibility | Further information |
|------------|-------------------|--------|----------------|--------------------|
| WQ1 | Degradation of Coastal Water Quality Due to Construction-Related Surface Water Runoff / Accidental Spills | Prior to commencing construction activities, consultation with SEAPA shall take place to agree consultation and engagement procedures going forward relating to activities at the port. Surface water management systems to be designed to maintain separate collection, treatment and disposal for contaminated and uncontaminated water. Designated vehicle refuelling and maintenance areas to be established. Hazardous materials storage to be within bunded area with adequate capacity for volumes stored. Absorbents and secondary containment to contain and recover potential release of hazardous materials. Dedicated impervious area for wash out following concrete delivery. All wash water shall be contained for subsequent treatment and re-use and/or disposal to an approved location. EPC Contractor shall develop, implement and maintain a CEMP and construction phase EERP which should consider the following:  
• Surface water protection plan;  
• Minimum technical standard of construction plant;  
• Competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency;  
• Spill control procedures;  
• Procedures to be implemented following an accidental release of hazardous substances, e.g. during refuelling, including details of measures to be adopted to stop, contain as far as practical on site, and clean up spills, and to inform the relevant authorities in the event that a spill migrates (or occurs) off-site so that appropriate regional plans can be activated;  
• Availability of pumps and spill mitigation materials such as absorbent granules to contain and recover hazardous substances releases;  
• Management and inspection of vehicles/sub-contractors used to transfer sanitary wastewater from collection tanks. These must be fit for purpose and operated by trained members of staff;  
• Water use will be minimised where possible; and  
• Schedule for regular audits of construction activities to assess and report on the ongoing effectiveness of measure employed. Potentially contaminated wastewater arising from construction activities such as, but not limited to, concrete washes (high alkaline), wheel washes (high sediments), and other equipment/vehicle cleaning activities (potentially containing detergents) is not permitted to infiltrate groundwater or be discharged to the storm water system. All construction wastewaters shall be contained, stored and disposed of as per RCER-2010. | Contractor | ESIA Section 11.3.2 | C01, C02, C04, C05 |
<p>| WQ2 | Degradation of Coastal Water Quality Due to Construction-Related Shipping | All ship movements related to construction are required to comply with RCER-2010 clause 3.10 and the standards outlined in Table E with regards ballast water. Liaise with SEAPA as appropriate. | Contractor; Ma’aden | ESIA Section 11.3.2 | C01, C02, C04, C05 |</p>
<table>
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<tbody>
<tr>
<td>W03</td>
<td>Impact of Contaminated Water on Wastewater Systems</td>
<td>Industrial waste water from construction (e.g. concrete washes etc) to be handled and disposed as per RCER-2010.</td>
<td>Contractor</td>
<td>C01, C02, C04, C05</td>
</tr>
<tr>
<td>CI6</td>
<td>Cumulative Impacts on Water Management</td>
<td>Continue to support liaison with other developers (specifically SEAPA with regards the port expansion) to ensure water use is minimised and potential physical and pollution impacts on existing water systems are effectively managed.</td>
<td>Ma'aden</td>
<td>C01, C02, C03, C04, C05</td>
</tr>
</tbody>
</table>

**Socio-Economic Aspects**

| SE01     | Community, Health, Safety and Security                                              | In consultation with Ma’aden, the EPC Contractor to develop and maintain grievance mechanism so that the resident worker ‘communities’ have a means of communicating any concerns regarding the facility’s construction. EPC Contractor to provide induction training to all foreign workers and non-Muslim workers on the local culture and practices that are acceptable and unacceptable. In addition, camp management procedures will be established to minimise interactions and possible tensions with the local communities. Ma’aden should work closely with the contractors and Royal Commission to develop hazard prevention programmes (e.g. road traffic accidents). | Contractor; Ma’aden | G02, G06             |
| SE02     | Degradation of Cultural Heritage                                                    | Develop protocol to be followed in the event of a discovery of archaeological features or artefacts. This would include contact details for the appropriate representatives at Saudi Commission for Tourism and Antiquities, Ma’aden, Royal Commission and/or other relevant stakeholders who can document and preserve the findings if necessary.                                                                                   | Contractor        |                     |
| CI7      | Cumulative impacts on Socio-economics                                               | Continue to work with the Royal Commission and Ministries to realise economic and social benefits associated with the wider development and cultural uses of the land.                                                                                                               | Ma’aden           | G01 - G12           |

**Traffic and Transport Infrastructure**

<p>| TI1      | Construction impacts on Road Infrastructure                                         | Conduct a Traffic and Logistics Study and prepare a Traffic and Transportation Management Plan in consultation with Ma’aden Project Management Team and the RC prior to commencement of construction, and is to include: • Responsibility and procedures for co-ordination and liaison with SEAPA, SAR and the Ministry of Transport as appropriate during construction; • Identify any temporary re-routing of traffic, procedures for managing delivery transportation companies, e.g. to avoid peak traffic times when delivering bulk material and equipment; • Procedures for staggering start and finish times where feasible to reduce peak traffic flows; • Confirmation of capacity within the rail network and availability of trains to deliver materials required during construction; • Confirmation of the capability for Ras Al Khair Industrial Port to accept equipment and materials required for construction; • Outcomes of traffic risk assessments undertaken; • Access routes for construction plant and materials; • Transport routes for the workforce (on arrival to and departure from the accommodation, and between accommodation and the work areas); • On-site traffic management; • Measures to segregate pedestrians from vehicle areas; • Training and awareness;                                                                                                                | Contractor       | G08                 |</p>
<table>
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<tbody>
<tr>
<td>TI2</td>
<td>Construction impacts on Rail Infrastructure</td>
<td>Ma’aden will continue to engage with SAR and SEAPA as appropriate to manage construction-related interfaces.</td>
<td>Ma’aden</td>
<td>ESIA Section 13.3.2</td>
</tr>
<tr>
<td>TI3</td>
<td>Construction impacts on Ports Infrastructure and Shipping</td>
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</table>

### Utilities Infrastructure

<table>
<thead>
<tr>
<th>UI1, UI2, UI3, UI4</th>
<th>Effects on water supply, power supply, waste water systems, and telecommunications</th>
<th>The construction phase EERP and the CEMP should consider the following:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Measures to protect the local community where appropriate;</td>
<td>• The supply of utilities during emergency situations, such as loss of grid power or water supply</td>
</tr>
<tr>
<td></td>
<td>• Schedule of audits of the management plan to confirm its ongoing effectiveness.</td>
<td>• Ensure that utilities requirements are detailed and communicated throughout the construction and commissioning period to the relevant utility suppliers to ensure the timely provision of Project demands.</td>
</tr>
<tr>
<td></td>
<td>The construction camp to be located in a close proximity to the Ras Al Khair Industrial Complex to reduce the distances required for the transport of construction personnel. The CEMP to be developed for the Project should consider following as relevant to transport:</td>
<td>Prior to commencing construction activities, consult with existing MPC operators should take place to agree the necessary consultation and engagement procedures going forward. For example, it will be necessary to ensure that any tie-ins to the existing MPC utilities are communicated and agreed with MPC in advance of any connection. Also, the appropriate timings for such tie-ins to MPC utilities should be agreed, e.g. during low periods of current usage.</td>
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<td></td>
<td>• No vehicles should leave the site with materials adhering to the wheels in a quantity which may result in its being deposited on the public highway, and creating nuisance, or hazard to vehicles. Suitable wheel washing equipment to avoid such problems should be installed if appropriate, operated and maintained on the site until the development is completed.</td>
<td>• Ensure that good environmental practice is considered for the use of utilities infrastructure during all stages of Construction, including (but not limited to):</td>
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<td></td>
<td>• The use of locally won materials, such as sand and fill etc will be utilised wherever possible to reduce the requirement to import bulk materials from other locations reducing truck movements bringing this material from external locations.</td>
<td>− Minimising utility consumption, such as minimising wastage and unnecessary discharges;</td>
</tr>
<tr>
<td></td>
<td>• Schedule of audits to monitor and record how all utility usage, storage and discharges requirements are undertaken with consideration of RCER-2010.</td>
<td>− Minimisation of the use of diesel generators; and</td>
</tr>
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<td>• Take advantage of the existing MPC utilities where feasible, particularly for water supply and waste water treatment to reduce the amount of water or waste water which requires transportation from/to external sources (such as Jubail).</td>
</tr>
</tbody>
</table>

### Health and Safety Aspects

| HS01a | Impacts on Workforce regarding Air Quality | It is recommended that the EPC contractor conduct regular maintenance checks on mobile and fixed plant in relation to exhaust emissions. Any sandblasting activities required should be done in a controlled environment. | Contractor | ESIA Section 15.5 |

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*Project Name: UMM WU'AL PHOSPHATE PROJECT*
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<tr>
<td>HS03</td>
<td>Impacts on Workforce health regarding Contaminated Soils</td>
<td>Prior to commencing construction, undertake a soil sampling and analysis exercise with consideration of potential hazardous contaminants such as heavy metals. Utilise the results of the soil sampling to undertake a detailed health risk assessment identifying the HSE process and methods to be employed on site during construction to protect the workforce.</td>
<td>Contractor</td>
<td>ESIA Section 15.5, G01, G08</td>
</tr>
<tr>
<td>HS05b</td>
<td>Impacts on Community regarding Traffic</td>
<td>Provide training and awareness on issues such as defensive driving for the workforce. Regular maintenance checks on the vehicle conditions should be conducted. Training and awareness on issues such as defensive driving would be beneficial to the suppliers and contractors, given the high number of motor vehicles accidents in the KSA. Safety performance, procedures and processes, and safety records should form part of any supplier evaluation.</td>
<td>Contractor</td>
<td>ESIA Section 15.5, G01, G08</td>
</tr>
<tr>
<td>CI10</td>
<td>Cumulative Impacts on Health &amp; Safety</td>
<td>As a key stakeholder, continue to liaise with the Royal Commission and ministries as appropriate throughout future developments to support the management of community health effects</td>
<td>Ma’aden</td>
<td>ESIA Section 17, G01, G04, G08</td>
</tr>
</tbody>
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## COMMISSIONING IMPLEMENTATION PLAN

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<tr>
<td>General Project Wide</td>
<td>Continue to identify potential sustainability benefits through this phase, specifically opportunities in line with Ma'aden corporate policy including: • Prevent or minimise environmental pollution, conserve natural resources, minimise waste, progressively rehabilitate impacts, and value cultural heritage. • Use cleaner energy and constantly improve the energy and material efficiency of operation. • Application of existing Ma'aden project processes, specifically the Environmental and Communities Assurance Manual • Establishment of objectives, targets and KPIs to monitor achievement of goals established for the Project and progress towards sustainable development; • Implementation of mitigation and recommended measures proposed within the ESIA, and the resultant EMMP and all procedures and plans developed to support the EMMP; and • Implementation of continuous improvements as identified by Ma'aden’s Environmental Management System and associated monitoring, measurement, auditing.</td>
<td>Ma’aden</td>
<td>ESIA Section 16</td>
<td>G01; G10; G11</td>
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<td>N/A</td>
<td>Sustainable Development</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>N/A</td>
<td>Communications and Training</td>
<td>Develop / implement / maintain the Stakeholder Engagement Plan (a framework of which is provided in Appendix C of the ESIA) including a grievance mechanism.</td>
<td>Ma’aden</td>
<td>Ma’aden corporate policies and procedures; ESIA Appendix C</td>
</tr>
<tr>
<td>N/A</td>
<td>Equator Principles and IFC Performance Standards</td>
<td>The project commitments outlined in Tables 2-1 and 2-2 of the ESIA Section 2 Policy, Legal and Administrative Framework will be implemented / monitoring / reviewed as appropriate during the life of the project.</td>
<td>Ma’aden</td>
<td>ESIA Section 2, Ma’aden corporate policies and procedures</td>
</tr>
<tr>
<td>TE6</td>
<td>Accidental leaks from pipe connections during commissioning</td>
<td>The Contractor shall undertake HAZOP studies to identify process hazards for the facility, including during its commissioning, and further control measures will be developed and implemented as required following the identification of specific hazards. The Contractor shall update, implement and maintain the EERP and CEMP developed during the construction phase so they appropriately reflect the changes in the project and ensure their ongoing effectiveness. The EERP will include an updated spill response/ control plan. Updates should consider the following: • Competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency (including accidental releases of hazardous substances); • Procedures to be implemented following an accidental release of hazardous substances, including details of containment and recovery measures to be applied; and • Availability of pumps and spill mitigation materials such as absorbent granules to contain and recover hazardous substances releases. An adequate quantity of absorbents will be available to contain and recover potential releases of hazardous substances.</td>
<td>Contractor</td>
<td>ESIA Section 7.4.3.3</td>
</tr>
<tr>
<td>NV3</td>
<td>Noise &amp; Vibration Impacts on off-site receptors</td>
<td>Activities to comply with RCER-2010. Adhere to measures outlined in the Noise and Vibration Plan.</td>
<td>Ma’aden</td>
<td>ESIA Section 9.3.2</td>
</tr>
</tbody>
</table>

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Project Name: UMM WU'AL PHOSPHATE PROJECT
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<tr>
<th>Impact ID</th>
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</thead>
<tbody>
<tr>
<td>WQ4</td>
<td>Impacts on Water Quality (including hydrotesting and pre-treatment of cooling water)</td>
<td>Prior to pre-commissioning / commissioning, procedures outlining the proposed management, analysis, treatment and discharge/disposal methods and locations for hydrotest water, including justification for any chemical additives, shall be outlined in the EMMP. The Contractor shall liaise with MPC to confirm available capacity of the existing surface water ponds to accept the calculated volume of water requiring disposal. The volume of water to be used shall be minimised through careful planning of the hydrotest sequence and water reuse. The Contractor shall control the flow rate of discharge of hydrotest water to the receiving water body to avoid overloading the receiving system/s. The EERP developed during the construction phase shall be updated as appropriate to include for the management of hydrotest water and the use of the existing surface water ponds in the event of an emergency.</td>
<td>Ma'aden</td>
</tr>
<tr>
<td>CI6</td>
<td>Cumulative Impacts on Water Management</td>
<td>Continue to support liaison with other developers to ensure water use is minimised, and potential physical and pollution impacts on existing water systems are effectively managed.</td>
<td>Ma'aden</td>
</tr>
<tr>
<td>CI8</td>
<td>Cumulative Impacts on Traffic and Transportation</td>
<td>Continue to support Royal Commission regarding the development of shared transport, rail and road infrastructure appropriate to the needs of the wider area.</td>
<td>Ma'aden</td>
</tr>
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</table>
## OPERATIONS IMPLEMENTATION PLAN

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>N/A</td>
<td>Sustainable Development</td>
<td>Continue to identify potential sustainability benefits through this phase, specifically opportunities in line with Ma'aden corporate policy including: • Prevent or minimise environmental pollution, conserve natural resources, minimise waste, progressively rehabilitate impacts, and value cultural heritage. • Use cleaner energy and constantly improve the energy and material efficiency of operation. • Application of existing Ma'aden project processes, specifically the Environmental and Communities Assurance Manual • Establishment of objectives, targets and KPIs to monitor achievement of goals established for the Project and progress towards sustainable development; • Implementation of mitigation and recommended measures proposed within the ESIA, and the resultant EMMP and all procedures and plans developed to support the EMMP; and • Implementation of continuous improvements as identified by Ma'aden’s Environmental Management System and associated monitoring, measurement, auditing.</td>
<td>Ma'aden</td>
<td>ESIA Section 16 G01; G10; G11</td>
</tr>
<tr>
<td>N/A</td>
<td>Communications and Training</td>
<td>Develop / implement / maintain the Stakeholder Engagement Plan (a framework of which is provided in Appendix C of the ESIA) including a grievance mechanism.</td>
<td>Ma'aden</td>
<td>Ma'aden corporate policies and procedures; ESIA Appendix C G02, G06</td>
</tr>
<tr>
<td>N/A</td>
<td>Equator Principles and IFC Performance Standards</td>
<td>The project commitments outlined in Tables 2-1 and 2-2 of the ESIA Section 2 Policy, Legal and Administrative Framework will be implemented / monitoring / reviewed as appropriate during the life of the project.</td>
<td>Ma'aden</td>
<td>ESIA Section 2 Ma'aden corporate policies and procedures G13, G14</td>
</tr>
<tr>
<td>AQ3, AQ4, AQ5, AQ6, AQ7, AQ8, AQ9, AQ10</td>
<td>Operational emission of NOx, CO, SO2, PM10, NH3, Fluorides, Greenhouse Gases</td>
<td>Development and implementation of an Operational Environmental Management Plan (and EERP as appropriate) should consider the following measures: • Emissions monitoring and reporting to relevant authorities; • Appropriate maintenance of important mitigation equipment such as scrubbers, catalyst beds etc; • Identify responsibilities for maintaining competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency (including accidental releases of hazardous substances); • Minimise use of auxiliary and back-up boilers. Prior to commencement of operations, ambient air quality data should again be gathered and such data sets built on during the course of operations. Undertake regular audits of the relevant management plans to confirm their ongoing effectiveness.</td>
<td>Ma'aden</td>
<td>ESIA Section 6.3.4 A01, A02</td>
</tr>
<tr>
<td>AQ9</td>
<td>Operational Fugitive Emissions</td>
<td>Ensure compliance with RCER-2010, Volume I, Section 2: Air Environment.</td>
<td>Ma'aden</td>
<td>ESIA Section 6.3.4 A01, A02</td>
</tr>
<tr>
<td>AQ10</td>
<td>Operational GHG Emissions</td>
<td>Annual quantification and reporting (as appropriate for Category B Projects) in accordance with the guiding principles of the Equator Principles / International Finance Corporation.</td>
<td>Ma'aden</td>
<td>ESIA Section 6.3.4 A04, A06, A07</td>
</tr>
<tr>
<td>CI1</td>
<td>Cumulative impacts on Air Quality</td>
<td>Continue to assess risk throughout project. As a key stakeholder, contribute to master planning of the Ras Al Khair peninsula.</td>
<td>Ma'aden</td>
<td>ESIA Section 17 A01, A02, A03, A04, A05, A06, A07</td>
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<tr>
<td>TE8</td>
<td>Degradation of soil and groundwater quality due to accidental spills during operation</td>
<td>Hazardous materials storage to be within bunded area with adequate capacity for volumes stored. An adequate quantity of absorbents and dedicated drip trays will be available to contain and recover potential releases of hazardous substances. Develop, implement and maintain an EMMP and EERP including details of a spill response/ control plan.</td>
<td>Ma'aden</td>
<td>ESIA Section 7.4.4.3; ESIA Section 7.4.4.4; ESIA Section 7.4.4.5 C01, D01, D02, D04</td>
</tr>
</tbody>
</table>
| TE9      | Degradation of soil and groundwater quality due to leakage from plant infrastructure during operation | These plans will detail responsibilities and procedures for environmental and emergency response management during operation of the facility and should consider the following:  
- Routine plant inspection and maintenance schedules and procedures;  
- Plant start-up and shut-down procedures;  
- Competencies and training requirements of staff with environmental responsibilities, and lines of communication in the event of an emergency (including accidental releases of hazardous substances);  
- Procedures to be implemented following an accidental release of hazardous substances, including details of containment and recovery measures to be applied; and  
- Availability of pumps and spill mitigation materials such as absorbent materials to contain and recover hazardous substances releases. Undertake HAZOP studies to identify process hazards for operation of the facility and further control measures will be developed and implemented as required following the identification of specific hazards. | Ma'aden        | ESIA Section 7.4.4.4; C01, D01, D02, D04 |
| TE10     | Degradation of soil and groundwater due to catastrophic failure of plant infrastructure during operation | Ensure adequate maintenance of jetty storage facilities, including checking for release of materials. All staff shall be appropriately trained to ensure competency in operation of loading/unloading equipment. The EERP / EMMP as appropriate shall include procedures for the event of a spillage at the port and to ensure all staff are fully trained in the implementation of such procedures. All equipment for loading and unloading ships shall be regularly maintained. | Ma'aden        | ESIA Section 8.3.3 E01, E02, E03, E04, E05 |
| E6       | Impacts of Waste and Hazardous Materials on Biological Resources                    | The construction phase EERP and the CEMP should consider the following:  
- Inductions to include an overview of the ecological value and sensitivity of the Project area and guidance on species identification and actions to take if encountered within Project area.  
- Restrict vehicle movements to defined access routes to minimise risk of wildlife collisions with vehicles.  
- Enforce speed limits on and around the Project area.  
- Appropriate waste storage to limit the potential proliferation of non-desirable fauna (e.g. rats, flies). | Ma'aden        | ESIA Section 8.3.3 E01, E02, E03, E04, E05 |
<p>| E7       | Impacts of Increased Traffic on Biological Resources                                | Ensure adequate maintenance of jetty storage facilities, including checking for release of materials. All staff shall be appropriately trained to ensure competency in operation of loading/unloading equipment. The EERP / EMMP as appropriate shall include procedures for the event of a spillage at the port and to ensure all staff are fully trained in the implementation of such procedures. All equipment for loading and unloading ships shall be regularly maintained. | Ma'aden        | ESIA Section 8.3.3 E01, E02, E03, E04, E05 |
| E8       | Potential Impact from Loading/Unloading on Marine Environment                       | The Noise and Vibration Management Plan will be updated as required prior to commencing this phase. This may involve consultation with Saudi Railway Authority (SAR) and Saudi Port Authority (SEAPA) to information this Plan. | Jacobs        | ESIA Section 9.3.3 B01, B02, B04 |
| NV4      | Potential noise impacts from operation of the Process Area                          | Activities to comply with RCER-2010. An Environmental Permit to Operate (EPO) shall be obtained which includes requirements for noise monitoring. | Jacobs        | ESIA Section 9.3.3 B01, B02, B04 |
| NV5      | Potential noise impacts from Rail Movements and Associated Activities              | Perimeter noise surveys will be undertaken (at least once per year) to ensure compliance with RCER-2010. The RC may waive or reduce the frequency of monitoring if it can be demonstrated that the facility is consistently in compliance with the applicable standard. | Jacobs        | ESIA Section 9.3.3 B01, B02, B04 |
| NV6      | Potential noise impacts from Port Activities during operation                      | The Noise and Vibration Management Plan will be updated as required prior to commencing this phase. This may involve consultation with Saudi Railway Authority (SAR) and Saudi Port Authority (SEAPA) to information this Plan. | Jacobs        | ESIA Section 9.3.3 B01, B02, B04 |</p>
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<tbody>
<tr>
<td><strong>Waste Management</strong></td>
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<tr>
<td>WM3</td>
<td>Generation of Non-Hazardous Wastes during operation</td>
<td>Updates to the Waste Management Plan and the EERP (as appropriate) should consider the potential impacts from wastes and spillages of wastes during operation, particularly those relating to there requirements of RCER-2010 and the Ministry of Transportation. These Plans should be continually monitored and re-evaluated to ensure the effectiveness measures are maintained.</td>
<td>Ma’aden</td>
<td>ESIA Section 10.4.2</td>
</tr>
<tr>
<td>WM4</td>
<td>Environmental Degradation due to Generation of Hazardous Wastes during operation</td>
<td></td>
<td>Ma’aden</td>
<td>ESIA Section 10.4.2</td>
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<tr>
<td>WM5</td>
<td>Environmental Degradation due to Accidental Events during operation</td>
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<tr>
<td><strong>Water Quality Management</strong></td>
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<tr>
<td>WQ5</td>
<td>Degradation of Coastal Water Quality Due to Direct Discharges</td>
<td>All discharges to the Royal Commission seawater return channel must comply with RCER-2010, Volume I, Table 3c. In accordance with RCER 2010 (requirements for cooling towers), monitoring programmes shall be implemented for biological components (weekly) and Legionella bacteria (monthly) for the tower circulating water and effluent water as well as any wastewater settled in the basin of the tower during turnaround time.</td>
<td>Ma’aden</td>
<td>ESIA Section 11.3.4</td>
</tr>
<tr>
<td>WQ6</td>
<td>Degradation of coastal water quality due to accidental spills/run-off</td>
<td>The EMMP and EERP shall be developed to acknowledge port operational and incident management plans in consultation with SEAPA (and other port operators as required). All staff shall be competently trained and response teams established. Designated contained areas for loading the liquid products shall be defined and equipped with appropriate collection systems to contain any spills on land. If proximity detection systems are not available to safely detect if marine loading arms are moving beyond safe operating limits, constant manual monitoring during product loading may implemented to detect the motion of the loading arm and initiate shutdown procedures if required. Occupational health and safety procedures must be followed at all times during such monitoring. The proposed method of monitoring shall be agreed with the RC and SEAPA as appropriate. Minimal drop distances for unloading potash shall be employed. Provide an adequate quantity of drip trays and spill kits to contain and recover potential releases of hazardous substances.</td>
<td>Ma’aden</td>
<td>ESIA Section 11.3.4</td>
</tr>
<tr>
<td>WQ5, WQ6, WQ7</td>
<td>Impacts on Coastal Water Quality and Wastewater Systems</td>
<td>In accordance with RCER-2010, the proposed Project design must include for storage capacity of 72 hours of normal plant effluent flow. Any wastewater directed to a Royal Commission Industrial Wastewater Treatment Plant is required to meet the pre-treatment standards specified in Tables 3B and 3B-1 of RCER-2010, Volume I. In the event that wastewater does not meet the pre-treatment standards, treatment and final disposal must be arranged at waste facility licensed by the Royal Commission. An appropriate level of engagement with SEAPA to be maintained to ensure emergency response procedures relating to port activities are aligned. Develop, implement, audit and maintain a Project EMMP and EERP. These plans will detail responsibilities and procedures for environmental management and environmental emergency response during operation of the facility. Of specific reference to water quality management, these plans should consider the following: • Routine plant inspection and maintenance schedules and procedures; • Procedures for implementing appropriate water quality detection instrumentation and monitoring and reporting the quality and volumes of process and discharges waters to enable compliance monitoring (in accordance with the RC Environmental Permit to</td>
<td>Ma’aden</td>
<td>ESIA Section 11.3.4</td>
</tr>
<tr>
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</tr>
<tr>
<td>CI6</td>
<td>Cumulative Impacts on Water Management</td>
<td>Continue to support liaison with other developers to ensure water use is minimised, and potential physical and pollution impacts on existing water systems are effectively managed.</td>
<td>Ma’aden</td>
<td>ESIA Section 17</td>
</tr>
<tr>
<td>SE4, SE5</td>
<td>Community Health, Safety and Security; Local Economy</td>
<td>Employ local resources where available. Maintain grievance mechanism so that the resident worker ‘communities’ have a means of communicating any concerns regarding the facility’s operation. Induction training should be provided to all foreign workers and non-Muslim workers on the local culture and practices that are acceptable and unacceptable. In addition, camp management procedures will be established to minimise interactions and possible tensions with the local communities. Safety training such as road safety training to be provided to workers, and material suppliers should be provided with information on delivery routes and speed limits.</td>
<td>Ma’aden</td>
<td>ESIA Section 12</td>
</tr>
<tr>
<td>CI7</td>
<td>Cumulative impacts on Socio-economics</td>
<td>Continue to work with the Royal Commission and Ministries to realise economic and social benefits associated with the wider development and cultural uses of the land.</td>
<td>Ma’aden</td>
<td>ESIA Section 17</td>
</tr>
<tr>
<td>T14, T15</td>
<td>Operation impacts on Road and Rail Infrastructure</td>
<td>A Traffic and Transportation Management Plan is to be developed, implemented and maintained for road traffic during the operational and decommissioning phase. This should consider the following: Responsibility and procedures for co-ordination and liaison with SEAPA, SAR and the Ministry of Transport during operation and decommissioning; Confirmation of capacity within the rail / road / port network to manage materials to and from the site during operation and decommissioning.</td>
<td>Ma’aden</td>
<td>ESIA Section 13.3.4</td>
</tr>
</tbody>
</table>
### Impact ID | Impact Description | Action | Responsibility | Further information
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- Rail scheduling and operational procedures;
- Access routes for operational vehicles and workforce transportation between Ma'aden accommodation and work areas;
- On-site traffic management;
- Measures to segregate pedestrians from vehicle areas;
- Training and awareness in road safety; and
- Measures to protect the local community where appropriate.

#### Utilities Infrastructure

| UI6, UI7, UI8, UI9, UI10, UI11, UI12, UI13, UI14 | Effects on Utilities Infrastructure | The following should be considered as part of the ongoing management and monitoring of operations:
- Monitor the use of utilities and provision of utilities services to ensure that there is no overloading of any system.
- Active communication between MPC divisions from both the existing and new facilities (and other utility suppliers) is important to ensure that reliable supplies can be maintained throughout to minimise impacts on production.
- EERP should detail the use of utilities and alternative utilities supply’s for emergency situations.
- Direct savings can be realised by the reduction in energy consumption and water supply reduction which can be achieved through the minimisation of wastage and unnecessary uses. Ma’aden’s existing Environmental Management System (EMS) can be used to document achievable goals for energy reduction through specific practical energy saving measures. | Ma’aden | ESIA Section 14.3.4 G01, G08

#### Health and Safety Aspects

| HS07 | Air Quality Impacts on the Workforce | A risk assessment shall be undertaken which to define the specific risks and mitigation, including working hours, exposure limits, and use of PPE as required. | Ma’aden | ESIA Section 15.5 A01, A02, A04, A05, G09

| HS09 | Accident & Injury Impacts on the Workforce | An EERP will be implemented with instructions on dealing with minor to major incidents including spillage. Updates to the EERP should consider the following:
- Liaisons with the relevant authorities to ensure services are (a) available, and (b) have sufficient capacity to support the Project workforce and the anticipated nature of any health incidents / issues;
- Provision for evacuation to hospitals in Jubail for any incident types which the local medical facilities cannot treat (e.g. chemical, burns, fractures etc.) which may be time critical;
- Given the distances involved in any transfer to Jubail, provision of fully training medical staff who can treat to a level which allows safe transfer of the patient to the hospital facilities either through air transport or road ambulance. | Ma’aden | ESIA Section 15.5 and Appendix B G01, G08

| CI10 | Cumulative Impacts on Health & Safety | As a key stakeholder, continue to liaise with the Royal Commission and ministries as appropriate throughout future developments to support the management of community health effects | Ma’aden | ESIA Section 17 G01, G04, G08
## Decommissioning

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<tbody>
<tr>
<td><strong>General Project Wide</strong></td>
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<tr>
<td>N/A</td>
<td>Sustainable Development</td>
<td>Continue to identify potential sustainability benefits through this phase, specifically opportunities in line with Ma’aden corporate policy including: • Prevent or minimise environmental pollution, conserve natural resources, minimise waste, progressively rehabilitate impacts, and value cultural heritage. • Use cleaner energy and constantly improve the energy and material efficiency of operation. • Application of existing Ma’aden project processes, specifically the Environmental and Communities Assurance Manual • Establishment of objectives, targets and KPIs to monitor achievement of goals established for the Project and progress towards sustainable development; • Implementation of mitigation and recommended measures proposed within the ESIA, and the resultant EMMP and all procedures and plans developed to support the EMMP; and • Implementation of continuous improvements as identified by Ma’aden’s Environmental Management System and associated monitoring, measurement, auditing.</td>
<td>Ma’aden</td>
<td>ESIA Section 16 G01; G10; G11</td>
</tr>
<tr>
<td>N/A</td>
<td>Equator Principles and IFC Performance Standards</td>
<td>The project commitments outlined in Tables 2-1 and 2-2 of the ESIA Section 2 Policy, Legal and Administrative Framework will be implemented / monitoring / reviewed as appropriate during the life of the project.</td>
<td>Ma’aden</td>
<td>ESIA Section 2, Ma’aden corporate policies and procedures G13, G14</td>
</tr>
<tr>
<td>N/A</td>
<td>Communications and Training</td>
<td>Develop / implement / maintain a Stakeholder Engagement Plan (a framework of which is provided in Appendix C of the ESIA) including a grievance mechanism.</td>
<td>Ma’aden</td>
<td>Ma’aden corporate policies and procedures; ESIA Appendix C G02, G06</td>
</tr>
<tr>
<td><strong>Terrestrial Environment</strong></td>
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<tr>
<td>TE12</td>
<td>Accidental spills during tank and pipe drain-down and decommissioning</td>
<td>An adequate quantity of absorbents will be available to contain potential release of hazardous materials. Review EERP and EMMP to reflect changing project stages.</td>
<td>Ma’aden</td>
<td>ESIA Section 7.4.5.3 C01, D01, D02, D04</td>
</tr>
<tr>
<td>TE13</td>
<td>Degradation of soil and groundwater quality due to accidental spills</td>
<td>Construct designated refuelling and vehicle maintenance areas. Hazardous materials storage to be within bunded area with adequate capacity for volumes stored. Absorbents to contain and recover potential release of hazardous materials. Review EERP and EMMP to reflect changing project stages.</td>
<td>Ma’aden</td>
<td>ESIA Section 7.4.5.4 C01, D01, D02, D04</td>
</tr>
<tr>
<td>CI2</td>
<td>Cumulative impacts on the Terrestrial Environment</td>
<td>Following decommissioning and demolition of the facility, a survey of the soil and groundwater quality at the site should be completed to confirm that the presence and operation of the facility has not led to an unacceptable deterioration of the site’s terrestrial environment. Should soil or groundwater contamination be identified that could have been caused by the facility, a specific remedial plan will be developed to define the extent of contamination and remedial measures to be implemented.</td>
<td>Ma’aden</td>
<td>ESIA Section 17 C01, D01, D02, D04</td>
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<tr>
<td><strong>Biological Resources</strong></td>
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<tr>
<td>E9</td>
<td>Potential impact from contamination on biological resources</td>
<td>The Decommissioning Plan to be developed shall identify all possible sources of contamination and outline the appropriate control and disposal measures that protect the natural environment.</td>
<td>Ma’aden</td>
<td>ESIA Section 8.3.4 E01, E02, E03, E04, E05</td>
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<tr>
<td>NV7 Noise and Vibration</td>
<td>Noise impacts at Off-site receptors</td>
<td>Prior to decommissioning / closure, Ma’aden should evaluate potential noise and vibration sources associated with planned decommissioning activities, and establish measures to ensure these activities comply with the necessary noise guidelines at the sensitive receptors. The Noise and Vibration Management Plan should be updated as required prior to commencing this phase.</td>
<td>Ma’aden ESIA Section 9.3.4 B01, B02, B04</td>
<td></td>
</tr>
<tr>
<td>WQ8 Water Quality Management</td>
<td>Decommissioning phase impacts</td>
<td>Prior to decommissioning: Prepare detailed decommissioning plans to detail the procedures to be adopted for the safe decommissioning of the facility’s tanks, pipelines, buildings and infrastructure. Incorporate such plans to the overall Project EMMP. Following decommissioning and demolition of the facility, survey the surface water quality at the site to confirm that the presence and operation of the facility has not led to an unacceptable deterioration of the quality of surface water. Should contamination be identified that could have been caused by the facility, a specific remedial plan will be developed to define the extent of contamination and remedial measures to be implemented.</td>
<td>Ma’aden ESIA Section 11.3.5 C01, C02, C04, C05</td>
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</tr>
<tr>
<td>SE06 Socio-Economic Aspects</td>
<td>Decommissioning activities</td>
<td>Where possible, encourage and support the use of local and provincial suppliers of goods and services by the wider Ras Al Khair Industrial City development. Seek to support employment in the region and within other Ma’aden projects following decommissioning of the Project facilities.</td>
<td>Ma’aden ESIA Section 12.4.4 G10, G11</td>
<td></td>
</tr>
<tr>
<td>TI4 Traffic and Transport Infrastructure</td>
<td>Impacts on Road, Rail and Port Infrastructure</td>
<td>Update the traffic and logistics study and Traffic and Transportation Management Plan first developed for the construction phase as required to manage traffic related to decommissioning. Consult with SEAPA, SAR and the Ministry of Transport as appropriate.</td>
<td>Ma’aden ESIA Section 13.3.5 G06, G08</td>
<td></td>
</tr>
<tr>
<td>HS11a, HS11b Health and Safety Aspects</td>
<td>Health and Safety Impacts on the Workforce and Community</td>
<td>Decommissioning shall be planned by developing, procedures, and any HSE requirements to ensure the project is decommissioned safely and effectively, using the correct PPE etc in line with RC requirements and intended future use. Where appropriate, monitoring post closure shall be considered.</td>
<td>Ma’aden ESIA Section 15.5 G01, G04, G08, G10</td>
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<tr>
<td>CI10</td>
<td>Cumulative Impacts on Health &amp; Safety</td>
<td>As a key stakeholder, continue to liaise with the Royal Commission and ministries as appropriate throughout future developments to support the management of community health effects</td>
<td>Ma’aden ESIA Section 17 G01, G04, G08</td>
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DEPARTMENT: SAFETY AND ENVIRONMENTAL
REPORT NO: 60-R400-WH/G.06F/0072 (APPENDIX B)

REPORT TITLE: RAS AL KHAIR
ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT (ESIA)
APPENDIX B – ENVIRONMENTAL EMERGENCY RESPONSE PLAN

PROJECT REFERENCE
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PROJECT TITLE: UMM WU’AL PHOSPHATE PROEJCT
CLIENT: MA’ADEN (SAUDI ARABIAN MINING COMPANY)
CLIENT PROJECT NO 2-115-12-12-2-2
CLIENT DOCUMENT NO MD-513-0000-HS-EN-RPT-0069 (APPENDIX B)

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B.1.0 PURPOSE OF THE ENVIRONMENTAL EMERGENCY RESPONSE PLAN

This Environmental Emergency Response Plan (EERP) has been prepared to meet the requirements of the Royal Commission Environmental Regulations (RCER) 2010. For the purpose of this EERP, the new developments proposed by Ma’aden Phosphate Company (MPC) at the Ras Al Khair Industrial City will be referred to collectively as the Ras Al Khair Industrial Complex (‘the Project’).

The purpose of the EERP is to identify process related risk, suitable control measures and steps to be followed in response to an emergency event or disaster situation at the Ras Al Khair Industrial Complex. The scope of the EERP includes both operational accidents, such as fire or road accident, and natural incidents, such as flood or earthquake, and is intended to prevent injury to staff and personnel, damage to property, harm to the environment and impact upon neighbouring communities.

This document provides a framework for the collation of applicable Ma’aden processes and procedures and recommends an approach to help ensure the requirements of the RCER 2010 are met prior to operation of the facility. The EERP will be consistent with existing Ma’aden requirements allowing for integration with project activities such as development of the Project’s Environmental Management System (EMS) and Health, Safety and Security Management Plan (HSSMP), as required by the Ma’aden Environment and Communities Assurance manual and Health and Safety Assurance manual, respectively. A review of where the requirements of the key Ma’aden project documents HSSEC Readiness (MD-101-SPRM-OM-HS-GUI-0001) and Health and Safety Assurance (MD-101-SMPM-PM-HS-GUI-0001) are applicable to the RCER 2010 is provided in Attachment 1.

Ma’aden will review and update the EERP as the design progresses and as more detailed information of the Project’s operations and processes becomes available, allowing for more informative review of potential operational accident and emergency situations and development of more detailed response procedures. Ma’aden will implement a Project HSS document review schedule for the HSSMP and its subordinate documents. Review of the EERP during the operational stage of the project will be included as part of this review schedule.

Procedures, as required by the EERP, and where applicable, will be consolidated when undergoing development to provide clear instruction to Ma’aden personnel on the step-by-step approach to be taken and implemented in the event of an accident or emergency situation occurring (e.g. consolidation of requirements under sections 13.0, 14.0 and 15.0).

The EERP is included as Appendix B of the Ras Al Khair Industrial Complex Environmental and Social Impact Assessment (ESIA).

B.2.0 REGULATORY FRAMEWORK

The RCER 2010 requires an EERP to be prepared by all operators of industrial facilities located in Jubail Industrial City, Yanbu Industrial City and Ras Al Khair Industrial City. The EERP supplements the Environmental Permit Application Package (PAP) and ESIA in order to obtain an Environmental Permit to Construct (EPC). RCER Volume I, Clause 1.1.10, states the requirement for an EERP to be produced in accordance with the issues outlined by Volume I, Clause 4.3.19. Guidelines for a suggested structure and required content for the EERP are provided by RCER 2010 Volume II, Appendix D.

The development of an EERP also contributes towards the meeting of the International Finance Corporation (IFC) Sustainability Framework Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts.
B.3.0 SITE DESCRIPTION

The proposed Ma’aden Umm Wu’al Phosphate Project will be based on two sites; a mine site at Umm Wu’al, which includes an open cast mine, beneficiation plant and a number of acid producing plants to process the extracted ore; and an industrial complex at Ras Al Khair Industrial City, which includes an Ammonia production plant, a Di-ammonium Phosphate (DAP)/Nitro Phosphate Potash (NPK) plant and materials storage and handling facility. The design life for the Ras Al Khair Industrial Complex is 25 years.

The proposed Ras Al Khair Industrial Complex will be located within the Ras Al Khair Industrial City, which lies on a peninsula of land on the south-western Arabian Gulf coast within the Eastern Province of Saudi Arabia. The site is approximately 4m above mean seal level at Latitude 27°32’15”N and Longitude 49°12’18”E (SOFRECO – TECHNIP, 2012). The Ras Al Khair Industrial City includes its own industrial port and is connected to the mine site at Umm Wu’al by railway. The Industrial City is also accessible by a 27km road linked to the Abu Hadriyah highway. The closest sizable population centre is Nairyah, which is approximately 68km to the West of the peninsula.

The Project is proposed to be constructed adjacent to an existing fertiliser complex operated by Ma’aden Phosphate Company (MPC). Ma’aden Aluminium Company (MAC) is also currently constructing alumina and aluminium production facilities to the west of the Project site comprising of an alumina refinery and aluminium smelter and rolling mill. The MAC site is anticipated to become operational in December 2013.

The existing MPC site covers an area approximately 1.9km x 1.5km and contains Ammonia, DAP, Purified Phosphoric Acid (PPA), power, desalination, Sulphuric Acid Plant (SAP), and a number of administrative and miscellaneous warehousing buildings/facilities. The site is fully serviced by existing road layout and utility networks. The MPC facilities currently utilise three surface ponds for water management; an irrigation pond receives treated sanitary wastewater and neutralised wastewater from the Ammonia plant and power and desalination plant (PDP) auxiliary boiler blow down; an adjacent evaporation pond receives neutralised wastewater from the SAP; and a retention pond receives surface water collected across the site.

The Ras Al Khair Industrial Complex will increase ammonia and fertiliser production and export from the Kingdom of Saudi Arabia, while also providing a material storage and handling facility to manage the use/export of Merchant Grade Phosphoric Acid (MGA), Sulphuric Acid (H₂SO₄) and PPA, which are produced at the Umm Wu’al mine site.

The Ras Al Khair Industrial Complex Ammonia plant is to be a stand-alone plant with its own associated facilities. The Project is designed to use natural gas to produce liquid Ammonia, which will be stored in adjacent tanks. The DAP/NPK Plant will then use the Ammonia to produce Ammonium Phosphate based granular fertilisers, which will be will be exported from Ras Al Khair Port and sold primarily into the international markets. It is anticipated that the Project will also produce quantities of Ammonia not required in the production process, which will be exported or sold domestically.

The main components of the Ras Al Khair Industrial Complex are as follows:

- Ammonia production plant and storage tanks;
- Cooling tower;
- DAP/NPK production units;
- DAP/NPK product and raw materials and storage warehouses (on plot and at the Port);
- Materials Storage and Handling Facility.
- rail and road infrastructure;
- Ras Al Khair port loading/unloading and storage facilities.
- Office and maintenance area (including diesel generator, fuel storage area and potable/process water tank).

A proposed plan of the Ras Al Khair Industrial Complex is provided in Attachment 2.
The Project will utilise the existing MPC irrigation pond, but a new surface water retention pond will also be constructed. An existing sanitary wastewater treatment plant (STP) is operational on the site and has sufficient capacity to support the Project.

**B.4.0 PROCESS RELATED RISKS**

In operation of the Ras Al Khair Industrial Complex, Ma’aden will take steps to identify the processes where the greatest risk of accident or emergency exists, prior to operation before developing and implementing operational control measures to ensure the risk of harm to people, the environment and equipment is reduced, and where possible, eliminated. The identification and assessment of risk associated with accident or emergency situations will be consistent with existing Ma’aden project activities to allow integration with development of the Project’s EMS and identification of significant environmental aspects, and the Risk Management process outlined by the Ma’aden Project Manual Health and Safety Assurance (MD-101-SMPM-PM-HS-GUI-0001).

The following section provides an overview of the main processes that will take place at the proposed Ras Al Khair Industrial Complex and how the assessment of process related risk of emergency or accident will be carried out prior to operation of the Project.

**B.4.1 PROCESS OVERVIEW**

The Ammonia plant will be operational 24 hours/day for 330 days/year producing Liquid Anhydrous Ammonia with an annual capacity of 1,089,000 MTPY. The Ammonia plant is comprised of natural gas desulphurisation and compression, steam reforming, Carbon Monoxide (CO) conversion, Carbon Dioxide (CO₂) removal, Methanation and Ammonia synthesis. Secondary plant objectives include waste heat recovery, Ammonia refrigeration, purge gas and Hydrogen recovery.

Key Project components for the proposed Ammonia plant are outlined in Table B4-1.

**Table B4-1: Key Project Component Associated with the Ammonia Plant**

<table>
<thead>
<tr>
<th>Process Unit Area</th>
<th>Plant Off-sites and Utilities</th>
<th>Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia production plant</td>
<td>Demineralisation unit and water tanks</td>
<td>Main control room to contain operation shelter and training room</td>
</tr>
<tr>
<td>Boiler feed water (BFW) system</td>
<td>Auxiliary boiler and steam turbine generator (STG)</td>
<td>Main 115/34,5kV substation for complex</td>
</tr>
<tr>
<td>Process condensate system</td>
<td>Nitrogen system</td>
<td>Ammonia process substation</td>
</tr>
<tr>
<td>Flaring system (process and synthesis gas flare; Ammonia flare; and Ammonia storage tanks flare)</td>
<td>Emergency generator and diesel oil storage</td>
<td>Ammonia utility substation</td>
</tr>
<tr>
<td></td>
<td>2 x 30,000 t Ammonia storage tanks and handling system</td>
<td>Operator cabins and labour cabins</td>
</tr>
<tr>
<td></td>
<td>Lube oil system</td>
<td>Warehouse</td>
</tr>
<tr>
<td></td>
<td>Instrument and plant air distribution</td>
<td>Central laboratory extension</td>
</tr>
<tr>
<td></td>
<td>Closed loop cooling water system</td>
<td>Shelters for analyser shelters (2 or more), compressors and pumps</td>
</tr>
<tr>
<td></td>
<td>Waste water and storm water system</td>
<td>Emergency diesel generator building</td>
</tr>
<tr>
<td></td>
<td>Sewage collection and pumping</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Port to ship loaders</td>
<td></td>
</tr>
</tbody>
</table>

The associated raw materials are natural gas, Nitrogen and desalinated water. A number of catalysts are also used in the process. The existing MPC desalination plant will provide both desalination and process water to the Ammonia plant.

The raw material types, and the processes in which they are used for Ammonia production, are summarised in Table B4-2.

**Table B4-2: Raw Materials for Ammonia Production**

<table>
<thead>
<tr>
<th>Raw Material/ Feedstock</th>
<th>Process</th>
<th>Delivery &amp; Storage Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>Fuel: primary reformer, package (auxiliary) boiler,</td>
<td>Pipe supplied by Saudi</td>
</tr>
</tbody>
</table>
### APPENDICES

#### Appendix B - EERP Revision A03

<table>
<thead>
<tr>
<th>Raw Material/ Feedstock</th>
<th>Process</th>
<th>Delivery &amp; Storage Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>start-up heater, flare / pilot burner; and Feedstock</td>
<td>Aramco</td>
<td></td>
</tr>
<tr>
<td>Desalinated and process water</td>
<td>Desalinated Water is used as feed to the Demineralised Water Unit (make-up water). Process (Service) Water can also be provided as required by the new Ammonia Plant outside normal operation. Recycling of condensates will minimise the consumption of desalinated water as make up water.</td>
<td>Pipe from existing MPC Power and Desalination Plant storage.</td>
</tr>
<tr>
<td>Seawater return water</td>
<td>Cooling Tower make up (blowdown and evaporation losses)</td>
<td>Seawater return headers of the existing plants.</td>
</tr>
<tr>
<td>Catalysts</td>
<td>Natural Gas Desulphurisation (Hydrogenation); Natural Gas Desulphurisation; CO Conversion; Methanation; Ammonia Synthesis; and CO₂ Removal</td>
<td></td>
</tr>
<tr>
<td>Antifoam agent</td>
<td>CO₂ Removal</td>
<td></td>
</tr>
<tr>
<td>Oxygen scavenger</td>
<td>Boiler Feed Water Treatment: May be required during start-up or upset plant conditions</td>
<td></td>
</tr>
<tr>
<td>Chemical agent for pH control</td>
<td>Boiler Feed Water Treatment: PH control</td>
<td></td>
</tr>
<tr>
<td>Corrosion inhibitor</td>
<td>Chemicals for Circulating Cooling Water</td>
<td></td>
</tr>
<tr>
<td>Bicocide</td>
<td>Chemicals for Circulating Cooling Water</td>
<td></td>
</tr>
<tr>
<td>Sodium Hydroxide (50%)</td>
<td>Water treatment (demineralisation unit, polishing unit, neutralisation)</td>
<td></td>
</tr>
<tr>
<td>Sulphuric acid (98%)</td>
<td>Water treatment (demineralisation unit, polishing unit, neutralisation); Regeneration of ion exchangers</td>
<td></td>
</tr>
<tr>
<td>Resin</td>
<td>Water treatment (condensate polishing – demineralisation unit and polishing unit)</td>
<td></td>
</tr>
</tbody>
</table>

The DAP/NPK complex will consist of four granulation units arranged in two pairs. One pair will consist of two DAP units in one common building (DAP 1 and DAP 2) and the second pair will consist of one NPK and one DAP unit (DAP 3). The combined DAP units (1, 2 and 3) will be designed to yield 2,228,094 MTPY of DAP. The NPK unit will be designed to yield 766,920 MTPY. The DAP unit will be operational for 330 days per year and 22 hours per day and the NPK unit for 332 days per year and 22 hours per day.

Key Project components proposed for the DAP/NPK Plant are outlined in Table B4- 3.

**Table B4- 3: Key Project Components Associated with the DAP/NPK Plant**

<table>
<thead>
<tr>
<th>Process Unit Area</th>
<th>Plant Off Site and Utilities</th>
<th>Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAP and NPK process plants</td>
<td>Off-site and maintenance area</td>
<td>Two-storey admin building including first aid/medical centre and rescue/fire fighting</td>
</tr>
<tr>
<td>DAP/NPK product storage buildings and associated conveyors between production units and towards port storage sheds</td>
<td>O&amp;M workshop and outdoor paved storage yard</td>
<td>Two-storey central laboratory</td>
</tr>
<tr>
<td>Raw material storage building Maintenance, stores and operation building Storage tanks with bund walls for secondary containment Road access</td>
<td>Electrical substation (maintenance)</td>
<td>Two-storey training centre</td>
</tr>
<tr>
<td></td>
<td>Road weighbridge house</td>
<td>Facility rail workers house and cafeteria</td>
</tr>
<tr>
<td></td>
<td>Diesel generator building</td>
<td>Sanitary block building</td>
</tr>
<tr>
<td></td>
<td>Fuel storage area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fire fighting water storage tanks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Potable/process water tank</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Administration area (electrical substation (admin), additional car parking and road access within administration area)</td>
<td></td>
</tr>
</tbody>
</table>

The main raw materials for the DAP/NPK process are concentrated Phosphoric Acid (H₃PO₄), Liquid Anhydrous Ammonia, H₂SO₄, Urea, Potassium Chloride and Filler. Raw materials will be stored in the materials storage and handling facility and at the port before transport to the process plants.
A fleet of road trucks will transport Potassium Chloride from a storage facility at the port to a sub-divided storage building adjacent to the process plants, in which Urea and Filler will also be stored. Solid raw materials will be transported from the storage building by payloader and conveyed to the DAP/NPK plants. One common raw material belt conveyor will be provided for the building housing DAP 1 and DAP 2 and a separate common raw material belt conveyor will be provided for the building housing DAP 3 and NPK. Liquid raw materials will be pumped from the materials storage and handling facility to local storage within the DAP/NPK plant and also from the Ammonia plant storage tanks.

The raw material types and the processes in which they are used for DAP/NPK production are summarised in Table B4- 4.

Table B4- 4: Raw Materials for DAP/NPK Production

<table>
<thead>
<tr>
<th>Raw Material/Feedstock</th>
<th>Process</th>
<th>Delivery and Storage Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filler</td>
<td>DAP plant</td>
<td>Truck to process area storage building Sourced within the Kingdom of Saudi Arabia (KSA)</td>
</tr>
<tr>
<td>Urea</td>
<td>NPK plant</td>
<td>Truck to process area storage building Sourced within KSA</td>
</tr>
<tr>
<td>Potassium Chloride (K20; Potash)</td>
<td>NPK plant</td>
<td>Ship to port storage building (by truck); storage building to plant (by conveyor)</td>
</tr>
<tr>
<td>Phosphoric Acid (P2O5) and Raffinate</td>
<td>Scrubbing; and preneutraliser reactor</td>
<td>Rail tanker to storage tank at materials storage and handling facility; pipe to plant</td>
</tr>
<tr>
<td>Sulphuric Acid</td>
<td>Preneutraliser reactor; granulation pre-scrubber tank; and tailgas scrubber</td>
<td>Rail tanker to storage tank at materials storage and handling facility; pipe to plant</td>
</tr>
<tr>
<td>Liquid Ammonia</td>
<td>Preneutraliser reactor; granulation; and Ammonia vapourisation</td>
<td>Pipe from storage tanks within Ammonia plant battery limit</td>
</tr>
<tr>
<td>Colouring and coating agents</td>
<td>Final product conditioning</td>
<td>Truck to storage tank at materials storage and handling facility; pipe to plant Sourced within KSA</td>
</tr>
<tr>
<td>Coating oil</td>
<td>Final product conditioning</td>
<td>Truck to storage tank at materials storage and handling facility; pipe to plant Sourced within KSA</td>
</tr>
<tr>
<td>Anti-foam agent</td>
<td>Scrubbers; preneutraliser/pipe reactor tank</td>
<td>Truck to storage tank at materials storage and handling facility; pipe to plant</td>
</tr>
<tr>
<td>Natural gas</td>
<td>Fuel to dryer burner</td>
<td>Pipe (supplied by SA)</td>
</tr>
<tr>
<td>Process water</td>
<td>Preneutraliser reactor (reaction of ammonia vapour and phosphoric acid); scrubbing (removal of both dust and volatiles); prescrubber and scrubber tanks; and tailgas scrubber</td>
<td>Pipe from existing MPC power and desalination plant storage</td>
</tr>
<tr>
<td>Medium pressure steam</td>
<td>Granulation</td>
<td>Ammonia plant (by desuperheating and demineralised water (start-up) and recovered condensate during normal operation)</td>
</tr>
<tr>
<td>Low pressure steam</td>
<td>Preneutraliser and product coating (coating oil dosing pumps – low pressure (LP) steam jacketed pipes and spray nozzle)</td>
<td>Ammonia plant (expanded MP steam)</td>
</tr>
</tbody>
</table>

B.4.2 IDENTIFYING PROCESS RELATED RISK

Prior to completing the risk assessment, a detailed review of the processes taking place within the Ras Al Khair Industrial Complex will be undertaken by Ma’aden to identify potential accident and emergency situations. Consideration will be given to factors including probability of occurrence and the greatest loss as a result of the accident or emergency situation.
happening, as well as technical design and manufacturer’s guidelines. The scope of the risk assessment will cover both operational accidents and natural incidents.

Following detailed review of the processes associated with the project to identify potential accident and emergency situations, a risk assessment will be completed in accordance with the Hazard Identification Risk Assessment and Control (HIRAC) process, as outlined by the Ma’aden Project Manual, Health and Safety Assurance (MD-101-SMPM-PM-HS-GUI-0001). For each operational activity to be undertaken on the Project, HIRAC requires:

- task definition;
- hazard identification;
- risk assessment;
- risk control implementation; and
- process monitoring.

Control measures for identified risks will be prioritised in accordance with the Risk Management Hierarchy of Controls, as shown in Figure B.4-1 below, and selected and implemented to ensure the final level of risk is as low as reasonably practicable (ALARP).

![Risk Management Hierarchy of Controls](image)

**Figure B.4-1: Risk Management Hierarchy of Controls (Ma’aden, 2011)**

The assessment of risk will be reviewed on a periodic basis and whenever a change, for example, the introduction of new, or change to existing, people, plant, process and/or procedures, introduces new potential accident and emergency situations. Review of existing, or introduction of new, control measures will be undertaken if new or additional risk of accident or emergency situations occurring is identified following review of the risk assessment.

### B.5.0 TYPES OF EMERGENCY

There are a number of accident and emergency situations that have the potential to occur during operation of the Ras Al Khair Industrial Complex. Ma’aden will ensure consideration and discussion of the types of accident and emergency situations that may potentially be encountered whilst reviewing the processes associated with operation of the Project and in identification and assessment of the associated risks and hazards.

Examples of the types of accident and emergency situations that could potentially occur and the resulting impacts are provided in Table B.5-1 below. This is not an exhaustive list and further consideration of potential accident and emergency situations will be given by Ma’aden during completion of the assessment of process related risks. Accident and emergency situations with regards to road accident and fire are covered by B.6.0 and B.7.0, respectively.
### Table B.5-1: Potential Accident and Emergency Situations Associated with Operation of the Ras Al Khair Industrial Complex

<table>
<thead>
<tr>
<th>Accident/Emergency</th>
<th>Potential Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant and equipment failure or malfunction</td>
<td>Human health impacts:</td>
</tr>
<tr>
<td>Fire and explosion</td>
<td>o burns;</td>
</tr>
<tr>
<td>Vehicle collision with plant and equipment</td>
<td>o respiratory difficulty;</td>
</tr>
<tr>
<td>Spillage or release of hazardous chemicals or materials</td>
<td>o blindness;</td>
</tr>
<tr>
<td>Non-road related transportation accidents</td>
<td>o sickness;</td>
</tr>
<tr>
<td>Natural incidents:</td>
<td>o disease/epidemic;</td>
</tr>
<tr>
<td>o sun exposure;</td>
<td>o electrocution;</td>
</tr>
<tr>
<td>o flood;</td>
<td>o trauma;</td>
</tr>
<tr>
<td>o sea level rise;</td>
<td>o injury.</td>
</tr>
<tr>
<td>o high wind;</td>
<td>o land contamination;</td>
</tr>
<tr>
<td>o heavy rainfall;</td>
<td>o water pollution;</td>
</tr>
<tr>
<td>o sandstorm;</td>
<td>o air pollution.</td>
</tr>
<tr>
<td>o earthquake.</td>
<td></td>
</tr>
<tr>
<td>Political/local instability.</td>
<td>Damage to infrastructure and assets</td>
</tr>
<tr>
<td></td>
<td>Material loss</td>
</tr>
</tbody>
</table>

An approach to the management (prevention and response) of accident and emergency situations, including for road accidents and fire, is discussed in section 8.0 below.

### B.6.0 ROAD ACCIDENTS

When assessing the risks associated with the operation of the Ras Al Khair Industrial Complex, Ma’aden will also review the potential accident and emergency situations that may occur as a result of road accidents, giving consideration to the special provisions set by Royal Commission (RC) or Occupational Safety and Health Administration (OSHA) for transport of all toxic and hazardous chemicals including fuels, product, raw materials and waste.

Supply of the majority of materials to the Project will be provided via the rail network and unloaded in specially constructed facilities. Other supplies include provisions, waste disposal and commuting of the local workforce, and will predominantly be undertaken via road vehicles. Traffic movements are predicted to increase by a maximum of 222 per 24 hour period (179 cars, 43 heavy goods vehicles (HGVs)) during the operation phase (see ESIA Section 13 Traffic & Transport).

The increase in road traffic will create an increased risk of motor vehicle accidents (MVA) both to the workforce (including suppliers) and local road users. Ma’aden will implement measures to minimise the likelihood of MVAs through measures including transportation of the workforce to and from the site by bus, reducing the need for driving, and implementation of training and driver awareness programmes for material supply drivers. This will reduce the risk of both MVAs and risk of environmental damage resulting from an accident.

### B.7.0 FIRE FIGHTING

When assessing the risks associated with the operation of the Ras Al Khair Industrial Complex, Ma’aden will also review the potential accident and emergency situations that may
occur as a result of fire through identification of all potential fire hazards on-site and fire hazard characteristics that apply to fuel, raw material, product, by-product and waste with reference to Material Safety Data Sheets (MSDS), plant design and OSHA. Experiences and existing procedures from Ma’aden’s other operational facilities will be considered for application on the Ras Al Khair Industrial Complex, as appropriate.

Requirements and methods to retain fire water and other fire fighting material, such as foam and powder, to prevent discharge to drains, controlled waters or ground, will be reviewed by Ma’aden and included in accident and emergency procedures, where applicable. The retention of fire water and fire fighting materials is considered further in section 15.0 below.

B.8.0 INCIDENT/ACCIDENT MANAGEMENT

Following the identification of potential accident and emergency situations and completion of the risk assessment in accordance with the HIRAC process, Ma’aden will develop procedures for management of potential incidents and accidents. Measures to avoid risk will be given preference in order to prevent potential emergency situations occurring. Where prevention or elimination of risk is not possible, operational control measures will be developed to reduce risk of an emergency situation occurring as far as possible.

Although steps to eliminate and reduce risk from the processes associated with the operation of the Project as far as possible will be taken, Ma’aden recognises that a degree of risk remains with regards to a potential accident or emergency situation occurring. Therefore, procedures will be developed which will be followed in the event of an accident or emergency situation, whether this is as a result of operational control failings or natural occurrences. This will include measures in response to the example situations outlined by Table 5-1 and also procedures relating to emergency shut-down of plant and equipment and other measures to prevent the potential escalation of emergency situations. Clean-up following containment, and rebuilding, if necessary, as a result of an accident or emergency situation will also be covered in the development of emergency response procedures.

Measures relating to accident and emergency response, including shut-down of plant and equipment, and clean-up and rebuilding are discussed in sections 13.0, 14.0, 15.0 and 16.0 below.

B.8.1 PREVENTATIVE MEASURES

Part of the process of risk management through identification and assessment is the application of the Risk Management Hierarchy of Control (Figure 4-1). In accordance with the hierarchy, Ma’aden will give preference to the elimination of risk when considering and developing emergency response procedures. Measures to eliminate, or prevent risk, include the redesigned of a task or the elimination or substitution of a substance to remove the hazard; however, the alternative method should not lead to a less acceptable product or a less effective process.

B.8.2 OPERATIONAL CONTROL

Where risk prevention and elimination is not a viable option in the preparation of emergency response procedures, Ma’aden will then investigate ways of implementing operational control measures to minimise the level of risk as far as reasonably practicable. Control measures will include the installation or use of additional machinery, such as local exhaust ventilation to control the risk, and separation of operators from the hazard by methods such as enclosing or guarding dangerous items of machinery. Other control measures will include reducing the time a worker is exposed to a hazard or risk and increasing the use of safety awareness signage.

B.9.0 ALARMS AND COMMUNICATION

Alarm systems in appropriate locations will be a key part of the process installations throughout the Ras Al Khair Industrial Complex and are likely to be used in operational control, as well as for alerting personnel to impending emergency situations. Ma’aden will include the different alarms, their application and what they signal, in the preparation of operational control.
and emergency response procedures. Alarms will also be communicated to site operatives through inclusion in the training programmes implemented by Ma'aden on the Project.

A directory of all appropriate authorities and organisations, from whom support is required or who require notification in the event of an accident or emergency, will be prepared by Ma'aden and held in appropriate locations at the Ras Al Khair Industrial Complex. This will include fire and police services and RC representatives. Emergency contact details will also be included in emergency response procedures, as appropriate.

B.10.0 TRAINING PRACTICES

Ma’aden will include emergency response training practices in the Health, Safety, Security, Environment and Community (HSSEC) training programme developed for the Project in accordance with Standard 6 of the Operational Readiness Manual, HSSEC Readiness (Ma’aden, 2011).

All site personnel will receive training that is appropriate to their role in the operation of the Ras Al Khair Industrial Complex. All employees will receive an initial site induction into the safety rules of the Project, which includes basic emergency response requirements, as a minimum.

Ma’aden will then assess the training needs of individual site operatives and their roles within the operation of the Project, giving due consideration to the completed risk assessment and the operational control and emergency response procedures produced. Training requirements will then be tailored to the risks and hazards of the area in which they operate and the potential accident and emergency situations that may be encountered. Training requirements for individuals performing specific roles in relation to accident and emergency situations will also be identified and addressed, for example, members of the EERP Team, fire fighting, spill response and emergency shut-down of plant and equipment.

B.11.0 ENVIRONMENTAL EMERGENCY RESPONSE PERSONNEL (EERP TEAM)

As the project progresses, more detailed information will become available to allow Ma’aden to implement procedures for the selection of key site personnel who will form the EERP Team and for the development of emergency response organisation (structure, authorities and responsibilities of the EERP Team) for the Ras Al Khair Industrial Complex. Consideration will be given to the suitability of individuals based on their role within the operation of the Project and their ability to provide rapid and effective response to accident and emergency situations.

Training programmes will be developed and provided to the members of the EERP Team to enable them to successfully fulfil their duties and obligations in the event of an accident or emergency situation. Training will include working jointly with external authorities or organisations, such as the fire services or RC, in assisting with the response to accidents and emergencies.

The names and contact details of all members of the EERP team will be listed in the emergency response directory, along with the authorities and organisations to be contacted in accident and emergency response situations.

B.12.0 SAFETY, HEALTH AND ENVIRONMENT (SHE)

Ma’aden will catalogue and provide a detailed breakdown of all hazardous materials that will be stored and handled on site at the Ras Al Khair Industrial Complex. Data will be obtained from sources such as environmental impact identification (ENVID) reviews, hazard identification (HAZID) reviews and MSDS to provide information on the characteristics of hazardous material stored on site such as health hazard characteristics, exposure controls, conditions to avoid and handling of associated waste.

Appropriate signage and symbols will be used for identification of hazardous materials in accordance with United States (US) National Fire Protection Association (NFPA) Code 704:
Standard System for the Identification of the Hazards of Materials for Emergency Response. The NFPA diamond labels and hazard labels for some of the key materials to be stored and used on site at the Ras Al Khair Industrial Complex are provided Figure B.12-1, below3.

![Ammonia](image)

![Phosphoric Acid](image)

![DAP](image)

*Figure B.12-1: NFPA Diamond Labels and Hazard Labels for Key Materials Stored/Used on the Project*

Regulations and guidelines from the US Environmental Protection Agency (EPA), OSHA, National Emission Standards for Hazardous Air Pollutants (NESHAP), Hazard and Operability Study (HAZOP) and Hazardous Waste Operations and Emergency Response (HAZWOPER) will also be applied.

Information gathered on the hazardous materials to be stored and used will advise the production of operational control, emergency response and clean-up procedures, and the selection and use of personal protective clothing and equipment (PPE) appropriate to the requirements of task-specific conditions and the associated potential hazards.

**B.13.0 IMMEDIATE RESPONSE MEASURES**

Emergency response procedures prepared by Ma’aden following completion of the risk assessment and identification of potential accident and emergency situations will include actions for immediate response measures, as necessary. These measures will include clear instructions to be followed by the EERP Team to respond, contain or stop the situation without

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3Ma’aden Phosphate Company, Environmental Management Plan (Ma’aden, 2012)
delay to avoid escalation. Such measures will include actions for emergency plant and equipment shutdown, responding to medical emergencies and responding to equipment failure emergencies.

B.14.0 EMERGENCY PROCEDURES

As discussed previously, Ma’aden will conduct an evaluation of hazardous material stored on-site as part of the risk identification and assessment prior to start of operations at the Ras Al Khair Industrial Complex. This evaluation will include all conditions that could create an accident or emergency situation which could cause danger to life or health, impact on the environment or damage to the site, surrounding communities or industrial installations. Procedures will be prepared providing instructions to be followed in the event of accident or emergency situation occurring, wherever a risk of a potential accident or emergency has been identified following completion of the risk assessment process.

Ma’aden also has a number of existing procedures which will be reviewed and amended, where applicable, to ensure they are specific to the Ras Al Khair Industrial Complex.

B.15.0 REDUCING ENVIRONMENTAL IMPACT

There are a number of adverse environmental impacts that can potentially occur following an accident or emergency situation. The key receptors with regards to the Project, include soil and subsoil; surface water, ground water and the marine environment; and the local and regional atmosphere. There are no inhabited areas in the immediate vicinity of the project (the closest sizeable population centre being Nuayriyah, 68km to the west of the Project) and therefore the impact on human settlements from an accident or emergency situation is unlikely, although cannot be entirely discounted. There is an existing housing complex (‘Ma’aden Housing’) within the Project site boundary for the MPC workforce. Potential impacts upon the Ma’aden Housing, and any workforce accommodation proposed for the Ras Al Khair Industrial Complex, will be considered by Ma’aden during the development of emergency procedures.

Ma’aden will prepare and establish procedures to be implemented and followed in order to minimise environmental impacts resulting from accident or emergency situations. The procedures will include methods to ensure the containment and control of the accident or emergency situation to minimise potential environmental damage, and the necessary removal, clean-up, repair and rehabilitation measures once the situation has been contained and controlled.

Potential environmental impact may occur as a result of any of the accident or emergency situations included in sections 5.0, 6.0 and 7.0 above and each situation, and the potential damage to each receptor, will be given full consideration by Ma’aden when procedures to minimise environmental impacts are developed.

Liquids represent the most significant risk of environmental damage to soil and water receptors, either through direct spillage, or indirectly through run-off or surface drainage systems, causing contamination and pollution of the soil and subsoil and surface, ground and marine waters. Solid materials (e.g. powder/crystalline forms) have the potential to cause similar environmental damage, particularly if they come into contact with a liquid substance during an emergency situation, however, solids are generally easier to contain and clean-up. Liquid pollutants may also be created and released during response to an emergency situation, for example, from the discharge of firewater or foam or powder fire retardant, and Ma’aden will ensure consideration of the containment and control of these potential pollutants during the preparation of emergency procedures.

Small, local spillages may also occur from site activities such as routine maintenance, which may also result in the accumulation of a pollutant and damage to a receptor over a prolonged time period. However, environmental impact from routine site activities should not be considered as an accident or emergency situation in the scale of those covered by this EERP.
Environmental damage to the atmosphere can potentially be caused through accidental release of gases or evaporation from liquid materials into the atmosphere, as well as through emergency situations such as explosion or fire. The potential for accidental release to atmosphere will be minimised by Ma’aden through due consideration to this potential environmental impact through development of the Project’s EMS and implementation of operational control procedures. Impact upon the local and regional atmosphere following an emergency situation will be minimised and controlled by Ma’aden through implementation of procedures and measures to contain the situation (e.g. extinguishing a fire).

Although Ma’aden will give due consideration in the identification of the specific actions to minimise environmental impacts in response to a specific emergency situation, there will be a number of common control measures to be considered during development of response procedures to be applied during emergency situations. Such common considerations include:

- identify other critical factors (e.g. pathways to controlled waters, ease to contain/recover material, material dispersion in air or water, etc.);
- review MSDS and apply measures accordingly;
- where possible, isolate the source of a spill and contain the spill using suitable response equipment (e.g. absorbent material, booms, mats, etc.);
- contain fire water to prevent discharge to drains and controlled waters; and
- recover fire fighting material (particularly foam or powder), especially where there is potential to discharge to controlled waters.

Waste generated as a result of response to emergency situations is likely to have hazardous properties, which in itself poses a risk with regards to additional impacts and environmental damage occurring. Ma’aden will include clear instruction for the management of hazardous waste generated from emergency response in accordance with the necessary legal requirements and relevant environmental/ waste procedures applicable on site. In situations where it is evident that hazardous substances have been discharged to the environment and damage to receptors has occurred, Ma’aden will employ suitably qualified contractors to plan and carry out appropriate clean-up, remediation and rehabilitation works.

**B.16.0 CORRECTIVE ACTION PLAN**

All accidents and emergency situations resulting in environmental impacts shall be recorded using the Ma’aden electronic incident report form and classified in accordance with the Ma’aden SHE Incident Severity Determination Guidelines. The completion of the incident report form will also be used to inform the PME within 24 hours of a major accident occurring.

As soon as the emergency has been contained, controlled and clean-up begins, Ma’aden will conduct an accident investigation and produce a report to determine the cause(s) of the incident; to provide a summary of the emergency response and success; to discuss lessons learned from the incident; and, to recommend corrective actions to be implemented to prevent escalation or repetition of the original or similar incident(s), as necessary.

Possible corrective actions for implementation may include:

- controlling the source of the pollution;
- a review of operational procedures;
- replacement of equipment;
- studies of the environmental impact upon the surrounding environment;

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4 Ma’aden Phosphate Company, Environmental Management Plan (Ma’aden, 2012)
• management of the clean-up or repair of the area affected by the incident to prevent further release of contaminants; and

• assessment of the need for additional operational training.

All accidents and emergency situations resulting in environmental impacts shall be recorded using the Ma’aden electronic incident report form and classified in accordance with the Ma’aden SHE Incident Severity Determination Guidelines.

B.17.0 MATERIAL HANDLED AND STORED AT SITE

Ma’aden will maintain and update at all times a register and inventory of all materials either stored and handled, or transported to and from the Project site. Hazardous materials will be specifically documented in a Hazardous Materials Inventory for which the Operation Supervisor, in coordination with the Ma’aden HSE department, will be responsible. Ma’aden will also retain additional resources, such as MSDS, in conjunction to the inventory for access to further information for each material stored on site.

The format for the materials inventory to be used by Ma’aden on the Project is shown in Table B.17-1 below.

<table>
<thead>
<tr>
<th>Material</th>
<th>Capacity</th>
<th>Inventory</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Average (m³)</td>
<td>Max (m³)</td>
</tr>
</tbody>
</table>

Table B.17-1: Template for Materials Inventory

B.18.0 EMERGENCY EQUIPMENT

Ma’aden will ensure that emergency equipment is held at key locations throughout the Project site for ease of access should an emergency situation or accident occur. The location of emergency equipment and applicability for use will also be detailed in emergency response procedures, as appropriate. An inventory of all emergency equipment will be maintained and updated by Ma’aden at all times and regular checks and inspections of emergency equipment will take place to ensure maintenance of stock and suitability for use.

Emergency equipment may include, but not be limited to:

• portable radios and phones;
• flashlights;
• gas detectors;
• hand tools;
• emergency lighting equipment;
• absorbent materials;
• water pumps;

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5 Ma’aden Phosphate Company, Environmental Management Plan (Ma’aden, 2012)
6 Ma’aden Phosphate Company, Environmental Management Plan (Ma’aden, 2012)
- firewater truck;
- dry chemical and foam truck;
- oxygen analyzers;
- hand portable extinguishers; and
- fire water loop system (hydrant, monitors).

**B.19.0 PPE FOR EMERGENCY PERSONNEL, FIRST AID AND MEDICAL EXAMINATION**

Ma’aden will ensure that PPE and first aid boxes are held at key locations throughout the Project site for ease of access should an emergency situation or accident occur. The location of PPE and applicability for use will also be detailed in emergency response procedures, as appropriate. An inventory of all PPE and first aid boxes will be maintained and updated by Ma’aden at all times and regular checks and inspections of PPE and first aid boxes will take place to ensure maintenance of stock and suitability for use.

PPE may include, but not be limited to:

- splash goggles;
- face shields;
- breathing apparatus;
- bunker suits;
- decontamination suits;
- life vests;
- cold temperature gloves; and
- rubber boots.

Ma’aden will also ensure establishment and operation of one or more site-based medical facilities for the Project for both emergency and periodic examination of employees, as required.

**B.20.0 EVACUATION**

Ma’aden will prepare appropriate evacuation procedures to be followed by site personnel in the event of emergency situations and accidents. The type of accident or emergency experienced will influence the evacuation procedure in terms of the evacuation route to be followed, the final evacuation point and assembly area. Environmental factors such as wind direction will also be considered by Ma’aden in the preparation of evacuation procedures and in determining which procedure should be followed in the event of an accident or emergency situation occurring.

Ma’aden will ensure that all site personnel receive sufficient training in the evacuation procedures to be followed for the different emergency situations that may be encountered whilst working at the Project site. In order to facilitate the optimum behaviour and responses, and to ascertain the adequacy of evacuation procedures, mock emergency situations (drills) will be periodically conducted by Ma’aden once the Project becomes operational.

The purpose of the mock drills will be to:

- test the adequacy, effectiveness, timing and all phases of evacuation procedures;
- test emergency equipment; and
- ensure that the emergency organisation personnel are familiar with their duties and responsibilities.
Drills will be conducted as realistically as is reasonably practical. Ma’aden will review and the success of each drill to evaluate the overall drill performance. A written evaluation will be produced, with the report including assessments and recommendations on:

- areas that require immediate correction;
- areas where additional training of personnel is needed;
- suggested modifications to the evacuation procedures; and
- deficiencies in equipment, training and the facility.

### B.21.0 REFERENCES


Jacobs (2013), Ras Al Khair ESIA – Detailed Description and Layout of the Proposed Development

Ma’aden (2012), Environmental Management Plan (HSE&S-101-0000-ENV-EMP-0001)
### ATTACHMENT 1: REFERENCE TO MA’ADEN DOCUMENTATION APPLICABLE TO ROYAL COMMISSION ENVIRONMENTAL REGULATIONS, VOLUME II, APPENDIX D

<table>
<thead>
<tr>
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<tbody>
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<td>1. PURPOSE OF THE EMERGENCY PLAN</td>
<td>6, 15.2.12</td>
<td>21.1.1</td>
</tr>
<tr>
<td>2. REGULATORY FRAMEWORK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. DESCRIPTION OF SITE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. PROCESS RELATED RISKS</td>
<td>14, 15.2.3, 15.2.4, 15.2.5, 15.2.11, 15.2.12</td>
<td>6, 12.2, 12.3, 21.14, 21.18, 23</td>
</tr>
<tr>
<td>5. TYPE OF EMERGENCIES</td>
<td>15.2.12</td>
<td>21.10, 21.14</td>
</tr>
<tr>
<td>6. ROAD ACCIDENTS</td>
<td></td>
<td>21.7</td>
</tr>
<tr>
<td>7. FIRE FIGHTING</td>
<td>15.2.12</td>
<td>21.7</td>
</tr>
<tr>
<td>8. INCIDENT/ACCIDENT MANAGEMENT</td>
<td>15.2.3, 15.2.4, 15.2.5, 15.2.9, 15.2.11, 15.2.12, 15.2.13</td>
<td>6, 12.2, 12.3, 19.4, 21, 21.3, 21.15.1, 23, 25.2</td>
</tr>
<tr>
<td>9. ALARMS AND COMMUNICATION</td>
<td>15.2.12</td>
<td>18.1</td>
</tr>
<tr>
<td>10. TRAINING PRACTICES</td>
<td>15.2.6, 15.2.11, 15.2.12, 16.2</td>
<td>6, 12.4, 15.3, 17.1, 17.2, 17.4, 21.15.2</td>
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<td>5, 15.2.12</td>
<td>12.4, 15.3, 17.1, 17.2, 17.4, 21.15.2</td>
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<td>12. SAFETY, HEALTH AND ENVIRONMENT (SHE)</td>
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<td>21.4, 21.8</td>
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<tr>
<td>13. IMMEDIATE RESPONSE MEASURES</td>
<td>15.2.12</td>
<td>19.4, 21.3, 21.15.1, 23</td>
</tr>
<tr>
<td>14. EMERGENCY PROCEDURES</td>
<td>15.2.12</td>
<td>19.4, 21.3, 21.15.1, 23</td>
</tr>
<tr>
<td>15. REDUCING ENVIRONMENTAL IMPACT</td>
<td>15.2.12</td>
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<tr>
<td>16. CORRECTIVE ACTION PLAN</td>
<td>15.2.12, 15.2.3</td>
<td>19.2, 25</td>
</tr>
<tr>
<td>17. MATERIAL HANDLED AND STORED AT SITE</td>
<td>15.2.9</td>
<td>21.18</td>
</tr>
<tr>
<td>18. EMERGENCY EQUIPMENT ON-SITE/OFF-SITE</td>
<td>15.2.12</td>
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<td>19. PPE FOR EMERGENCY PERSONNEL, FIRST AID, AND MEDICAL EXAMINATION</td>
<td>15.2.5, 15.2.11, 15.2.12</td>
<td>15.4, 17.4, 21.6</td>
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<tr>
<td>20. EVACUATION PROCEDURES AND ENVIRONMENTAL EMERGENCY DRILLS</td>
<td>15.2.12</td>
<td>17.4</td>
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ATTACHMENT 2: PROPOSED LAYOUT OF THE RAS AL KHAIR INDUSTRIAL COMPLEX
## ATTACHMENT 3: NFPA LABELLING AND CHIP SYMBOLS


<table>
<thead>
<tr>
<th>Health Hazard</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Deadly</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Extreme Danger</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Hazardous</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Slightly Hazardous</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Normal Material</td>
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</table>

<table>
<thead>
<tr>
<th>Fire Hazard – Flash Points</th>
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</thead>
<tbody>
<tr>
<td>4</td>
<td>Below 73°F</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Below 100°F</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Between 100°F and 200°F</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Above 200°F</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Will not burn</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Reactivity</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>4</td>
<td>May Detonate</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Shock/Heat May Detonate</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Violent Chemical Change</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Unstable if Heated</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Stable</td>
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</table>

<table>
<thead>
<tr>
<th>Specific Hazard</th>
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</thead>
<tbody>
<tr>
<td>ACID</td>
<td>Acid</td>
<td></td>
</tr>
<tr>
<td>ALK</td>
<td>Alkali</td>
<td></td>
</tr>
<tr>
<td>COR</td>
<td>Corrosive</td>
<td></td>
</tr>
<tr>
<td>OXY</td>
<td>Oxydiser</td>
<td></td>
</tr>
<tr>
<td>Use No Water</td>
<td>Use No Water</td>
<td></td>
</tr>
<tr>
<td>Radioactive</td>
<td>Radioactive</td>
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</table>
### Hazard Symbols – Physiochemical

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>ABBREVIATION</th>
<th>HAZARD</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>E</td>
<td>Explosive</td>
<td>Chemicals that explode.</td>
</tr>
<tr>
<td>O</td>
<td>O</td>
<td>Oxidising</td>
<td>Chemicals that react exothermically with other chemicals.</td>
</tr>
<tr>
<td>F+</td>
<td>F+</td>
<td>Extremely flammable</td>
<td>Chemicals that have an extremely low flash point and boiling point, and gases that catch fire in contact with air.</td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td>Highly flammable</td>
<td>Chemicals that may catch fire in contact with air, only need brief contact with an ignition source, have a very low flash point or evolve highly flammable gases in contact with water.</td>
</tr>
</tbody>
</table>

### Hazard Symbols – Health

<table>
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<td>T+</td>
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<td>Very toxic</td>
<td>Chemicals that at very low levels cause damage to health.</td>
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### SYMBOLS

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<td>Harmful</td>
<td>Chemicals that may cause damage to health.</td>
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<tr>
<td><img src="image5" alt="C" /></td>
<td>C</td>
<td>Corrosive</td>
<td>Chemicals that may destroy living tissue on contact.</td>
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<td><img src="image6" alt="Xi" /></td>
<td>Xi</td>
<td>Irritant</td>
<td>Chemicals that may cause inflammation to the skin or other mucous membranes.</td>
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### Hazard Symbols – Environment

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<td><img src="image7" alt="N" /></td>
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<td>Dangerous for the environment</td>
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DEPARTMENT: SAFETY AND ENVIRONMENTAL
REPORT NO: 60-R400-WH/G.06F/0072 (APPENDIX C)

REPORT TITLE: RAS AL KHAIR
ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT (ESIA)
APPENDIX C – STAKEHOLDER ENGAGEMENT PLAN

PROJECT REFERENCE
PROJECT NO: 60-R400-WH
PROJECT LOCATION: SAUDI ARABIA
PROJECT TITLE: UMM WU’AL PHOSPHATE PROEJCT
CLIENT: MA’ADEN (SAUDI ARABIAN MINING COMPANY)
CLIENT PROJECT NO: 2-115-12-12-2-2
CLIENT DOCUMENT NO: MD-513-0000-HS-EN-RPT-0069 (APPENDIX C)

PM Authorisation: Andy Dodd

APPROVALS

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DOCUMENT ISSUED FOR:
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- [x] For Information
- [ ] For Review
- [ ] For Use
- [ ] For Approval
- [ ] For Enquiry
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C1.0 INTRODUCTION

C1.1 SCOPE

This Stakeholder Engagement Plan outlines the approach to be taken in supporting the communications and engagement objectives, processes and deliverables required to support successful delivery of the Ma’aden Phosphate Project (herein referred to as ‘the Project’). The Plan identifies the range of people and organisations that may be regarded as stakeholders in the Project, and describes the strategy to be used for engaging with these stakeholders in a culturally appropriate manner.

This Plan has been developed at ‘Stage 3 – Feasibility’ of Ma’aden’s Stage Gate Governance process and will provide a template for Ma’aden to develop and update as appropriate for the remaining stages of this process: Stage 4 – Engineering, Procurement and Construction and Stage 5 – Turn Over and Close-out.

The key goal of the Stakeholder Engagement Plan is to provide a framework for the timely provision of relevant and understandable information; and create a process that provides opportunities for stakeholders to express their views and concerns and allow the Project to consider and respond to these.

The communication and engagement objectives of this Stakeholder Engagement Plan are to:

- Establish and maintain stakeholder and community awareness of the Project and the roles and responsibilities of different bodies and organisations associated with its operation;
- Manage expectations about what the Projects’ outcomes will be;
- Provide appropriate opportunities for involving and engaging with relevant stakeholders;
- Provide a means for recording consultation - the issues raised and by whom, and responses to these issues provided to stakeholders;
- Provide a process in which project planning and operation can take account of issues raised by stakeholders;
- Reduce the potential for stakeholder disaffection, which can result from a misunderstanding of the Project; and
- Establish and maintain a constructive relationship with stakeholders as relevant over the life of the project.

The Stakeholder Engagement Plan is a live and iterative document that will be updated periodically throughout the life of the Project.

C1.2 COMMITMENT TO STAKEHOLDER ENGAGEMENT

Ma’aden has developed a guide to External Stakeholder Management1 and also a guide to Environment and Communities Assurance2 for their projects as part of the Ma’aden Project Manual series.

Ma’aden has adopted the International Council on Mining and Metals (ICMM) Sustainable Development Framework as the basis for its corporate management philosophy. The following framework principles are identified by Ma’aden as specifically relating to Stakeholder Engagement:

- ICMM Principle 9: Contribute to the social, economic and institutional development of the communities in which we operate; and

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ICMM Principle 10: Implement effective and transparent engagement, communication and independently verified reporting arrangements with our stakeholders.

As published in their Corporate Brochure, Ma’aden is committed to Corporate Social Responsibility (CSR) allowing them “to contribute positively to the well being of our people, the environment, economy and society”.

Ma’aden recognise that “responsible behaviour generates greater value for our stakeholders and earns us the trust of our employees, the communities in which we operate and our customers”.

Core to Ma’aden’s commitment to social responsibility are the following 10 principles which are published in the Corporate Brochure:

- To implement and maintain ethical business practices and sound systems of corporate governance.
- To integrate sustainable development considerations within the corporate decision-making process.
- To uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities.
- To implement risk management strategies based on valid data and sound science.
- To seek continual improvement of our health and safety performance.
- To seek continual improvement of our environmental performance.
- Contribute to conservation of biodiversity and integrated approaches to land use planning.
- To facilitate and encourage responsible product design, use, re-use, recycling and disposal of our products.
- To contribute to the social, economic and institutional development of the communities in which we operate.
- To implement effective and transparent engagement, communication and independently verified reporting arrangements with our stakeholders.

Ma’aden’s commitment to CSR focuses on the four pillars of ethics, environment, community commitment and employee commitment.

C1.3 PROJECT DESCRIPTION

The Project will be based on two sites, namely Umm Wu’al Mine and Waad Al Shamaal Phosphate Industrial Complex and Ras Al Khair, and a linking transport system. The site at Umm Wu’al in the Sirhan-Turaif region of northern Saudi Arabia, will include an open cast mine, beneficiation plant and a number of acid producing plants to process the extracted ore. The Project will take advantage of an existing railway infrastructure to transfer these processed materials 1500km to Ras Al Khair (RAK), on the Arabian Gulf. RAK is an existing industrial complex and port facility located on a peninsula in the Eastern Province of Saudi Arabia. New industrial facilities will be constructed at Ras Al Khair and the port will be upgraded. The Project will also include all supporting infrastructure and connections to utilities.
C2.0 REGULATIONS AND REQUIREMENTS

The Ma’aden Phosphate Project aims to conform to good international practice, and therefore guidance produced by the World Bank Group, including the International Finance Corporation and also from the Equator Principles has been used. Currently, KSA legislation does not specifically include for stakeholder engagement.

C2.1 SAUDI ARABIAN REGULATIONS AND STANDARDS

The Saudi Arabian legislation includes the PME General Environmental Regulations and Rules for Implementation enacted in October 2001 (for the Umm Wu’al mine site), the Royal Commission Environmental Regulations (RCER) 2010 (for the Ras Al Khair site) and Islamic Principles for conservation of the natural environment.

The Presidency of Meteorological and Environment (PME), as the competent authority in the Kingdom of Saudi Arabia, operates under the permitting legislation (General Environmental Regulation, PME 2001). There are no specific requirements for stakeholder engagement within this legislation, however, the PME Rules for Implementation requires the Competent Agency to document and publish environmental information (Chapter Two, Duties and Obligations, Article Three).

The RC has developed and adopted the RCER 2010 (Volumes I, II and III) to control substances emitted, discharged, or deposited, and noise generated within the industrial cities. Volume II, Appendix D (Environmental Emergency Response Plan (EERP)) of the Royal Commission Environmental Regulations 2010, requires that the EERP for an industrial facility includes guidelines for communicating emergency messages/alarm, and that a hot-line is established so that all concerned government authorities/organisations can be contacted in an emergency.
C2.2 WORLD BANK & INTERNATIONAL FINANCE CORPORATION GUIDELINES

C2.2.1 WORLD BANK OPERATION MANUAL

The World Bank Environmental Assessment requirements relevant to stakeholder engagement for a Project such as this are provided in Operational Policy (OP) 4.01 and Bank Procedures (BP) 4.01. The OP provides guidance to allow ‘borrower decision makers and Bank operational staff to ensure that the project options under consideration are environmentally sound and sustainable’. BP 4.01 explains how the World Bank representatives implement the policies set out in OP 4.01, and clarifies the procedures and documentation required.

The following World Bank policies will continue to be reviewed for relevance to this Project, however currently, during scoping stage, their relevance is considered to be limited:

- OP/BP 4.10 Indigenous Peoples
- OP/BP 4.12 Involuntary Resettlement
- OP/BP 4.11 Physical Cultural Resources

C2.2.2 WORLD BANK ENVIRONMENTAL ASSESSMENT SOURCEBOOK AND UPDATES

The World Bank provides practical guidance for designing sustainable World Bank-assisted projects by way of a Sourcebook. The following Sourcebook chapters and Updates have been reviewed as most relevance to this Stakeholder Engagement Plan:

- Chapter 7: Community involvement and the role of nongovernmental organisations in environmental assessment.

C2.2.3 INTERNATIONAL FINANCE CORPORATION

The private-sector investment arm of the World Bank, the International Finance Corporation (IFC) requires environmental assessment of projects proposed for IFC financing. The IFC Performance Standards (IFC, 2012) are:

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts
- Performance Standard 2: Labour and Working Conditions
- Performance Standard 3: Resource Efficiency and Pollution Prevention
- Performance Standard 4: Community Health, Safety, and Security
- Performance Standard 5: Land Acquisition and Involuntary Resettlement
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources
- Performance Standard 7: Indigenous Peoples
- Performance Standard 8: Cultural Heritage

Those Performance Standards of specific relevance to stakeholder engagement are highlighted in *italics*. The extent to which the Performance Standards apply to the implementation (and revision) of this Stakeholder Engagement Plan will be reviewed as the

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4 Defined as movable or immovable objects, sites, structures, groups of structures, and natural features and landscapes that have archaeological, paleontological, historical, architectural, religious, aesthetic, or other cultural significance.
Project develops. The applicability of these Standards to the wider project is assessed as part of the environmental impact assessment process and reported in the Environmental and Social Impact Assessment reports for both the Umm Wu’al and Ras Al Khair sites as relevant.

C2.3 EQUATOR PRINCIPLES

The Equator Principles, established in June 2003, and subsequently reviewed in 2006 and 2013, is a risk framework for identifying, assessing, and managing environmental and social risks in project finance transactions. This framework is based on the IFC Performance Standards and the World Bank Group EHS Guidelines. Equator Principles Financial Institutions (EPFIs) have adopted the Equator Principles in order to ensure that the Projects financed are developed in a manner that is socially responsible and reflects sound environmental management practices. The principles comprise a set of ten broad principles that are underpinned by the environmental and social policies, standards and guidance of the IFC.

Equator Principle 5 (Stakeholder Engagement) and Principle 6 (Grievance Mechanism) are of most relevance to stakeholder engagement for this Project. Principle 5 requires effective stakeholder engagement to be demonstrated on an ongoing process in a structured and culturally appropriate manner with affected communities and where appropriate other stakeholders. Principle 6 requires the Client (in this case, Ma’aden) to establish a grievance mechanism designed to receive and facilitate resolution of concerns and grievances about the Project’s environmental and social performance.

C3.0 PREVIOUS STAKEHOLDER ENGAGEMENT ACTIVITIES

Whilst investigating the feasibility of phosphate mining and export projects in the northern and eastern regions of Saudi Arabia, Ma’aden representatives have liaised with various stakeholders directly as well as commissioning a number of studies/reports for which stakeholder engagement was undertaken.

Local community consultation was undertaken in the vicinity of the Umm Wu’al site by SRK Consulting in 2000 as part of the Environmental Baseline Assessment Studies for the Northern Phosphate Project Sites. This assessment identified that there were no existing settlements in the immediate area of the exploration license area of Umm Wu’al, and that Turayf is the nearest town, approximately 40km to the south-west (Source: SOFRECO – TECHNIP, 2012).

A summary of the concerns of local community in the Umm Wu’al area is recorded (by SRK, 2000 and SOFRECO – TECHNIP, 2012) as: In general, employment opportunities are the main concern for the local people. The Bedouin in Thaniyat Turayf and Al Jalamid were most concerned that access through the mining areas will be restricted and that their families, who have traditionally used the area for many generations, will be forced to move elsewhere.

Consultation in the Ras Al Khair area was undertaken in 2004 as part of the environmental and social baseline surveys for the Ras Az Zawr peninsula completed in the framework of the Al Jalamid Project. Consultation was undertaken by GHD Consulting (Source: SNC-Lavalin, 2005, and SOFRECO – TECHNIP, 2012).

A Community Impact Assessment undertaken by Environmental Consulting Bureau in 2006 for the Al Jalamid Project included consultation in the vicinity of both the Umm Wu’al (Al Jalamid) and Ras Al Khair (Ras Az Zawr) areas. The main objective of this Community Impact Assessment was to identify community concerns and potential adverse impacts to the local communities due to the proposed project activities. Consulted parties included:

- Key Government agencies for Al Jalamid and Ras Al Khair areas;
- Bedouin communities of Al Jalamid and Ras Al Khair;
- The Coast Guard at Ras Al Khair; and
- Soldiers at Ras Al Khair.
In relation to both the Al Jalamid and Ras Al Khair areas, the Community Impact Assessment reports that ‘during the consultation, no specific concerns were raised against the proposed project by either government agencies or by the people interviewed’. Consulted parties for the Al Jalamid area expressed a general expectation ‘that as a result of the project, employment opportunities for locals in the area will increase and therefore be beneficial’.

Ma’aden representatives have liaised directly with the Turaif Chambers of Commerce regarding the Project elements at the Umm Wu’al site. The Chambers of Commerce have communicated a positive opinion of the Project as expressed by the surrounding communities. This Project is seen as an opportunity for employment for local men and women as well as local business/community enhancement. Ma’aden is also liaising with the Royal Commission and the Port Authority with regards Project elements at Ras Al Khair.

### C4.0 STAKEHOLDER ENGAGEMENT ACTIVITIES UNDERWAY TO INFORM THE PROJECT

The following represents a summary of the stakeholder consultation initiated during the ESIA process as relevant to both the Umm Wu’al and Ras Al Khair project locations:

- **Ma’aden**: Day-to-day project-related liaisons and formal Survey Questionnaire;
- **Saudi Railway Authority**: Construction, permitting and operation of rail connection between Umm Wu’al and Ras Al Khair.

### C4.1 UMM WU’AL

On commencement of the ESIA process, a meeting was held with the PME in 2012 to present the ESIA Scope of Works. Other key stakeholders with which consultation is ongoing as part of the ESIA include:

- Ministry of Water and Environment (MoWE); and
- The Waad Al-Shamall City Development Project Team representatives (within Ma’aden).

A socio-economic survey was conducted in January 2013 to:

- Obtain baseline information at the local level and to help determine the attitudes of local residents and government officials regarding the project; and
- Help to determine potential positive and negative impacts the project may have on the local population.

Survey questionnaires were firstly circulated to a number of Government representatives to gather their responses with regards to the project. The following Government representatives responded to the questions posed:

- Governor of Turaif, Faris Al Nuaimi;
- President of Municipality, Mr. Ayed Ben Ayash Al Inizi;
- President of Education in Turaif, Mr. Ahmed Ben Salim Al Shareef;
- Manager of Labor Office in Turaif, Mr. Abdulla Nazel Al Rouwaily;
- Manager of Utilities in Turaif Municipality, Mr. Hussain Ali Al Khlaif; and
- Manager of Public Relations of Turaif Municipality, Mr. Thabt Ben Jaddou Al Rouwaily.

The Government representatives provided valuable information to contribute towards establishing the baseline for the project and also gave permission to conduct a community survey within Turaif. Survey questions are included within Attachment 3. After consulting with the Government representatives, it was decided that the community survey would be conducted to reach as broad a spectrum of stakeholders as possible. Approximately 200 survey questionnaires were distributed, with 107 people completing and returning the survey.
between 4th to the 10th January 2013 (refer to Attachment 4). Answers were either written by the respondent or given verbally and recorded by the site team (fewer than 10 respondents answered verbally). The following groups were included in the community survey:

- Education sector – questionnaires were distributed to male and female teachers and students in schools;
- Health sector – the project was explained by the WHGME team who recorded the answers to the questions asked orally – the respondents were primarily female nurses; and
- General community –
  - An “Esteraha” (a villa that a group of people collect money to rent or buy for evening enjoyment with friends) and explained the project to the people present before distributing the questionnaires. Some of those present also offered to distribute questionnaires to friends not present at the time;
  - Proprietors and customers in the local marketplace, which also included a hotel and pharmacy, as well as shops; and
  - One water tanker owner, who works as a herder for a Jordanian livestock owner (who does not reside in Saudi Arabia), was questioned in the area of the project.

C4.2 RAS AL KHAIR

On commencement of the ESIA process, a meeting was held with the Royal Commission in 2012 to present the ESIA Scope of Works.

Due to the location and industrial nature of the Ras Al Khair Project area, community consultation was not considered appropriate to the proposed Industrial Complex at Ras Al Khair. ‘Affected’ communities are considered to be limited to those associated with the Ma’aden Housing Complex and the temporary camps located on the Ras Al Khair peninsula.

The following is a summary of the key stakeholder consultation initiated:

- Royal Commission - with regards information requests and site permitting;
- Saudi Port Authority: Construction and permitting of new berths for use by Ma’aden (reclamation and possibly dredging will be required);
  - Technical Interface meeting held on 13th April 2013;
  - Actions agreed on drawing up a Land lease agreement between Ma’aden & SEAPA;
  - Interfaces with RC, HCISS and Coast Guard discussed and actions agreed;
  - Ma’aden and SAR Sr. Management meeting held on 28th April 2013.
- Saudi Railway Authority: Meetings held in 2013 to develop a Memorandum of Understanding.

C5.0 PROJECT STAKEHOLDERS

C5.1 IDENTIFICATION AND MAPPING OF STAKEHOLDERS

Stakeholders are those parties or individuals with an interest in the Project, who can potentially influence, or be influenced by its construction, operation and/or decommissioning. A preliminary list of stakeholder groups likely to be impacted by, or benefit from, the Project has been identified in Table C.1. A Stakeholder Interface Register is currently being developed based on the framework outlined in this Stakeholder Engagement Plan. This will continue to be developed by the Project Team and can be included with this Plan as appropriate.
### Table C.1: Stakeholder Groups Likely to be Impacted by, or Benefit from the Project (preliminary, subject to edit)

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<tr>
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<td><strong>Intended Beneficiaries</strong></td>
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<td>Ma'aden</td>
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</tr>
<tr>
<td>Lender</td>
<td>Project success; Mitigation of project risks; Environmental and social responsibilities.</td>
</tr>
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<td><strong>Government Policymakers</strong></td>
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<td>Presidency of Meteorology and Environment</td>
<td>Environmental and social responsibilities (including environmental permitting)</td>
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<td>Principal landowners</td>
<td>Royalties and other benefits; Community benefits</td>
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<tr>
<td>Royal Commission</td>
<td>Environmental and social responsibilities (including environmental permitting)</td>
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<td>Ministry of Agriculture</td>
<td>Environmental and social responsibilities.</td>
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<tr>
<td>Ministry of Interior</td>
<td>Social responsibilities; Security. Permits to modify border guards fence route etc.</td>
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<tr>
<td>Ministry of Labor and Social Affairs</td>
<td>Social responsibilities. Permits to obtain foreign labour visas.</td>
</tr>
<tr>
<td>Ministry of Municipalities and Rural Affairs</td>
<td>Environmental and social responsibilities (including water discharge permits).</td>
</tr>
<tr>
<td>Ministry of Petroleum and Mineral Resources</td>
<td>Project success; Mitigation of project risks; Environmental and social responsibilities. Mine permitting.</td>
</tr>
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<td>High Commission of Industrial Safety &amp; Security (HCiSS)</td>
<td>Responsibility to check adherence to Safety &amp; Security Directive (security design submissions at the EPC stage by Security &amp; Safety Contractor)</td>
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<td>Ministry of Water and Electricity</td>
<td>Environmental and social responsibilities. Permitting for water pumping and electrical supply (in case of interference with national network)</td>
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<td>Saudi Customs Department (Ministry of Finance)</td>
<td>Social responsibilities; Security. Importation permits.</td>
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<td>MODON-Saudi Industrial Property Authority</td>
<td>Regulation and promotion of Industrial Estates and Technology Zones in the Kingdom of Saudi Arabia on both public and private industrial lands</td>
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<td>Ministry of Economy and Planning</td>
<td>Land Allocation</td>
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<td>ECRA- Electricity &amp; Cogeneration Regulatory Authority</td>
<td>Registration of any power plant, constructed for benefit of project</td>
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<td>Ministry of Commerce and Industry</td>
<td>Industrial License</td>
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<td>Department of Zakat - D2IT</td>
<td>Requirement as per country law</td>
</tr>
<tr>
<td>Ministry of Communication and Information Technology</td>
<td>Approval, Supervision of the activities of communications and information.</td>
</tr>
<tr>
<td><strong>Civil Society Organisations</strong></td>
<td></td>
</tr>
<tr>
<td>Non-governmental organisations (NGOs) &amp; community-based organisations (CBOs)</td>
<td>Environmental and social responsibility; Community development opportunities; Impact on cultural heritage, archaeological sites and community facilities.</td>
</tr>
<tr>
<td>TVTC-Technical and Vocation Training Centre</td>
<td>For training centre building design and equipment [cooperation] agreement</td>
</tr>
<tr>
<td><strong>Communities, Local and Commercial Groups</strong></td>
<td></td>
</tr>
<tr>
<td>Bedouins</td>
<td>Access restrictions on access through Project areas; Impact on cultural heritage.</td>
</tr>
<tr>
<td>Herders Living in the Mine Vicinity</td>
<td>Access restrictions on access through Project areas.</td>
</tr>
</tbody>
</table>
### Stakeholder Interest / Potential Concerns

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Interest / Potential Concerns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Communities</td>
<td>Employment opportunities; New services and infrastructure; Business opportunities; Social pathologies, including conflicts, due to ongoing presence of foreign workers with lifestyle and cultural difference; Forceful land acquisition and involuntary re-settlement.</td>
</tr>
<tr>
<td>Principal landowners</td>
<td>Royalties and other benefits; Community benefits</td>
</tr>
<tr>
<td>Emergency Services</td>
<td>Environmental and social responsibilities.</td>
</tr>
<tr>
<td>Saudi Wildlife Authority</td>
<td>Environmental impacts including trans-boundary issues; Proposed environmental mitigation measures.</td>
</tr>
<tr>
<td>Saudi Geological Survey</td>
<td></td>
</tr>
<tr>
<td><strong>Infrastructure, Transport and Development</strong></td>
<td></td>
</tr>
<tr>
<td>Operators / Suppliers (desalination and potable water, natural gas, molten sulphur supplies; Ma’aden Phosphate Company (MPC) 1 site operators. Other entities which will supply feed materials for the plant.)</td>
<td>Project success; Mitigation of project risks; Environmental and social responsibilities.</td>
</tr>
<tr>
<td>“Quintet” 5 Coast Guard, PME, Ministry of Agriculture, Municipality (Ras Al Khair), Ministry of Finance)</td>
<td>Project success; Mitigation of project risks; Environmental and social responsibilities; Security.</td>
</tr>
<tr>
<td>Road Authority</td>
<td>Provision of transport link; Restrictions on operations.</td>
</tr>
<tr>
<td>Saudi Port Authority (SEAPA)</td>
<td>Provision of transport link; Restrictions on operations.</td>
</tr>
<tr>
<td>Saudi Railway Company</td>
<td>Provision of transport link; Business opportunities; Restrictions on operations.</td>
</tr>
<tr>
<td><strong>Workforce</strong></td>
<td></td>
</tr>
<tr>
<td>Expatriate Employees, International Contractors, National Contractors, Saudi National Employees</td>
<td>Health and safety and general wellbeing; Mitigation / management of e.g. radiation, air and noise emissions; Social pathologies, including conflicts, due to ongoing presence of foreign workers with lifestyle and cultural difference.</td>
</tr>
<tr>
<td><strong>Academic Institute</strong></td>
<td></td>
</tr>
<tr>
<td>Jubail University College</td>
<td>Benefit from employment opportunities</td>
</tr>
<tr>
<td>Jubail Technical Institute</td>
<td>Benefit from employment opportunities</td>
</tr>
</tbody>
</table>

5 The Quintet committee is statutory consultee for projects that will require construction within the foreshore or marine coastal environments. No such works are currently proposed for this Project and therefore consultation with the Quintet is not required at this time. However, this committee is included as reference for any future works at the port. The committee are required to be consulted with and given access to project documentation such as the EIA. Typically documentation will be required to be submitted in Arabic, and typically meetings are also undertaken in Arabic. Quintet approval for projects is usually coordinated through the relevant municipality. Early engagement of the Quintet is important to avoid delays on approvals.

Initial analysis has been undertaken to firstly determine the potential level of impact, interest and / or influence of a stakeholder group’s relationship with the Project, i.e. is this of High, Medium or Low significance? Table C.2 below outlines the criteria used to determine the significance of each stakeholder group.

The stakeholder groups and their level of interest or influence will vary throughout the life of the Project and therefore this stakeholder identification and mapping process will be revisited prior to the start of construction phase and again prior to the operation phase so as to prioritise engagement and establish the most appropriate level of engagement required for each stakeholder group.
Table C.2: Criteria used to determine the significance of each stakeholder group, and identify appropriate level of engagement

<table>
<thead>
<tr>
<th>Significance</th>
<th>Impact</th>
<th>Interest</th>
<th>Influence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High</strong></td>
<td>Stakeholder will experience a high degree of impact as a result of the Project.</td>
<td>The Project is directly related to the stakeholder's field of interest and/or responsibilities.</td>
<td>Stakeholder has decision-making powers regarding the Project.</td>
</tr>
<tr>
<td><strong>Medium</strong></td>
<td>Stakeholder will experience moderate degree of impact as a result of the Project, but these can be mitigated/managed.</td>
<td>The Project has some relevance to the stakeholder's field of interest and/or responsibilities.</td>
<td>Stakeholder can influence the scope and timing of (any stage of) the Project.</td>
</tr>
<tr>
<td><strong>Low</strong></td>
<td>Stakeholder will experience very few effects as a result of the Project.</td>
<td>The Project has limited relevance to the stakeholder's field of interest and/or responsibilities.</td>
<td>Stakeholder has very little control over the Project.</td>
</tr>
</tbody>
</table>

The level of impact/interest or influence identified for each stakeholder group is then used to determine the appropriate level of engagement for each group (refer to Section C6.0). This will assist with designing targeted group-specific engagement activities. The levels of engagement have been defined as **High**, **Enhanced** and **Standard** as illustrated in Figure C.2.

![Figure C.2: Levels of engagement matrix](image)

Attachment 2 includes an extract from the stakeholder database developed for the Project. This tabulates the levels of Significance and Engagement identified for each stakeholder group listed in Table C.1.

Stakeholders can move from one level of engagement to another as the Project progresses. For example, in the early data collection and technical appraisal stages, a local environmental interest group may just want to be kept informed of progress via the newsletter and have very limited impact on the project. However, in later stages in the ESIA process, that same group may become influential or responsible to some degree for implementing measures on the ground, thus changing from **Standard** to a **High** level of engagement.

As with the identification of stakeholders, the mapping and analysis of these groups is an ongoing process and will be revisited as the Project develops.
C6.0 STAKEHOLDER ENGAGEMENT PLAN

C6.1 APPROACH

This Plan will enable a wide range of stakeholders and interested parties to be identified and engaged, from statutory and regulatory stakeholders who are of high importance and influence, to those who require just to be kept informed through less intensive engagement processes.

Attachment 1 outlines the action plan proposed to promote understanding of the Project. This action plan aims to document the activities required to engage key stakeholders using communication methods that meet the cultural norm.

Figure C.2 in Section C5.0 illustrated how this Plan will use three levels of engagement to focus stakeholder activities based on the level of impact/interest or influence identified for each stakeholder group the Project; High, Enhanced and Standard outlined below. It is important to mention again that level of engagement attached to any stakeholder can change throughout the Project in a direct response to the needs of the stakeholder and the appropriate level of engagement required.

A High level of engagement can be achieved using ‘Focused Engagement’. The objectives of Focused Engagement are to:

- Achieve effective participation, engagement and therefore influence the Project process; and
- Help manage, mitigate (or compensate) impacts to enable stakeholders, where possible, to take advantage of the benefits proposed by the Project.

Mechanisms can include:

- Steering Group and individual meetings;
- Workshops;
- Participatory monitoring and evaluation.

An Enhanced level of engagement can be achieved using ‘Consultation & Engagement’. The objectives of Consultation & Engagement are to:

- Provide stakeholders with opportunities to present their views, interests, and concerns; and
- Disclose information prior to consultations in a form both understandable and accessible to the groups being consulted.

Mechanisms can include:

- Questionnaires;
- Feedback and grievance mechanisms;
- Community visits;
- Public meetings;
- Facility tours.

A Standard level of engagement can be achieved using ‘Disclosure / Information Dissemination’. The objectives of Disclosure / Information Dissemination are to:

- Ensure the timely (and culturally appropriate) communication of relevant Project information; and
- Disclose information in a form both understandable and accessible to the groups being consulted.
Mechanisms can include:
- Newsletters;
- Website content;
- Email updates;
- Frequently Asked Questions (FAQ) Brochure;
- Notice Boards;
- Status updates and reporting.

C7.0 REFERENCES

IFC (2012), Performance Standards on Environmental and Social Sustainability.

Kingdom of Saudi Arabia Royal Commission for Jubail and Yanbu, Royal Commission Environmental Regulations Volume I Regulation & Standards 2010

Kingdom of Saudi Arabia Royal Commission for Jubail and Yanbu, Royal Commission Environmental Regulations Volume II Environmental Permit Program 2010

PME. General Environmental Law and Rules for Implementation. 28 Rajab 1422 H (15 October 2001)

SOFRECO – TECHNIP. Pre-Feasibility Study, Preliminary Environmental Study, Sofreco (2012)


## ATTACHMENT 1 - STAKEHOLDER ENGAGEMENT ACTION PLAN

The action plan shall be regularly reviewed and updated to maintain a record of all communication and engagement activities undertaken is maintained.

<table>
<thead>
<tr>
<th>WHAT? Activities</th>
<th>WHO? Stakeholders</th>
<th>WHY and Key Messages</th>
<th>HOW? Communication Method</th>
<th>Responsibility</th>
<th>Progress / Outcome</th>
<th>Date Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactive planning / Kick-off meetings</td>
<td>Jacobs, Ma'aden, Lender, Royal Commission, PME, Contractor.</td>
<td>Programme development: Scope elements; Aim to reach mutual agreement between all parties on a project plan.</td>
<td>Focused Engagement Meetings</td>
<td>Jacobs</td>
<td>Jacobs</td>
<td></td>
</tr>
<tr>
<td>Scoping</td>
<td>All</td>
<td>Disclose project information: Summary of the proposed project's objectives, description, and potential impacts. Determine stakeholder concerns for consideration in Scope of Works / Terms of Reference</td>
<td>Focused Engagement, Consultation, Disclosure Preliminary socio-economic baseline site visit to initiate contact with local communities/businesses (update Stakeholder Plan based on findings); Targeted briefings with communities and Bedouin including surveys / questionnaires (socio-economic baseline collection) Newsletter with questionnaires Website update</td>
<td>Jacobs/WHGME Ma'aden</td>
<td>Jacobs/WHGME Ma'aden</td>
<td></td>
</tr>
<tr>
<td>Intended beneficiaries Government policy makers Infrastructure, transport and development</td>
<td>Identify and discuss key issues, including any potential conflicts Determine stakeholder concerns for consideration in Scope of Works / Terms of Reference</td>
<td>Focused Engagement, Consultation, Disclosure Presentations Workshop - avail of their perspective on local issues</td>
<td>Jacobs/WHGME; Ma'aden</td>
<td>Jacobs/WHGME; Ma'aden</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Assessment and production of draft ESIA</td>
<td>All</td>
<td>Disclose information on study methods and findings</td>
<td>Disclosure Newsletters Website update Targeted briefings (for any communities identified as significantly affected)</td>
<td>Jacobs/WHGME; Ma'aden</td>
<td>Jacobs/WHGME; Ma'aden</td>
<td></td>
</tr>
<tr>
<td>Intended beneficiaries Government policy makers Infrastructure, transport and development</td>
<td>Disclose information on study methods and findings Review mitigation measures</td>
<td>Focused Engagement, Consultation, Disclosure Presentations Workshop</td>
<td>Jacobs/WHGME; Ma'aden</td>
<td>Jacobs/WHGME; Ma'aden</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>Establish if stakeholders concerns have been addressed</td>
<td>Consultation Record of consultation</td>
<td>Jacobs/WHGME</td>
<td>Jacobs/WHGME</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>• Outline activities undertaken during the preceding quarter; • Inform of activities planned for the following quarter; • Present any other information relevant at the time of preparation; • To be distributed via email (e.g. to NGOs) and Ma'aden website.</td>
<td>Disclosure Quarterly Newsletters</td>
<td>Ma'aden</td>
<td>Ma'aden</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activities</td>
<td>Stakeholders</td>
<td>WHY and Key Messages</td>
<td>HOW? Communication Method</td>
<td>Responsibility</td>
<td>Progress / Outcome</td>
<td>Date Completed</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Final EA reports (to include a record of interagency and consultation</td>
<td>All</td>
<td>World Bank OD 4.01: Summary of EA conclusions in a form and language meaningful to the</td>
<td>Disclosure Non-technical summary including mitigation plan as appropriate distributed via</td>
<td>Jacobs / Ma’aden</td>
<td></td>
<td>August 2013</td>
</tr>
<tr>
<td>consultation meetings, including consultations for obtaining the</td>
<td></td>
<td>groups being consulted - for review and comment.</td>
<td>email to key stakeholders and accessible online as appropriate.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>informed views of the affected people and local NGOs)</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Ma’aden, Lender</td>
<td></td>
<td>Agree mechanisms for any ongoing consultation if required.</td>
<td>Focused Engagement</td>
<td>Jacobs, Lender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ma’aden, Lender</td>
<td></td>
<td>EA Report officially submitted to the Lender.</td>
<td>Disclosure</td>
<td>Jacobs, Lender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implement Environmental Management Plan</td>
<td></td>
<td>Inform communities, industries and transport authorities as relevant of schedules</td>
<td>Disclosure</td>
<td>Ma’aden</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>for potentially disruptive work/events.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disclosure</td>
<td></td>
<td>Discrim results of environmental monitoring</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grievance Mechanism</td>
<td>All</td>
<td>Establish mechanism for stakeholder to raise concerns and grievances about the project.</td>
<td>Stakeholder database</td>
<td>Stage 3: Jacobs / WHGME / Others Stages 4-5: Ma’aden</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project implementation</td>
<td>Lender</td>
<td>World Bank Group Guidance requires a report demonstrating the following:</td>
<td>Disclosure Report to the Lender</td>
<td>Ma’aden</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Compliance with measures agreed with the Bank on the basis of the findings and</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>results of the EA, including implementation of any EMP;</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>• The status of mitigation measures; and the</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>findings of monitoring programs.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Ensure migrate workers are aware of cultural</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>sensitivities, practices and restrictions as well as the consequences of deviations.</td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>
## ATTACHMENT 2 – STAKEHOLDER DATABASE EXTRACT – LEVELS OF SIGNIFICANCE AND ENGAGEMENT

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Significance</th>
<th>Level of Engagement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intended Beneficiaries</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ma'aden</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Lender</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Government Policymakers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presidency of Meteorology and Environment</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Principal landowners</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Royal Commission</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Local Authorities</td>
<td>Medium</td>
<td>Enhanced</td>
</tr>
<tr>
<td>Ministry of Water and Electricity</td>
<td>Medium</td>
<td>Enhanced</td>
</tr>
<tr>
<td>Ministry of Interior</td>
<td>Low</td>
<td>Standard</td>
</tr>
<tr>
<td>Ministry of Labor and Social Affairs</td>
<td>Low-Medium</td>
<td>Standard</td>
</tr>
<tr>
<td>Ministry of Municipalities and Rural Affairs</td>
<td>Medium</td>
<td>Enhanced</td>
</tr>
<tr>
<td>Ministry of Petroleum and Mineral Resources</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Ministry of Agriculture</td>
<td>Low-Medium</td>
<td>Standard</td>
</tr>
<tr>
<td>High Commission of Industrial Safety &amp; Security (HCISS)</td>
<td>Medium</td>
<td>Enhanced</td>
</tr>
<tr>
<td>Saudi Customs Department (Ministry of Finance)</td>
<td>Medium</td>
<td>Enhanced</td>
</tr>
<tr>
<td>MODON-Saudi Industrial Property Authority</td>
<td>Low</td>
<td>Standard</td>
</tr>
<tr>
<td>Ministry of Economy and Planning</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Civil Society Organisations</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-governmental organisations &amp; community-based organisations</td>
<td>Medium</td>
<td>Enhanced</td>
</tr>
<tr>
<td><strong>Communities and local groups</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedouins</td>
<td>Low-Medium</td>
<td>Enhanced</td>
</tr>
<tr>
<td>Herders Living in the Mine Vicinity</td>
<td>Low-Medium</td>
<td>Enhanced</td>
</tr>
<tr>
<td>Local Communities</td>
<td>Low-Medium</td>
<td>Enhanced</td>
</tr>
<tr>
<td>Principal landowners</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Emergency Response</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emergency Services</td>
<td>Medium</td>
<td>Enhanced</td>
</tr>
<tr>
<td>Stakeholder</td>
<td>Significance</td>
<td>Level of Engagement</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------</td>
<td>--------------</td>
<td>---------------------</td>
</tr>
<tr>
<td><strong>Environmental</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saudi Wildlife Authority</td>
<td>Medium</td>
<td>Enhanced</td>
</tr>
<tr>
<td>Saudi Geological Survey</td>
<td>Low</td>
<td>Standard</td>
</tr>
<tr>
<td><strong>Infrastructure, Transport and Development</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ma‘aden Phosphate Company (MPC) 1 site operators</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>‘Quintet’ (Coast Guard, PME, Ministry of Agriculture, Municipality (Ras Al Khair), Ministry of Finance)</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Saudi Aramco</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Road Authority</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Saudi Port Authority (SEAPA)</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Saudi Railway Company</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td><strong>Workforce</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expatriate Employees; International Contractors; National Contractors; Saudi National Employees</td>
<td>Low - Medium</td>
<td>Enhanced</td>
</tr>
</tbody>
</table>
ATTACHMENT 3 – UMM WU’AL GOVERNMENT REPRESENTATIVES QUESTIONNAIRE

SOCIOECONOMIC ASSESSMENT on Umm Wu’al Phosphate Project

Questions for Mayor and Other Local Government Representatives

Name of Respondent:

Government Position:

General Questions:

Are you aware of the proposed project?

Do you believe it will have a positive or negative effect on the local community? Please explain your response.

Please discuss any concerns you may have about the project.

Are there any academic, governmental, or non-governmental reports on the area (e.g., census, local government reports, university reports, international agency reports – UNDP, Oxfam, etc., reports from national government agencies or ministries)?

What is the history of settlement in the area (e.g., what year did it begin, when did it grow, etc.)?

Demographic Questions:

1. Are there any other populated areas in the vicinity of the Phosphate Project, other than Turaif? If so, please describe in detail.

2. What is the population of Turaif? What is the demographic make-up of Turaif (e.g., age of residents, educational level of residents, nationality of residents, occupation of residents, and economic status of residents)?

3. Are there any government or academic reports available about the demographics and the population of the area? Can we have access to these documents?

4. Are the populations of these areas in the process of changing, or are they expected to change in the near future?

5. What are educational opportunities currently available in Turaif?

Government Services Questions:

6. How many schools are in the affected areas and how many students are enrolled in these schools? Is there additional capacity in the schools when additional employees are moved to the area to work for the Ma’aden?

7. What social services are provided to local residents currently? (e.g., health care – number of hospitals/doctor’s/clinics, family services, food banks or other services) Are the services currently adequate to serve the existing population? Will the communities be able to provide services to employees relocated to the area by Ma’aden?
8. What municipal services are currently provided to residents of the area? (e.g., water/sewer, garbage collection, police and fire department)

9. Will the municipal services currently available be sufficient to meet the needs of the project, or will additional municipal services be required?

10. How have the population of the area and the services provided to local residents changed in recent years? And how are they expected to change in future years?

11. Will the project provide any services or facilities for the local community (e.g., health care, community center)

### Waste Management

12. Please provide the location of current or planned waste management facilities.

13. Please describe each of the currently existing waste facilities in the vicinity of the Phosphate project? Provide the following for each facility:
   a. Type of facility
   b. Types of waste accepted at each facility, i.e. hazardous or non-hazardous, with details
   c. Size / processing capacity of the waste management facility
   d. Void space / spare capacity over 25 years, i.e. capability to accommodate wastes from the project

14. Please provide detailed information on any planned future waste management facilities.

### Transportation

15. Are current transportation routes sufficient for the project? Will additional roads need to be constructed? Will increased traffic from mining operations affect the local population?

16. Are any data available on traffic in the vicinity of the proposed project? If so, please provide.

17. Are there any planned expansions of the current road system in the vicinity of the project?

18. Are there data on traffic accidents occurring in the vicinity of the proposed project?

### Employment and Local Manpower Questions:

19. How are local residents currently employed?

20. Are there expatriate workers currently living in the area? If so, how many, from where do they come and how are they employed? Are there any concerns regarding expatriate workers living in the area?

21. What is the training level of local residents and are there residents who have skills suitable for working in the project?

22. Are there training opportunities currently available to local residents?

23. What are current wages/salaries in the area based on required skill levels?
24. What is the level of unemployment in the area? What types of skills do the currently unemployed have?

25. Will community members take advantage of job opportunities in the project?

26. What raw materials, supplies and services required by the project are available locally (e.g., cement, building materials, chemical reagents, computers, heavy equipment, groceries and food)?

27. Will local businesses in the community be able to benefit from selling goods and materials to the project / would any be negatively impacted by the project?

28. Some of the following new businesses will be needed in the area to support the project:
   a. Gasoline stations
   b. General stores
   c. Apartments
   d. Car workshop
   e. Restaurant
   f. Hotel
   g. Clinic

Will the community be able to build these new businesses? Will the community be able to support these businesses once the mining operations cease?

**Land Use and Natural Resources Questions:**

29. How is land currently used in the area of the project? (e.g., grazing area and agriculture) Please provide as detailed information as possible on what land is being used, who is using it, how often the land is used and for what purposes.

30. How is land currently used adjacent to the project? (e.g., grazing area and agriculture) Please provide as detailed information as possible on what land is being used, who is using it, how often the land is used and for what purposes.

31. Please provide any information available on locations and sizes of farms in the vicinity of the project, as well as types of crops grown and amount of crops harvested.

32. Do you believe that the project will change land use patterns by local residents?

33. What is the availability of natural resources such as groundwater and surface water?

34. Where do people in the affected area currently get water? What are their current daily water needs? Is this projected to increase?

35. Are there concerns that the project could affect local water quality or quantity?

**Archaeological, Cultural and Heritage Sites Questions:**

36. Are there any biological resources of consequence that could be affected by the project (e.g., threatened or endangered species)?

37. Is there information available on the Harrat al Harrah Reserve? Do you believe this Phosphate Project will negatively affect the Reserve? Please explain.

38. What local cultural and heritage sites are located in the project area and its vicinity?
39. How are these currently used and/or protected?

40. How is the proposed project likely to affect these cultural and heritage sites?

41. Are there any known grave sites in the project areas?

42. Is there any additional information or opinions you would like to provide about how this proposed project will affect the community?
ATTACHMENT 4 – UMM WU’AL LOCAL RESIDENTS QUESTIONNAIRE

SOCIOECONOMIC ASSESSMENT on Umm Wu’al Phosphate Project

Questions for Local Residents

Purpose of the Survey: Record the attitudes, concerns and perceptions about the project in the local communities.

Name of Respondent (optional):

Gender and Age of Respondent:

Location of Respondent:

Length of Residence in Area of Respondent:

General Questions:

1. Are you aware of the proposed project?

2. Do you believe it will have a positive or negative effect on the local community? Please explain your response.

3. Please discuss any concerns you may have about the project.

Demographic Questions:

4. How many people live in your household?

5. What is the demographic make-up of the household (e.g., age of residents, educational level of family members, nationality of family members, and economic status of residents)?

Government Services Questions:

6. What social services do your household use?

7. What municipal services do your household use? (e.g., water/sewer, garbage collection, police and fire department)

Employment and Local Manpower Questions:

8. How are you and the adult members of your household currently employed?

9. What education and/or training have you had for these positions?

10. What are your wages based on your skill level?
11. Are you seeking other types of employment? Are you interested in working for the project?

12. Do you own or work for a local business that might be impacted by or could provide supplies and/or services to the project?

**Land Use and Natural Resources Questions:**

13. Do you, your family or your neighbors currently use land in the area of the project? If so, in what capacity? (e.g., for grazing area and agriculture) Please indicate what areas are being used, how often and for what purposes.

14. Do you, your family or your neighbors currently use land adjacent to the project area? If so, in what capacity? (e.g., for grazing area and agriculture) Please indicate what areas are being used, how often and for what purposes.

15. If you are not currently using lands in or adjacent to the project area, have you used them in the past and/or do you have plans to use them in the future?

16. Do you believe the proposed project will affect your current and/or future use of the lands?

17. Do you know of anyone else who uses the lands in and around the project area?

18. If you know of these lands being used for agricultural purposes, please describe the types of crops grown and location of these farms.

19. Do you use water resources (groundwater and/or surface water) from the area of the project? If so please indicate from where this is sourced.

20. Is groundwater and/or surface water scarce in the vicinity of the project area?

21. Do you believe the project will affect your future access to water resources?

22. Are there any biological resources of consequence that could be affected by the project (e.g., threatened or endangered species)?

23. Do you ever visit the Harrat al Harrah Reserve? Do you believe this Phosphate Project will negatively affect the Reserve? Please explain.

**Archaeological, Cultural and Heritage Sites Questions:**

24. Do you know of any archaeological, cultural and heritage sites that are located in the project area and its vicinity?

25. How are these archaeological, cultural and heritage sites currently used and/or protected?

26. Do you believe that the project will affect these archaeological, cultural and heritage sites?

27. Are there grave sites located in the project area?

28. Is there any additional information or opinions you would like to provide about how this proposed project will affect the community?
DEPARTMENT: SAFETY AND ENVIRONMENTAL
REPORT NO: 60-R400-WH/G.06F/0072 (APPENDIX D)

REPORT TITLE: RAS AL KHAIR
ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT (ESIA)
APPENDIX D – AMBIENT AIR QUALITY ASSESSMENT

PROJECT REFERENCE
PROJECT NO: 60-R400-WH
PROJECT LOCATION: SAUDI ARABIA
PROJECT TITLE: UMM WU’AL PHOSPHATE PROEJCT
CLIENT: MA’ADEN (SAUDI ARABIAN MINING COMPANY)
CLIENT PROJECT NO: 2-115-12-12-2-2
CLIENT DOCUMENT NO: MD-513-0000-HS-EN-RPT-0069 (APPENDIX D)

PM Authorisation: Andy Dodd

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D.1 INTRODUCTION & OBJECTIVES

Ma’aden proposes to utilise the phosphate reserves at Umm Wu’al in northern Kingdom of Saudi Arabia (KSA) to supply merchant grade phosphoric acid to the fertilizer, food and animal feed industries. This project will be split over two sites. (1) Open cast mining of phosphate rich ore: beneficiation and acid production will be undertaken at Umm Wu’al. (2) The second site will be at the existing Ras Al Khair Industrial City and will comprise a new Ammonia plant (with cooling tower) and DAP/NPK fertiliser plants. Material will be transferred between the two sites by an existing railway (managed by Saudi Arabian Railways), and the port facilities at Ras Al Khair will be utilised for export to world markets of the DAP/NPK and phosphate mine products as well as the import of raw materials (potash).

The Umm Wu’al site is a new development with little existing infrastructure. The proposed Ras Al Khair complex (the ‘Project’) will be constructed within the existing Ma’aden Phosphate Company (MPC) industrial complex. This document presents the results for the air quality assessment of the incorporation of the new Ammonia plant and phosphate fertilizer plants within the MPC complex, and forms part of the Environmental and Social Impact Assessment (ESIA) for the Project.

A variety of air pollutants from a wide range of sources will need to be considered to assess the impact of the development as a whole. The assessment is complicated by the need to assess the contribution of existing air pollution sources and future proposed air pollution sources outside of this Project, namely:

1) Existing Ma’aden Phosphate Company (MPC) ammonia, sulphuric/phosphoric acid plants and DAP plants,

2) Ma’aden Aluminium Company (MAC) aluminium smelter/refinery

3) Future impacts resulting from construction of the Saline Water Conversion Corporation (SWCC) Power and water plant.

As each plant in the industrial city will be developed at different rates, the step changes in air concentrations are provided based on reported timelines for plant development. The planned operational dates for the external facilities are as follows:

- Aluminium Facility:
  - Smelter: December 2013;
  - Rolling Mill: December 2014; and
  - Refinery: December 2014.

- Power and Desalination Plant: December 2013.

Based on available data, the contributions from the Project (new Ammonia and DAP/NPK plants, Materials Storage and Handling Facility as well as port loading and unloading activities) will be calculated as additional contributions to the existing /proposed plants to determine the overall impact of the Project on air quality.

D.2 ASSESSMENT METHODOLOGY

The assessment uses the CALPUFF dispersion model (Scrire et al., 2000) to undertake assessments of the impact on air concentrations of emissions from a range of plant at Ras Al Khair over a large domain surrounding the area. Impacts are assessed using 5 years of simulated meteorological data suitable for use within CALPUFF. Individual sites are modelled separately; namely the Power plant, the aluminium plant, the existing MPC facility and the new MPC plant. Total impact is also assessed by combining summed contributions from all industrial sources and also representative background air concentration data derived from a remote RC site. The assessment assumes that all plant are constructed and operating, but is based on available meteorological data, namely for 2008-2012.
Point source emissions were obtained from Ma'aden, and fugitive emission data calculated for a number of activities associated with the site. These were represented within the model and assigned to the relevant site within the assessment.

The modelled pollutant air concentrations resulting from discharges from a source or defined group of sources is known as the process contribution (PC). The overall predicted air concentration resulting from these sources and including additional contributions from other sources on adjacent sites and also ambient background concentrations is known as the predicted environmental concentration (PEC).

D.2.1 CONSTRUCTION PHASE

The assessment of construction phase impacts on air quality and climate primarily relates to fugitive emissions such as dust and vehicle emissions. These occur primarily during construction of the chemical complex.

The US EPA AP42 methodologies were used as the basis of the assessments of the construction phase. Dust emissions arise from road traffic on un-metalled roads and earth clearance operations.

D.2.2 COMMISSIONING AND OPERATION PHASES

To inform the impact assessment for these project phases, air dispersion modelling was undertaken to represent point source emissions and model outputs compared with RC and international guideline values.

For fugitive emissions, US EPA AP42 was used primarily to estimate dust emissions from activities at the site, EU and EPA approaches are used to estimate fugitive emissions from vehicles at the site.

The approach taken was to assess the reported individual impact contributions from each of the existing facilities, as well as fugitive emissions resulting from activities at each site.

D.2.3 DECOMMISSIONING PHASE

At the end of operational lifespan of the Project the plant structures and equipment will be dismantled and salvaged using the best available techniques at the time of decommissioning. Usable materials should be salvaged for recycling or reuse while hazardous and toxic waste shall be disposed of according to RC regulations.

D.2.4 SOFTWARE

As the Project is assessed as a ‘Type I’ facility in accordance with RCER-2010, potential impacts have been assessed for up to 75km from the source using the ‘CALPUFF’ air dispersion model (RCER, 2012 - Volume ii, App C). AERMOD (US EPA, 2004) has also been used for screening calculations.

CALPUFF is a multi-layer, multi-species non-steady-state puff dispersion modelling system that simulates the effects of time- and space-varying meteorological conditions on pollutant transport, transformation, and removal. The CALPUFF modelling system simulates dispersion of emissions as a series of puffs released from the emission sources. Once these puffs are present in the modelling domain, each puff transports and disperses at each time step corresponding to the local meteorological conditions of the grid point and vertical layer where the puff is located. Pollutant concentrations at each receptor (and in the case of this Project, at the site boundary) are calculated based on the contributions from all puffs that have an impact on the receptor. Therefore, as per U.S. EPA guidance (EPA, 2005):

**CALPUFF is intended for use on scales from tens of metres from a source to hundreds of kilometres. It includes algorithms for near-field effects such as stack tip downwash, building downwash, transitional buoyant and momentum plume rise, rain cap effects, partial plume penetration, subgrid scale terrain and coastal interactions effects, and terrain impingement as well as longer range effects such as pollutant removal due to wet scavenging and dry**
deposition, chemical transformation, vertical wind shear effects, overwater transport, plume fumigation, and visibility effects of particulate matter concentrations.

As a result, it is appropriate to use the CALPUFF modelling system for both near-field and long-range transport studies. This conclusion is also consistent with the conclusions of the U.S. EPA peer review of the CALMET/CALPUFF modelling system.

The modelling will be performed using the following options:

- Stack-tip downwash;
- Transitional plume rise;
- Partial plume penetration with inversion strength computed from temperature gradients;
- Pasquill-Gifford (PG) coefficients for rural areas and McElroy-Pooler (MP) coefficients for urban areas concentration estimates with adjustments to the effective puff height above the ground.

The plants within the model domain (power plant, aluminium plant, existing MPC plant and new MPC plant) will be represented as a series of point source, area and line emissions, to represent identified stacks, road, railway lines and fugitive emissions from identified areas of the sites. Individual emission sources, point or fugitive, will be assigned to one of four source groups: Power plant, Aluminium plant, Existing MPC plant or New MPC plant, thus allowing the peak air concentrations arising from each area to be identified, the PC, and compared to relevant ambient air quality standard (AAQS). The total PEC in air is calculated by combining the PC with the ambient background concentration (see below).

Royal Commission (RC) AAQS (RCER, 2010) will be the standard for comparison, as the World Bank allows the use of appropriate well established national standards for comparison within its projects.

D.3 BASELINE CONDITIONS

D.3.1 BACKGROUND AIR CONCENTRATION DATA

To identify the baseline conditions representative of the existing site, baseline air quality data collected at the Project site was supplemented with air quality data from Jubail RC Station 6 which is located some 15 km to the south-west of the Jubail industrial city, and so should provide a good indication of ambient background air concentrations over Saudi Arabia as a whole, in the relative absence of industrial development. The historic data for this site provides a good representation of air quality data in KSA away from development but will be subject to sand storms in the region. It is judged that this data will give an acceptable indicator for background air quality for use in this assessment. This should be equally applicable to other desert areas of Saudi Arabia, and as such will be used here.

5 years of data are available, from 2008 -2012. These data have been analysed against the RC AAQS (using the background source group within AERMOD). The following table (Table D 1) shows the results. The averaging period nomenclature is as follows: 1H3H indicates a 1 hour averaging period and the 3rd highest value is presented for comparison to the AAQS. Similarly, 24H1H, presents the highest value from a 24 hour averaging period.
The background concentrations show that ambient PM$_{10}$ concentrations are dominated by local sand storm events, which will dominate the predicted environmental concentration for any assessment of normal controlled operations.

NO$_X$ background concentrations are quite high, but visual inspection suggests they tend to be dominated by small periods of elevated levels, possibly when there is intermittent local vehicle activity. Whether these are relevant in assessment obviously depends upon whether these periods coincide with periods of high predicted process contribution by the model.

Total hydrocarbon values are also available but these are a) very high and b) difficult to interpret due to uncertainty in conversion from ppm to µg/m$^3$, so have not been analysed further or included within this assessment.

### Table D 1: Background ambient air concentrations compared to RC AAQS (µg/m$^3$)

<table>
<thead>
<tr>
<th>Pollutant and averaging period</th>
<th>RC AAQS</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
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</thead>
<tbody>
<tr>
<td>NO$_X$ 1H3H</td>
<td>660</td>
<td>362</td>
<td>415</td>
<td>424</td>
<td>390</td>
<td>473</td>
</tr>
<tr>
<td>NO$_X$ annual</td>
<td>100</td>
<td>33.5</td>
<td>31.7</td>
<td>45.6</td>
<td>36.6</td>
<td>59.3</td>
</tr>
<tr>
<td>CO 1H3H</td>
<td>40000</td>
<td>3123</td>
<td>3442</td>
<td>1634</td>
<td>2159</td>
<td>1531</td>
</tr>
<tr>
<td>CO 8H3H</td>
<td>10000</td>
<td>2894</td>
<td>1291</td>
<td>1388</td>
<td>1115</td>
<td>1062</td>
</tr>
<tr>
<td>SO$_2$ 1H3H</td>
<td>730</td>
<td>42.1</td>
<td>56.8</td>
<td>131</td>
<td>91.1</td>
<td>58.6</td>
</tr>
<tr>
<td>SO$_2$ 24H2H</td>
<td>365</td>
<td>10.2</td>
<td>23.7</td>
<td>34.2</td>
<td>17.8</td>
<td>15.6</td>
</tr>
<tr>
<td>SO$_2$ Annual</td>
<td>80</td>
<td>4.1</td>
<td>7.3</td>
<td>11.9</td>
<td>6.5</td>
<td>5</td>
</tr>
<tr>
<td>PM$_{10}$ 24H1H</td>
<td>150</td>
<td>2434</td>
<td>3086</td>
<td>2425</td>
<td>2407</td>
<td>3990</td>
</tr>
<tr>
<td>PM$_{10}$ annual</td>
<td>50</td>
<td>321</td>
<td>270</td>
<td>134</td>
<td>229</td>
<td>371</td>
</tr>
</tbody>
</table>

The background concentrations show that ambient PM$_{10}$ concentrations are dominated by local sand storm events, which will dominate the predicted environmental concentration for any assessment of normal controlled operations.

### D.3.2 METEOROLOGY

Meteorological data for CALPUFF can be derived from a number of approaches. The base data tends to be derived from complex mesoscale weather field models such as MM5 ([http://www.mmm.ucar.edu/mm5/](http://www.mmm.ucar.edu/mm5/)). This can be supplemented by local station data in a number of regions to provide site-specific features to the windfield. However, the model can be run entirely using model data and the developers of CALPUFF, the main developers of CALPUFF, suggest this as appropriate for ESIA level assessments ([http://www.environment.nsw.gov.au/resources/air/CALPUFFModelGuidance.pdf](http://www.environment.nsw.gov.au/resources/air/CALPUFFModelGuidance.pdf)).

Although the RC has installed an air quality and meteorological mobile station at Ras Al Khair, the RC has reported that this data is not as yet adequate to describe the conditions in Ras Al-Khair. For this assessment, MM5 data for a 160 ° 160 km grid around Ras Al Khair has been sourced in the appropriate format for input to CALMET (the meteorological pre-processor for CALPUFF). The 160km allows for an extra margin of 5km around the 150km domain required to meet the RC 75km assessment distance, for source “puffs” to be traced as they leave and possibly re-enter the domain under local wind direction changes. 5 years data have been sourced at a 12km grid cell resolution (the highest available for domains of this size). Land use and terrain height data to support this meteorological information were obtained from public domain data linked via the SRC web site. Gridded terrain elevations, derived from 3 arc-second digital elevation data from the Shuttle Radar Topography Mission (SRTM-3) were used. The spatial resolution is approximately 90 m in the horizontal plane. The USGS Global Land Use data in the vicinity of the facility has been used to produce a gridded field of dominant land use categories. The land use data were obtained from the USGS FTP site, with a resolution of 0.9 km.
D.4 MODEL DEVELOPMENT

D.4.1 DOMAIN AND RECEPTORS

A grid was used to undertake the assessment:

i) The outer model domain will encompass the 75km range required by the RC. To facilitate contour plotting and to give indications of the variation of concentration with distance, an array of axial polar co-ordinates is specified within CALPUFF. These extend from 4km to 75km with decreasing resolution away from the site and are spaced every 30 degrees.

ii) To increase resolution, a grid arrangement will be used with higher resolutions at distances closer to the site. A 200m grid spacing is used at distances up to 3km from the site. However, concentrations at locations within site boundaries are not presented, as RC regulation only applies to ground-level concentrations at locations at or beyond the site boundary. For this assessment, the site boundary has been assumed to extend beyond the railway sidings to the east of the site, as fugitive emissions from this area are considered within the assessment. (see Figure D 1 for site boundaries).

iii) Discrete receptors were identified sensitive locations, such as for the main residential areas. Due to the large distances from the site to the receptors, the impacts within a settlement are considered comparable for the entire settlement. Therefore the approach taken was to locate the receptor for a residence area at the closest distance of the settlement to the site. Discrete receptor locations have been identified as defined in Table D 2.

<table>
<thead>
<tr>
<th>Table D 2: Discrete Receptors</th>
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</thead>
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<td><strong>Discrete Receptors</strong></td>
</tr>
<tr>
<td>Worker accommodation constructed close to the site</td>
</tr>
<tr>
<td>Coast Guard station (close to site)</td>
</tr>
<tr>
<td>Petrol station (6km south of the site)</td>
</tr>
<tr>
<td>Housing (to east of aluminium plant)</td>
</tr>
<tr>
<td>Radio post (10km at the east of the peninsula)</td>
</tr>
<tr>
<td>Manifah (~25km west)</td>
</tr>
<tr>
<td>Nairiyah (68km west)</td>
</tr>
<tr>
<td>Al Jubail (65km south)</td>
</tr>
</tbody>
</table>
Notes: Triangles represent discrete receptors; red crosses represent point sources; and dashed lines represent area sources. The solid lines represent the site boundaries of MAC and MPC.

**Figure D 1: Ras Al Khair plan showing layout of sites and sources**

**D.4.2 BUILDINGS**

The existing MPC site at Ras Al Khair has a complex industrial layout comprising buildings, tanks, conveyors and pipe trains of varying sizes. Buildings with a significant height in the vicinity of an air emission source can significantly modify the dispersion characteristics of the release, usually by lowering the effective release height, leading to reduced dispersion. Usual US EPA guidance (EPA, 2005) is to include buildings within a factor of \( H + 1.5L \) of the release height. Because the site is complex, the approach taken was to include all significant structures or groups of structures within the model. Aerial photography (April 2012) and satellite imagery (2013) was used with the plot plans (MD-513-10A0-EG-Pi-DPP-0004 MD-512-2A00-EG-Pi-DPP-9001_(mm).dxf, dated December 2012 and March 2013 respectively) to identify buildings for inclusion in the model. Building heights were determined for the maximum average height of a structure or group of structures and were identified using design drawings, datasheets and site photographs (see Table D 3 for summary). Buildings in the aluminium plant are not detailed as the site is judged to be too remote for downwash to affect dispersion from that site significantly at locations around the MPC.
Table D 3: Buildings represented in the model

<table>
<thead>
<tr>
<th>Structure (or group of structures)</th>
<th>Number</th>
<th>Building Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing ammonia plant</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>Existing ammonia storage tanks</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>Existing Sulphuric acid plant</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Existing DAP plants</td>
<td>2</td>
<td>57</td>
</tr>
<tr>
<td>Existing DAP storage warehouses</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>Existing phosphoric acid plants</td>
<td>3</td>
<td>40</td>
</tr>
<tr>
<td>Existing sulphuric acid tanks</td>
<td>6</td>
<td>18</td>
</tr>
<tr>
<td>Existing phosphate warehouse (in south)</td>
<td>1</td>
<td>32</td>
</tr>
<tr>
<td>Existing power and desalination plant</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>New ammonia plant</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>New ammonia storage tanks</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>New DAP/NPK plant</td>
<td>2</td>
<td>57</td>
</tr>
<tr>
<td>New DAP/NPK product storage</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>New DAP/NPK raw material storage</td>
<td>1</td>
<td>29</td>
</tr>
<tr>
<td>New cooling tower</td>
<td>1</td>
<td>50</td>
</tr>
</tbody>
</table>

Early stages of the model were initiated using AERMUD. A 3D representation of buildings and sources at the site within AERMUD is shown below for illustrative purposes in Figure D 2.

Figure D 2: Ras Al Khair buildings in a 3D representation of the site in AERMUD

D.4.3 DISCRETE RELEASE SOURCES

Discrete release sources are features within the plant that are modelled as point sources, such as emission stacks. All emission sources represented within the model are described in Table D 16; stack locations are indicated in Figure D 1.
D.4.3.1 PROJECT DISCRETE RELEASE SOURCES

The new plant at the MPC complex which comprise this project are a new ammonia plant (with cooling tower) and DAP/NPK fertiliser plants. As detailed design for the new plant are not yet available, similar stack dispersion parameters are adopted to those of the existing MPC complex.

As the Front End Engineering Design (FEED) for the proposed ammonia plant had not been completed at the time of this assessment was undertaken, it was assumed that the discrete release points would be identical copy of the existing MPC ammonia plant. It is proposed that this will be located south of the existing unit. However, NOx emissions from the proposed plant are lower than the existing plant due to the requirement for low NOx burners to be incorporated to the new design.

The exhaust stacks of the proposed DAP/NPK fertilizer plants are assumed to be identical copies of the existing DAP plants and emissions from the new plant are in compliance with RC point source emission standards.

The proposed cooling tower was added in the indicated location in the plot plan and was represented as a volume source within CALPUFF. The cooling tower was represented as a 50m radius circular area source, with a height of 50m. Particulate emissions are assumed to be PM$_{10}$, resulting from entrainment of water droplets (“drift”) and subsequent evaporation of these droplets (US EPA 13.4.2). Assuming a required cooling tower flow of 40000 m$^3$/hr, this leads to a drift production of 8 tonnes/hr (AP42 Table 13.4-1 gives a drift composition of 0.2 g/l – note, this exceeds the RC cooling tower standard of <0.0005% drift losses, but is likely to be a conservative estimate). The particulate emission is derived from the assumed evaporation of these droplets. Assuming a PM$_{10}$ concentration of 0.0023 g/l in circulating cooling water (AP42 Table 13.4-1), this leads to a discharge of 0.005 g/s of PM$_{10}$.

D.4.3.2 EXISTING / OTHER DISCRETE RELEASE SOURCES

Existing MPC Operations

The existing MPC site comprises the following operating plant, which contribute to pollutant emissions.

- Ammonia plant
- 3 sulphuric acid plants
- 3 phosphoric acid plants
- 4 DAP fertiliser plant, comprising 2 buildings, each with 2 stacks.

Emission data are taken from the spreadsheet titled “Emissions from MPC (General).xls” supplied by Ma’aden. Emissions from the existing DAP and phosphoric acid plants are based on current performance testing at these plants (SGS, 2012).

Aluminium Smelter / Refinery

This comprises a smelter, a refinery and a rolling plant. Data were taken from the recent Air quality impact assessment for the Ras Al Khair Aluminium plant (Exponent, 2012). This assessment includes details on a large number of discrete sources for the aluminium plant. To reduce the complexity of the representation of the site within the model, some simplification of the source terms has been undertaken, by combining stacks with similar locations, dimensions and emissions. These are simplified as follows.

1) The 58 anode stacks have been represented as 5 line sources within the model (as described in Table 2 of the aluminium smelter air quality report.

2) The pot rooms are represented as 4 line sources as described in Table 3 of the aluminium smelter air quality report.
3) The paste plant is represented by a single stack, combining the discharges of the 2 separate stacks for this plant.

4) The 11 cast house stacks are represented by a single stack.

5) The individual calciner and boiler stacks associated with the refinery are each represented. The 18 minor stacks associated with refinery operations have been represented by a single stack.

6) The 8 ATM vents in the rolling mill are represented by a single stack.

7) The remaining stacks of the rolling mill plant are represented by a single stack.

New Power Plant

This facility is still being constructed, but will obviously impact on local air quality in combination with other sources. Although few details about the plant are available, the following assumptions will be made to allow derivation of emission data for this plant.

The plant is a linked facility to provide electrical power and also steam which is used in a desalination facility to provide potable water for the industrial city. This will be achieved by the construction of stream turbine generators, powered by natural gas. The quoted electrical power output of the plant is 2500 MW. A conversion efficiency of 40% (which is the middle of the range of quoted efficiencies for this type of plant) is assumed, implying a fuel input requirement of 6250 MW.

The US EPA AP42 emission factor database contains data for natural gas combustion, in Chapter 1.4. These are given in units of lb/10^6 scf. Multiplying by 16 converts these factors to kg/10^6 m^3, and assuming an energy equivalence of 39 MJ/m^3 for natural gas allows the expression of these emission factors as kg pollutant /MJ energy from natural gas used, and the equivalence of 1 MW = 1 MJ/s allows the calculation of emission rates of these pollutants whilst supplying an energy equivalent of 6250 MW to the plant. These are shown in Table D 4 (the NOx values are for boilers with NOx abatement technologies).

By way of validation, the UK National Atmospheric Emissions Inventory ([http://naei.defra.gov.uk/data/](http://naei.defra.gov.uk/data/)) gives emission factors for natural gas fired power plant. These are expressed per therm of energy used. A conversion factor of 1 therm = 105.5 MJ allows the direct comparison of these values to the AP42 values as seen in . The excellent agreement between the values provides confidence that the approach used is robust.

### Table D 4: Derived power plant emissions as represented in the model

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>RC emission standard (kg / MJ)</th>
<th>NAEI Emission factor (kg / MJ)</th>
<th>AP42 Emission factor (kg / MJ)</th>
<th>Plant emission (based on AP42) (g/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Monoxide</td>
<td>1.09E-05</td>
<td>3.45E-05</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td>Nitrogen Oxides as NO_2</td>
<td>4.3E-05</td>
<td>3.42E-05</td>
<td>4.10E-05</td>
<td>256</td>
</tr>
<tr>
<td>Sulphur Dioxide</td>
<td>3.4E-04</td>
<td>5.04E-07</td>
<td>2.46E-07</td>
<td>1.5</td>
</tr>
<tr>
<td>PM_{10} (Particulate Matter &lt; 10um)</td>
<td>1.3E-05</td>
<td>7.72E-07</td>
<td>3.12E-06</td>
<td>19.5</td>
</tr>
<tr>
<td>Non Methane VOC</td>
<td>1.16E-06</td>
<td>2.26E-06</td>
<td>14.1</td>
<td></td>
</tr>
</tbody>
</table>

The plant is assumed to be located close to the coast, some 4km to the west of the dock area and to the north west of the MPC facility. It is likely that up to four boilers will be required, but that aerial discharges will be routed via two 150m stacks with each stack combining the outlets from two boilers.
Auxiliary Boilers on Ammonia Plant

Each ammonia plant requires an auxiliary boiler which is running constantly at low power, assumed to be 22 MW. It is assumed these are fired by natural gas, and so the same methodology as above can be used to derive discharges. Using the same factors as for the main power plant described above, then emissions from each auxiliary boiler will be 114 times lower than for the main power plant, and the emissions are calculated proportionately.

Stack parameters are assumed to be a stack height of 30m, a diameter of 2.3m, an exit velocity of 15 m/s and an exit temperature of 185°C.

D.4.4 FUGITIVE EMISSIONS - CONSTRUCTION PHASE

Fugitive emissions are those which arise from generic operations on a site such as traffic movement or leakage from storage tanks and are diffuse in nature.

Table D 5 outlines the parameters and total suspended particulate (TSP) emission rates derived for calculating dust emissions relevant to site clearance and construction activities assuming typical good practice measures such as the mitigation measures and recommendations outlined in the ESIA are in place.

Table D 5: Mitigated Dust Emission Calculations

<table>
<thead>
<tr>
<th>Activity</th>
<th>Parameter</th>
<th>Calculation Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck unloading</td>
<td></td>
<td>Calculated based on AP-42 Table 11.9-4</td>
</tr>
<tr>
<td>Truck Unloading (veh/hr)</td>
<td>35</td>
<td>Estimated maximum truck flow</td>
</tr>
<tr>
<td>Truck Volume (Mg)</td>
<td>10</td>
<td>Estimated</td>
</tr>
<tr>
<td>Total Material Handling (Mg/hr)</td>
<td>350</td>
<td>Calculated</td>
</tr>
<tr>
<td>Dust mitigation efficiency (%)</td>
<td>75</td>
<td>For four times daily watering</td>
</tr>
<tr>
<td>TSP emission rate (kg/hr)</td>
<td>0.38</td>
<td>Calculated based on AP-42 Table 11.9-4</td>
</tr>
<tr>
<td>Truck Loading</td>
<td></td>
<td>Calculated based on AP-42 Table 11.9-4</td>
</tr>
<tr>
<td>2-way truck flow (veh/hr)</td>
<td>40</td>
<td>Estimated maximum truck flow</td>
</tr>
<tr>
<td>Truck volume (Mg)</td>
<td>10</td>
<td>Estimated</td>
</tr>
<tr>
<td>Total material handling (Mg/hr)</td>
<td>200</td>
<td>Calculated</td>
</tr>
<tr>
<td>Dust mitigation efficiency (%)</td>
<td>75</td>
<td>For four times daily watering</td>
</tr>
<tr>
<td>TSP emission rate (kg/hr)</td>
<td>0.17</td>
<td>Calculated based on AP-42 Table 11.9-4</td>
</tr>
<tr>
<td>Bulldozing</td>
<td></td>
<td>Calculated based on AP-42 Table 11.9-2, Refer to Equation (3)</td>
</tr>
<tr>
<td>Moisture content (%)</td>
<td>7.9</td>
<td>Mean value from AP-42 Table 11.9-3</td>
</tr>
<tr>
<td>Silt content (%)</td>
<td>6.9</td>
<td>Mean value from AP-42 Table 11.9-3</td>
</tr>
<tr>
<td>Dust mitigation efficiency (%)</td>
<td>75</td>
<td>For four times daily watering</td>
</tr>
<tr>
<td>TSP emission rate (kg/hr)</td>
<td>0.45</td>
<td>Calculated based on AP-42 Table 11.9-2, Refer to Equation (3)</td>
</tr>
<tr>
<td>Vehicle traffic on unpaved road</td>
<td></td>
<td>Calculated based on AP-42 Sec 13.2.2, Refer to Equation (4)</td>
</tr>
<tr>
<td>Silt content (%)</td>
<td>4.3</td>
<td>Mean value from AP-42 Table 11.9-3</td>
</tr>
<tr>
<td>Moisture content (%)</td>
<td>2.4</td>
<td>Mean value from AP-42 Table 11.9-3</td>
</tr>
<tr>
<td>Average weight of vehicle (Mg)</td>
<td>36</td>
<td>Estimated</td>
</tr>
<tr>
<td>2-way truck flow (veh/hr)</td>
<td>100</td>
<td>Estimated maximum truck flow</td>
</tr>
<tr>
<td>Average one-way travel distance w/in the site</td>
<td>0.7</td>
<td>Estimated</td>
</tr>
<tr>
<td>Dust mitigation efficiency (%)</td>
<td>75</td>
<td>For four times daily watering</td>
</tr>
<tr>
<td>Dust reduction due to speed control (%)</td>
<td>50</td>
<td>Speed limit reduced to 10 km/hr</td>
</tr>
<tr>
<td>TSP emission rate (kg/hr)</td>
<td>4.5</td>
<td>Calculated based on AP-42 Sec 13.2.2, Refer to Equation (4)</td>
</tr>
</tbody>
</table>
Site erosion

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSP emission rate (Mg/ha/yr)</td>
<td>0.85</td>
</tr>
<tr>
<td>Total site area (m²)</td>
<td>28983 Estimated</td>
</tr>
<tr>
<td>Percentage exposed active work area</td>
<td>50 Estimated</td>
</tr>
<tr>
<td>Dust mitigation efficiency (%)</td>
<td>75 For four times daily watering</td>
</tr>
<tr>
<td>TSP emission rate (kg/hr)</td>
<td>0.03 Calculated</td>
</tr>
<tr>
<td>Total TSP emissions (unmitigated)</td>
<td>5.53 kg/hr</td>
</tr>
<tr>
<td></td>
<td>5.3e-5 g/s/m²</td>
</tr>
</tbody>
</table>

Equations:

1. $TSP \text{ emission rate (kg/hr)} = 0.001 \times (\text{Total material handling}) \times (\text{Mg/hr})$

2. $TSP \text{ emission rate (kg/hr)} = 0.018 \times (\text{Total material handling}) \times (\text{Mg/hr})$

3. $EF = \frac{2.6(s)^{1.2}(W/3)^{1.2}}{(M/0.2)^{1.2}}$

4. $E = \frac{k(s/12)^a(W/3)^b}{(M/0.2)^c}$

Conversion:

$E = E(281.9)\text{Veh(L)}$.

$s$ = silt moisture content
$W$ = mean vehicle weight
$M$ = surface material moisture content (%)
$L$ = Ave one way travel distance w/site.

Constant for TSP: $k=10; a=0.8; b=0.5; c=0.4$
1 lb/VMT = 281.9 g/VKT
1 kg = 2.2 lb.

This was modelled as a separate exercise using a single area source covering the entire site, and modelling additional contributions to PM$_{10}$ from external sources. Using AERMOD with 2009 Jubail meteorological data, a peak daily off-site concentration of 170 µg/m$^3$ and an annual concentration of 29 µg/m$^3$ was calculated. The annual concentration is slightly above the AAQS, but will be masked by the influence of local dust storms on the ambient background concentration.

D.4.5 FUGITIVE EMISSIONS - COMMISSIONING & OPERATION PHASE

Fugitive emissions will arise from a number of site operations (existing and proposed) and as a result of activities associated with the site. For operational sources of dust emissions, US EPA AP42 standard data was used to derive discharge figures and the assessment process. A variety of area and line sources were used to represent these emissions (refer to Table D 11 and in Table D 16).

Both the existing and proposed process plants utilise urea, potash and filler as solid raw materials (in addition to ammonia, sulphuric acid and phosphoric acid). Raw materials will be delivered via road, rail and sea. Solid materials will be delivered to the new DAP/NPK storage area at the Port and transferred to the fertiliser plants by conveyor. Finished product will be transferred from the DAP/NPK storage sheds in the process area to the Port by conveyor for final export.

Fugitive emission sources associated with the existing and proposed MPC operations are summarised as:

- Unloading of liquid raw materials from rail at the process area (i.e. rail emissions);
- Unloading of solid raw materials from trucks;
- Loading solid raw materials onto the conveyor in the Port storage area;
- Unloading the solid raw materials from the conveyor at the DAP/NPK process area;
- Loading the DAP/NPK product onto conveyor at the process area for export to the Port;
- Unloading the DAP/NPK from the conveyor at the Port; and
- Vehicle emissions from cars/coaches/trucks/locomotives whilst attending the site.
In addition to the above, processed phosphate ore is currently delivered to site as a feed material for the existing Phosphoric Acid Plant (PAP). The ore is delivered to a storage area in the south of the existing MPC site and then fed to the PAP by conveyor. Fugitive emission sources associated with this process are summarised as follows:

- The delivery of the phosphate ore by rail;
- Unloading of trucks;
- Loading ore onto the conveyor in the storage area; and
- Unloading the ore from the conveyor at the PAP.

External to the MPC Complex, fugitive dust sources arise in the following adjacent areas:

- The aluminium plant residue area (for aluminium plant wastes).
- The phosphogypsum storage area associated with the existing PAP.

**D.4.5.1 ESTIMATES OF FUGITIVE EMISSION SOURCES**

**Dust Emissions during Conveyor Transfers**

Table 11.19.2-1 in AP42 gives values of PM$_{10}$ dust emissions from conveyor transfer points of 5.5e-4 kg/Mg (i.e. tonne) for unmitigated transfers and 2.3e-5 kg/Mg for controlled transfers. It is assumed that the dust will be generated at each transfer i.e. at unloading and unloading of the material from the conveyor and also that mitigation measures will be in place as examples of best practice. Therefore, the estimated fugitive discharge in kg/yr simply equals 2.3e-5 kg/Mg multiplied by the annual throughput (tonnes/yr) of the relevant material by that conveyor route. The calculated average emission rates are given in Table D 6 below.

**Table D 6: Calculated Mitigated Dust Emissions from Conveyor Transfers**

<table>
<thead>
<tr>
<th>Material</th>
<th>Operation (Existing &amp; Proposed)</th>
<th>Material flow (t/yr)</th>
<th>Annual dust generation (kg/yr)</th>
<th>Average emission rate (g/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphate ore</td>
<td>Existing MPC operation</td>
<td>5.3e6</td>
<td>121.9</td>
<td>0.0039</td>
</tr>
<tr>
<td>DAP product</td>
<td>Existing MPC operation</td>
<td>2.22e6</td>
<td>51.2</td>
<td>0.0016</td>
</tr>
<tr>
<td>DAP product</td>
<td>Umm Wu'al Phosphate Project</td>
<td>2.22e6</td>
<td>51.2</td>
<td>0.0016</td>
</tr>
<tr>
<td>NPK product</td>
<td>Umm Wu'al Phosphate Project</td>
<td>7.66e5</td>
<td>17.6</td>
<td>0.00056</td>
</tr>
<tr>
<td>Potash</td>
<td>Umm Wu'al Phosphate Project</td>
<td>1.92e5</td>
<td>4.4</td>
<td>0.00014</td>
</tr>
<tr>
<td>Urea</td>
<td>Umm Wu'al Phosphate Project</td>
<td>11,504</td>
<td>0.26</td>
<td>0.00000084</td>
</tr>
<tr>
<td>Filler</td>
<td>Umm Wu'al Phosphate Project</td>
<td>64,491</td>
<td>1.48</td>
<td>0.000047</td>
</tr>
</tbody>
</table>

**Dust Emissions during Unloading from Trucks**

US EPA AP42, Chapter 13.2.4 deals with the fugitive emissions from material storage piles. For unloading of material from trucks onto the pile, the following equation is used.

\[ EF = k \times (0.0016) \times \left[ \frac{(U/2.2)^{3/2}}{\sqrt{M/2}} \right] \]

Where:

- \( EF \) is the emission factor (kg/Mg);
- \( k = 0.35 \) for 10µm particles;
- \( U \) is the mean wind speed taken to be 5 m/s in this case; and
- \( M \) is the moisture content for which a value of 1% is used.

This gives an emission factor of 0.0043 kg/Mg. Mitigation measures can reduce this by up to 90%, giving a value of 0.00043 kg/Mg for material unloading. As with conveyor transport above, the actual emission value is then scaled by the material throughput of the site to get
average emission factors which are then ascribed to the storage fugitive emission area. The calculated average mitigated emission rates are shown in Table D 7 below.

Table D 7: Calculated Mitigated Dust Emissions from Truck Unloading

<table>
<thead>
<tr>
<th>Material</th>
<th>Plant operation</th>
<th>Material flow (t/yr)</th>
<th>Annual dust generation (kg/yr)</th>
<th>Average emission rate (g/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphate ore</td>
<td>Existing MPC operation</td>
<td>5.3e6</td>
<td>2279</td>
<td>0.07</td>
</tr>
<tr>
<td>DAP product</td>
<td>transfer from storage to ship</td>
<td>2.22e6</td>
<td>958</td>
<td>0.03</td>
</tr>
<tr>
<td>Urea</td>
<td>Umm Wu’al Phosphate Project</td>
<td>11,504</td>
<td>4.9</td>
<td>1.6e-4</td>
</tr>
<tr>
<td>Filler</td>
<td>Umm Wu’al Phosphate Project</td>
<td>64,491</td>
<td>28</td>
<td>8.8e-4</td>
</tr>
</tbody>
</table>

Emissions from Railway Locomotives whilst in Rail Sidings

Emission factors for diesel locomotive operations are derived from EPA document EPA-420-F-09-025 (EPA, 2009). This presents a series of factors for locomotives of differing ages operating either on long-haul or within switch yards. The Saudi Rail Authority is producing an assessment of the operation of the railway as a whole. Within this assessment we consider emissions from the locomotives within the loading/unloading sidings within the MPC site. This will make use of the long-haul locomotives available rather than switch locomotives. For this, emissions are taken from Table 1 of EPA-420-F-09-025. As new locomotives are operating, it is judged that Tier 3 will give a reasonable approximation to the emissions for current locomotives (since Tier 4 only applies to locomotives constructed in 2015 and beyond).

<table>
<thead>
<tr>
<th>Emission factor Grams per brake horsepower – hour (g / bhp- hr)</th>
<th>PM_{10}</th>
<th>VOC</th>
<th>NO_{x}</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 2+&amp;3</td>
<td>0.08</td>
<td>0.13</td>
<td>4.95</td>
<td>1.28</td>
</tr>
</tbody>
</table>

Emissions are calculated by:

\[ \text{Emissions} = \text{HP} \times \text{LF} \times \text{A} \times \text{EF} \]

Where:

- \( \text{HP} \) = horsepower;
- \( \text{LF} \) = load factor (-);
- \( \text{A} \) = hours used per year; and
- \( \text{EF} \) = emission factor (EPA, 2009).

The locomotives operating in the project are ElectroMotive SD70ACs, which have a power rating of 4312 HP (manufacturer’s product sheet). However, within the switch yard operations context of this assessment, it is assumed that the locomotives are operating with a load factor of 10% (http://www.epa.gov/oms/nonrdmdl.htm).

Operations at the MPC complex suggest that loading and unloading will be achieved within a 12-hour turnaround period. For the existing plant, there are two trains per week delivering phosphate ore from Al Jalamid mine. For the new fertiliser plants, there will be two trains per day from Umm Wu’al delivering liquid materials for use in production and also for storage prior to export via the port area.

For the existing MPC site, fugitive emissions from locomotives occur while the phosphate ore is being unloaded in the siding adjacent to the phosphate ore storage area. Two trains per week with a 12 hour turnaround is equivalent to 1248 hrs yr^{-1} (total time locomotives are in sidings) which gives a scaling factor of 5.38e6 bhp-hrs for the emission factor.
For the new MPC phosphate plant, 2 trains per day is equivalent to 8760 hours in which locomotives are in sidings per year, a scaling factor of 3.78e7 bhp-hrs. These are assumed to occur from the area of the new railway sidings, to the east of the Ma'aden MPC site.

Scaling to relevant emission units gives the following emission factors (Table D 8).

**Table D 8: Calculated Emissions from Locomotive Operations**

<table>
<thead>
<tr>
<th>Emission factor (g / s)</th>
<th>PM$_{10}$</th>
<th>VOC</th>
<th>NO$_X$</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing MPC</td>
<td>0.0014</td>
<td>0.0022</td>
<td>0.084</td>
<td>0.022</td>
</tr>
<tr>
<td>New Phosphate plant</td>
<td>0.0096</td>
<td>0.0156</td>
<td>0.59</td>
<td>0.15</td>
</tr>
</tbody>
</table>

**Vehicle Emissions**

The aerial emissions resulting from vehicle operations can be assessed from standard emission factors reported in literature. These factors indicate the specific emissions of the single pollutants (CO, HC, NO$_X$, particulate matter) for each vehicle type. The estimate of the emissions produced by the site will be calculated by multiplying the emission factor by the number of items of that type of equipment that will be present at the site and by repeating this calculation for each type of equipment.

The emission factors (Table D 9) are taken from the EMEP/EEA emission inventory guidebook (EMEP/EEA, 2009), updated June 2010; using Table 3-15 – 3.22 Tier 2 emission factors for cars, heavy goods vehicles (HGV) and buses in [g/km] for typical road vehicles observed at the site. Emission factors are selected from the relevant tables assuming Passenger cars are “PC Euro 4, diesel > 2l”; Buses are “Coaches, standard, Euro VI” and HGV are “Euro VI, Rigid >32t”.

**Table D 9: Emission Factors for Road Vehicles**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Vehicle (g/km)</th>
<th>Idling (g/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Car</td>
<td>Bus</td>
</tr>
<tr>
<td>CO</td>
<td>0.097</td>
<td>0.15</td>
</tr>
<tr>
<td>VOCs</td>
<td>0.016</td>
<td>0.021</td>
</tr>
<tr>
<td>NO$_X$</td>
<td>0.601</td>
<td>0.496</td>
</tr>
<tr>
<td>T.S.P</td>
<td>0.0342</td>
<td>0.0018</td>
</tr>
</tbody>
</table>

As part of the baseline study for the current project, a traffic survey was undertaken during site visits in March 2013 over two 7-hour periods. Vehicle numbers are summarised as Cars 100 hr$^{-1}$; buses 10 hr$^{-1}$; Trucks 22 hr$^{-1}$.

Some validation of the number of trucks can be obtained by looking at the bulk transport implied by the production rates for the plant. For the sulphuric acid plant, a production rate of 16500 tonnes per day implies a sulphur requirement of 5500 tonnes per day, which require 183 30-tonne truck deliveries a day. Similarly for the DAP plant, an annual requirement of 76000 tonnes per year of urea and filler etc. implies a delivery rate of 7 30 tonne trucks per day. This gives around 300 truck deliveries per day which can be compared to the observed 11 trucks per hour (assuming each truck delivery is “2-way”).

It is assumed that most journeys are “2-way” and that conservatively; each journey is around half the perimeter of the MPC site, which is approximately to be 7 km.

$$E_i = N \times HRS \times DIST \times EF_i$$

Where:
\( E_i = \text{mass of emission of pollutant } i \text{ during the inventory period (g/yr)} \)

\( N = \text{source population (units/hour)} \)

\( \text{HRS} = \text{annual hours of use (8760 hr/yr)} \)

\( \text{DIST} = \text{average journey distance (7 km)} \)

\( \text{EF}_i = \text{emission factor of pollutant } i \text{ per unit of use (g/km)} \)

In addition, HGVs are assumed to spend 1 hour with the engine running whilst standing idle, loading/unloading or waiting in queues for these activities. Emission factors for this are taken from US EPA420-F-08-025 (EPA, 2008). They are entered into Table D 9.

The traffic data are assumed to apply continuously (as the site operates 24/7).

The calculated emission factors in Table D 10 apply to the existing MPC site. For the new development, most transport is by rail, the only extra road requirement will be for an equal amount of urea and filler to be delivered for the new fertilizer plant. This equates to an extra 7 trucks per day, which is approximately 5% of the existing traffic. It will be assumed that the traffic emissions for the new MPC development will be equal to 5% of those of the current site.

### Table D 10: Calculated Emissions for Road Traffic Operations at MPC

<table>
<thead>
<tr>
<th>Emission factor (g/yr)</th>
<th>PM(_{10})</th>
<th>VOC</th>
<th>NO(_X)</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>2.10E+05</td>
<td>9.81E+04</td>
<td>3.69E+06</td>
<td>5.95E+05</td>
</tr>
<tr>
<td>Bus</td>
<td>1.10E+03</td>
<td>1.29E+04</td>
<td>3.04E+05</td>
<td>9.20E+04</td>
</tr>
<tr>
<td>Truck</td>
<td>1.17E+05</td>
<td>3.49E+05</td>
<td>3.94E+06</td>
<td>2.63E+06</td>
</tr>
<tr>
<td>Total</td>
<td>3.28E+05</td>
<td>4.60E+05</td>
<td>7.93E+06</td>
<td>3.32E+06</td>
</tr>
</tbody>
</table>

Expressed as g/s

<table>
<thead>
<tr>
<th>PM(_{10})</th>
<th>VOC</th>
<th>NO(_X)</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.010395</td>
<td>0.01459</td>
<td>0.251359</td>
<td>0.105262</td>
</tr>
</tbody>
</table>

**Emissions from Diesel Storage Tanks**

For the new MPC plant, diesel emergency generators will be located as necessary to provide emergency power for a safety shutdown of the facilities in the event of loss of grid power. Wherever a diesel generator set is provided, diesel day tank storage will also be provided. Centralised storage to supply these day tanks is provided by the existing MPC facility. The sizing of the diesel storage tanks is the responsibility of the EPC contractor, but indicative tank sizes have been used for the purpose of assessment.

Fugitive emissions from these structures are calculated using the US EPA TANKS model v4.07 (US EPA AP42). Emissions are calculated for a fixed height cone storage tank. Diesel is entered as a compound in the database, rather than using Fuel oil distillate No 2, and Jubail temperature data are entered in the meteorological database.

**D.4.5.2 MODELLING OF FUGITIVE SOURCES**

The fugitive sources identified were simplistically modelled as line and area sources, defined by the footprints of the areas of site where these activities take place. They can be seen as areas delineated by dashed red lines in Figure D 1.

Fugitive emissions are calculated using the generic methodologies described above. The fugitive emissions from each region are then calculated by the activities in that region. These are described as follows. The emissions are scaled by the area of each region and are summarised in Table D 11, with parameterisation as described in Table D 16.
Table D 11: Summary of fugitive emission factors represented in the model

<table>
<thead>
<tr>
<th>Area/Line</th>
<th>Description</th>
<th>Area (m²)</th>
<th>Activities</th>
<th>Emissions (g/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area 1</td>
<td>Storage area for phosphate ore from Al Jalamid for existing PAP</td>
<td>3.78e5</td>
<td>Unloading from rail to truck Unloading from truck to storage area loading on to truck for transfer to conveyor</td>
<td>0.074 (PM₁₀)</td>
</tr>
<tr>
<td>Area 2</td>
<td>Existing PAP/DAP unloading / delivery area</td>
<td>1.2e5</td>
<td>Conveyor unloading of phosphate ore Delivery of urea and filler by lorry</td>
<td>4.9e-3 (PM₁₀)</td>
</tr>
<tr>
<td>Area 3</td>
<td>Dust emissions from existing DAP export area</td>
<td>1.75e5</td>
<td>Conveyor transfer of DAP export</td>
<td>0.0016 (PM₁₀)</td>
</tr>
<tr>
<td>Area 4</td>
<td>Dust emissions from export of existing DAP from port area</td>
<td>1.8e-5</td>
<td>Conveyor transfer of DAP at port for export</td>
<td>0.0016 (PM₁₀)</td>
</tr>
<tr>
<td>Area 5</td>
<td>Dust emissions from existing aluminium residue storage area</td>
<td>1.445e6</td>
<td>Dust emissions from wind erosion</td>
<td>3.89 (PM₁₀)</td>
</tr>
<tr>
<td>Area 6</td>
<td>Dust emissions from existing phosphogypsum storage area</td>
<td>6.44e5</td>
<td>Assumed to be identical to those estimated for the Umm Wu’al phosphogypsum transfers. Unloading of material from conveyor from PAP and beneficiation. Truck unloading in waste area</td>
<td>0.052 (PM₁₀)</td>
</tr>
<tr>
<td>Line 7</td>
<td>Emissions from locomotives in existing phosphate ore storage sidings</td>
<td>2.025e5</td>
<td>Locomotive emissions (2 trains per week)</td>
<td>0.0014 (PM₁₀) 0.0022 (VOC) 0.084 (NOₓ) 0.022 (CO)</td>
</tr>
<tr>
<td>Line 8</td>
<td>Emissions from locomotives while unloading in new MPC sidings</td>
<td>1.25e5</td>
<td>Locomotive emissions (2 trains per day)</td>
<td>0.0096 (PM₁₀) 0.0156 (VOC) 0.59 (NOₓ) 0.15 (CO)</td>
</tr>
<tr>
<td>Area 9</td>
<td>DAP unloading / delivery area for new plant</td>
<td>1.2e5</td>
<td>Delivery of urea and filler by lorry</td>
<td>1.0e-3 (PM₁₀)</td>
</tr>
<tr>
<td>Area 10</td>
<td>Dust emissions from new DAP export area</td>
<td>1.75e5</td>
<td>Conveyor transfer of DAP export</td>
<td>0.0016 (PM₁₀)</td>
</tr>
<tr>
<td>Area 11</td>
<td>Dust emissions from export of new DAP from port area</td>
<td>1.8e-5</td>
<td>Conveyor transfer of DAP at port for export 3 transfers as material will be stored in port area before loading. Also potash will be delivered by sea for new NPK plant</td>
<td>0.00494 (PM₁₀)</td>
</tr>
<tr>
<td>Area 12</td>
<td>Vehicle emissions from activities on the site (existing MPC plant)</td>
<td>2.93e6</td>
<td></td>
<td>0.0104 (PM₁₀) 0.015 (VOC) 0.251 (NOₓ) 0.105 (CO)</td>
</tr>
<tr>
<td>Area 13</td>
<td>Vehicle emissions from new MPC activities on site</td>
<td>2.93e6</td>
<td></td>
<td>5.2e-4 (PM₁₀) 7.5e-4 (VOC) 0.0126 (NOₓ) 5.25e-3 (CO)</td>
</tr>
<tr>
<td>Area 14</td>
<td>VOC emissions from new MPC diesel storage tanks</td>
<td>1.105e4</td>
<td></td>
<td>4.3e-3 (VOC)</td>
</tr>
</tbody>
</table>
Indicative diesel tank sizes were used in the model for VOCs, however subsequent to the modelling, tank sizes are expected to be less (with capacities no greater than 25m³ each), and therefore fugitive VOC emissions will be less than those quoted in D-11.

D.5 RESULTS

As previously noted, the modelled pollutant air concentrations resulting from discharges from a source or defined group of sources is known as the process contribution (PC). The overall predicted air concentration resulting from these sources and including additional contributions from other sources on adjacent sites and also ambient background concentrations is known as the predicted environmental concentration (PEC).

Results are presented in the following two sub-sections. In section D.5.1, the PC resulting from the new MPC plant are described, and section D.5.2 the overall air concentrations in the region are discussed, assessing the contributions from the new and existing MPC plant, the aluminium plant and the power plant, along with ambient background concentrations. Results will be compared to relevant ambient air quality standards.

Where the relevant AAQS allows a number of exceedances over the period (e.g. NOx or SO₂ hourly AAQS), results will be read from the CALPUFF/CALPOST summary file as the third highest value calculated at a unique location. This has a degree of conservatism, as, for the RC hourly AAQS for SO₂, NOx and CO, where two exceedances are allowed per month, the worst case is assumed whereby the third highest value is selected. The actual value could be between the 3rd or the 25th ranked value, since the “worst” case is all three exceedances occurring within the same month, whereas the “best” case would be where there are two exceedances equally distributed through all months in the year, with the next highest value (i.e. the 25th highest in the year) resulting in the AAQS being exceeded.

D.5.1 PROCESS CONTRIBUTIONS RESULTING FROM THE NEW MPC PLANT

The combined process contributions resulting from the new ammonia plant and DAP/NPK plant for all pollutants are summarised below in Table D 12 for all 5 years assessed.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>RC AAQS</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOₓ 1H3H</td>
<td>660</td>
<td>136</td>
<td>176</td>
<td>274</td>
<td>218</td>
<td>123</td>
</tr>
<tr>
<td>NOₓ annual</td>
<td>100</td>
<td>3.5</td>
<td>3.2</td>
<td>4.2</td>
<td>2.6</td>
<td>3.7</td>
</tr>
<tr>
<td>CO 1H3H</td>
<td>40000</td>
<td>24</td>
<td>19.9</td>
<td>22.0</td>
<td>20.4</td>
<td>20.7</td>
</tr>
<tr>
<td>CO 8H3H</td>
<td>10000</td>
<td>7.3</td>
<td>7.8</td>
<td>8.6</td>
<td>7.4</td>
<td>8.4</td>
</tr>
<tr>
<td>SO₂ 1H3H</td>
<td>730</td>
<td>0.33</td>
<td>0.28</td>
<td>0.3</td>
<td>0.28</td>
<td>0.28</td>
</tr>
<tr>
<td>SO₂ 24H2H</td>
<td>365</td>
<td>0.046</td>
<td>0.052</td>
<td>0.05</td>
<td>0.037</td>
<td>0.061</td>
</tr>
<tr>
<td>SO₂ Annual</td>
<td>80</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
<td>0.003</td>
</tr>
<tr>
<td>PM₁₀ 24H1H</td>
<td>150</td>
<td>24.8</td>
<td>60.8</td>
<td>26.3</td>
<td>33.9</td>
<td>35.9</td>
</tr>
<tr>
<td>PM₁₀ annual</td>
<td>50</td>
<td>3.5</td>
<td>3.2</td>
<td>2.8</td>
<td>4.0</td>
<td>2.8</td>
</tr>
<tr>
<td>VOC 3H1H</td>
<td>160</td>
<td>1.9</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Fluorides monthly</td>
<td>1</td>
<td>0.76</td>
<td>0.96</td>
<td>0.85</td>
<td>0.92</td>
<td>0.75</td>
</tr>
<tr>
<td>NH₃ 1H1H</td>
<td>1800</td>
<td>253</td>
<td>1522</td>
<td>510</td>
<td>648</td>
<td>565</td>
</tr>
</tbody>
</table>

Table D 12 shows the peak air concentration at any of the grid receptors outside the MPC site boundary averaged over the period of the relevant ambient air quality standard. Results are compared to the Royal Commission AAQS.

These show that process contributions for all pollutant emissions from the proposed MPC plant extension are within RCER ambient air quality standards. No year is noticeably the “worst case” for all pollutants, reflecting the multiplicity of pollutants and sources in the complex site covered in this project. Results for SO₂ are unusually low for this type of assessment but this is because the only source term in the new MPC plant is the auxiliary.
boiler on the ammonia plant, which is powered by natural gas and operates at a very low power level.

The calculated PCs at the defined sensitive receptors are shown in Table D 13 for 2009 for the shortest averaging period for the four pollutants closest to the AAQS in Table D 12. All concentrations are below ambient air quality standards.

**Table D 13: Process contribution from new MPC plant at discrete receptors (µg/m³)**

<table>
<thead>
<tr>
<th>Discrete Receptors</th>
<th>NOₓ 1H3H</th>
<th>PM₁₀ 24H1H</th>
<th>Fluorides 1M1H</th>
<th>NH₃ 1H1H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worker accommodation constructed close to the site</td>
<td>14.5</td>
<td>6.9</td>
<td>0.17</td>
<td>35.4</td>
</tr>
<tr>
<td>Coast Guard station (close to site)</td>
<td>11.2</td>
<td>6.7</td>
<td>0.25</td>
<td>35.4</td>
</tr>
<tr>
<td>Petrol station (6km south of the site)</td>
<td>8.9</td>
<td>3.5</td>
<td>0.087</td>
<td>18.7</td>
</tr>
<tr>
<td>Housing (to east of aluminium plant)</td>
<td>4.6</td>
<td>2.7</td>
<td>0.039</td>
<td>9.9</td>
</tr>
<tr>
<td>Radio post (10km at the east of the peninsula)</td>
<td>5.1</td>
<td>2.0</td>
<td>0.044</td>
<td>10.6</td>
</tr>
<tr>
<td>Manifah (~25km west)</td>
<td>3.9</td>
<td>0.96</td>
<td>0.017</td>
<td>7.3</td>
</tr>
<tr>
<td>Nairiyah (68km west)</td>
<td>0.77</td>
<td>0.371</td>
<td>0.008</td>
<td>1.9</td>
</tr>
<tr>
<td>Al Jubail (65km south)</td>
<td>0.84</td>
<td>0.35</td>
<td>0.007</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Contour plots of PCs over a range of 3km from the site for the six pollutants closest to the AAQS (excluding CO) resulting from the new MPC plant are shown in Figure D 3. These are results for 2009 which was selected as having the highest PM₁₀ and Fluorides concentrations for the Project. The results are only presented for locations outside the site boundaries.
Figure D 3: Contour plots of PC from new MPC plant to 3km from site (µg/m³) (2009)
D.5.2 PREDICTED ENVIRONMENTAL CONCENTRATIONS FROM ALL SOURCES

The contributions of other sources in the area to the predicted total air concentration, i.e. the sum of PCs allows comparison of the relative inputs from the various sources. Because this is an assessment of the contributions from a number of sources in different sites within the Industrial City (IC) plant, these results are presented as the peak concentration outside the boundary of the IC. Presenting results in this way is also consistent with earlier assessments (e.g. Exponent, 2012). Because the main focus of this assessment has been the new MPC ammonia and fertilizer plants, the detailed CALPUFF receptor grid is only around the MPC plant. Thus, peak concentrations are only assessed around the north-east border of the IC (see Figure D 4). This is justified as this assessment is part of an ESIA for the new MPC plant: it is not an air quality assessment of the IC. However the aim of comparing the contributions from the new MPC with contributions from other sources in the vicinity of the MPC plant is achieved.

The predicted air concentrations resulting from industrial contributions from plant either operating or under construction in the area are shown in Table D 14 for 2011 (which had the highest predicted SO2 concentration for the existing MPC plant). The first “Total” column is the highest concentration resulting from the modelled contributions from local industrial sources at any of the receptors within the receptor grid outside the IC boundary. It is not the sum of the individual contributions from the columns to the left. The second “Total” column (at the right hand end of the table) is the total including the contribution from ambient background air concentration (based on data from Jubail RC site 6). The CALPOST post-processor takes the hourly results data and combines these with the hourly background air concentration to provide a better indication of the actual air concentration than that achieved by simply adding an average background level. This also provides more relevant comparisons for the shorter averaging period RC AAQS.

Table D 14: Breakdown of contribution from all sites to the PC and PEC (2011) (µg/m³)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>RC AAQS</th>
<th>Power plant</th>
<th>Aluminium works</th>
<th>MPC Existing</th>
<th>MPC New</th>
<th>Total</th>
<th>Total including ambient background</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx1H3H</td>
<td>660</td>
<td>21.4</td>
<td>64.3</td>
<td>60.6</td>
<td>38.4</td>
<td>90.4</td>
<td>422</td>
</tr>
<tr>
<td>NOx annual</td>
<td>100</td>
<td>0.09</td>
<td>0.33</td>
<td>0.86</td>
<td>0.67</td>
<td>1.7</td>
<td>38</td>
</tr>
<tr>
<td>CO 1H3H</td>
<td>40000</td>
<td>18</td>
<td>674</td>
<td>8.4</td>
<td>5.1</td>
<td>676</td>
<td>2161</td>
</tr>
<tr>
<td>CO 8H3H</td>
<td>10000</td>
<td>5.7</td>
<td>223</td>
<td>3.3</td>
<td>2.3</td>
<td>224</td>
<td>1224</td>
</tr>
<tr>
<td>SO2 1H3H</td>
<td>730</td>
<td>0.25</td>
<td>232</td>
<td>659</td>
<td>0.068</td>
<td>662</td>
<td>676</td>
</tr>
<tr>
<td>SO2 24H2H</td>
<td>365</td>
<td>0.066</td>
<td>34.7</td>
<td>89.2</td>
<td>0.02</td>
<td>92.6</td>
<td>97.9</td>
</tr>
<tr>
<td>SO2 Annual</td>
<td>80</td>
<td>0.001</td>
<td>2.1</td>
<td>7.2</td>
<td>0.001</td>
<td>8.6</td>
<td>15.1</td>
</tr>
<tr>
<td>PM10 24H1H</td>
<td>150</td>
<td>0.88</td>
<td>13.2</td>
<td>54.9</td>
<td>16.0</td>
<td>61.8</td>
<td>2624</td>
</tr>
<tr>
<td>PM10 annual</td>
<td>50</td>
<td>0.014</td>
<td>0.47</td>
<td>3.6</td>
<td>1.3</td>
<td>4.4</td>
<td>234</td>
</tr>
<tr>
<td>VOC 3H1H</td>
<td>160</td>
<td>0</td>
<td>36.6</td>
<td>3.1</td>
<td>0.35</td>
<td>36.6</td>
<td>36.6</td>
</tr>
<tr>
<td>Fluorides monthly</td>
<td>1</td>
<td>0</td>
<td>0.006</td>
<td>0.6584</td>
<td>0.22</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>NH3 1H1H</td>
<td>1800</td>
<td>0</td>
<td>17.9</td>
<td>287</td>
<td>78.4</td>
<td>287</td>
<td>287</td>
</tr>
</tbody>
</table>

NB no background data for VOC, Fluorides, or NH3

These show that PCs for individual sites and the total PC from all sites for all pollutants are within RCER ambient air quality standards. The inclusion of background ambient air concentration data shows the domination of ambient air concentration data for PM10 by local dust storm events in the area, which mask any industrial contribution.

The total PC from all sites for the shortest averaging period at the discrete sensitive receptors is shown in Table D 15 for 2011. All concentrations are within the AAQS.
Table D 15: Process contribution from all plant at discrete receptors in 2011 (µg/m³)

<table>
<thead>
<tr>
<th>Discrete Receptors</th>
<th>NOₓ</th>
<th>PM₁₀</th>
<th>Fluorides</th>
<th>SO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worker accommodation constructed close to the site</td>
<td>86.7</td>
<td>26.8</td>
<td>0.41</td>
<td>522</td>
</tr>
<tr>
<td>Coast Guard station (close to site)</td>
<td>66.8</td>
<td>23.1</td>
<td>0.5</td>
<td>397</td>
</tr>
<tr>
<td>Petrol station (6km south of the site)</td>
<td>68.3</td>
<td>72.0</td>
<td>0.25</td>
<td>250</td>
</tr>
<tr>
<td>Housing (to east of aluminium plant)</td>
<td>15.6</td>
<td>7.1</td>
<td>0.12</td>
<td>85.5</td>
</tr>
<tr>
<td>Radio post (10km at the east of the peninsula)</td>
<td>157</td>
<td>15.5</td>
<td>0.081</td>
<td>231</td>
</tr>
<tr>
<td>Manifah (~25km west)</td>
<td>30.5</td>
<td>3.4</td>
<td>0.031</td>
<td>72.2</td>
</tr>
<tr>
<td>Nairiyah (68km west)</td>
<td>7.7</td>
<td>1.6</td>
<td>0.012</td>
<td>38.3</td>
</tr>
<tr>
<td>Al Jubail (65km south)</td>
<td>8.9</td>
<td>1.5</td>
<td>0.016</td>
<td>54.2</td>
</tr>
</tbody>
</table>

Contour plots over a range of 3km from the site of the total concentration of the six pollutants closest to the AAQS (excluding NH₃) resulting from contributions from the Power plant, aluminium plant, existing MPC and new MPC plant are shown in Figure D 4 for 2011.

Finally, contour plots of the regional spread of PEC of SO₂ and PM₁₀ across the entire CALPUFF modelling domain are shown in Figure D 5. These show the extent of the spread of SO₂ at levels of between the 50µg/m³ and 100 µg/m³ some distance from the facility - these levels however are well within the ambient air quality standards.
Figure D 4: Contour plots of total PC from all plant out to 3km from site ($\mu g/m^3$) (2011)
Figure D 5: Contour plots of PC from all plant over the CALPUFF domain (150 km) ($\mu$g/m$^3$) (2011)
### Table D 16: Discrete Release Points and fugitive emission sources as represented in the model

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<th>Diameter  m</th>
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<th>CO g/s</th>
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## Aluminium plant (Ma’aden Aluminium Company) – Rolling Mill (Point)

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<th>CO g/s</th>
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<th>VOC g/s</th>
<th>Fluorides g/s</th>
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## Fugitive Area Sources (g/m²/s)

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### D.6 SUMMARY

Emissions from the new MPC plant result in air concentrations for process contribution below RC AAQS.

When PCs are calculated for the contribution from all industrial plant in the area, these comply with RC AAQS. Addition of background air concentration contributions gives PEC values which are also below RC AAQS, except PM\(_{10}\) (see below).

Dust storms in KSA dominate ambient background air concentrations for PM\(_{10}\).
## D.7 REFERENCES


SGS (2012). Stack emission monitoring at the Ma’aden DAP and AP plants.


DEPARTMENT: SAFETY AND ENVIRONMENTAL
REPORT NO: 60-R400-WH/G.06F/0072 (APPENDIX E)

REPORT TITLE: RAS AL KHAIR
ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT (ESIA)
APPENDIX E – TERRESTRIAL ENVIRONMENT

PROJECT REFERENCE
PROJECT NO: 60-R400-WH
PROJECT LOCATION: SAUDI ARABIA
PROJECT TITLE: UMM WU’AL PHOSPHATE PROEJCT
CLIENT: MA’ADEN (SAUDI ARABIAN MINING COMPANY)
CLIENT PROJECT NO 2-115-12-12-2-2
CLIENT DOCUMENT NO MD-513-0000-HS-EN-RPT-0069 (APPENIDX E)
PM Authorisation: Andy Dodd

APPROVALS

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DOCUMENT ISSUED FOR:
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- For Use
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- For Enquiry
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### Table 7-1a: Groundwater Monitoring Well and Sample Analysis January 2012 screened against Water Quality Standards for Direct Discharge to Coastal Waters

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### Table 7-1b: Groundwater Monitoring Well and Sample Analysis December 2012 screened against Water Quality Standards for Direct Discharge to Coastal Waters

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<td>Nitrate</td>
<td>0.05</td>
<td>1</td>
<td>mg/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td>0.01</td>
<td>1</td>
<td>mg/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>0.01</td>
<td>1</td>
<td>mg/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Key:
- LOD: Limit of Detection
- DCW: Direct Discharge Water Quality
- MW: Monitoring Well

* Water Quality Standards for Direct Discharge to Coastal Waters
  - Discharge to the Seawater Cooling Return Canal, Variance Streams and Surfline Drainage Ditches
  - Different Temperature between Seawater Cooling Intake and Seawater Cooling Discharge
  - ALS Amelab Method EGG20-Metals: Due to matrix interference, client sample IDs’ MW2, MW5, MW6, MW7, MW8, MW9, MW10 and MW11” have been diluted prior to analysis. The LOD for “metals” have been adjusted accordingly to the dilution factor.
  - ALS Amelab method EP020: Oil & Grease is equivalent to n-hexane extractable materials.

Project Name: UMM Wu’al Phosphate Project
E1.2  BIOSCREEN MODEL INPUT AND RELEVANT OUTPUT SCREENS
E1.2.1 INPUT 1: SPILL MODELLING SCENARIO 1: ACCIDENTAL SPILLAGE OF DIESEL – PLUME EXTENT AFTER 1000 YEARS

Bioscreen Natural Attenuation Decision Support System

1. HYDROGEOLOGY
   - Seepage Velocity \( V_s \) = 34.6 (m/y)
   - Hydraulic Conductivity \( K \) = 0.000344 (cm/sec)
   - Hydraulic Gradient \( i \) = 0.00017 (m/m)
   - Porosity \( n \) = 0.2

2. DISPERSION
   - Longitudinal Dispersivity \( \alpha_x \) = 48.6 (m)
   - Transverse Dispersivity \( \alpha_y \) = 4.9 (m)
   - Vertical Dispersivity \( \alpha_z \) = 8.6
   - Estimated Plume Length \( L_p \) = 6561 (m)

3. ADSORPTION
   - Retardation Factor \( R \) = 22.4
   - Soil Bulk Density \( \rho_c \) = 1.7 (kg/m³)
   - Partition Coefficient \( K_{OC} \) = 2511.89 (L/kg)
   - Fraction Organic Carbon \( fOC \) = 1.0E-3

4. BIODEGRADATION
   - 1st Order Decay Coefficient \( k_{1st} \) = 1.7E-1 (1/yr)
   - Solute Half-Life \( t_{1/2} \) = 4.11 (yrs)

5. GENERAL
   - Modeled Area Length* = 6561 (m)
   - Modeled Area Width* = 656 (m)
   - Simulation Time* = 1000 (y)

6. SOURCE DATA
   - Source Thickness in Sat Zone* = 9 (m)
   - Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3

7. FIELD DATA FOR COMPARISON
   - Concentration (mg/L)
     - 0 666 1332 1998 2624 3291 3978 4543 5103 5669
   - Dist. from Source (m)

8. CHOOSE TYPE OF OUTPUT TO SEE:
   - RUN CENTERLINE
   - RUN ARRAY
   - Help

Project Name:
UMM WU’AL PHOSPHATE PROJECT
E1.2.2 OUTPUT 1: SPILL MODELLING SCENARIO 1: ACCIDENTAL SPILLAGE OF DIESEL – PLUME EXTENT AFTER 1000 YEARS

Dissolved Hydrocarbon Concentration Along Plume Centerline (mg/L at Z=0)

<table>
<thead>
<tr>
<th>Type of Model</th>
<th>Distance from Source (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>No Degradation</td>
<td>10.062</td>
</tr>
<tr>
<td>1st Order Decay</td>
<td>10.062</td>
</tr>
<tr>
<td>Instantaneous Reaction</td>
<td>10.062</td>
</tr>
<tr>
<td>Field Data from Site</td>
<td></td>
</tr>
</tbody>
</table>

Project Name:
UMM WU’AL PHOSPHATE PROJECT
E1.2.3 INPUT 2: SPILL MODELLING SCENARIO 1: ACCIDENTAL SPILLAGE OF DIESEL – PLUME EXTENT AFTER 100 YEARS WITHOUT DEGRADATION

BIOSCREEN Natural Attenuation Decision Support System

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seepage Velocity (V_s)</td>
<td>3.46</td>
</tr>
<tr>
<td>Hydraulic Conductivity (K)</td>
<td>0.00339 (cm/sec)</td>
</tr>
<tr>
<td>Hydraulic Gradient (i)</td>
<td>0.0017 (ft/day)</td>
</tr>
<tr>
<td>Porosity (n)</td>
<td>0.2</td>
</tr>
<tr>
<td>Longitudinal Dispersivity (alpha_x)</td>
<td>4.86</td>
</tr>
<tr>
<td>Transverse Dispersivity (alpha_y)</td>
<td>4.9</td>
</tr>
<tr>
<td>Vertical Dispersivity (alpha_z)</td>
<td>6.6</td>
</tr>
<tr>
<td>Estimated Plume Length (L_p)</td>
<td>234.11 (ft)</td>
</tr>
<tr>
<td>Retardation Factor (R)</td>
<td>22.4</td>
</tr>
<tr>
<td>Soil Bulk Density (rho)</td>
<td>1.7   (g/cm³)</td>
</tr>
<tr>
<td>Partition Coefficient (Koc)</td>
<td>2511.89 (L/kg)</td>
</tr>
<tr>
<td>Fraction Organic Carbon (foc)</td>
<td>1.0E-3 (g/L)</td>
</tr>
<tr>
<td>1st Order Decay Coefficient (k)</td>
<td>1.7E-1 (yr⁻¹)</td>
</tr>
<tr>
<td>Solute Half-Life (t_half)</td>
<td>4.11  (yr)</td>
</tr>
</tbody>
</table>

Delta Oxygen (DO) = 0 (mg/L)
Delta Nitrate (NO₃) = 0 (mg/L)
Observed Ferrous Iron (Fe²⁺) = 0 (mg/L)
Delta Sulfate (SO₄) = 0 (mg/L)
Observed Methane (CH₄) = 0 (mg/L)

Data Input Instructions:
- Enter values directly or calculate by filling in grey cells below.
- To restore formulas, hit button below.
- Value calculated by model (Don't enter any data).

View of Plume Looking Down
Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter 0

Choose Type of Output to See:
- Run Centerline
- Run Array

Help
- Recalculate This Sheet
- Paste Example Dataset
- Restore Formulas for Vs, Dispersivities, R, lambda, other

Project Name: UMM WU’AL PHOSPHATE PROJECT
### Dissolved Hydrocarbon Concentration Along Plume Centerline (mg/L at Z=0)

<table>
<thead>
<tr>
<th>Type of Model</th>
<th>Distance from Source (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>No Degradation</td>
<td>22.41</td>
</tr>
<tr>
<td>1st Order Decay</td>
<td>22.41</td>
</tr>
<tr>
<td>Instantaneous Reaction</td>
<td>22.41</td>
</tr>
</tbody>
</table>

The graph shows the concentration of dissolved hydrocarbons along the plume centerline at different distances from the source, with time set to 100 years. The concentration decreases significantly with distance, indicating effective degradation or dispersion of the spill over time.
E1.2.5 INPUT 3: SPILL MODELLING SCENARIO 1: ACCIDENTAL SPILLAGE OF DIESEL – PLUME EXTENT AFTER 100 YEARS WITH DEGRADATION

**BIOSCREEN Natural Attenuation Decision Support System**

**1. HYDROGEOLOGY**
- Seepage Velocity: $V_s = 34.6 \text{ (m/d)}$
- Hydraulic Conductivity: $K = 0.00094 \text{ (m/d)}$
- Hydraulic Gradient: $i = 0.0017 \text{ (m/m)}$
- Porosity: $n = 0.2$

**2. DISPERSION**
- Longitudinal Dispersion: $a_{L} = 48.6 \text{ (m)}$
- Transverse Dispersion: $a_{T} = 4.9 \text{ (m)}$
- Vertical Dispersion: $a_{V} = 6.5 \text{ (m)}$
- Estimated Plume Length: $L_p = 6561 \text{ (m)}$

**3. ADSORPTION**
- Retardation Factor: $R = 22.4$
- Soil Bulk Density: $\rho = 1.77 \text{ (kg/m}^3\text{)}$
- Partition Coefficient: $K_{oc} = 2511.69 \text{ (L/kg)}$
- Fraction Organic Carbon: $f_{oc} = 1.0 \times 10^{-3}$

**4. BIODEGRADATION**
- 1st Order Decay Coefficient: $k_1 = 1.7 \times 10^{-1} \text{ (yr}^{-1}\text{)}$
- Half-Life: $t_{1/2} = 4.11 \text{ (yr)}$
- Instantaneous Reaction Model: $k_0$

**5. GENERAL**
- Modeled Area Length: $200 \text{ (m)}$
- Modeled Area Width: $556 \text{ (m)}$
- Simulation Time: $100 \text{ (yr)}$

**6. SOURCE DATA**
- Source Thickness in Sat Zone: $9 \text{ (ft)}$
- Source Zones: Width: $5 \text{ (ft)}$
- Concentration: $15 \text{ (mg/L)}$
- Source Half-Life: $800 \text{ (yr)}$
- Instantaneous Reaction: $k_0$
- Soluble Mass: $832 \text{ (Kg)}$
- In Source NAPL, Soil: Observed Centerline Concentrations at Monitoring Wells

**7. FIELD DATA FOR COMPARISON**
- Concentration: $0 \text{ to } 200 \text{ (mg/L)}$

**8. CHOOSE TYPE OF OUTPUT TO SEE:**
- RUN CENTERLINE
- RUN ARRAY
- View Output
- Help

---

**Project Name:**
UMM WU’AL PHOSPHATE PROJECT
### Dissolved Hydrocarbon Concentration Along Plume Centerline (mg/L at Z=0)

<table>
<thead>
<tr>
<th>Type of Model</th>
<th>Distance from Source (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>No Degradation</td>
<td></td>
</tr>
<tr>
<td>1st Order Decay</td>
<td>22.4</td>
</tr>
<tr>
<td>Inst. Reaction</td>
<td>22.4</td>
</tr>
<tr>
<td>Field Data from Site</td>
<td>22.4</td>
</tr>
</tbody>
</table>

---

**E1.2.6** OUTPUT 3: SPILL MODELLING SCENARIO 1: ACCIDENTAL SPILLAGE OF DIESEL – PLUME EXTENT AFTER 100 YEARS WITH DEGRADATION

---

**Project Name:** UMM WU’AL PHOSPHATE PROJECT

---
E1.2.7 INPUT 4: SPILL MODELLING SCENARIO 1: ACCIDENTAL SPILLAGE OF LUBRICATING OIL – PLUME EXTENT AFTER 1000 YEARS

**Bioscreen Natural Attenuation Decision Support System**

**1. HYDROGEOLOGY**

- Seepage Velocity: V_s = 34.6 (m/d)
- Hydraulic Conductivity: K = 0.00094 (m/d)
- Hydraulic Gradient: i = 0.00017 (m/m)
- Porosity: n = 0.2

**2. DISPERSION**

- Longitudinal Dispersivity: α_x = 48.6 (m)
- Transverse Dispersivity: α_y = 4.9 (m)
- Vertical Dispersivity: α_z = 6.6 (m)
- Estimated Plume Length: L_p = 5861 (m)

**3. ADSORPTION**

- Retardation Factor: R = 43.6
- Soil Bulk Density: ρ_s = 1.7 (g/cm³)
- Partition Coefficient: K_d = 5011.87 (L/kg)
- Fraction Organic Carbon: f OC = 1.0E-3

**4. BIODEGRADATION**

- 1st Order Decay Coefficient: k = 1.7E-1 (per yr)
- Solute Half-Life: t_1/2 = 4.11 (years)

**5. GENERAL**

- Modeled Area Length: 66E1 (m)
- Modeled Area Width: 656 (m)
- Simulation Time: 1000 (yr)

**6. SOURCE DATA**

- Source Thickness: 9 (m)
- Source Zones:
  - Width: 2.5, 5, 10, 15, 25, 50, 100, >1000 (m)
  - Concentration: 4, 5, 6, 7, 8, 9, 10, 11, >11 (mg/L)

**7. FIELD DATA FOR COMPARISON**

- Concentration (mg/L)
  - Dist. from Source (m):
    - 0: 505, 1012, 1519, 2024, 2531, 3037, 3543, 4050, 4556, 5062

**8. CHOOSE TYPE OF OUTPUT TO SEE:**

- Run Centerline
- Run Array
- View Output

---

PROJECT NAME:

UMM WU’AL PHOSPHATE PROJECT

MA’ADEN - South Arabia Mining Company
E1.2.8 OUTPUT 4: SPILL MODELLING SCENARIO 1: ACCIDENTAL SPILLAGES OF LUBRICATING OIL – PLUME EXTENT AFTER 1000 YEARS

**Dissolved Hydrocarbon Concentration Along Plume Centerline (mg/L at Z=0)**

<table>
<thead>
<tr>
<th>TYPE OF MODEL</th>
<th>Distance from Source (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>No Degradation</td>
<td>3.488</td>
</tr>
<tr>
<td>1st Order Decay</td>
<td>3.488</td>
</tr>
<tr>
<td>Instantaneous Reaction</td>
<td>3.488</td>
</tr>
</tbody>
</table>

**Calculate Animation**

**Project Name:**
UMM WU’AL PHOSPHATE PROJECT

**Return to Input**
**Recalculate This Sheet**
E1.2.9 INPUT 5: SPILL MODELLING SCENARIO 1: ACCIDENTAL SPILLAGE OF LUBRICATING OIL – PLUME EXTENT AFTER 100 YEARS WITHOUT DEGRADATION

**BIOSCREEN Natural Attenuation Decision Support System**

**1. HYDROGEOLOGY**
- Seepage Velocity: $34.6 \text{ ft/yr}$
- Hydraulic Conductivity: $0.00384 \text{ ft/day}$
- Hydraulic Gradient: $0.0017 \text{ ft/ft}$
- Porosity: $0.2$

**2. DISPERSION**
- Longitudinal Dispersivity: $48.6 \text{ ft}$
- Transverse Dispersivity: $4.9 \text{ ft}$
- Vertical Dispersivity: $6.6 \text{ ft}$
- Estimated Plume Length: $6661 \text{ ft}$

**3. ADSORPTION**
- Retardation Factor: $43.6$
- Soil Bulk Density: $1.7 \text{ (kg/L)}$
- Partition Coefficient: $5011 \text{ (L/kg)}$
- Fraction Organic Carbon: $1.0E-3$

**4. BIODEGRADATION**
- First Order Decay Coefficient: $1.7E-1 \text{ (per yr)}$
- Solute Half-Life: $4.11 \text{ year}$

**5. GENERAL**
- Modeled Area Length: $350 \text{ ft}$
- Modeled Area Width: $666 \text{ ft}$
- Simulation Time: $100 \text{ yrs}$
- Source Thickness in Sat.Zone: $9 \text{ ft}$

**6. SOURCE DATA**
- Source Plane Source: Concentrations for Zones 1, 2, and 3
- Observed Centerline Concentrations at Monitoring Wells
  - If No Data Leave Blank or Enter '0'

**7. FIELD DATA FOR COMPARISON**

**8. CHOOSE TYPE OF OUTPUT TO SEE:**
- RUN CENTERLINE
- RUN ARRAY

---

**Document Title:** RAS AL KHAI ESIA – APPENDICES
**Ma’aden Doc No.:** MD-513-000-HS-EN-RPT-0069
** Jacobs Doc No.:** 60-R400-WH/G.06f/0072
**Page:** E-14
**Date:** August 2013

**Project Name:** UMM WU’AL PHOSPHATE PROJECT
E1.2.10 OUTPUT 5: SPILL MODELLING SCENARIO 1: ACCIDENTAL SPILLAGE OF LUBRICATING OIL – PLUME EXTENT AFTER 100 YEARS WITHOUT DEGRADATION

Dissolved Hydrocarbon Concentration Along Plume Centerline (mg/L at Z=0)

<table>
<thead>
<tr>
<th>TYPE OF MODEL</th>
<th>Distance from Source (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>No Degradation</td>
<td>5.470</td>
</tr>
<tr>
<td>1st Order Decay</td>
<td>5.470</td>
</tr>
<tr>
<td>Instantaneous Reaction</td>
<td>5.470</td>
</tr>
</tbody>
</table>

Field Data from Site

Calculate Animation

Time: 100 Years

Return to Input  Recalculate This Sheet

Project Name: UMM WU’AL PHOSPHATE PROJECT
E1.2.11 INPUT 6: SPILL MODELLING SCENARIO 1: ACCIDENTAL SPILLAGE OF LUBRICATING OIL – PLUME EXTENT AFTER 100 YEARS WITH DEGRADATION
E1.2.12 OUTPUT 6: SPILL MODELLING SCENARIO 1: ACCIDENTAL SPILLAGE OF LUBRICATING OIL – PLUME EXTENT AFTER 100 YEARS WITH DEGRADATION

### Dissolved Hydrocarbon Concentration Along Plume Centerline (mg/L at Z=0)

<table>
<thead>
<tr>
<th>Type of Model</th>
<th>Distance from Source (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>No Degradation</td>
<td>5.470</td>
</tr>
<tr>
<td>1st Order Decay</td>
<td>5.470</td>
</tr>
<tr>
<td>Inst. Reaction</td>
<td>5.470</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field Data from Site</th>
<th>Distance from Source (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

**Diagram:**

- **1st Order Decay**
- **Instantaneous Reaction**
- **No Degradation**
- **Field Data from Site**

**Calculate Animation**

**Time:**

- 100 Years

**Return to input**

**Recalculate This Sheet**
E1.2.13 INPUT 7: SPILL MODELLING SCENARIO 2: CATASTROPHIC FAILURE OF DIESEL STORAGE TANK – PLUME EXTENT AFTER 1000 YEARS

BIOSCREEN Natural Attenuation Decision Support System
Air Force Center for Environmental Excellence

1. HYDROGEOLOGY
Seepage Velocity* \( V_s \) 34.6 (m/yr)

2. DISPERSION
Longitudinal Dispersivity* \( \alpha_x \) 43.6 (m)
Transverse Dispersivity* \( \alpha_y \) 6.6 (m)
Vertical Dispersivity* \( \alpha_z \) 6.6 (m)

3. ADSORPTION
Retardation Factor* \( R \) 22.4 (-)

4. BIODEGRADATION
1st Order Decay Coeff* \( k \) 1.7E-1 (per yr)

5. GENERAL
Modelled Area Length* 6561 (m)
Modelled Area Width* 656 (m)
Simulation Time* 1000 (yr)

6. SOURCE DATA
Source Thickness in Sat. Zone* 9 (m)

7. FIELD DATA FOR COMPARISON

8. CHOOSE TYPE OF OUTPUT TO SEE:
- RUN CENTERLINE
- RUN ARRAY
### E1.2.14 OUTPUT 7: SPILL MODELLING SCENARIO 2: CATASTROPHIC FAILURE OF DIESEL STORAGE TANK – PLUME EXTENT AFTER 1000 YEARS

#### Dissolved Hydrocarbon Concentration Along Plume Centerline (mg/L at Z=0)

<table>
<thead>
<tr>
<th>Type of Model</th>
<th>Distance from Source (ft)</th>
<th>0</th>
<th>656</th>
<th>1312</th>
<th>1968</th>
<th>2624</th>
<th>3281</th>
<th>3937</th>
<th>4593</th>
<th>5249</th>
<th>5905</th>
<th>6561</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Degradation</td>
<td></td>
<td>12.63E6</td>
<td>0.825</td>
<td>0.436</td>
<td>0.063</td>
<td>0.001</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>1st Order Decay</td>
<td></td>
<td>12.63E6</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Inst. Reaction</td>
<td></td>
<td>12.63E6</td>
<td>0.825</td>
<td>0.436</td>
<td>0.063</td>
<td>0.001</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

#### Diagram

- **1st Order Decay**
- **Instantaneous Reaction**
- **No Degradation**
- **Field Data from Site**

---

**Project Name:** UMM WU’AL PHOSPHATE PROJECT

---

**Document Title:** RAS AL KHAIR ESIA – APPENDICES

**Appendix E - Terrestrial Environment**

**Revision:** A03

**Ma’aden Doc Nº:** MD-513-000-HS-EN-RPT-0069

**Page:** E-19

**Jacobs Doc Nº:** 60-R400-WH/G.06f/0072

**Date:** August 2013
E1.2.15 INPUT 8: SPILL MODELLING SCENARIO 2: CATASTROPHIC FAILURE OF DIESEL STORAGE TANK – PLUME EXTENT AFTER 100 YEARS WITHOUT DEGRADATION

**BIOSCREEN Natural Attenuation Decision Support System**

1. **HYDROGEOLOGY**
   - Seepage Velocity \( V_s \) = 34.6 (m/yr)
   - Hydraulic Conductivity \( K \) = 0.00394 (cm/sec)
   - Hydraulic Gradient \( i \) = 0.0017 (ft/ft)
   - Porosity \( n \) = 0.2

2. **DISPERSSION**
   - Longitudinal Dispersion \( \alpha_x \) = 48.6 (m)
   - Transverse Dispersion \( \alpha_y \) = 4.9 (m)
   - Vertical Dispersion \( \alpha_z \) = 6.6 (m)

3. **ABSORPTION**
   - Retardation Factor \( R \) = 32.4
   - Soil Bulk Density \( \rho_b \) = 1.7 (kg/m³)
   - Partition Coefficient \( K_d \) = 251.189 (L/kg)
   - Fraction Organic Carbon \( f_{OC} \) = 1.0E-3

4. **BIODEGRADATION**
   - 1st Order Decay Coeff \( \lambda_{1st} \) = 1.7E-1 (per yr)
   - Solute Half-Life \( t_{1/2} \) = 4.11 (years)

5. **GENERAL**
   - Modeled Area Length \( L_a \) = 600 (m)
   - Modeled Area Width \( W_a \) = 655 (m)
   - Simulation Time \( t_s \) = 100 (years)

6. **SOURCE DATA**
   - Source Thickness in Soil Zone \( d \) = 9 (m)
   - Source Zones:
     - Width \( W \) = 10, 40, 100, 24.5
     - Conc. \( (mg/L) \) = 5, 15, 15, 5

7. **FIELD DATA FOR COMPARISON**
   - Concentration (mg/L):
     - Dist. from Source \( d \) = 0, 60, 120, 180, 240, 300, 420, 480, 540, 600

8. **CHOOSE TYPE OF OUTPUT TO SEE:**
   - **RUN CENTERLINE**
   - **RUN ARRAY**

---

**Project Title:**
UMM WU’AL PHOSPHATE PROJECT

**Ma’aden Doc No.:** MD-513-000-HS-EN-RPT-0069

**Page:** E-20

**Date:** August 2013
### E1.2.16 OUTPUT 8: SPILL MODELLING SCENARIO 2: CATASTROPHIC FAILURE OF DIESEL STORAGE TANK – PLUME EXTENT AFTER 100 YEARS WITHOUT DEGRADATION

#### Dissolved Hydrocarbon Concentration Along Plume Centerline (mg/L at Z=0)

<table>
<thead>
<tr>
<th>Type of Model</th>
<th>Distance from Source (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>No Degradation</td>
<td>22.930</td>
</tr>
<tr>
<td>1st Order Decay</td>
<td>22.930</td>
</tr>
<tr>
<td>Inst. Reaction</td>
<td>22.930</td>
</tr>
</tbody>
</table>

#### Diagram

- **1st Order Decay**
- **Instantaneous Reaction**
- **No Degradation**
- **Field Data from Site**

**Project Name:**
UMM WU’AL PHOSPHATE PROJECT

**Date:**
August 2013
E1.2.18 OUTPUT 9: SPILL MODELLING SCENARIO 2: CATASTROPHIC FAILURE OF DIESEL STORAGE TANK – PLUME EXTENT AFTER 100 YEARS WITH DEGRADATION

Dissolved Hydrocarbon Concentration Along Plume Centerline (mg/L at Z=0)

<table>
<thead>
<tr>
<th>Type of Model</th>
<th>Distance from Source (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>No Degradation</td>
<td>22.930</td>
</tr>
<tr>
<td>1st Order Decay</td>
<td>22.930</td>
</tr>
<tr>
<td>Instantaneous Reaction</td>
<td>22.930</td>
</tr>
<tr>
<td>Field Data from Site</td>
<td></td>
</tr>
</tbody>
</table>

Calculate Animation

Time: 100 Years

Return to Input

Recalculate This Sheet
E1.2.19 INPUT 10: SPILL MODELLING SCENARIO 2: CATASTROPHIC FAILURE OF SULPHURIC ACID STORAGE TANK – PLUME EXTENT AFTER 105 YEARS

**BIOSCREEN Natural Attenuation Decision Support System**

**Air Force Center for Environmental Excellence**

**1. HYDROGEOLOGY**

- Ssepage Velocity $V_s$: 34.6 (ft/hr)
- Hydraulic Conductivity $K$: 0.00394 (ft/sec)
- Hydraulic Gradient $i$: 0.0017 (ft/ft)
- Porosity $n$: 0.2

**2. DISPERSION**

- Longitudinal Dispersivity $\alpha_x$: 43.6 (ft)
- Transverse Dispersivity $\alpha_y$: 4.9 (ft)
- Vertical Dispersivity $\alpha_z$: 6.6 (ft)
- Estimated Plume Length $L_p$: 6661 (ft)

**3. ADSORPTION**

- Retardation Factor $R$: 1.1
- Soil Bulk Density $\rho_s$: 1.7 (kg/L)
- Partition Coefficient $K_{oc}$: 6.1 (L/kg)
- Fraction Organic Carbon $\alpha_{OC}$: 1.0E-3

**4. BIODEGRADATION**

- 1st Order Decay Coefficient $\lambda$: 6.9E-7 (per hr)
- Solute Half-Life $t_{1/2}$: 0.147 (hrs)

**5. GENERAL**

- Modeled Area Length $L_x$: 6661 (ft)
- Modeled Area Width $L_y$: 566 (ft)
- Simulation Time $T$: 105 (yr)

**6. SOURCE DATA**

**Source Thickness in Sat. Zones**

<table>
<thead>
<tr>
<th>Zone</th>
<th>10</th>
<th>20</th>
<th>40</th>
<th>50</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conc. (mg/L)</td>
<td>100000</td>
<td>50000</td>
<td>10000</td>
<td>5000</td>
<td>1000</td>
</tr>
</tbody>
</table>

**Source Halflife (see Help):**

- 40 yrs

**Observed Centerline Concentrations at Monitoring Wells**

- If No Data Leave Blank OR Enter "0"

**7. FIELD DATA FOR COMPARISON**

**Concentration (mg/L)**

| Dist. from Source (ft) | 0 | 666 | 3132 | 1968 | 2524 | 2521 | 5164 | 5393 | 5952 | 6551 |

**8. CHOOSE TYPE OF OUTPUT TO SEE:**

- **RUN CENTERLINE**
- **RUN ARRAY**

**Data Input Instructions:**

1. Enter value directly... or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below. Data used directly in model. Value calculated by model. (Don’t enter any data))

**Recalculate This Sheet**

- Paste Example Dataset
- Restore Formulas for $V_s$, Dispersivities, $R$, $\lambda$, and other

**Project Name:**

UMM WU’AL PHOSPHATE PROJECT
## E1.2.20 OUTPUT 10: SPILL MODELLING SCENARIO 2: CATASTROPHIC FAILURE OF SULPHURIC ACID STORAGE TANK – PLUME EXTENT AFTER 105 YEARS

### Dissolved Hydrocarbon Concentration Along Plume Centerline (mg/L at Z-0)

<table>
<thead>
<tr>
<th>Distance from Source (R)</th>
<th>0</th>
<th>656</th>
<th>1312</th>
<th>1968</th>
<th>2624</th>
<th>3281</th>
<th>3937</th>
<th>4593</th>
<th>5249</th>
<th>5905</th>
<th>6561</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No Degradation</strong></td>
<td>179951.986</td>
<td>11675.760</td>
<td>8707.711</td>
<td>6219.048</td>
<td>4044.776</td>
<td>6019.262</td>
<td>1605.472</td>
<td>190.049</td>
<td>6.617</td>
<td>0.071</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>1st Order Decay</strong></td>
<td>178851.986</td>
<td>11675.618</td>
<td>8707.471</td>
<td>6218.708</td>
<td>4044.346</td>
<td>6017.892</td>
<td>1605.363</td>
<td>190.036</td>
<td>6.617</td>
<td>0.071</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Instant Reaction</strong></td>
<td>178951.986</td>
<td>11675.760</td>
<td>8707.711</td>
<td>6219.048</td>
<td>4044.776</td>
<td>6019.262</td>
<td>1605.472</td>
<td>190.049</td>
<td>6.617</td>
<td>0.071</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Field Data from Site</strong></td>
<td>11675.760</td>
<td>8707.711</td>
<td>6219.048</td>
<td>4044.776</td>
<td>6019.262</td>
<td>1605.472</td>
<td>190.049</td>
<td>6.617</td>
<td>0.071</td>
<td>0.000</td>
<td></td>
</tr>
</tbody>
</table>
E1.2.21 INPUT 11: SPILL MODELLING SCENARIO 2: CATASTROPHIC FAILURE OF SULPHURIC ACID STORAGE TANK – PLUME EXTENT AFTER 120 YEARS

BIOSCREEN Natural Attenuation Decision Support System
Air Force Center for Environmental Excellence

1. HYDROGEOLOGY
   Seepage Velocity* \( V_s \) 34.6 (ft/yr)
   or
   Hydraulic Conductivity \( K \) 0.000934 (conv/ft
   Hydraulic Gradient \( i \) 0.0017
   Porosity \( n \) 0.2

2. DISPERSION
   Longitudinal Dispersivity* \( \alpha_x \) 18.6 (ft)
   Transverse Dispersivity* \( \alpha_y \) 4.9 (ft)
   Vertical Dispersivity* \( \alpha_z \) 6.6 (ft)
   Estimated Plume Length \( L_p \) 6661 (ft)

3. ADSORPTION
   Retardation Factor* \( R \) 1.1
   Soil Bulk Density \( \rho_s \) 1.7 (kg/L)
   Partition Coefficient \( K_d \) 6.1 (L/kg)
   Fraction Organic Carbon \( F_{OC} \) 1.0E-3

4. BIODEGRADATION
   1st Order Decay Coefficient* \( k_{1} \) 6.9E-7 (per y)
   Solvent Half-Life \( t_{1/2} \) (year)
   or Instantaneous Reaction Model
   Delta Oxygen* \( DO \) 0 (mg/L)
   Delta Nitrate* \( NO_3 \) 0 (mg/L)
   Observed Ferrous Iron* \( Fe^{2+} \) 0 (mg/L)
   Delta Sulphate* \( SO_4 \) 0 (mg/L)
   Observed Methane* \( CH_4 \) 0 (mg/L)

5. GENERAL
   Modeled Area Length* \( A_1 \) 6661 (ft)
   Modeled Area Width* \( A_2 \) 666 (ft)
   Simulation Time* \( T \) 120 (h)

6. SOURCE DATA
   Source Thickness in Sat Zone* \( W_1 \) (ft)
   Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3
   Source Zones:
   Width* \( W \) (ft)
   Conc. (mg/L)*
   10 10000
   40 50000
   100 100000
   400 500000
   1000 1000000

7. FIELD DATA FOR COMPARISON
   Concentration (mg/L)
   Dist. from Source (ft)
   0 626 7312 1568 2624 3219 3337 4933 5049 5905 5961

8. CHOOSE TYPE OF OUTPUT TO SEE:
   RUN CENTERLINE
   RUN ARRAY
   Help
   Paste Example Dataset
   Restore Formulas for Vs, Dispersivities, R, lambda, other

Project Name:
UMM WU’AL PHOSPHATE PROJECT

Ma’aden Doc Nº. MD-513-000-HS-EN-RPT-0069 Page E-26
Jacobs Doc Nº. 60-R400-WH/G.06f/0072 Date August 2013
E1.2.22 OUTPUT 11: SPILL MODELLING SCENARIO 2: CATASTROPHIC FAILURE OF SULPHURIC ACID STORAGE TANK – PLUME EXTENT AFTER 120 YEARS

DISTRIBUTION HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

<table>
<thead>
<tr>
<th>TYPE OF MODEL</th>
<th>Distance from Source (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>No Degradation</td>
<td>139973.328 9131.469 6810.254 6486.349 6697.644 6543.352 4489.379 1142.300 120.461 4.768 0.067</td>
</tr>
<tr>
<td>1st Order Decay</td>
<td>139973.328 9131.334 6810.278 6486.361 6697.278 6542.932 4488.063 1142.213 120.451 4.767 0.067</td>
</tr>
<tr>
<td>Instantaneous Reaction</td>
<td>139973.328 9131.469 6810.254 6486.349 6697.644 6543.352 4489.379 1142.300 120.461 4.768 0.067</td>
</tr>
</tbody>
</table>

Calculate Animation

Field Data from Site

Project Name: UMM WU’AL PHOSPHATE PROJECT

Jacobs Doc Nº. 60-R400-WH/G.06f/0072 Date August 2013

Ma’aden Doc Nº. MD-513-000-HS-EN-RPT-0069 Page E-27

Document Title. RAS AL KHAIR ESIA – APPENDICES

Revision A03

Appendix E - Terrestrial Environment
E1.2.23 INPUT 12: SPILL MODELLING SCENARIO 2: CATASTROPHIC FAILURE OF SULPHURIC ACID STORAGE TANK – MAXIMUM CONCENTRATION REACHING COAST

**BIOSCREEN Natural Attenuation Decision Support System**

**Air Force Center for Environmental Excellence**

**1. HYDROGEOLOGY**
- Seepage Velocity \( V_s \) = 34.6 (ft/yr)
- Hydraulic Conductivity \( K \) = 0.00333519 (cm/sec)
- Porosity \( n \) = 0.2

**2. DISPERSION**
- Longitudinal Dispersion \( D_L \) = 48.6 (ft)
- Transverse Dispersion \( D_T \) = 4.9 (ft)
- Vertical Dispersion \( D_V \) = 6.6 (ft)
- Estimated Plume Length \( L_p \) = 6561 (ft)

**3. ADSORPTION**
- Retardation Factor \( R \) = 1.1
- Soil Bulk Density \( \rho_o \) = 1.7 (kg/m³)
- Partition Coefficient \( K_{OC} \) = 6.1
- Fraction Organic Carbon \( f_{OC} \) = 1.0E-3

**4. BIODEGRADATION**
- 1st Order Decay Coefficient \( k_{1st} \) = 6.9E-7 (per day)
- Salute Half-Life \( t_{half} \) = 1000000.00 (years)

**5. GENERAL**
- Modeled Area Length \( L \) = 8000 (ft)
- Modeled Area Width \( W \) = 656 (ft)
- Simulation Time \( T \) = 210 (yr)

**6. SOURCE DATA**
- Source Thickness in Sat.Zone \( h \) = 9 (ft)
- Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3
- Source Halflife (see Help): 4000 (yr)
- Inst. React. 1st Order
- Soluble Mass = 1.5272000 (Kg)
- In Source NAFL Soil

**7. FIELD DATA FOR COMPARISON**
- Concentration (mg/L)
- Dist. from Source (ft)
- 0, 800, 1000, 2400, 3200, 4000, 4800, 5600, 6400, 7200, 8000

**8. CHOOSE TYPE OF OUTPUT TO SEE:**
- [RUN CENTERLINE](#)
- [RUN ARRAY](#)

**HELP**
- Recalculate This Sheet
- Paste Example Dataset
- Restore Formulas for Vs, Dispersion, R, lambda, other
### Dissolved Hydrocarbon Concentration Along Plume Centerline (mg/L at Z=0)

<table>
<thead>
<tr>
<th>Type of Model</th>
<th>Distance from Source (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>No Degradation</td>
<td>31991.608</td>
</tr>
<tr>
<td>1st Order Decay</td>
<td>31991.608</td>
</tr>
<tr>
<td>Inst. Reaction</td>
<td>31991.608</td>
</tr>
<tr>
<td>Field Data from Site</td>
<td></td>
</tr>
</tbody>
</table>

#### Diagram

![Graph showing dissolved hydrocarbon concentration along plume centerline](image)

- **1st Order Decay**
- **Instantaneous Reaction**
- **No Degradation**
- **Field Data from Site**

**Time:** 210 Years
E1.2.25 INPUT 13: SPILL MODELLING SCENARIO 3: CHRONIC LEAKAGE OF DIESEL – PLUME EXTENT AFTER 1000 YEARS

### BIOSCREEN Natural Attenuation Decision Support System

**Air Force Center for Environmental Excellence**

1. **HYDROGEOLOGY**
   - Seepage Velocity* \( V_s \) 34.6 (ft/y)
   - Hydraulic Conductivity \( K \) 0.00394 (cm/s)
   - Hydraulic Gradient \( i \) 0.0017 (ft/ft)
   - Porosity \( n \) 0.2 (%)

2. **DISPERION**
   - Longitudinal Dispersion* \( \alpha_x \) 481.5 (ft)
   - Transverse Dispersion* \( \alpha_y \) 4.9 (ft)
   - Vertical Dispersion* \( \alpha_z \) 6.6 (ft)
   - Estimated Plume Length \( L_p \) 6661 (ft)

3. **ABSORPTION**
   - Retardation Factor* \( R \) 22.4 (-)
   - Soil Bulk Density \( \rho_s \) 1.7 (kg/m³)
   - Partition Coefficient \( K_{oc} \) 2511.89 (L/kg)
   - Fraction Organic Carbon \( f_{oc} \) 1.0E-3 (-)

4. **BIODEGRADATION**
   - 1st Order Decay Coefficient \( k_{1} \) 1.7E-1 (per year)
   - Solute Half-Life \( t_{1/2} \) 4.11 (years)
   - Delta Oxygen* \( DO \) 0 (mg/L)
   - Delta Nitrate* \( NO_3 \) 0 (mg/L)
   - Observed Ferrous Iron* \( Fe^{2+} \) 0 (mg/L)
   - Delta Sulfate* \( SO_4 \) 0 (mg/L)
   - Observed Methane* \( CH_4 \) 0 (mg/L)

### Data Input Instructions:
1. Enter value directly... or
2. Calculate by using in gray cells below. (To restore formulas, hit button below).
   - Data used directly in model.
   - Value calculated by model.

### SOURCE DATA
- Source Thickness in Salt Zone* 9 (ft)
- Source Zones
  - Width* (ft) Conc. (mg/L)
    - 10 5
    - 40 15
    - 100 24.5
    - 40 15
    - 10 5

### FIELD DATA FOR COMPARISON
- Concentration (mg/L) Dist. from Source (ft)
  - 0 006 1312 1908 2064 3287 3937 4593 5249 5905 6661

### CHOOSE TYPE OF OUTPUT TO SEE:
- **RUN CENTERLINE**
- **RUN ARRAY**

### Help
- Paste Example Dataset
- Restore Formulas for Vs, Dispersivities, R, lambda, other
### Dissolved Hydrocarbon Concentration along Plume Centerline (mg/L at Z=0)

<table>
<thead>
<tr>
<th>Type of Model</th>
<th>Distance from Source (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>No Degradation</td>
<td>17.829</td>
</tr>
<tr>
<td>1st Order Decay</td>
<td>17.829</td>
</tr>
<tr>
<td>Instantaneous Reaction</td>
<td>17.829</td>
</tr>
</tbody>
</table>

#### Animation Time:

- 1,000 Years

[Calculate Animation] [Return to Input] [Recalculate This Sheet]
E1.2.27 INPUT 14: SPILL MODELLING SCENARIO 3: CHRONIC LEAKAGE OF DIESEL – PLUME EXTENT AFTER 100 YEARS WITHOUT DEGRADATION

**BIOSCREEN Natural Attenuation Decision Support System**

- **Hydrogeology**
  - Seepage Velocity: $V_s = 34.6$ ft/yr
  - Hydraulic Conductivity: $K = 0.00394$ (coarse)
  - Porosity: $\eta = 0.2$

- **Dispersion**
  - Longitudinal Dispersion: $\alpha_L = 48.8$ ft
  - Transverse Dispersion: $\alpha_T = 4.9$ ft
  - Vertical Dispersion: $\alpha_Z = 6.8$ ft
  - Estimated Plume Length: $L_p = 6561$ ft

- **Adsorption**
  - Retardation Factor: $R = 22.4$
  - Soil Bulk Density: $\rho_s = 1.7$ (kg/L)
  - Partition Coefficient: $KOC = 2511.80$ (L/kg)
  - Fraction Organic Carbon: $FOC = 1.063$

- **Biodegradation**
  - 1st Order Decay Coefficient: $k = 1.7E-1$ (per yr)
  - Solvent Half-Life: $t_{1/2} = 4.11$ (year)

**Source Data**

- Source Thickness in Sat Zone: $9$ ft
- Source Zones:
  - Width: $5$, Conc: $5$ mg/L
  - $40$, $15$
  - $100$, $24.5$

**Field Data for Comparison**

- Concentration: $mg/L$
- Dist from Source (%): 0, 50, 120, 180, 240, 300, 350, 420, 450, 640, 800

**Choose Type of Output to See:**

- **Run Centerline**
- **Run Array**

**Help**

- Recalculate This Sheet
- Paste Example Dataset
- Restore Formulas for $Vs$, Dispersion, R, lambda, other
E1.2.28 OUTPUT 14: SPILL MODELLING SCENARIO 3: CHRONIC LEAKAGE OF DIESEL – PLUME EXTENT AFTER 100 YEARS WITHOUT DEGRADATION

**Dissolved Hydrocarbon Concentration Along Plume Centerline (mg/L at Z=0)**

<table>
<thead>
<tr>
<th>Type of Model</th>
<th>0</th>
<th>60</th>
<th>120</th>
<th>180</th>
<th>240</th>
<th>300</th>
<th>360</th>
<th>420</th>
<th>480</th>
<th>540</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Degradation</td>
<td>25.734</td>
<td>4.586</td>
<td>2.511</td>
<td>1.347</td>
<td>0.647</td>
<td>0.268</td>
<td>0.034</td>
<td>0.027</td>
<td>0.008</td>
<td>0.001</td>
<td>0.000</td>
</tr>
<tr>
<td>1st Order Decay</td>
<td>23.734</td>
<td>0.304</td>
<td>0.042</td>
<td>0.003</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Instantaneous Reaction</td>
<td>23.734</td>
<td>4.586</td>
<td>2.511</td>
<td>1.347</td>
<td>0.647</td>
<td>0.268</td>
<td>0.034</td>
<td>0.027</td>
<td>0.006</td>
<td>0.001</td>
<td>0.000</td>
</tr>
</tbody>
</table>

[Graph showing dissolved hydrocarbon concentration along plume centerline with different models compared]
### BIOSCREEN Natural Attenuation Decision Support System

#### Version 1.4

**1. HYDROGEOLOGY**
- Seepage Velocity: 34.6 ft/day
- Hydraulic Conductivity: 0.00384 cm/sec
- Porosity: 0.2

**2. DISPERSION**
- Longitudinal Dispersion: 48.6 ft
- Transverse Dispersion: 4.9 ft
- Vertical Dispersion: 6.6 ft

**3. ADSORPTION**
- Retardation Factor: 22.4
- Soil Bulk Density: 1.7 km/d
- Partition Coefficient: 261.89 L/kg

**4. BIODEGRADATION**
- 1st Order Decay Coefficient: 1.7E-1 (per day)

#### Data Input Instructions:
1. Enter value directly... or
2. Calculate by filling in grey cells below. (To restore formulas, hit button below)  
3. - Variable - Data used directly in model. (Don't enter any data)

#### SOURCE DATA
- Source Thickness in Sat. Zone: 9 ft
- Source Zones:
  - Width: 10, 40, 100 ft
  - Conc. (mg/L): 10, 15, 245 mg/L
  - Source Half-life (see Help):

#### FIELD DATA FOR COMPARISON
- Concentration (mg/L):
  - Dist. from Source (ft): 0, 25, 50, 100, 125, 150, 175, 200, 250

#### CHOOSE TYPE OF OUTPUT TO SEE:
- **RUN CENTERLINE**  
- **RUN ARRAY**  
- **Help**  
  - Recalculate This Sheet
  - Paste Example Dataset
  - Restore Formulas for Vs, Dispersivities, R, lambda, other

---

**Project Name:** UMM WU’AL PHOSPHATE PROJECT  
**Ma’aden Doc Nº:** MD-513-000-HS-EN-RPT-0069  
**Jacobs Doc Nº:** 60-R400-WH/G.06f/0072  
**Date:** August 2013
E1.2.30 OUTPUT 15: SPILL MODELLING SCENARIO 3: CHRONIC LEAKAGE OF DIESEL – PLUME EXTENT AFTER 100 YEARS WITH DEGRADATION

**Dissolved Hydrocarbon Concentration Along Plume Centerline (mg/L at Z=0)**

<table>
<thead>
<tr>
<th>Type of Model</th>
<th>Distance from Source (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>No Degradation</td>
<td>23.734</td>
</tr>
<tr>
<td>1st Order Decay</td>
<td>23.734</td>
</tr>
<tr>
<td>Inst. Reaction</td>
<td>23.734</td>
</tr>
<tr>
<td>Field Data from Site</td>
<td></td>
</tr>
</tbody>
</table>

**Graph:**

- 1st Order Decay
- Instantaneous Reaction
- No Degradation
- Field Data from Site

**Calculate Animation**

**Time:**

- 100 Years

**Return to Input**

**Recalculate This Sheet**
**E1.2.31 INPUT 16: SPILL MODELLING SCENARIO 3: CHRONIC LEAKAGE OF SULPHURIC ACID – PLUME EXTENT AFTER 105 YEARS**

**BIOSCREEN Natural Attenuation Decision Support System**

**Air Force Center for Environmental Excellence**

**Version 1.4**

### 1. HYDROGEOLOGY

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seawage Velocity**</td>
<td>34.6 (m/yr)</td>
</tr>
<tr>
<td>Hydraulic Conductivity **</td>
<td>0.00394 (c/sec)</td>
</tr>
<tr>
<td>Hydraulic Gradient **</td>
<td>0.0017 (m/yr)</td>
</tr>
<tr>
<td>Porosity **</td>
<td>0.2 (-)</td>
</tr>
</tbody>
</table>

### 2. DISPERSION

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longitudinal Dispersivity **</td>
<td>43.6 (L)</td>
</tr>
<tr>
<td>Transverse Dispersivity **</td>
<td>4.9 (L)</td>
</tr>
<tr>
<td>Vertical Dispersivity **</td>
<td>6.6 (L)</td>
</tr>
</tbody>
</table>

### 3. ADSORPTION

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retardation Factor **</td>
<td>1.1 (-)</td>
</tr>
</tbody>
</table>

### 4. BIODEGRADATION

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Order Decay Coeff **</td>
<td>6.9E-7 (per yr)</td>
</tr>
</tbody>
</table>

### 5. GENERAL

- **Modeled Area Length**
- **Modeled Area Width**
- **Simulation Time**

### 6. SOURCE DATA

- **Source Thickness in Sal Zone**

### 7. FIELD DATA FOR COMPARISON

- **Concentration (mg/L)**

### 8. CHOOSE TYPE OF OUTPUT TO SEE:

- **RUN CENTERLINE**
- **RUN ARRAY**
- **View Output**

---

**Project Name:**

**UMM WU’AL PHOSPHATE PROJECT**

**Ma’aden Doc No.:**

**Jacobs Doc No.:**

**Date:**

**Revision:** A03
E1.2.32 OUTPUT 16: SPILL MODELLING SCENARIO 3: CHRONIC LEAKAGE OF SULPHURIC ACID – PLUME EXTENT AFTER 105 YEARS

DISTRIBUTED HYDROCARBON CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

<table>
<thead>
<tr>
<th>TYPE OF MODEL</th>
<th>Distance from Source (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>No Degradation</td>
<td>0.000</td>
</tr>
<tr>
<td>1st Order Decay</td>
<td>0.000</td>
</tr>
<tr>
<td>Instant Reaction</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Field Data from Site

Calculate Animation

Time: 105 Years

Return to Input

Recalculate This Sheet

Project Name: UMM WU’AL PHOSPHATE PROJECT

Ma’aden Doc No. MD-513-000-HS-EN-RPT-0069 Page E-37

Jacobs Doc No. 60-R400-WH/G.06f/0072 Date August 2013
E1.2.33 INPUT 17: SPILL MODELLING Scenario 3: CHRONIC LEAKAGE OF SULPHURIC ACID – PLUME EXTENT AFTER 120 YEARS

### BIOSCREEN Natural Attenuation Decision Support System

**Air Force Center for Environmental Excellence**

#### 1. HYDROGEOLOGY

- Seepage Velocity: \( V_s = 34.8 \) (m/hr)
- Hydraulic Conductivity: \( K = 0.00384 \) (cm/sec)
- Hydraulic Gradient: \( i = 0.0017 \) (m/m)
- Porosity: \( n = 0.2 \) (-)

#### 2. DISPERSION

- Longitudinal Dispersivity: \( \alpha_x = 43.6 \) (m)
- Transverse Dispersivity: \( \alpha_y = 4.9 \) (m)
- Vertical Dispersivity: \( \alpha_z = 6.6 \) (m)
- Estimated Plume Length: \( L_p = 8656 \) (m)

#### 3. ADSORPTION

- Retardation Factor: \( R = 1.1 \) (-)
- Soil Bulk Density: \( \rho_s = 1.7 \) (kg/m³)
- Partition Coefficient: \( K_{OC} = 6.1 \) (L/kg)
- Fraction Organic Carbon: \( f_{OC} = 1.0 \times 10^{-3} \) (-)

#### 4. BIODEROSATION

- 1st Order Decay Coefficient: \( k_{1st} = 5.8 \times 10^{-7} \) (day⁻¹)

#### 5. GENERAL

- Modeled Area Length: \( 8561 \) (m)
- Modeled Area Width: \( 2500 \) (m)
- Simulation Time: \( 120 \) (yr)

#### 6. SOURCE DATA

- Source Thickness in Sat Zone: \( 0 \) (m)
- Source Zones:
  - Width: \( 10 \) (m), Conc: \( 100000 \) (mg/L)
  - Width: \( 40 \) (m), Conc: \( 500000 \) (mg/L)
  - Width: \( 100 \) (m), Conc: \( 100000 \) (mg/L)

#### 7. FIELD DATA FOR COMPARISON

<table>
<thead>
<tr>
<th>Concentration (mg/L)</th>
<th>Dist from Source (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>856</td>
</tr>
<tr>
<td>0</td>
<td>1912</td>
</tr>
<tr>
<td>0</td>
<td>1968</td>
</tr>
<tr>
<td>0</td>
<td>2624</td>
</tr>
<tr>
<td>0</td>
<td>3281</td>
</tr>
<tr>
<td>0</td>
<td>3937</td>
</tr>
<tr>
<td>0</td>
<td>4593</td>
</tr>
<tr>
<td>0</td>
<td>5240</td>
</tr>
<tr>
<td>0</td>
<td>5905</td>
</tr>
<tr>
<td>0</td>
<td>6561</td>
</tr>
</tbody>
</table>

#### 8. CHOOSE TYPE OF OUTPUT TO SEE:

- **RUN CENTERLINE**
- **RUN ARRAY**

---

**Project Name:**

UMM WU’AL PHOSPHATE PROJECT

**Ma’aden Doc No.**

MD-513-000-HS-EN-RPT-0069

**Jacobs Doc No.**

60-R400-WH/G.06f/0072

**Date:**

August 2013
## E1.2.34 OUTPUT 17: SPILL MODELLING SCENARIO 3: CHRONIC LEAKAGE OF SULPHURIC ACID – PLUME EXTENT AFTER 120 YEARS

### Dissolved Hydrocarbon Concentration Along Plume Centerline (mg/L at z=0)

<table>
<thead>
<tr>
<th>TYPE OF MODEL</th>
<th>0</th>
<th>666</th>
<th>1312</th>
<th>1968</th>
<th>2624</th>
<th>3281</th>
<th>3937</th>
<th>4593</th>
<th>5243</th>
<th>5905</th>
<th>6561</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Degradation</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>2528.864</td>
<td>1142.300</td>
<td>120.461</td>
<td>4.768</td>
<td>0.067</td>
<td></td>
</tr>
<tr>
<td>1st Order Decay</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>2528.861</td>
<td>1142.213</td>
<td>120.451</td>
<td>4.767</td>
<td>0.067</td>
<td></td>
</tr>
<tr>
<td>Inst. Reaction</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>2528.864</td>
<td>1142.300</td>
<td>120.461</td>
<td>4.768</td>
<td>0.067</td>
<td></td>
</tr>
</tbody>
</table>

### Graphical Representation

- **1st Order Decay**
- **Instantaneous Reaction**
- **No Degradation**
- **Field Data from Site**

**Project Name:** UMM Wu’al Phosphate Project

**Ma’aden Doc Nº:** MD-513-000-HS-EN-RPT-0069

**Jacobs Doc Nº:** 60-R400-WH/G.06f/0072

**Date:** August 2013
E1.2.35 INPUT 18: SPILL MODELLING SCENARIO 3: CHRONIC LEAKAGE OF SULPHURIC ACID – MAXIMUM CONCENTRATION REACHING COAST

BIOSCREEN Natural Attenuation Decision Support System

1. HYDROGEOLOGY
- Seepage Velocity: 34.6 m/day
- Hydraulic Conductivity: 0.0033 m/day
- Porosity: 0.2

2. DISPERSION
- Longitudinal Dispersion: 48.6 m
- Transverse Dispersion: 4.9 m
- Vertical Dispersion: 6.6 m

3. ADSORPTION
- Retardation Factor: 9.9
- Soil Bulk Density: 1.7 (kg/m³)
- Partition Coefficient: 6.1 (L/kg)
- Fraction Organic Carbon: 0.0013

4. BIODEGRADATION
- 1st Order Decay Coefficient: 6.3×10⁻⁴ (day⁻¹)
- Half-Life: 1000 days

5. GENERAL
- Modeled Area Length: 9000 m
- Modeled Area Width: 200 m
- Simulation Time: 180 days

6. SOURCE DATA
- Source Thickness in Sat Zone: 9 m
- Width: 100 m
- Conc.: 100000 mg/L
- Source Halflife: 152720 days

7. FIELD DATA FOR COMPARISON
- Concentration (mg/L): 0, 300, 1600, 2700, 3600, 4500, 5400, 6300, 7200, 8100, 9000

8. CHOOSE TYPE OF OUTPUT TO SEE:
- RUN CENTERLINE
- RUN ARRAY
E1.2.36 OUTPUT 18: SPILL MODELLING SCENARIO 3: CHRONIC LEAKAGE OF SULPHURIC ACID – MAXIMUM CONCENTRATION REACHING COAST

**Dissolved Hydrocarbon Concentration Along Plume Centerline (mg/L at Z=0)**

<table>
<thead>
<tr>
<th>Type of Model</th>
<th>0</th>
<th>900</th>
<th>1800</th>
<th>2700</th>
<th>3600</th>
<th>4500</th>
<th>5400</th>
<th>6300</th>
<th>7200</th>
<th>8100</th>
<th>9000</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Degradation</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1737.974</td>
<td>227.377</td>
<td>9.030</td>
<td>0.099</td>
</tr>
<tr>
<td>1st Order Decay</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1737.775</td>
<td>227.350</td>
<td>9.029</td>
<td>0.099</td>
</tr>
<tr>
<td>Inst. Reaction</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1737.974</td>
<td>227.377</td>
<td>9.030</td>
<td>0.099</td>
</tr>
</tbody>
</table>

Field Data from Site

---

**Graph:**

- 1st Order Decay
- Instantaneous Reaction
- No Degradation
- Field Data from Site

**Controls:**

- Replay Animation
- Next Timestep
- Prev Timestep
- Time: 180 Years
- Return to Input
- Recalculate This Sheet

---

**Project Name:**

UMM WU’AL PHOSPHATE PROJECT