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Shoaiba Stage III Marine Works  
**EIA Study**  
Saudi Archirodon Ltd.

# **ENVIRONMENTAL IMPACT ASSESSMENT STUDY PROPOSAL (Rev. 1) For**

## **Dredging Operation (Marine Works) At Shoaiba Power Plant Extension, Stage III**

**August 2008**



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## **ENVIRONMENTAL IMPACT ASSESSMENT STUDY PROPOSAL**

### **For Dredging Operation (Marine Works) At Shoaiba Power Plant Extension, Stage III**

#### **Issue Record**

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## **Acronym**

EIA – *Environmental Impact Assessment*

SARCO – *Saudi Archirodon Limited*

MTEV – *Dr. Mohamed A. Turki for Environmental Studies and Consultancy*

IUCN – *International Union for Conservation of Nature*

UNEP – *United Nation Environmental Programme*

PME – *Presidency of Meteorology and Environment*

MEPA – *Meteorology and Environmental Protection Administration*

PERGSA - *Regional Organization for the Conservation of the Environment of the Red Sea and Gulf of Aden*

SWCC – *Saline Water Conversion Corporation*

IADC – *International Association of Dredging Company*

CEDA – *Central Dredging Association*

NWDC – *Navy Welfare Development Command*

BAT – *Best Available Technology*

EMP – *Environmental Management Plan*

## **i. Executive Summary**

This document is the Environmental Impact Assessment study for the proposed project of Shoaiba Power Plant Extension Stage III. The study was prepared by Dr. Mohamed A. Turki for Environmental Studies and Consultancy (MTEV) upon the request from the Project consortium member Saudi Archirodon Ltd. (SARCO).

This study (EIA) is prepared to layout the findings of the Environmental Impact and it is presented in such a way to be easily understood by the reader and it is outlined as follows:

### **Section 1.0 - Presentation of the Project**

#### **1.1 Introduction**

The Shoaiba Power Plant Extension Stage III is located in Shoaiba about 110km south of Jeddah Saudi Arabia. A consortium headed by Alstom Power Centrals, which includes Saudi Archirodon (SARCO) are planning to construct new (stage III) 1,200MW power plant for a total combined output (stages I, II and III) of 5,250MW consisting of total 14 units of 375MW. Within the consortium, SARCO is responsible for all the associated civil works both onshore and offshore which includes among other things, Marine Dredging Works which is the subject of this EIA study.

Site Map of this EIA Study





## 1.2 Consultant/Client Profile

The environmental consultant for this project, **Dr. Mohamed A. Turki for Environmental Studies & Consultancy (MTEV)** has been formed under the management of Dr./Eng. Mohamed Turki Office for Engineering Consultancy (MTEC) to address the needs of environmental studies and protection.

**Saudi Archirodon Limited** (Client) is an International Private joint venture of ARCHIMIDIS, a marine contractor and ODON & ODOSTROMATON, a road and bridge construction specialist group established in 1971. Archirodon started its operations initially in Saudi Arabia and subsequently expanded into other Gulf countries, North Africa and the Mediterranean area. In the 1980s, The company further developed into a general contracting group diversifying into other fields including, roads, bridges, railroads, industrial facilities, water and sanitation, dredging as well as

electromechanical and geotechnical works. Archirodon has also recently established an in-house

Engineering Department.

## 1.3 EIA Methodology

PME's Environmental Guidelines and Rules for Implementation provide the guidelines on whether an EIA study is required for a particular type and scale of a project and determining the category of the EIA study required which are outlined in the Appendix 2.1 of the PME's General Environmental Guidelines and Rules for Implementation.

A methodology report was submitted to the Presidency of Meteorology and Environment (PME) on the 20<sup>th</sup> of September, 2008 which included the scoping of the environmental issues of the project. It was recognized that the project may have a number of potentially significant impacts, as it will involve dredging works in the marine environment that may also affect the current, sea water quality and marine biology.

## 1.4 Policies, Laws and Regulations

This EIA has been prepared and completed to comply with the following requirements:

- PME's Environmental Guidelines and Rules for Implementation.
- Royal Commission's Environmental Regulation Section - 6 for Dredging Operation
- World Bank Standards "Pollution Prevention & Abatement Handbook"
- Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment, 1982 (The Jeddah Convention)

## Section 2.0 - Description of the Project and its Objectives

### 2.1 Goals





This section is to establish the goals and the objectives in preparing this Environmental Impact Assessment (EIA) study. The following goals and objectives shall be established in this study as a minimum:

- Ensure compliance to PME and other governmental agency’s regulations as well as International Standards related to dredging and deep sea disposal.
- Ensure that the operational process for the dredging and disposal is of the best environmentally friendly practice and the Best Available Technology (BAT) known worldwide.
- Protect the marine environment and the ecosystem during the dredging and disposal operation.
- Prepare monthly monitoring plan and reporting method in analyzing environmental impact to ensure compliance with the EIA recommendations on site
- Establish negative impacts of the dredging to the environment and recommend the proper mitigation measures

Saudi Archirodon and MTEV Consultant had set the goals and measures to protect the environment during the project operation as follows

No.	Goals/Objectives	Targets
1	To protect marine environment habitat and ecosystem	Current marine environment and ecosystem will not be adversely impacted
2	To ensure compliance to PME and other governmental agency regulations related to dredging and disposal	Prepare a comprehensive EIA study to established appropriate precaution and mitigations require to achieve compliance with the regulations and laws to protect the environment during the operation of this project
3	To protect marine flora and fauna environment	No significant marine flora and fauna environment will be completely damaged or disappeared
4	To Protect marine water quality	No significant adverse impact to marine water quality during the project operation
5	To ensure the discharge water temperature increase from the power plant to be limited to $\leq 3^{\circ}\text{C}$ from the ambient seawater temperature at 100m from the discharge point	Modeling design, use of diffusers and putting temperature sensors along the discharge channel
6	Adequate solid waste management	All solid waste will be separated and reused where applicable, disposed in accordance with local and project environmental requirements
7	To comply with environmental permits	Complete requirements and permits relevant to proceed with the project operation
8	To ensure proper environmental monitoring during operation	Design a suitable environmental monitoring plan and implementation procedures in accordance to EIA requirements
9	To ensure the air quality of the site of operation	Follow EIA and implements its recommendation to ensure keeping the air quality within acceptable limits
10	To ensure minimum noise level during	To keep noise level within acceptable level



	operation	
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## 2.2 Need of the Project

As part of the power plant cooling water system, dredging into the marine environment was found to be needed to construct a seawater intake channel and twin outfall brine discharge channels to ensure continuous supply and discharge of cooling water to and from the power plant. Therefore marine dredging is needed to make sure the cooling water system has continuous supply and discharge of water.

## 2.3 Project Description

The Marine Scope of Works for the project requires the construction of the Cooling Water Intake Channel and the Cooling Water Discharge Channel. The construction of these channels involves dredging operation to ensure a continuous supply and discharge of cooling water to and from the Power Plant. Most of the dredged material shall be used for backfilling of some designated areas around the plant and embankment of the channels structures and the remaining shall be disposed of at a marine deep sea disposal area which was approved by the concerned Government Agency/PME. The project will last approximately six (6) months. There will be a monthly monitoring procedure on site to ensure full compliance of this EIA's recommendations and requirements. The proposed dredging schedule for the project is indicated in table 2.3A below.

**Table 2.3A Preliminary Proposed Dredging Schedule**

Item	Activity	Days	Start	Finish	Equipment
<b>Intake Channel</b>					
1	Offshore Dredging (by floating equipment)	80	15FEB09	05MAY09	Grab Dredger Atlantis, Split Barge, Tugboat
2	Onshore Dredging/Excavation (by land equipment)	80	06APR09	24JUN09	Excavator ,Bulldozer, Wheel Loader, Trucks
3	Preparation of Reclamation Area	90	06MAY09	03AUG09	Various equipment
<b>Discharge Channel</b>					
1	Offshore Dredging (by floating equipment)	90	17MAR09	14JUN09	Grab Dredger Atlantis, Split Barge, Tugboat
2	Onshore Dredging/Excavation (by land equipment)	60	16MAY09	14JUL09	Excavator ,Bulldozer, Wheel Loader, Trucks
3	Preparation of Reclamation Area	70	15JUN09	23AUG09	Various equipment

## 2.4 Process Description of Dredging and Disposal

This section describes the methodology statement, best available technology (BAT) in the dredging operation and the manner of disposal (dumping), which covers the sections as follows:



- Discharge Channel Method Statement for Dredging and Excavation (refer to section 2.4.1)
- Intake Channel Method Statement for Dredging (refer to section 2.4.2)
- Method Statement for Placing of Concrete Underwater (refer to section 2.4.3)
- Method Statement for Protection of Shoreline (refer to section 2.4.5)
- Disposal Site Designation and Evaluation (refer to section 2.4.6)

## **2.5 Alternative and Options**

Alternative dredging options will be discussed and examined them against the proposed option to find out if they would achieve the same objectives. This includes dredging method and procedures, equipment used, vessels type and disposal sites in order to establish the most environmentally friendly option.

Dredging practices and the kind of equipments used has evolved considerably in recent years to increase dredging efficiency and to minimize the potential adverse effects on the environment. To some extent the environmental effects due to the re-suspension and settlement of sediments during the excavation process can be minimized by selecting the most appropriate method for dredging. A summary of the main dredging methods, types of equipment, their potential to cause suspension of sediments and how dredging equipment can be modified to improve environmental conditions was described in details in section 2.5.2. The characteristics of the dredging site have also a significant bearing on the type of dredger which can be used and the extent of precautions needed to minimize sediment suspension. Subject to appropriate modifications, proper protection and measures on the site, most types of dredgers can be operated in a manner that does not cause excessive loss of sediment to the surrounding environment, thus the environmental impact due to dredging could be minimized.

## **Section 3.0 - Natural Environmental Condition**

The Red Sea is about 1,932 km long with an average width of 280 km and an average depth of 491m. The maximum depth recorded in the Red Sea is 2850m. The total surface area is 450,000 square kilometers. The Red Sea is a relatively young ocean and is unique among the seas of the world. It does not have many permanent streams flow into it. Average rainfall in the coastal area is very low, less than a total average of 70 mm/yr along the broad coastal of Tihama, with about 16 mm/yr at Al Wejh, and 63 mm/yr at Jeddah and Jizan (MEPA/IUCN, 1987). As the climate is extremely arid, much of Saudi Arabia's marine biological productivity is confined to a narrow coastal strip and originate mostly from habitats such as coral reefs, mangrove and sea grass communities found in shallow embayment. An extensive survey on Saudi Arabian coastal resources has been conducted by Meteorological and Environmental Protection Administration (MEPA), in collaboration with the World Conservation Union (IUCN).

Shoaiba plant is situated in a relatively flat coastal desert plain, with little or no vegetation and a step of 1 to 2m from the shoreline. The main coastal characteristic is the presence of the coral reef immediately offshore, extending for a distance of 400-600m from the shoreline, where the depth is extremely varied from 0.2m near the shore to more than 1.5m near the reef face with respect to the mean sea level.

The west coast of Saudi Arabia is a hot and arid region. In general most of the time, the sky is clear, or lightly clouded. Average air pressure shows seasonal trends, being at a maximum in January, and a minimum in July. Rainfall is very scarce with mean annual amount of 25.7mm, the wettest months



being November and December; most precipitating is in one or two days. Fog is very rare, but visibility of less than 100m is common due to dust or sandstorms, and is occasionally reduced to less than 100m in July.

Other summary climatic data as follows:

- Minimum/maximum relative humidity : 3/100%
- Maximum wind speed : 26 ms<sup>-1</sup> (northerly)
- Minimum/maximum monthly precipitation : 0/18.3mm
- Extreme 24hrs. maximum rainfall : 51.5mm
- Maximum month days with thunder : 1.6 November
- Maximum month days with rain : 2.9 November
- Maximum month days with mist : 3.6 September
- Maximum months days with fog : 0.8 September

The monthly average sea water temperature in Jeddah varies from about 25°C in February to about 31°C in September. The extreme surface water temperature in the open seas is 19°C in January and February, and more than 34°C in July to September. Shallow water in the vicinity of the fringing reefs often has temperature between 1.5 and 2.0°C higher than surrounding deeper waters. Temperature stratification is generally absent in the area, mainly due to the surface mixing by the waves and the wind drift current, and the absence of significant fresh water inflows, (SWCC 1996).

The salinity of the Red Sea near Jeddah varies only slightly over the year, with means of about 38.5% in the winter and 39.8% in summer, without rapid change between the two seasons.

The measured dissolved oxygen concentration on the surface water of the Red Sea is near saturation level (UNEP/PERGSA, 1997). The saturation values are in the range of 4.8 to 6.5 ml of oxygen per liter depending on the temperature and the salinity values. The saturated layer extends to about 100m of depth. Below the 100m, the dissolved oxygen concentration values drop to only 10-25% saturation levels.

In order to have a baseline data of the seawater within the project site, three (3) designated locations around the proposed dredging area was selected to be used as reference points for water and sediment sampling and testing. Water and Sediments sampling and testing were conducted by SARCO through RGF on January 7, 2009

## **Section 4.0 - Significant Impact Assessment**

### **Methodology**

The EIA study has predicted few environmental impacts and assessed their significance based on well accepted methodology, based on World Bank and other international methodologies. The general approach is described below. The criteria for assessing the significance of the impacts were based on the current legislations, international standards and the guidelines in the Kingdom where these are available.

### Impact Magnitude

The magnitude of impact is the degree of effect to the state of an environmental resources resulting from the proposed development. The magnitude of the environment impact due to dredging depends on several factors, these could include:

- The distribution and proximity to sensitive habitats
- The style of dredging and the disposal equipments used
- Physical nature of sediments being dredged and those of the spoil ground
- Quantity and quality of the dredged materials
- Hydrodynamics of the spoil ground including current depth, bathymetry and the influence of the wave conditions and actions
- Natural turbidity regimes and the adaptation of local flora and fauna to pulsed turbidity event

An appropriate scale was developed for each environmental topic, ranging from negligible impact (no change or imperceptible change) to high impact. The evaluation of the impact magnitude considers the duration (short/medium/long term), probability, magnitude, spatial extent, reversibility and the likelihood of indirect effect. Impact can be either adverse or beneficial.

### Receptor Sensitivity

Each potential receptor (e.g. human population, marine and land habitats, water resources and land use) was assigned a level of sensitivity to change, ranging from negligible sensitivity to high sensitivity. This level of sensitivity was based on the perceived value of the receptor (e.g. local, district, regional, national or international significance) and its sensitivity to a change in the existing conditions. These judgments were concluded by using the local legislations or guidelines where these were available or otherwise were based on the typical procedural practices during EIA studies of similar developments.

### Impact Significance

The significance of an impact is the product of both the magnitude of the impact and the sensitivity of the receptor. Impact significance can be:

- Adverse or Beneficial
- Direct or Indirect
- Short or Long-term
- Local or Regional

A standard significance table was used for all environmental topics, Table 4.1A

Table 4.1A General Impact Significance Assessment Matrix

Receptor Sensitivity	Magnitude of Impact			
	High	Moderate	Low	Negligible
High	Very substantial	Substantial	Moderate	Minor
Moderate	Substantial	Moderate	Minor	Negligible
Low	Moderate	Minor	Negligible	Negligible
Negligible	Minor	Negligible	Negligible	Negligible

Any moderate, substantial or very substantial effect was considered likely to be significant for the purposes of this EIA study. For each of the impacts, mitigation measures were proposed with the goal of reducing the significance of the impacts as far as possible.

Figure 4.1A is a conceptual diagram illustrating the impact of dredging

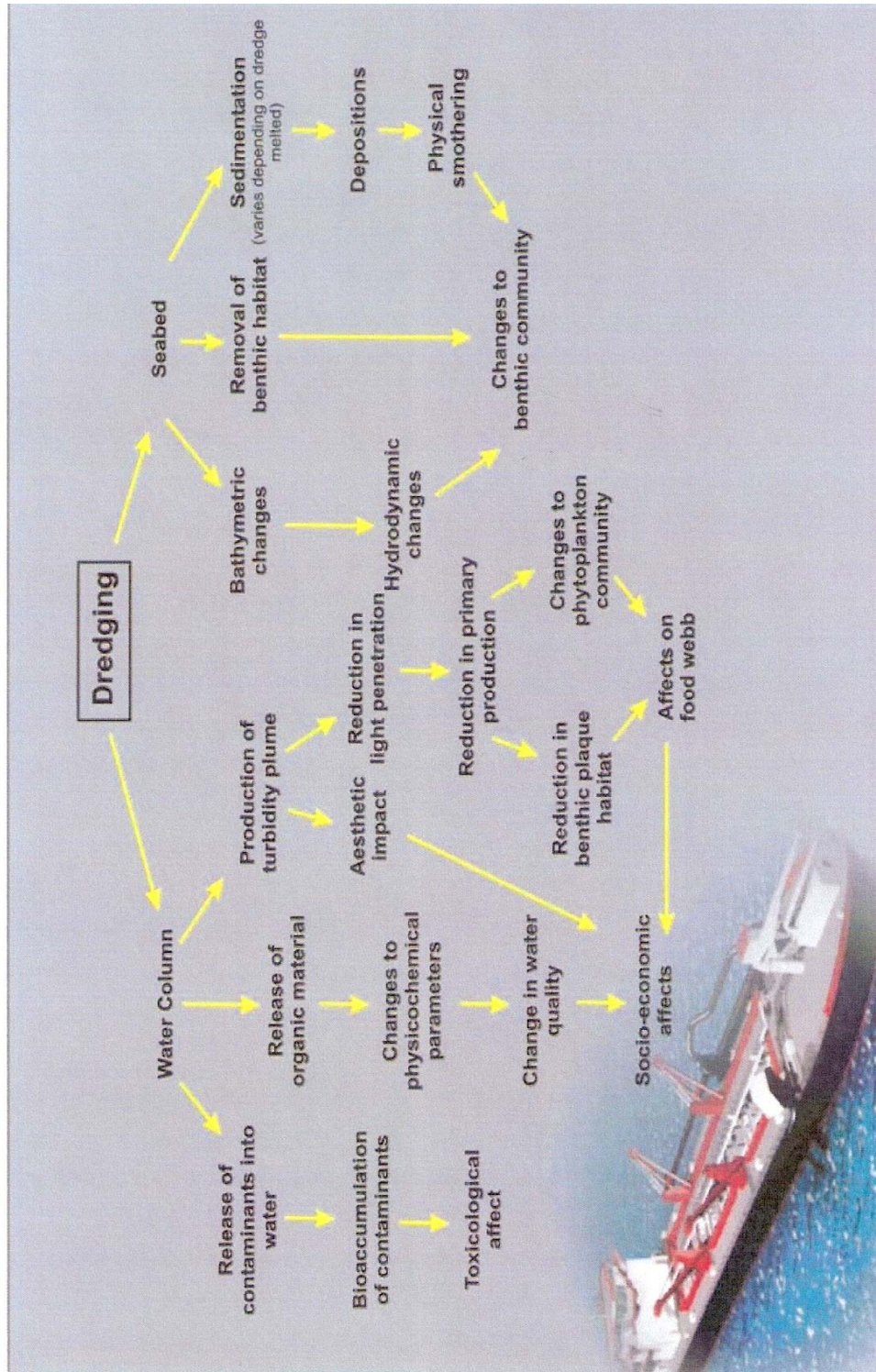
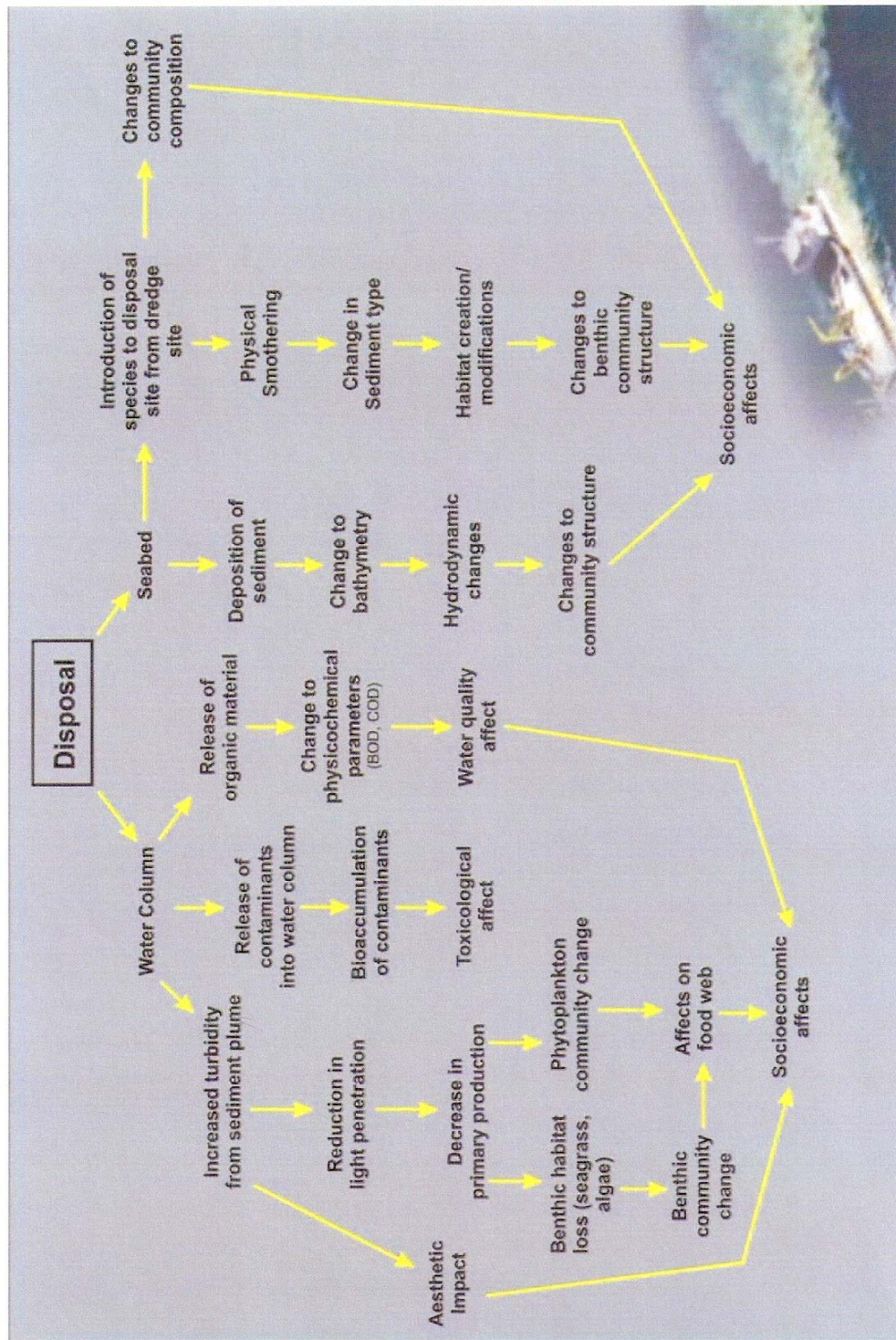


Figure 4.1B is a conceptual diagram illustrating the impact of disposal



Based on the Methodology and subsequent information gathering about the project, all the potentially significant impacts which may arise from the project were identified. These are summarized in Table 4.1B and formed the basis of further study under the impact assessment topics in this Chapter. It should be noted that these are only the potential impacts and not necessarily impacts that will happen, as it may never happen in the actual site of operation.

Table 4.1B: Potential Significant Impacts Assessment

<b>Activity Causing Impact</b>	<b>Predicted Impact</b>	<b>Receptor</b>	<b>Magnitude of Impact</b>	<b>Significance of Impact</b>
Dredging	Direct removal of reef area	Reef	High	Substantial
	Carryover of silt plume from the dredging	Bio-system in the area	Moderate	Moderate
	Reduced water quality and Increase in turbidity and Oxygen Depletion due to suspension of sediments	Reef, Flora & Fauna, Bio-system or benthic community in the area	High	Substantial
	Fine fraction of the sediments can travel over significant distances	Ecological and marine life	Moderate	Substantial
	Nutrients availability and level change	Marine life	Moderate	Moderate
	Dispersion of contaminants during dredging and disposal	Marine life	Moderate	Substantial
	Impact from noise (surface/underwater) from equipment	Marine Habitat	Negligible	Negligible
	Air contaminants due to transport and reclamation works of dredged materials generated from dust	Nearby populated community	Negligible	Negligible
	Over-spill from split barge that handles dredged material	Bio-system or benthic community in the area	Negligible	Negligible
	Workplace hazard	Workers	Moderate	Minor
Operation	Re-colonization build-up of benthic communities to channel structures	Benthic communities	Negligible	Positive





Activity Causing Impact	Predicted Impact	Receptor	Magnitude of Impact	Significance of Impact
	Entrainment and impingement of marine organism at the intake structure	Marine life	Moderate	Substantial
	Water quality due to temperature increase, thermal pollution and dispersion of potential contaminants from discharge channel	Marine life	Moderate	Substantial

### Section 5.0 - Analysis of Significant Impact, Mitigation Plan and Control Measures

Although historically the primary objective was to optimize the dredging operations and its economical benefits with little regard to the environment, today in most cases dredging projects are evaluated and managed with the consideration to minimize adverse environmental effects, whilst still maximizing the economical and environmental benefits. Presently, there are existing procedures and regulations in place which are generally considered to effectively avoid and/or minimize the environmental impact potential associated with of the dredging and its disposal operations, particularly the requirements of the PME licensing process and its enforcement procedures. In addition, in recent years, dredging has become more of a scientific process with greater emphasis being placed on continuous survey on the channels to minimize dredged volumes. Positive changes in the dredging practices and its operations have greatly reduced the amounts of material dredged over the past decade. Improved dredging technology and position fixing equipment allowed more precision techniques which have resulted in real reductions of the amounts of materials dredged and deposited.

In most cases and certainly in this EIA study, existing PME’s and international regulations and well managed dredging practice techniques are sufficient to avoid the potential impacts discussed above and no further steps need to be taken other than monitoring procedure to make sure all the regulations and the recommendations of this EIA are being implemented on site. Where adverse effects are identified on the site or as a precautionary approach is considered necessary, the following actions may be taken to avoid and/or minimize impacts, many of which are already in the present dredging operation practice:

- Managing and informing the contractors of the site conditions and specifications,
- Best timing of dredging and disposal operations according to site specifics,
- Selection of the Best Available Technique (BAT) dredging methods
- Reducing amounts of dredging,
- Promotion of beneficial use,
- Selection of best possible disposal sites, and
- Monitoring and record keeping.
- Monthly data collection and reporting



**Table 5.7A Summary of Predicted Impact and Proposed Mitigation Measures**

<b>Activity causing impact</b>	<b>Predicted Impact</b>	<b>Significance</b>	<b>Proposed Mitigation and Enhancement Measures</b>	<b>Residual Impact Significance</b>
Dredging	Direct removal of coral reef	Substantial	Benthic study and choosing the best location of channels to minimize coral reef damage or loss	Minor
	Carryover of silt plume from the dredging and disposal operation	Moderate	<ul style="list-style-type: none"> <li>▪ Method of dredging</li> <li>▪ Emphasis on using best available technology (BAT)</li> <li>▪ Use of Silt curtains to minimize spreading of silt plume</li> <li>▪ Best equipment and barge used in the operation</li> <li>▪ Limit the volume of offshore disposal and instead plan to use large volume inland productively, i.e. for beautification, land reclamation, and backfilling</li> </ul>	Minor
	Reduced water quality by increase in turbidity and reduced dissolved oxygen due to re-suspension of sediments	Substantial	<ul style="list-style-type: none"> <li>▪ Daily and monthly Environmental Monitoring</li> <li>▪ Avoid sensitive areas</li> <li>▪ Avoid trenching activities where there is nearby aquaculture</li> <li>▪ Use of appropriate geo- textile curtains to control spread of sediments</li> <li>▪ Use of silt curtain</li> <li>▪ Proper planning and scheduling on the dredging and disposal to avoid strong wind, current and tides that will further add to widen the effect of spreading of sediments</li> </ul>	Negligible



Activity causing impact	Predicted Impact	Significance	Proposed Mitigation and Enhancement Measures	Residual Impact Significance
			<ul style="list-style-type: none"> <li>▪ Used of best available method</li> <li>▪ Testing and analyzing the water column at upstream and downstream from all the dredging activities</li> </ul>	
	Water contamination during dredging and disposal	Substantial	<ul style="list-style-type: none"> <li>▪ Method of Dredging and Disposal</li> <li>▪ Daily and monthly Environmental Monitoring</li> <li>▪ Sampling of sediment and water of the dredging site to determine compliance with the World Bank and PME standards before and during dredging</li> <li>▪ Apply environmental management plan (EMP)</li> <li>▪ Ensure that all necessary permit prior to dredging and disposal works has been acquired by SARCO</li> </ul>	Negligible
	Impact of noise (surface/underwater) from equipment	Negligible	<ul style="list-style-type: none"> <li>▪ High maintenance standard of equipment</li> <li>▪ Installation of noise suppressors in all the equipments</li> <li>▪ Provision of silencer and muffler</li> <li>▪ Limit the hours of operation</li> <li>▪ Apply health and safety and environment manual (HSE)</li> </ul>	Negligible
	Air contaminants	Moderate	<ul style="list-style-type: none"> <li>▪ Watering of pavement</li> </ul>	Negligible



Activity causing impact	Predicted Impact	Significance	Proposed Mitigation and Enhancement Measures	Residual Impact Significance
	due to transporting and reclamation works of dredged materials		to minimize dust <ul style="list-style-type: none"> <li>▪ Use of Personal Protective Equipment (PPE) as per health &amp; safety guidelines</li> </ul>	
	Potential over-spill from split barge that handles dredged material	Negligible	<ul style="list-style-type: none"> <li>▪ Limit the capacity to avoid overloading</li> <li>▪ Good housekeeping</li> <li>▪ Use of well maintained barge</li> <li>▪ Daily monitoring and inspection</li> </ul>	Minor
	Workplace hazard	Negligible	<ul style="list-style-type: none"> <li>▪ Good housekeeping</li> <li>▪ Applying and enforcing the company's HSE system</li> <li>▪ Safe operation through the use of safety management system, protective equipment daily site inspection and safety training</li> </ul>	Negligible
Operation	Re-colonization build-up of benthic communities on channel structures	Negligible	No mitigation needed	Positive Impact
	Entrainment and impingement of marine organism at the intake structure	High	<ul style="list-style-type: none"> <li>▪ Maintaining intake velocity rate</li> <li>▪ Use of velocity caps to reorient flow pattern</li> <li>▪ Fitting of screens at the bottom ceiling of the intake</li> <li>▪ Frequent cleaning</li> </ul>	Moderate
	Reduced water quality due to temperature increase from power plant discharge, thermal pollution and dispersion of potential	High	<ul style="list-style-type: none"> <li>▪ Modeling design parameter of maximum <math>\leq 3^{\circ}\text{C}</math> temperature increase from the ambient temperature at 100 meters of the discharge point</li> <li>▪ Constant monitoring</li> </ul>	Moderate



Activity causing impact	Predicted Impact	Significance	Proposed Mitigation and Enhancement Measures	Residual Impact Significance
	contaminants		to make sure that the temperature increase is within $\leq 3^{\circ}\text{C}$ from the ambient marine temperature at 100 meters from the point of discharge <ul style="list-style-type: none"> <li>▪ Increase retention time in the channel to reduce the temperature before discharge</li> <li>▪ Use of diffusers (as appropriate)</li> <li>▪ Installation of sensors to continuously record the temperature at the discharge point to ensure compliance with World Bank standards</li> <li>▪ Periodic sampling and analyzing of water at the discharge channel at appropriate points to comply with PME and World Bank standard related to direct effluent discharge</li> </ul>	

**Section 6.0 - Environmental Management Plan and Monitoring Implementation**

Identifying the critical issues on a daily basis requiring a daily monitoring procedure to apply the proper impact management and monitoring plan and also to ensure compliance to the mitigation measures for dredging and disposal operations.

This section will discuss the site monitoring activities, procedures and reporting method on a periodic basis to ensure the Company’s (SARCO) compliance with the approved method of operations stated in this EIA study.

An ongoing plan for establishing an environmental management database for the site would include a routine monthly sampling and analyzing the water and sediment quality around the site during the marine dredging and disposal activities. For the construction phase an additional program for soil sampling should be developed on the dredging site.



For the water quality survey, locations of the sampling should be evenly spaced out and identified by GPS and should be within the area of the dredging operation. The water sampling should be conducted at the mid-water depth only. Three (3) GPS locations has been identified around the area of dredging for sampling water and sediment and are to used as reference points during the dredging operation. Analyzing the samples from the three (3) points should be done on a monthly basis. Measurements of the water depth could be taken by using a portable, laser monitoring device. The following parameters should be measured:

- Temperature (°C)
- Dissolved oxygen (mg/l)
- pH
- Salinity (ppt)
- Turbidity (Nephelometric Turbidity Units (NTU))
- Ammonium
- Depth (m).

In addition, a representative number of water samples from the same locations should be taken and analyzed in a locally approved PME laboratory for the full suite of physical-chemical and biological parameters. The sampling and analytical methods should be explained through the reporting procedure and each sample should have a correspondent chain of custody that should be available for auditing purposes should the need arise. The following analyses shall be conducted on each water sample:

- Total Suspended Solids (TSS)
- Biological Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Total Coliforms
- Total Petroleum Hydrocarbons
- Heavy metals, arsenic, mercury, cadmium, copper, lead.

Collected data should be compared to the national standards, however, in the absence of such standards, suitable international standards should be chosen.

The distribution of the deposited sediment must be monitored to avoid any build up beyond the 2.0m cap. The even distribution of the material is the contractor's responsibility. Confirmation should be given on the dredging procedure, as well as the even deposition of the spoil material are done correctly by the contractor and that it would be subjected to be reviewed by the PME. To ensure an even spread of materials, the contractor must submit to MTEV's Site Environmental Specialist, on a quarterly basis, a detailed deposition plan which need to be approved. This plan must contain the following.

- 1) A clear grid pattern which divides the deposition site into 6 equal size areas.
- 2) Deposition locations using GPS, all barges shall be equipped with GPS devices
- 3) The previous quarter's dumping statistics (e.g track plots, exact amounts, location (GPS) and date).
- 4) The results of the latest surveys.
- 5) The proposed deposition plan which takes consideration of the results of the previous quarter.



The Contractor/SARCO should keep daily records and submit a monthly report to the MTEV's Environmental specialist on site, outlining how the stipulated objectives in the quarterly report are being met. The Environmental specialist must be authorized to stop the disposal activities if the deposition plan is not being adhered to.

To accumulate relevant data during the dredging and the disposal activities, an environmental specialist from MTEV and SARCO's environmental staff shall monitor such activities on site and record all the data of the activities daily by using the "Environmental Monitoring Report" form (see appendix 17). This collected information shall be used to create an overall Monthly Environmental Report that will be produced by MTEV and submitted to PME for their review and approval.

MTEV's environmental specialist is planning to visit the dredging site at least twice (2x) per week to monitor, supervise and consult on the dredging procedures and plan.

The monthly Environmental Report shall include the following sections as a minimum:

1. Project Profile (Introduction)
2. Weather and Marine Condition
3. Description of Dredging & Disposal works
4. Accumulated volume of dredged materials and disposals to date
5. Hard-copy of all Environmental Monitoring Reports
6. Hard-copy of all Water and Sediment Laboratory Analysis Report
7. HSE Accident/Incident Report
8. Maps (as appropriate)
9. Site Photographs
10. Risk Assessment
11. Conclusion and Recommendation

MTEV have selected three (3) points to be used as reference points for contamination during the dredging operation

## **Section 7.0 - Recommendation and Conclusion**

### **RECOMMENDATION**

Fine sediments are likely to be released into the water column during the dredging and embankment. These will be transported by the waves and currents and deposited onto the coral reef under certain environmental conditions.

The sediments will be suspended (either partially or fully) and dispersed over a substantial area due to magnitude of the sheer stress of waves and currents.

It is highly recommended that silt curtains are to be used, which will form as a physical barrier to the transport of fine sediments. The use of best equipment and barges will also minimize this impact dramatically. Timing is also plays an important role in controlling the transport of sediments as the



impact will multiply when the waves are strong. Complete mitigations and recommendations are discussed in section 5.7 of this study.

For the embankment works, the use of protective bunds would limit the transport of silts from the areas that are being filled. Using proper geo-textile materials which cannot be transported by waves and currents in making the bunds, and positioned the bunds at the edge of area being embanked, is highly recommended.

These structures then act as a physical barrier to the silt which is released into the water column in the areas that are being filled. The use of bunds could significantly reduce the environmental impact of silt disposition on the shallow reef areas.

The construction of bunds can introduce direct (bund on the coral reef) and indirect (fine material release and sedimentation on reefs) impact during the establishment; therefore special care is needed to be applied in the constructing and the placing of these bunds.

The quality and quantity of the discharged water from the power plant could cause an impact to the marine life if it is not monitored and applied the proper means to eliminate or at least to minimize the impact. Proper monitoring sensors need to be put in place to monitor the temperature of the discharged water. Also by increasing the retention time by installing proper diffusers at the discharge point would help in reducing the temperature in the channel as well as minimizing the impact at the discharge point to the marine environment. Constant monitoring is to make sure that the temperature is within  $\leq 3^{\circ}\text{C}$  temperature increase limit from the ambient marine temperature at 100 meters from the point of discharge is recommended.

In order to enforce and satisfy the monitoring and mitigation measures recommended in this study, MTEV's environmental specialist is planning to visit the site at least twice (2X) per week during the dredging and construction phases as mentioned in the scoping paper submitted to PME.

During the site visits, MTEV's environmental specialist along with SARCO staff will monitor all the dredging activities to make sure that full compliance with this EIA findings and recommendations, as well as PME's and World Bank standards are being applied.

MTEV will provide a monthly report to PME which will include the parameters mentioned above to satisfy the mitigation measures mentioned in this EIA for review and approval.

In view of this EIA study, SARCO has to apply all the mitigation measures discussed with regards to the impacts and to follow and implement the environmental monitoring plan and monthly reporting during the marine dredging and disposal activities to ensure full compliance with the World Bank's and PME's Standards.

## **CONCLUSION**

This section covers the results of the study based on the collected data, establishment of impacts, mitigation measures and recommendations to be implemented by the client upon approval from the PME and other governmental agencies.

This EIA Report has identified that the marine dredging activities will have a number of environmental impacts, both positive and negative. The significant impacts have been summarized in





Table 5.7A, and set out in details in the individual impacts sections. Mitigation measures were addressed for each of the impacts and recommendations were made to eliminate and or minimize the impact. If the recommended mitigation techniques detailed in Table 5.7A, and the environmental management and monitoring recommendations given in section 6.0 are to be followed, it is not anticipated that negative impacts will lead to significant effects.

Significant impacts are considered to be those for which will be anticipated to create a negative “impact significance” prior to any mitigation was proposed. Impacts which are anticipated to be beneficial have also been included

The most significant impacts occurring during the construction of the project will be during the dredging phase. However, these impacts are anticipated to be short term and, providing the full mitigation measure that was discussed earlier are applied, the impacts will not be severe.

Beneficial socio-economic impacts was also concluded resulting from the new additional capacity of the Power Plant, both to the residents of Jeddah, and throughout Saudi Arabia, which will be in terms of improving their standards of living, creating more jobs to local residents and allowing the development of the infrastructure in the area through building more facilities, factories and governmental and private institution.

By applying all he mitigation measures and the Environmental Monitoring Plan (EMP) and the reporting procedure throughout the dredging and disposal activities, the proposed marine dredging activities is anticipated to have a controlled and localized impacts on the marine environment.

MTEV will monitor the dredging activities on site through their environmental specialist to make sure that all the mitigation measures and monitoring plan are being implemented on site to satisfy the World Bank and PME’s standards for dredging and deep sea dredged material disposal procedures.

*In view of this EIA study, the main environmental impacts due to the dredging projects are:*

- 1. Direct removal and/or destruction of coral reef in and around the dredging site.*
- 2. Carry-over of silt from the dredging and disposal activities.*
- 3. Reduced water quality and reduced dissolved oxygen due to the increase of turbidity and suspension of sediments.*
- 4. Increased water temperature at the discharge point due to high power plant water discharge*
- 5. Water contamination during dredging and deep sea disposal of dredged material*

*Through our mitigation plan, recommendations on works procedure on site and the monitoring plan, all the above impacts have been addressed. It was concluded that the above impacts can be controlled and localized and their environmental effects would be minimum.*

*The recovery of the ecosystem will take anywhere from 2 to 5 years after completion of this dredging project.*

## 1.0 Presentation of the Project

### 1.1 Introduction

The Shoaiba Power Plant Extension Stage III is located in Shoaiba about 110km south of Jeddah Saudi Arabia. A consortium headed by Alstom Power Centrals, which includes Saudi Archirodon (SARCO) are planning to construct new (stage III) 1,200MW power plant for a combined output (stages I, II and III) of 5,250MW consisting of 14 units of 375MW. Within the consortium, SARCO is responsible for all the associated civil works both onshore and offshore which includes among other things, Marine Dredging Works which is the subject of this EIA study. This study is prepared by Dr. Mohamed A. Turki for Environmental Studies and Consultancy (MTEV) under the guidelines of the Presidency of Meteorology and Environment (PME's) Environmental Regulations and Rules of Implementation (Print 1427 H, 2006 G).

Figure 1 (Study Area Map)





## 1.2 Consultant/Client Profile

**Dr. Mohamed A. Turki for Environmental Studies & Consultancy (MTEV)** has been formed under the management of Dr./Eng. Mohamed Turki Office for Engineering Consultancy (MTEC) to address the needs of environmental studies and protection. New stringent legislation being implemented on atmospheric emission has now been adopted by the Government due to recent fact of global warming. Saudi Arabia being a signatory on numbers of international legislation and protocols on environmental protection, MTEV's environmental impact assessment studies is being prepared under the guidelines of Saudi Presidency of Meteorology & Environment (PME) and International Finance Corporation's (IFC) Equator Principles (World Bank Standard), this is to allow a much extensive guidelines in preparing our studies in the field of Power Generation, Water & Wastewater Treatment, Transmission & Distribution , Process Industry etc.

**Saudi Archirodon Limited** (Client) is an International Private joint venture of ARCHIMIDIS, a marine contractor and ODON & ODOSTROMATON, a road and bridge construction specialist group established in 1971. Archirodon started its operations initially in Saudi Arabia and subsequently expanded into other Gulf countries, North Africa and the Mediterranean area. In the 1980s, The company further developed into a general contracting group diversifying into other fields including, roads, bridges, railroads, industrial facilities, water and sanitation, dredging as well as

electromechanical and geotechnical works. Archirodon has also recently established an in-house

Engineering Department.

Archirodon Group N.V. is registered in the Netherlands and having branches and/or project sites in, Saudi, Arabia, UAE, Kuwait, Bahrain, Cyprus, Greece, Egypt, Jordan, Libya, Oman, Qatar, Singapore, Kazakhstan and Greece. Archirodon is certified by TUV Cert under ISO 9001, OHSAS 18001 and ISO 14001 quality, health, safety and environmental standards.

## 1.3 EIA Methodology

### 1.3.1 Guidelines

PME's Environmental Guidelines and Rules for Implementation provide guidance on whether EIA study is required for a particular type and scale of a project and determining the category of EIA required. The three categories outlined in the Appendix 2.1 of the PME's General Environmental Guidelines and Rules for Implementation are as follows:

- Category 1 : project with limited environmental impacts which require forms to be filled and approved by PME
- Category 2 : project with significant environmental impacts which require forms to be filled and approved by PME
- Category 3 : project with serious negative environmental impacts which requires a full comprehensive Environmental Impact Assessment and PME approval

Third Category projects require a comprehensive Environmental Impact Assessment study. The proposed project which includes dredging and disposal was concluded a category 3 and a comprehensive EIA.

After SARCO received a copy of the preliminary marine dredging works license from, Makkah Municipality, an EIA Scoping was submitted to the Presidency of Meteorology and Environment (PME) for approval.

The methodology for preparing the EIA report, assessment and reporting will be to satisfy the requirements of the Presidency of Meteorology and Environment (PME) and will be as follows:

- Information gathering and assimilation
- Impact identification
- Impact assessment and liabilities
- Proposition of mitigation measures and environmental monitoring system.
- Development of recommendations.
- Review of appropriateness and adequacy of SARCO proposals for mitigation measures and environmental monitoring systems.
- Preparation and submittal of report to the authorities / PME.

Once the significant environmental impacts have been determined, MTEV will identify realistic and achievable measures to ensure regulatory compliance. These measures will consist of physical mitigation, management initiatives, environmental management plan and establishing and monitoring scheme. Each of the mitigation measures proposed will be prioritized and reviewed with the client prior to inclusion in the EIA report.

### *1.3.2 Scoping*

A methodology report was submitted to the Presidency of Meteorology and Environment (PME) on the 20<sup>th</sup> September, 2008, which includes the scoping of the environmental issues on the project. Quickly, it was recognized that the project may have a number of potentially significant impacts, as it will involve dredging works in the marine environment and may also affect the currents, sea water quality and neighboring land uses.

The key environmental issues for the study were considered to be the following:

- Seawater quality in and around the dredging area, particularly due to sediment disturbance during dredging.
- Potential damage to marine ecology and destruction of coral reef and marine habitat due to dredging and disposal of dredged material, if the material is not all used for reclamation.
- Raising the seawater temperature due to power plant water discharge
- Air quality disturbance due to dredging, piling and construction equipment movement
- Noise level in and around the project area due to equipment movement and dredging activities.

### *1.3.3 Data Gathering*

The EIA studies commenced in September 20, 2008, according to the following program:

- Review of available information about the site, and further data gathering.

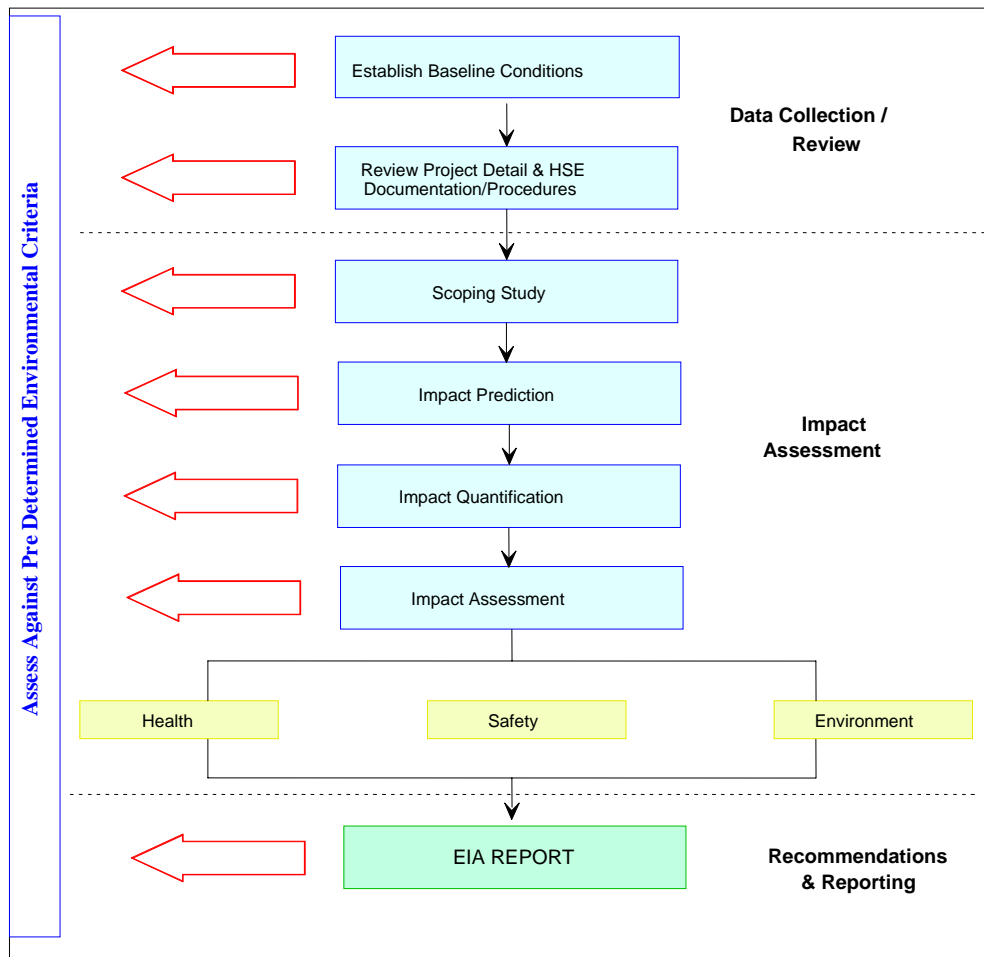


- Site visit (Sept. 07, 2008, Sept. 14, 2008, January 05, 2009 with PME) for project overview
- Identification of further data requirements that includes but not limited to water and sediment analysis
- Scoping of significant impacts and development of Methodology Report for submission to PME
- Commissioning and management of additional studies identified as necessary
- Assessment of impacts and consideration of alternatives and mitigation options

MTEV had obtained the following details from the Client:

- Dredging and Open Water Disposal Process
- Equipment/Technology Description
- Site Coordinate (map, drawing etc.)
- Project Schedule
- Baseline Data
- Relevant Work Permits (from concerned government agencies)

### A typical flow diagram for EIA





Once the significant impacts have been identified for the project and proper mitigations has been assigned to each impact, followed by recommendation and conclusion of the study, the environmental impact assessment report will be presented in hard copy and digital format. It will be concise and focus on significant environmental issues. It will contain the findings, mitigations, conclusions and recommended actions supported by summaries of the data collected and citations for any references used in interpreting those data. The environmental assessment report will be organized according to, but not necessarily limited by, the outline suggested below.

- Executive Summary
- Presentation of the Project
- Description of Project and its Objectives
- Environmental Conditions (Baseline Data)
- Significant Environmental Impacts Assessment
- Analysis of Significant Impact & Mitigation Plan and Control Measures
- Environmental Management Plan and Monitoring
- Recommendation and Conclusion
- Appendices

#### *1.3.4 Site Visit & Consultation*

Two sites visits were undertaken, September 07 and 14 in 2008. These visits involved overview of the site, kick-off meeting, which includes:

- Time and schedule
- Communication, representation
- Documentation
- Specifications
- Project Management Meetings
- Schedule of submittals
- Progress Reporting
- Scoping questionnaires has been discussed

Throughout the scoping, close liaison and its interpretation between the Client (SARCO) and MTEV to ensure understanding of data input has been established as well as other data needed to incorporate in this report.

#### *1.3.5 Monitoring*

Once the EIA study is completed and approved by the PME, MTEV is planning with the approval of SARCO and PME to monitor the dredging activities by visiting the site at least two (2) times per week to ensure SARCO compliance to the EIA mitigations and recommendations measures during project operation.

## **1.4 Policies, Laws, Regulations**

This section will review environmental regulations and national/regional policy as relevant to dredging activities and this EIA study.

### **1.4.1 Kingdom of Saudi Arabia**



### **Basic Law 1992**

The basic law is commonly referred to as the Constitution of Saudi Arabia. Article 32 of the basic law states; *The State works for the preservation, protection and improvement of the environment and for the prevention of pollution.*

### **Presidency of Meteorology and Environment (PME) General Environmental Regulations and Rules for Implementation (Oct. 2001):**

- Article 12.1; *Anyone performing digging, demolition, construction, and/or involved with debris and dirt transportation works must take necessary precaution for the safe storage and transportation of such materials, which must be treated before and disposed off properly.*

*Article 13; All persons engaged in productive activities, service or other activities shall take the necessary actions to comply with the regulations. These should be achieved in accordance with environmental standards and criteria issued by the competent agency according to the regulations*

- Article 13.1; *Prevent direct or indirect contamination of surface, ground and coastal waters that may cause by solid or liquid residues.*
- Article 13.1.2; *To employ the best available technology (BAT) and means to avoid contamination of surface, ground and coastal waters and minimize and control pollution in accordance with approved environmental criteria.*
- Article 13.1.3; *Remove all forms of contamination of surface, ground or coastal waters resulting from this activities and bear all the costs of the prevention, control and minimization of containment, remediation of the contaminated environment and compensate the affected parties*
- Article 13.1.4; *Prevent the discharge, in any quantity, of any type of solid or liquid wastes, substance, element, organic or inorganic compound that may be classified as hazardous into surface, ground or coastal waters*
- Article 13.3.2; *Use technology and equipment with low noise level in new projects and upgrade technologies and equipment used in existing activities in order to attain allowable noise levels.*

MTEV also refer to other standards and regulations for dredging activities that are adopted by Kingdom of Saudi Arabia such as the Royal Commission for Jubail/Yanbu as a reference only.

### **Royal Commission for Jubail & Yanbu**

Referring to Royal Commission Environmental Regulation Section - 6 for Dredging Operation

#### **6.1 Dredging Regulations**

- Article 6.1.1; *No dredging or disposal of dredged material shall take place outside the Harbor without specific approval being granted by the Royal Commission.*

*Approval will be subject to an assessment of the environmental impact of the proposed dredging and dredged material disposal activities, which will be based on information provided to the Royal Commission in accordance with Section A.11.*

- Article 6.1.2; *No dredged materials shall be disposed of within enclosed bays, inlets or within the 20m low tide depth contour unless the dredged material is being used for approved construction purposes.*
- Article 6.1.3; *Dredged material that does not meet the standards in Table 1.A shall not be disposed of at offshore locations. Such materials may be disposed of at onshore facilities in accordance with Sections 4 and 5*
- Article 6.1.4; *Supernatant water decanted from dredged material shall not be disposed of within enclosed bays or inlets or within the 20m low tide depth contour unless a visual clarity of at least 0.5m has been achieved. Supernatant water quality parameters shall meet the maximum pollutant level standards established in Section 3.2.1.*
- Article 6.1.5; *The use of surface impoundments to retain and settle dredged materials shall conform to the standards given in Section 3.4.11 of these Regulations.*

Table 1.A: **Maximum Pollutant Levels for Offshore Dredged Material Disposal**

PARAMETER	DRY SEDIMENT (mg/kg)
<b>Volatile Solids</b>	8
<b>Chemical Oxygen Demand (COD)</b>	50,000
<b>Total Kjeldahl Nitrogen (TKN)</b>	1,000
<b>Oil and Grease</b>	1,500
<b>Mercury</b>	1
<b>Lead</b>	50
<b>Zinc</b>	75
<b>Arsenic</b>	5
<b>Cadmium</b>	2
<b>Chromium</b>	100
<b>Copper</b>	50
<b>Nickel</b>	50

#### 1.4.2 Regional Policies

##### **Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment, 1982 (The Jeddah Convention)**

This Convention was ratified by Saudi Arabia in 1985 and resulted in the creation of PERSGA (Regional Organization for the Conservation of the Red Sea and the Gulf of Aden) as its secretariat and implementing body. The aim is to ensure rational human use of living and non-living marine and coastal resources. Particularly relevant to this project is the following statement:

*“Conscious is needed to ensure that the processes of urban and rural development and resultant land use should be carried out in such a manner as to preserve, as far as possible,*



*marine resources and coastal amenities, and that such development should not lead to deterioration of the marine environment”*

**Protocol for the Protection of the Marine Environment against Pollution from Land Based Sources (February 1990)**

This Protocol states that Saudi Arabia shall take all appropriate measures to prevent, abate and combat pollution by discharges from land reaching the sea, whether water-borne, air-borne, or directly from the coast. Regional regulations should be developed for the following types of wastes:

- Waste generated from coastal development activities which may have a significant impact on the marine environment
- Ballast water, slops, bilges and other oily water discharges generated by land-based reception facilities and ports through loading and repair operations.
- Brine water and mud discharges from oil and gas drilling and extraction activities from land-based sources.
- Oily and toxic sludge from crude oil and refined products storage facilities.
- Effluents and emissions from petroleum refineries
- Effluents and emissions from petrochemical and fertilizer plants
- Toxic effluents and emissions from industries such as chlor-alkali, primary aluminum production, pesticides, insecticides, and lead recovery plants.
- Emissions from natural gas flaring and desulphurization plants.
- Dust emissions from major industrial sources, such as cement, lime, asphalt and concrete plants.
- Effluents and emissions from power and desalination plants.
- Sewage and solid wastes

**1.4.3 International Protocols and Guides**

**The Protocol Concerning Regional Cooperation in combating Pollution by Oil and other Harmful Substances in cases of Emergency 1982**

This Protocol aims to enhance measures for responding to pollution emergencies on a national and regional basis.

**International Conventions**

<b>International Conventions</b>	<b>Signatory</b>
International Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter 1972 (also called the London Convention)	Signed and ratified
Convention Concerning the Protection of the World Cultural and Natural Heritage 1972 (World Heritage Convention)	Signed and ratified
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) 1973	Signed and ratified
Law of the Sea 1982 (Part XII)	Signed but not ratified



Prevention of Pollution of the Sea by Oil (OILPOL – 1954) as amended	Signed and ratified
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal 1989 (Basel Convention)	Signed and ratified
Intervention on the High Seas in cases of Oil Pollution Casualties 1969 as amended	Signed and ratified
Civil Liability for Oil Pollution Damage (CLC 1969) as amended	Signed and ratified
Convention on Biological Diversity 1992	Signed but not ratified
Convention on the Conservation of Migratory Species of Wild Animals, 1979	Signed and ratified
International Convention for the Prevention of Pollution from Ships (MARPOL) 1983	Signed and ratified
Framework Convention on Climate Change 1992	Signed and ratified
Convention for the Protection of the Ozone Layer 1985	Signed and ratified
Montreal Protocol on Substances that Deplete the Ozone Layer 1987 (Montreal Protocol)	Signed and ratified

#### **Convention on Biological Diversity, 1992 (United Nations Conference on Environment and Development)**

The Convention on Biological Diversity is an international treaty that was adopted at the Earth Summit in Rio de Janeiro in 1992. The Convention has three main goals:

- Conservation of biological diversity (biodiversity)
- Sustainable use of its components
- Fair and equitable sharing of benefits arising from genetic resources.

The Kingdom of Saudi Arabia became a signatory to the Convention in 2001.

#### **Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (also called as the London Convention)**

The Convention has a global character, and contributes to the international control and prevention of marine pollution. It prohibits the dumping of certain hazardous materials, requires a prior special permit for the dumping of a number of other identified materials and a prior general permit for other wastes or matter. "Dumping" has been defined as the deliberate disposal at sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures, as well as the deliberate disposal of these vessels or platforms themselves. Wastes derived from the exploration and exploitation of sea-bed mineral resources are, however, excluded from the definition. The provision of the Convention shall also not apply when it is necessary to secure the safety of human life or of vessels in cases of force majeure. Among other requirements, Contracting Parties undertake to designate an authority to deal with permits, keep records, and monitor the condition of the sea.



## 2.0 Description of the Project and its Objectives

### 2.1 Goals/Objectives and Targets

Saudi Archirodon had set the goals and measures to protect the environment during the project operation as follows:

No.	Goals/Objectives	Targets
1	To protect marine environment habitat and ecosystem	Current marine environment and ecosystem will not be adversely impacted
2	To ensure compliance to PME and other governmental agency regulations related to dredging and disposal	Prepare a comprehensive EIA study to establish appropriate precaution and mitigations required to achieve compliance with the regulations and laws to protect the environment during the operation of this project
3	To protect marine flora and fauna environment	No significant marine flora and fauna environment will be completely damaged or disappeared
4	To Protect marine water quality	No significant adverse impact to marine water quality during the project operation
5	To ensure the discharge water temperature increase from the power plant to be limited to $\leq 3^{\circ}\text{C}$ from the ambient seawater temperature at 100m from the discharge point	Modeling design, use of diffusers and putting temperature sensors along the discharge channel
6	Adequate solid waste management	All solid waste will be separated and reused where applicable, disposed in accordance with local and project environmental requirements
7	To comply with environmental permits	Complete requirements and permits relevant to proceed with the project operation
8	To ensure proper environmental monitoring during operation	Design a suitable environmental monitoring plan and implementation procedures in accordance to EIA requirements
9	To ensure the air quality of the site of operation	Follow EIA and implements its recommendation to ensure keeping the air quality within acceptable limits
10	To ensure minimum noise level during operation	To keep noise level within acceptable level

- Communication with Saudi Archirodon's Project Managers and his Engineers and the Regulatory Agency shall be maintained and ensure that the above environmental objectives and targets are fully communicated.
- The project manager of Saudi Archirodon will ensure the above environmental objectives and targets are achieved during the operation of the project.
- MTEV plan to monitor the operation by visiting the site at least two (2) times per week during the operation period to ensure compliance of these objectives and the EIA recommendations.

## 2.2 Need of the Project

Shoaiba's Power Plant originally commissioned in 1999 and SEC decided for an extension (Stage II) to another six units to increase (stage I and II) for a combined output to 4000MW in 2004. Stage III extension currently under construction was approved by SEC to provide additional capacity of 1200MW for a total output of 5250MW (of the 3 stages), the complete plant will consist of 14 units of gas turbine combined cycle modules with a capacity of 375MW each. As part of the power plant cooling water system, dredging works are to be performed to construct a seawater intake channel and twin outfall brine discharge channels to ensure continuous supply and discharge of cooling water to and from the power plant.

## 2.3 Project Description

The Marine Scope of Works of the project requires the construction of the Cooling Water Intake Channel and Cooling Water Discharge Channel. The construction of these channels involves Dredging operation to ensure the continuous supply and discharge of Cooling Water to and from the Power Plant. Some of the dredged material shall be used for backfilling of the plant areas, embankment of channels structures and the remaining shall be dumped at a Marine Disposal Area approved by the concerned Government Agency/PME.

**Table 2.3A Preliminary Proposed Dredging Schedule**

Item	Activity	Days	Start	Finish	Equipment
<b>Intake Channel</b>					
1	Offshore Dredging (by floating equipment)	80	15FEB09	05MAY09	Grab Dredger Atlantis, Split Barge, Tugboat
2	Onshore Dredging/Excavation (by land equipment)	80	06APR09	24JUN09	Excavator ,Bulldozer, Wheel Loader, Trucks
3	Preparation of Reclamation Area	90	06MAY09	03AUG09	Various equipment
<b>Discharge Channel</b>					
1	Offshore Dredging (by floating equipment)	90	17MAR09	14JUN09	Grab Dredger Atlantis, Split Barge, Tugboat
2	Onshore Dredging/Excavation (by land equipment)	60	16MAY09	14JUL09	Excavator ,Bulldozer, Wheel Loader, Trucks
3	Preparation of Reclamation Area	70	15JUN09	23AUG09	Various equipment

## 2.4 Process Description of Dredging and Disposal

### 2.4.1 Discharge Channel Method Statement for Dredging and Excavation

- This method statement describes the procedures to be followed for the dredging in the discharge channel by Rock Grab Dredger "Atlantis" and land excavation by tracked excavator
- The site is located on the coast of Shoaiba, 120km south of Jeddah
- The discharge channel will be formed by dredging through the natural reef, from the concrete discharge culverts. The discharge channel is part of the cooling water system and will transfer used cooling water from the concrete discharge culvert to sea. Its



position is shown on the attached Appendix 1 General Site Layout (Drawing No. SHA 00 MA00—GA001)

- The earthen channel will have a typical bottom width of 19.00 ~ 34.00m, side slope of 1.5H:1V or 2.0H:1V and an invert level of +1.00 ~ -1.40 (TSS Shoaiba). At the downstream end of the channel it changes direction to steer the discharge water away from the intake channel, thus avoiding recirculation through the plant
- At the upstream end of the channel, a concrete outfall structure is formed (with a controlling weir) perpendicular to the flow. This maintains the discharge water level, through the concrete culverts, back to the plant
- To prevent the surrounding seawater from mixing with the cooling water being discharged from the power plant, embankment will be formed on both banks of the discharged channel, using suitable dredged material

A number of trial pits, spaced at 50 – 100m will be dug along the line of the channel. Visual inspections as well as laboratory tests (gradation of the Attenberg limits) on samples will be carried out to assess the suitability of the soil in both cases:

- Formation of embankments above the natural ground
- Stability of the cut forming the lower part of the channel

The soil sampling and testing will be taken at the necessary frequency to establish the engineering characteristics of the dredged materials for use as selected fill. A full interpretative report of the investigation will be submitted. Sufficient geotechnical data will be obtained from these trial pits, for the analysis and design of the embankments and foundations, including the lower slopes. The slopes of the pits will be checked for stability and samples taken for analysis in the laboratory

- The manmade embankments, as well the canal bottom at the end, will be protected from erosion and wave action by using a suitable and approved protection system

#### 2.4.1.1 Equipment Resources

##### Plant & Machinery

- a. Rock Grab Dredger “Atlantis”
- b. Split Barge
- c. Tugboat
- d. Bulldozer
- e. Shovels
- f. Dump trucks
- g. Survey boats
- h. Tracked 360°
- i. Excavators

#### 2.4.1.2 Manpower Resources

The personnel engaged in this work will have adequate experience in underwater concreting.

- a. Marine Civil Engineer
- b. Marine foreman
- c. Marine surveyor
- d. Concrete pump operator



- e. Transit mixer operator
- f. Divers
- g. Floating crane operator
- h. Tug boat operator

#### 2.4.1.3 Discharge Channel Dredging Methodology

##### 2.4.1.3.1 *Reference*

BS 6349 Part 5, 1991 (Code of Practice for Dredging and Land Reclamation) as Appendix 2 attachment

##### 2.4.1.3.2 *Survey Works*

- The setting-out survey will be carried out by qualified and experienced surveyors
- The limits of the bottom width, and of the top line of the side slopes, will each be demarcated by a minimum of two poles with red flag set up onshore. Flashlights will be attached to the poles to indicate the limits during the night
- A pre-dredged survey on the discharge channel area will be carried out on a 10m x 20m grid. Seabed levels will be taken by echo sounder in deep water areas and by leveling instruments in shallow water. A baseline will be set up onshore perpendicular to the axis of the intake channel. Grid points will be marked by steel rods along the base line. Levels will be taken along the gridline by setting up a theodolite over the grid points and turning it through 90° from the baseline.
- A pre-survey will also be carried out for the proposed surplus spoil dumping area. Permission for dumping offshore will be obtained from PME and Coast Guard authorities prior to starting the dredging works.
- Vertical dredging tolerance will be + 0mm/ - 300mm as per BS 6349: Part 5, 1991 (Appendix 2).
- Horizontal accuracy for dredging plant under various site conditions is attached in Appendix 2.

##### 2.4.1.3.3 *Execution of Works*

- Prior to starting the dredging operation, all the design drawings of the dredging area will be prepared and submitted to the Engineer for information
- Two tide gauges will be installed at each end of the dredge box, at a relatively calm location to monitor the dredging depth in relation to the tide level. The tide gauges will be graduated to read centimeter difference of the tide level
- The dredger will be secured in position using four anchor lines. The front anchor will be in an open position approximately 300-350m away from the dredger to

facilitate the movement of the grab bucket. The rear anchor will be in a cross position, approximately 100m away from the dredger

- Tracked excavator may commence excavation on land. The area to be excavated in this way will be shown on the drawings

#### *2.4.1.3.4 Dredging in Box Section*

Dredging will be carried out in one continuous strip, 19m ~ 35m wide parallel to the axis of the discharge channel as shown in enclosed Appendix 3 “schematic diagram of side slope dredging” sketch no. DIS-002. Once 100 – 150m of the dredging is complete, the back anchor will be lifted by tug boat and dropped at a new location further along the channel so that a further length of 100 – 150m can be dredged. Using this method dredging will continue until the entire channel length is complete. Suitable materials will be deposited directly on the embankment, or will be stockpiled nearby.

Immediately after the box dredging of the channel is complete, the channel will be surveyed at 20m intervals paying particular attention to the measurement of the side slopes. After one week has elapsed, these sections shall be again surveyed and drawing produced showing the comparison of the sections over the period. Any over excavation of the side slope shall be based upon these comparative cross sections.

#### *2.4.1.3.5 Cutting Side Slopes*

Side slopes will be formed by one of two methods:

1<sup>st</sup> The dredging of a series of steps that approximate to the required slope. The height of each step will not be more than 1.0m as shown in Appendix 4 sketch no. DIS-001.

2<sup>nd</sup> By use of an excavator working from the top of the embankment, where during the excavation, excavated materials will be placed in position by trucks and the slopes will be formed by land excavators. The operation will take place simultaneously with the construction of the embankment

#### *2.4.1.3.6 Installation of Silt Barrier*

Careful consideration will be given to the potential adverse effect of dredging on the immediate environment, in order to minimize this effect in line with the recommendation of the EIA guidelines.

Purpose made floating silt barrier will be installed near to the dredging area, as shown in Appendix 5 “Floating Silt Barrier”.



#### 2.4.1.3.7 *Over-dredging*

Over dredging being the depth of material removed from below the specific design level will be limited; particularly alongside structures of quay walls and cassions. However, the over-dredged area, if any will be treated by filling with the ‘channel bed protection type B (rock class G)’.

#### 2.4.1.3.8 *Post Survey*

- When the dredging, excavation, cleaning and sweeping operation is completed, a post-survey of the dredged area will be done by echo-sounder along grids at 10m x 200m intervals. Post-dredged survey levels will be plotted on a drawing and submitted for Engineer’s information
- A post-survey will also be done for the dumping area, and the result will be submitted to the Client

#### 2.4.1.3.9 *Navigation Safety*

- To ensure safe navigation during night, barges will be equipped with yellow color flash lights at the front and rear of the barge according to international standards
- Buoys with yellow flashing light will be placed to mark the area of dumping to prevent the fishing boats if any, etc. entering the dumping area

#### 2.4.1.3.10 *Maintenance*

- The channel will be kept clear of rubbish and debris during construction and up to the completion of the works

#### 2.4.1.3.11 *Quality Control*

- The above works will be executed as per the relevant ITP which will be submitted separately to the Engineer
- The site laboratory will be conducting sampling and testing on the dredged materials as per section 2.4.1 above.

### 2.4.2 *Intake Channel Method Statement for Dredging*

#### 2.4.2.1 Reference

BS 6349 Part 5, 1991 (Code of Practice for Dredging and Land Reclamation) as Appendix 2 attachment

#### 2.4.2.2 Introduction

- The intake channel will be formed by dredging through the natural reef and will extend from the deep water intake system beyond the reef to the cooling water filtration and pump station. The intake channel is part of the cooling water system and will transfer the cooling water from the deep water intake system to the pump station.





- The earthen channel will have a typical bottom width of 70m, and a base level of approximately -2.97m (TSS Shoaiba). The channel will fall to approximately -3.60m (TSS) to tie into the C.W. pump station. At the upstream (west) end the channel will be cut down the face of the reef to allow installation of the intake pipes at a slope down to -18.45m (TSS Shoaiba)
- The channel will have a side slope of 1.5H:1V to be extended up to level +6.20 TSS. To achieve this, embankments will be formed on both banks of the intake channel, using suitable dredged materials, to prevent the surrounding sea wave water from mixing with the cooling water flowing in the channel. At the final stage of construction, these man-made embankments will be protected from erosion and wave action by a suitable and approved protection system. The core of embankments will consist of a selected dredged sandy material of more or less uniform gradation, with low permeability and with coral gravel but without big rock fragments.

#### 2.4.2.3 Survey Works

- The setting-out survey will be carried out by qualified and experienced surveyors
- The limits of the bottom width, and of the top line of the side slopes, will each be demarcated by a minimum of two poles with red flag set up onshore. Flashlights will be attached to the poles to indicate the limits during the night
- A pre-dredged survey on the intake channel area will be carried out on a 20m x 20m grid. The grid will be 10 x 10m or denser in sloped reef area. Seabed levels will be taken by echo sounder in deep water areas and by leveling instruments in shallow water. A baseline will be set up onshore perpendicular to the axis of the intake channel. Grid points will be marked by steel rods along the base line. Levels will be taken along the gridline by setting up a theodolite over the grid points and turning it through 90° from the baseline.
- Vertical dredging tolerance will be + 0mm/ - 300mm as per BS 6349: Part 5, 1991 (Appendix 2).

#### 2.4.2.4 Execution of Works

- A tide gauge will be installed near the dredging area at a relative calm location to monitor the dredging depth in relation to the tide level will be graduated to read each centimeter difference of the tide level.
- The dredging of intake channel will be done from the land and by floating equipment in deeper regions. The excavation to a length of approximately 300m from the shore line will be done by land equipments. The rest of dredging will be done by floating equipments.



- The dredging will be done in strips of approximately 25m as shown in Appendix 6 “Plan of Intake Channel” (sketch INT-001). The dredger will be secured in position at strip no.1 first using four drag anchor lines.
- Dredging of each strip of the intake channel will be carried out in several stages, as described below:
  - Step 1: Excavation of reef slope (see Appendix 7 “Dredging sequence for each strip, longitudinal section at reef” sketch no. INT-002). The dredging will be done up to level -3.00 in step no. 1 from E=486.50 to E=621.35 as shown in sketch no. Appendix 7. During the excavation of strip 1 and 3, the side slopes of the south and north side embankment has to be maintained. The excavation of these slopes will be done in 3 stages and the height of excavation should not exceed 1m (refer to Appendix 8 “Schematic diagram of side slope, dredging of intake structure” sketch no. INT-003)
  - Step 2: The portion marked step-2, which is up to -8.00 (TSS) will be excavated. The slope will be cut into steps.
  - Step 3: The next excavation will be another 5m up to -13.00 level maintaining the slope of 1.5H : 1V.
  - Step 4: Excavation of the deep channel up to final depth -18.45.
  - Step 5: The slope will be properly trimmed in step 5 from level -3.0 to -18.45.
- After trimming the slope, the dredger will move to the next strip and the dredging will be done in same sequence.
- During the dredging operation, the tide level will be observed every 2 hours, and dredging depth will be adjusted in relation to the new tide level.
- Dredge material other than that used in the formation of the embankment will be loaded into split barges moored alongside the dredger. When the barge is loaded to capacity, the mooring line will be removed and the barge towed to a deep sea area for dumping.  
The permission for dumping offshore will be obtained from the concerned government authorities prior to starting of the dredging works.
- Whilst dredging the final cuts immediately adjacent to embankment slopes, the dredged materials will be deposited directly by the dredger on the adjacent bank. This material will be tested for compliance with the specification and only selected suitable dredged materials will be used in the permanent works. The first layer of dredged material for the formation of the embankment will be placed and graded up to El. +3.0 TSS. Grading will be made by means of a grader. A vibrating roller will be used for the compaction above water. This will allow also for compaction of the submerged part. The top part of this layer will be compacted to 98% relative density as per the specification. In order to prevent erosion of the embankment by the waves and tides immediately after laying and compacting this first layer, the slopes will be trimmed by means of a back-hoe



excavator and the geo-textile will be laid and covered with permanent rock material of proper gradation. Each subsequent layer will be placed in layers of 200mm loose thickness. Each layer will be graded and compacted using 15T vibrator roller to a relative density of 98%. The slope will be trimmed; the geo-textile will be rolled upwards and covered with stones and so on. Prior to the placing of subsequent layers, compaction tests will be carried out for the previous layer and test results will be reported to Engineer for approval. Testing will be carried out on average rate of one test per 500m<sup>3</sup> of fill placed.

- When dredging is completed, the dredged area will be cleaned and swept by the grab in a closed position to make the bottom dredged area to be an even surface and to cut any high spots left during dredging and bring the cut to the true lines and levels.
- The portion of intake channel from 300m away from the shore line to C.W. pump house will be done by means of an excavator type POCLAIN 300 and the excavation will be carried out in two steps. First up to level approx. +2.50 TSS and then up to final level and lines. The excavated materials will be directly loaded in dump truck hauled to deposit areas. Suitable materials will be dumped on the embankment. The leveling of the bottom will proceed simultaneously with the second stop excavation. The scour protection concrete apron and sand trap canal in front of the pump house will be installed at the same time. The portion up to 40m away from C.W. pump house will be sloped from 2.97 (TSS) to -3.60 (TSS) to tie in with C.W. pump house.

#### 2.4.2.5 Post Survey

- When the dredging, cleaning and sweeping operation is completed, a post-survey of the dredged area will be done by echo-sounder along grids at 20m x 20m intervals. Post-dredged survey levels will be plotted on a drawing and submitted for Engineer's approval.
- A post-survey will also be done for the dumping area, and the result will be submitted.

#### 2.4.2.6 Navigational Safety

- To ensure safe navigation during night, barges will be equipped with yellow color flash lights at the front and rear of the barge according to international standard
- Buoys with yellow flashing lights will be placed to mark the area of dumping to prevent the fishing boats etc. to enter the dumping area.

#### 2.4.2.7 Provision of Silt Barrier

- Careful consideration will be given to the potential adverse effects of dredging on the immediate environment, in order to minimize these effects in line with the recommendations of this EIA guidelines and PME



- Purpose made floating silt barrier (see appendix 9 sketch INT-004 and related photos) will be installed near to the dredging area, against the wind direction to prevent the possible movement and deposition of fine sediments into the intake area as well as over the existing coral formation in the vicinity. The location of silt barrier can be shifted or extended according to the changes in the wind direction

#### **2.4.3 Method Statement for Placing of Concrete Underwater**

This statement described the method to be adopted for underwater concreting in the intake and discharge channel areas. Underwater concreting is necessary to place the blinding concrete where the precast bell mouths will be seated. Underwater tremmie concreting also plugs the gap between the precast lower headwall base slab and the precast apron slabs. Mass concrete fill inside the bell mouths is also placed by means of tremmie, as is the concrete locating the accropodes in the toe trench.

##### 2.4.3.1 Equipment Resources

- |                      |          |
|----------------------|----------|
| a. Transit Mixer     | : 3 nos. |
| b. Concrete Pump     | : 1 no.  |
| c. Tremmie Equipment | : 1 no.  |
| d. Crane Barge       | : 1 no.  |
| e. Deck Barge        | : 1 no.  |
| f. Tug Boat          | : 2 nos. |

##### 2.4.3.2 Manpower Resources

- Marine Civil Engineer
- Marine Foreman
- Concrete Pump Operator
- Transit Mixer Operator
- Divers
- Floating Crane Operator
- Tug Boat Operator

##### 2.4.3.3 Methodology

- Before the concreting operations start, the divers will check the dimensions of the trench, formworks etc. to ensure that they conform to the approved drawings
- The concrete will be placed by using a tremmie pipe or directly by the concrete pump, if the depth of water allows. The tremmie pipe is a 150mm diameter steel pipe with a hopper in the hopper end to receive the concrete. Its length can be adjusted to suit the location. The concrete will be pumped into a hopper, the tremmie tube immediately below the hopper shall be blocked by a sponge rubber ball or similar plug. Once the weight of the concrete in the hopper exceeds the resistance of the rubber plug, the concrete shall flow down the tremmie pipe and gently discharge into the required location. Once concreting commence great care shall be taken to ensure

that the end of the tremmie tube remains within the concrete mass already placed. See attached appendix 11 “Placing Trimmie Concrete in Trench” sketch.

- For lean concrete or thin concrete in general, the concrete will be cast in adequate number and pattern of heaps, each time repeating the starting procedure with the rubber plug. The divers will spread and finish to the required level
- The bell mouth filling (mass concrete), two tremmie pipes will be placed, one in each side of the pipe. Concrete will be placed in such a way to ascertain equal rise all over the bell mouth area. In addition, care will be carried out in the shortest possible time so as to reduce the use of retarder and plasticizer in the concrete. Minimizing the retarder/plasticizer will reduce the setting time of the concrete and thereby reduce the risk of the cement washing out from the concrete
- Divers will check the sufficient of the placed concrete & finish the final surface of the concrete. If necessary a floating barge will be used as a diving platform.

#### 2.4.3.4 Quality Control

The workability of concrete will continuously be monitored at the delivery point before casting by the Material Engineer by conducting slump tests in accordance with ASTM C-143.

The temperature of the concrete at the point of discharge will be monitored; concreting will not be carried out if the temperature is more than 32°C.

Samples for conducting tests for determining the compressive strength if concrete will be taken according to specification ACI 301 (one set of 3 cylindrical samples for every 75m<sup>3</sup> of concreting).

### **2.4.4 Method Statement for Protection of Shoreline**

#### 2.4.4.1 Material Resources

b. Geo-textile (Filter Fabric)

Unit weight 200g/m<sup>2</sup>, Alyaf non-woven geo-textile A1 series

c. Secondary Layer

The secondary layer is to consist of rocks from a minimum weight of 50kg to a maximum of 120kg (rock size d=0.30 - 0.40m) with 50% of the rocks weighing more than 80kg

d. Armoring Layer

The armoring layer is to consist of rocks from a minimum weight of 400kg to a maximum weight of 1000kg (rock size d=0.58 – 0.79kg) with 50% of the rock weighing more than 600kg

#### 2.4.4.2 Survey Works

- Qualified and experienced surveyors will carry out the setting-out and surveying
- The fill limit on the existing bed level will be marked by a minimum of two poles with red flags upon them
- The existing levels of the area are already known due to the survey carried out for the dredging works. A baseline will be set-up on shore perpendicular to the



revetment cross section at pre-determined locations at each area. The alignment will be monitored by turning 90° with a theodolite from these baselines

#### 2.4.4.3 Site Preparation for Placing

- The shore protection revetments will be constructed along the well compacted reclamations areas 4, 5 & 6 as per the attached Appendix 12 “Shore Protection Setting Out Plan” drawing ref. 80-Y-C-78300 and Appendix 13 “Shore Protection Revetment Cross Section. The site slope will be trimmed to the required slope, forming also a hard bed surface for laying and securing the filter fabric and the rock layers.

Surveyors will set-up a profile model along the slope to guide the operators from trimming the dredged fill materials. The surface of the core will be leveled properly before laying the membrane. Any protrusions, which would puncture the membrane will be removed. Excavation for trench toe will be carried out by excavator.

#### 2.4.4.4 Laying and Securing the Filter Fabric

- The width of the geo-textile filter fabric will be according to the standard width prepared by the manufacturer. The length will be variable according to the sea bottom level and top level of the shore.
- Before placing rock fill, filter fabric will be laid with one of the following recommended method by the manufacturer
  - Filter fabric in rolls are placed on improvised attachments to facilitate handling. Initial placement starts after unrolling the filter fabric from top to bottom. Bottom ends have to be secured by stones. The same to be done for points in between top and bottom end. The filter fabric cut to required length and the top end to be secured.
  - This method required pre-estimation of the length of the fabric to be placed. Each length is rolled on a 3-5m long piece of steel pipe. Pipe and filter fabric to be brought to the seabed and the same procedure as above starts bt from top to bottom.
- Adjacent rolls should be seamed or overlapped by 200-300mm as per manufacturer recommendation. Additional care should be given during the installation of the geotextile in order to avoid any damage on it. During the installation folds and wrinkles of the fabric should be avoided

#### 2.4.4.5 Placing of Secondary Layer

Immediately upon the successful installation of the geo-textile, the placing of the secondary layer will commence. This layer will be placed by both 360° excavator and loading shovel and will be lightly compacted using the excavator. Surveyor will form the profile of the revetment on the slope to indicate the thickness of the secondary layer. The rocks will be individually placed long the profile by excavator from outer line to inwards towards the core and from bottom to top so that the rocks are properly interlocked. The height of drop for stones less than 110kg should be less than 0.90m.



#### 2.4.4.6 Placing of Armoring Layer

Profile of armoring layer will be with the same method as the secondary armor. Excavator will place, with no free fall, the rocks individually inward towards the secondary armor, and from bottom to top for proper interlocking of rock pieces. The correct slope will be maintained by following the profile as given by surveyors. Rocks with one axis predominantly longer than other axis will be placed in such manner that the longer axis will be lays perpendicular to the face of the slope.

In case of soft spots areas on the bottom of the trench toe, an armoring layer of 4 rocks wide will be applied over the secondary layer to form the toe.

#### 2.4.5 *Disposal Site Designation and Evaluation*

This section highlighted the requirements of PME as follows:

- Determining the need for dumping at the disposal site
- Designating the main site proposed for disposing of excavated material providing that this site does not lead to unacceptable damage to the environment
- Locating other sites which could be designated for disposal and the feasibility of dumping at each location will be studied
- Determining the final status of the disposal site upon completion of the site evaluation and designation study

##### 2.4.5.1 The Need for a Disposal Site

Current construction by Saudi Archirodon at the site includes the excavation and dredging of the intake and the discharge channels at a jetty area for the new extension plant. Approximately the volume of dredged material to be disposed to 3 different usages is as follows:

- Inland Reclamation usage of approx. 150,000m<sup>3</sup> (see Appendix 10 “Overall site facility layout” drawing no. SHA/89/M/A00-/GA/003)
- Onshore usage of approx 120,000m<sup>3</sup> for embankment of channel structure
- Offshore disposal of approx 80,000m<sup>3</sup> at designated disposal site

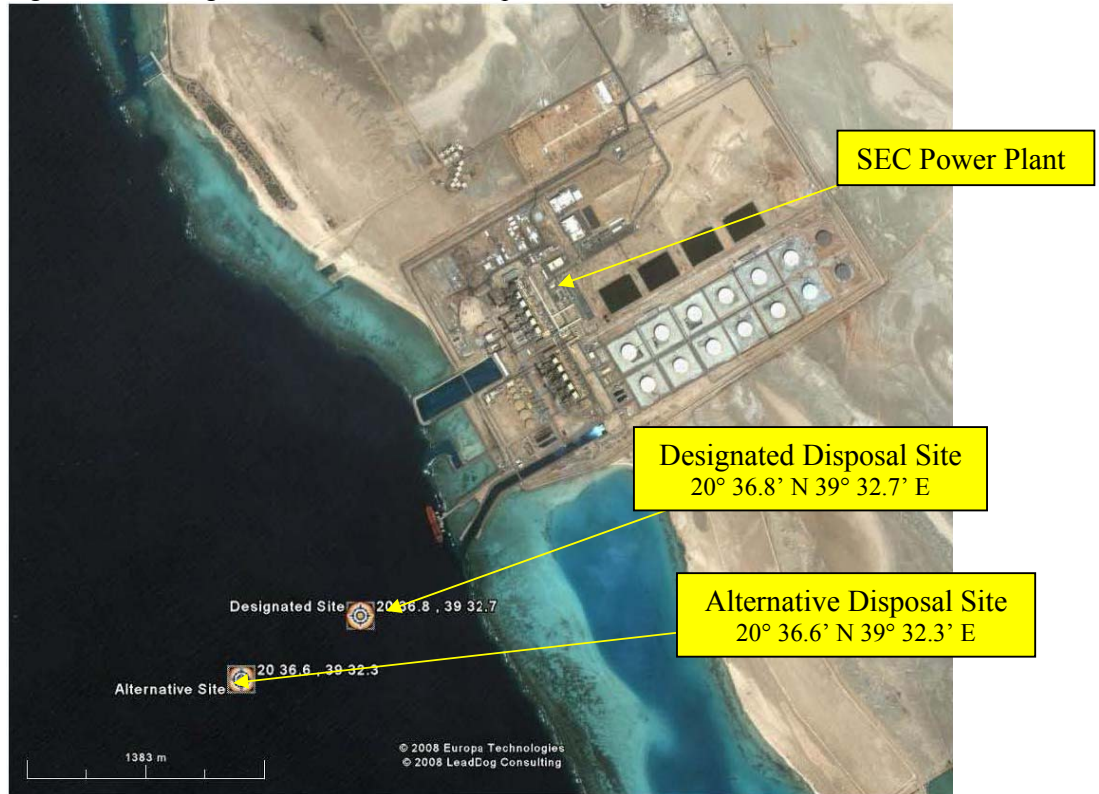
With a total of 350,000m<sup>3</sup> of dredged materials for this project, only 80,000m<sup>3</sup> will be disposed off to the sea. This small ratio of deep sea disposal is to minimize as much as possible the volume of dredged material that will be disposed offshore and eventually minimize the possible negative effect to the marine environment.

##### 2.4.5.2 Overview of the Proposed Disposal Site

The center of the designated site is located approximately 1500m offshore from the reef edge in a water depth of 70 - 100m with coordinates as shown on figure 2.4A below. Material is dumped in an area which is a 300m diameter as shown in figure 2.4A below. As the excavated material is thought to be un-contaminated the primary environmental issue

resulting from disposal is the deposition (sedimentation) of fine sediments onto adjacent coral reefs. Fine sediments are released into the water column during marine disposal and also during excavation and embankment works.

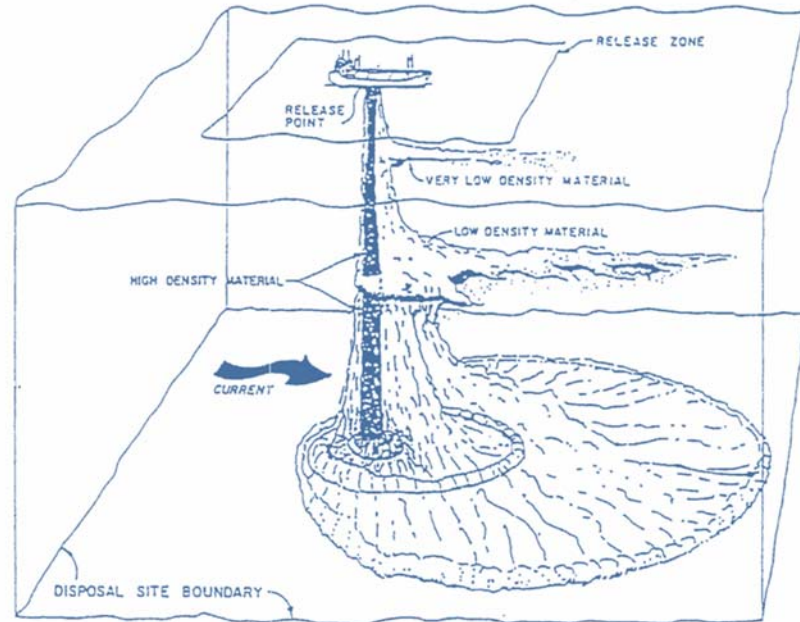
Figure 2.4A: Designated and Alternative Disposal Site



A significant fraction of the excavated materials (>98% of the material's volume) consists of large particles which settle immediately to the sea floor on disposal as shown in figure 2.4B. The disposal site has a water depth of about 120m which means that any sediment that settles and deposit during disposal will remain at this location i.e. not moved by waves or currents. Some of the fine sediments particles (silts) that are small enough to be transported by the local currents also settle as they will be aggregated with other particles of similar size of larger. The remainder of the fine sediment is transported away from the disposal site and settles gradually as shown in figure 2.4B. Local currents are predominantly to the south or south-east, so some of the transported sediment may settle on the reef in shallow areas to the south of the site.



Figure 2.4B: Releasing Dredged Material from a Bottom Release Barge



The project site located to the south of Shoaiba Desalination Plant which has been operating since 1989 with a capacity to produce 181,800 m<sup>3</sup> of fresh water per day (UNEP/PERGSA 1997). The desalination plant's discharge almost certainly contains high level of salinity, temperature and biocides that affect the local aquatic environment. The main current direction flows towards the south which would explain why the reef appears to be in better condition to the north of the desalination plant that is to the south. Pollution of this type has been documented by Aleem (1990) for the shoreline adjacent to a desalination plant located at Jeddah.

It is acknowledged that the shading of reef biological communities directly by sedimentation and indirectly by increases in turbidity can be detrimental (Rogers 1979). However, any sediments that are deposited onto the reef, can be regarded as transient as they will be re-eroded by waves during storm conditions and will then be dispersed in lower concentrations over a larger area (including deep water locations). It should be noted that the sand is naturally deposited onto the reef from land areas during offshore wind conditions.

Since the approved disposal site is located on a section of coastline that is dominated by past and ongoing negative environmental impact from industry. It is considered that the designated site is environmentally acceptable for temporary dumping during the construction of intake and discharge channel of the power plant project.

#### 2.4.5.3 Feasibility of other potential sites

An alternative disposal site is shown in figure 2.4A above. The site is located approximately 1500m offshore from the reef edge in around 90m of water and therefore it is less likely that fine sediment released during disposal will be transported over the inshore coral reef area. With a dump site further offshore the released fine sediments will be dispersed over a wider area and are likely to be advected (conveyed horizontally) into deeper less sensitive areas

where it will deposit. Disposal at the alternative site is less feasible than the designated site due to the increased distance offshore with the disposal process while take longer. As a result, there will be increased costs associated with the boat time and the related activities.

#### 2.4.5.4 Dump Site Framework

The coastline material is excavated using Saudi Archirodon's Atlantis Grab Dredger. Approximately 270,000m<sup>3</sup> of the 350,000m<sup>3</sup> of the dredged material is used for the construction of embankment and land backfilling with the remainder being disposed of at a marine disposal site. The excavated material is transported to the disposal site by bottom release barges which have a hopper capacity of approximately 500m<sup>3</sup>.

## 2.5 Alternative and Options

### 2.5.1 Selection of Dredging Methods

Dredging practices and the kind of equipments has evolved considerably in recent years to increase dredging efficiency and to minimize the potential adverse effects on the environment. To some extent the environmental effects due to the re-suspension and settlement of sediments during the excavation process can be minimized by selecting the most appropriate method of dredging. A summary of the main dredging methods and types of equipment, their potential to cause the re-suspension of sediments and how dredging equipment can be modified to improve environmental performance is shown in section 2.5.2. The characteristics of the dredging sites have a significant bearing on the type of dredger which can be used and the extent of precautions need to minimize the sediment re-suspension. Subject to appropriate modifications, most types of dredgers can be operated in a manner that does not cause excessive loss of sediment to the surrounding environment.

The type of dredgers used may not be an important consideration for all dredging operations. For example when dredging in enclosed areas, such as docks or within docks, where there is little potential for any adverse effects on the wider marine environment or in highly turbid environments where any adverse effects due to sediment re-suspension are unlikely. Consideration should be given to the type of dredger used where adverse effects on marine animals and/or plants due to suspended solids have been predicted and cannot be avoided by careful programming of the timing of the dredging works. Assessments on the most suitable dredger to be used must be made on a case by case basis, giving consideration to both practical and economic considerations. The type of dredger employed is often determined by the depth of water, scale of the maintenance operations, the type of material to be dredged, and can be a question of meeting the supply and demand equation.

Protective silt curtains or screens can be used with certain dredging equipment (grab and backhoe dredgers) in order to decrease the amount suspended sediment being transported outside the dredging area or can be placed around sensitive marine areas. The use of silt curtains is reported to considerably reduce the loss of suspended sediments from the dredge area, by up to 75% where current velocities are very low. However they are generally ineffective in areas with high wave action and current velocities which exceed 0.5 m/s.

Over the recent years, certain dredging methods have been used in ports and harbors, such as Water Injection dredging or sea bed leveling (section 2.5.2). These methods operate by moving material from one place to another along the seabed and as long as sediments are not



raised from the surface of the water, there are no disposals of these materials to speak of takes place. Although the aim of these methods is to keep sediments in the same vicinity of the seabed, there is potential for increased suspended sediments to occur possibly causing disturbance to marine animals and plants, especially where sediments are contaminated. Another kind of dredging is the Agitation dredging, which encompasses a number of different techniques. Unlike other types of dredging, as its name implies, agitation dredging aims to disturb sediments and raise them into suspension in order to move materials through the water column. It is therefore inevitable that there will be greater increases in suspended solids and siltation levels, and subsequently the magnitude and the extent of impacts on the natural habitat of the site may possibly be great, although the impact may remain within the range of natural variation, depending on the local conditions at the site.

As with other types of dredging, these above mentioned dredging methods are used in areas with high background levels of suspended sediments, there is unlikely to be a major problem,, however in other areas extra caution is required particularly with regard to agitation dredging. Although, it should be noted that the amounts of material redistributed during agitation dredging may not be more than what normally occurs during a natural phenomena, such as storm events.

When these dredging methods are proposed within a harbor area, either by the port themselves or by a third party, consideration by the port authority should be given to the potential effects on activities on safe navigation and the potential of effects on designated sensitive marine features. This should be based on information provided by those who are proposing to undertake the dredging activities, these information could including answers to questions such as, where, when, over what area, how much material, and how often? When considering whether there are likely to be any effects on the communities of the designated sensitive features of a particular site, ports and harbors authorities may consult with the country conservation agencies for advice. Any identified effects of the proposed activities on designated features should be addressed and a proposal to minimize by careful and planning operation of the dredging to avoid any particularly sensitive areas.

### **2.5.2 A summary of main dredging methods/types**

#### **a. Grab Dredgers**

Grab dredgers are a relatively simple method of dredging operation which involves the collection of sediments in a crane mounted bucket, the jaws of which are opened and closed (rope operated or hydraulically) like a clamshell trapping sediments. There are various grab buckets designed for different types of material, such as mud grab, sand grab and the heavy digging grab. The upper structures of the conventional grab buckets are open, and if they are overfilled, which is a common occurrence, sediments spill out of the bucket as it is raised through the water column. Suspended sediments are also released from the impact of the grab on the bottom, pulling the grab out of the sediments, seepage from grabs and from overflow of barges or hoppers.

Specially designed grabs are available with a closed plated upper structure which reduces spillage by over-topping, however whilst they appear to reduce suspended sediment levels in the upper water column, there is evidence to suggest that they may increase the levels of suspended sediments near the bottom. When dredging thin layers of sediment, for example to

remove a thin layer of contaminated sediments, the closing arc of a conventional grab may cause over-dredging which can be avoided by using a ‘cable arm grab’ which closes horizontally.



#### **b. Backhoe Dredgers**

Backhoes are shore-based or pontoon mounted ‘diggers’ which can be used in marine environments. Especially where ground conditions are difficult, such as shallow waters and confined spaces. Suspended solids can be released into the water column during excavation of the sediments, as the bucket is raised and lowered to the seabed, and from the overflow of barges. Suspended solid levels generated during this activity are likely to be similar to those generated using grab dredgers. This method of dredging is highly accurate and may be of particular benefit when working on environmentally sensitive areas or contaminated sediments.



#### **c. Trailing Suction Hopper Dredgers**

The trailing suction hopper dredger or ‘trailer’ is commonly used for maintenance dredging in coastal areas. As the ship moves slowly, sediments from the seabed are pumped through trailing drag heads into a hopper (reception tank). Suspended sediments can be generated as the drag head moves over the seabed, as well as from various other operating activities from the ship, although the largest contribution of suspended sediments arises from overflow during loading. Trailer dredgers can be used for maintenance dredging in environmentally

sensitive area if special care is taken. Certain modifications can be made to equipment to minimize the release of suspended solids including:

- use of special drag heads which minimize sediment suspension,
- reduced trailing speed,
- increased under keel clearance to minimize propeller scour,
- use of degassing to maximize pump performance in areas with organic materials,
- use of underwater pumps to maximize solid concentration, and
- avoid using drag-head water jets.



#### **d. Water Injection Dredging**

Water injection 'jetsed' is relatively new method of dredging which operates by injecting water into certain fine-grained sea bed materials, reducing their density to the point where they act as a fluid and flow over the bed through the action of the gravity to lower levels. The aim of this type of dredging is to not raise the sediments into the water column, and if properly applied the environmental affects due to suspended solids are restricted to the dredging vicinity of the seabed and reduced to a minimum level. However, some re-suspension of sediments can occur using this equipment, intentionally or otherwise.

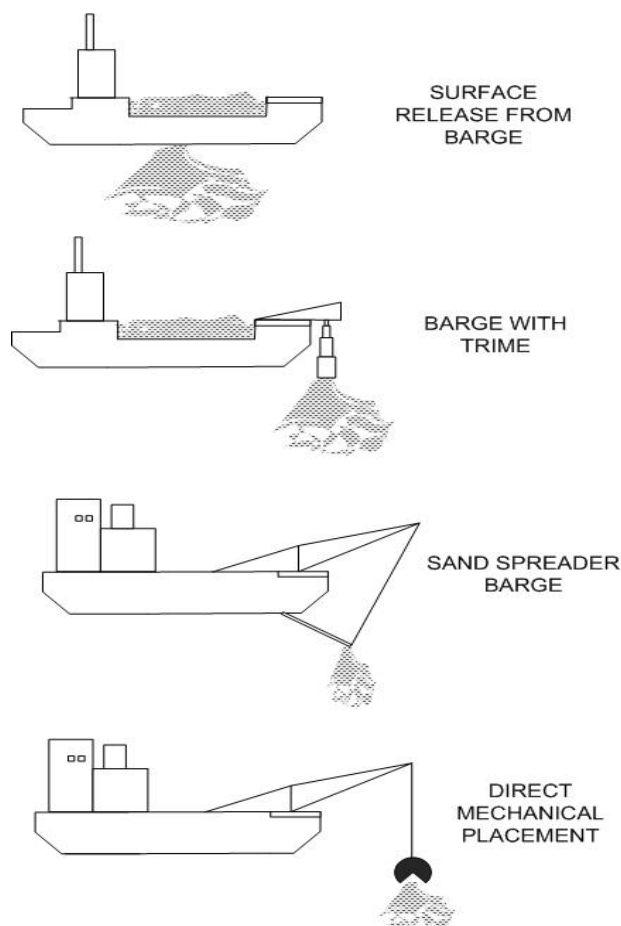


### 2.5.3 Overview of Disposal Equipment and Technique

A variety of equipment types and techniques have been used for disposal of dredged materials. Conceptual illustrations of equipment which can be considered for capping are shown in Figure 2.5A.

Considerations that can influence equipment selection include water depths and wave/current conditions. Other site conditions such as bottom topography, other vessel traffic, thermal/salinity stratification of the water columns (for deep water sites), etc. may also have an influence. Pipeline and barge placement of dredged material is appropriate in more open areas such as harbors or wide rivers. In constricted areas, narrow channels, or shallow near shore areas, conventional land-based construction equipment may also be considered.

**Figure 2.5A. Conceptual illustrations of equipment and technique which can be considered for disposal**



Potential re-suspension of contaminated material by impact of dredged material should be considered in selecting equipment and placement technique.

## 2.5.4 Proposed Main Equipment for the Project

### 2.5.4.1 Grab Dredger (Atlantis)



- Heavy-duty rock grab dredger, capable of digging to a depth of 60m
- Highly automated electronic control system to ensure high efficiency in the dredging and loading cycle
- Rapid conversion to heavy-duty crane barge of 110 tons capacity

#### Specification

Year of Construction	: 1977
Built by	: Kobe Steel Japan/ Model GE 1100
Gross Tonnage	: 1,243 tons
Length Overall	: 48.0 m
Breadth	: 20.0 m
Depth molded	: 3.6 m
Draught molded	: 2.2 m
Installed power	: 3,000HP (diesel-electric)
Hosting load	: 110 tons
Operating radius	: 18 m
Grab bucket medium	: 23 cu.yd. struck capacity/60t bucket weight
Grab bucket heavy-duty	: 12.53 cu.yd. struck capacity/85t bucket weight
Hoisting x lowering speed	: 40 m/min x 55 m/min
Classification	: B.V.

#### 2.5.4.2 Split Barge



#### **Specification**

Name	: Nausika C-402
Type of Vessel	: Split Barge
Length (overall)	: 44.0 m
Breadth	: 11.0 m
Depth (molded)	: 3.6 m
Gross tonnage	: 449 tons
Net tonnage	: 134 tons
Built by	: Scheepswerft, Netherland
Year	: 1977
Flag	: St. Vincent & the Grenadines
Port of Registry	: Kingstown
Official No.	: 7204
Call Sign	: J8SA6
Hopper Capacity	: 500 m <sup>3</sup>
Maximum load	: 1000 tons
Closing & Opening time	: ± 3.15 minutes



#### 2.5.4.3 Tug Boat



#### **Specification**

Name	: Achilles
Year of Construction	: 1982
Built by	: Astilleros Glinos S.A., Piraeus Greece
Length (overall)	: 18.5 m
Breadth	: 5.7 m
Depth	: 2.7 m
Draught minimum	: 1.6 m
Speed	: 11 knots (20.4 kph)
Bollard pull	: 7.63 T
Gross / Net tonnage	: 65.87 T / 19.76 T
Propelling power	: 2 x 550 BHP
Classification	: Hellenic Register of Shipping
Fuel Capacity	: 30 tons
Water Capacity	: 15 tons
Equipment Special	: Kort Nozzles, Anchor Handling Winch/5t, Generator, Radar, VHF. Compass, Rubber Push Bow



### **3.0 Natural Environmental Conditions**

#### **3.1 Red Sea Overview**

The Red Sea is 1932 km long with an average width 280 km and an average depth 491m. The maximum depth recorded in the Red Sea is 2850m. The total surface area is 450,000 square kilometers. The Red Sea is a relatively young ocean and is unique among the seas of the world. It has not many permanent streams flow into it. Average rainfall in the coastal area is very low, less than 70 mm/yr along the broad coastal Tihama, 16 mm/yr at Al Wejh, 63 mm/yr at Jeddah and Jizan (MEPA/IUCN, 1987). As the climate is extremely arid, much of Saudi Arabia's biological productivity is confined to a narrow coastal strip and originate mostly from habitats such as coral reefs, mangrove and sea grass communities found in shallow embayment. An extensive survey on Saudi Arabian coastal resources has been conducted by MEPA, in collaboration with the World Conservation Union (IUCN).

Red Sea was established as a distinct trough in the Oligocene, about 38 million years ago. It has a range of climatic conditions. Rainfall is very irregular. Mostly north westerly wind and occasional rain-torrents contribute terrigenous sediments. The arid climate makes the aeolian and biogenic materials form a significant contribution to the marine realm. It's nearly 2000 km of navigable waters connected in the south with the Indian Ocean and very nearly joins the Mediterranean Sea at the north of the Gulf of Suez. The narrow southern strait of Bab al Mandab marks the boundary between the Red Sea and the Gulf of Aden.

#### **3.2 Site Topography and Bathymetry**

The Shoaiba plant site is a relatively flat coastal desert plain, with little or no vegetation and a step of 1 to 2m from the shoreline. The main coastal characteristic is the presence of the coral reef immediately offshore, extending for a distance of 400-600m from the shoreline, whose depth is extremely variable from 0.2m near shore to more than 1.5m near the reef face with respect to the mean sea level.

The tide in the Red Sea is not affected by the Indian Ocean, so only a local oscillatory tide, of semi-diurnal type is developed with not large amplitude. Accounting for the tidal effect, the sea levels at Shoaiba site, with respect to the absolute reference level assumed as the zero level (TSS) are in range from +3.00m (HHWL) to +1.92m (LLHL), with a mean sea level (MSL) of +2.35m

The bathymetry for the shoreline at the project site is typical of that for fringing coral reefs in the Red Sea. The reef back has a width of between 300 to 500m and is very shallow with depths of less than 2m. The reef slope is fairly steep and depths of 50m are reached in distance of between 300 and 700m from the reef edge. The designated site is located in a hollow where depths exceed 120m. For full profile of the site, please refer to Bathymetric Map Appendix 14 "Red Sea Saudi Arabian Coast"



Figure: Red Sea Bathymetric Map



### 3.3 Site Climate and Weather Record

#### 3.3.1 Overview

The west coast of Saudi Arabia is a hot and arid region. In general the sky is clear, or lightly clouded. Average air pressure shows seasonal trends, being at a maximum in January, and a minimum in July. Rainfall is very scarce with mean annual amount of 25.7mm, the wettest months being November and December, most precipitating in one or two days. Fog is very rare, but visibility of less than 100m is common due to dust or sandstorms, and is occasionally reduced to less than 100m in July.

Other summary climatic data as follows:

- Minimum/maximum relative humidity : 3/100%
- Maximum wind speed : 26 m/s (northerly)
- Minimum/maximum monthly precipitation : 0/18.3mm
- Extreme 24hrs. maximum rainfall : 51.5mm
- Maximum month days with thunder : 1.6 November
- Maximum month days with rain : 2.9 November
- Maximum month days with mist : 3.6 September
- Maximum months days with fog : 0.8 September

#### 3.3.2 Climatic Condition

Temperature in the Kingdom differs widely from one season to another. The most moderate season in the Kingdom is spring (March, April and May) and autumn (September, October and November). These periods enjoy relatively cool nights and warm, sunny days.

Sudden changes in temperature are often associated with changes in wind characteristics. Southerly winds, such as Khamsin from North Africa, tend to bring a rise in temperature followed by a rapid fall caused by the subsequent up-welling of the Red Sea along the south west coast. At such times high relative humidity is recorded.

The predominant wind direction is northerly in the months of November to June and westerly from July to October. Mean wind speeds are 6 to 8 knots with little variation between months. The highest monthly average maximum occurs in March (46 knots) and the lowest monthly average maximum occurs in July and September (26 knots). Again, data is taken from PME records for 1996 to 2005.

Sand storms can occur at any time of the year but are more likely during the summer months. Dust and sand storms occur on average 6 days a year. However, due to strong winds, airborne dust is to be expected to occur on average 81 days a year.

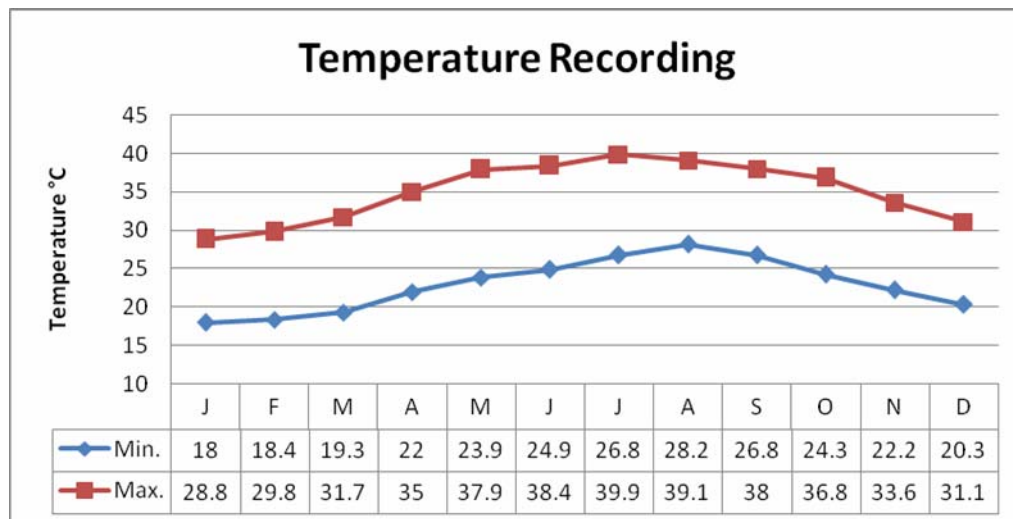


Table 3.3.A: “Temperature Recording” shows the average maximum and minimum temperature in Jeddah  
(source; PME – 1996 to 2005 for station at KAIA - PME Station Reference No. 41024).

### 3.3.3 Wind Speed

Between the latitude of 20 and 22°N the records shows that in the summer, 80% of the winds are 6.5m/s or less. Wind category (Force 5) is reached by about 15% of the winds during the winter and less in other months. Winds from the N-NE and SE are more frequent between November and February than in other months. From May to September the direction 270°N and 300°N occur more frequently than in other months.

Table 3.3.3.A: Design Value of Extreme Wind Speeds near Shoaiba (m/s)

Return Period	Wind Direction (°N)							
	150	180	210	240	270	300	330	All
Year	150	180	210	240	270	300	330	All
10	17.5	17.5	13.0	13.0	12.9	17.5	19.5	21.6
50	19.0	19.0	14.5	14.5	13.9	18.5	20.6	23.1
100	20.1	20.0	15.0	15.0	14.4	19.0	21.1	23.7
500	21.6	22.0	16.5	16.5	15.9	20.6	22.1	25.2

### 3.3.4 Air Quality

Air quality baseline data in the vicinity of the project has been collected at the Royal Saudi Navy Base since February 1998. The data indicates that Jeddah’s Station registered one exceeding level of the PME’s one hour hydrogen sulphide standard of 0.140 ppm and one exceeding of the one hour sulphur dioxide standard of 0.28 ppm. In 1998 there were two exceeding of the one hour hydrogen sulphide standard. Meteorological conditions in Jeddah are generally favorable for effective air dispersion with a monthly mean wind speed greater than 4 m/s, turbulent coastal wind flows, infrequent inversion and dispersion coastal sea breezes.

Values of the air pollution determinants are generally on average well below PME’s standards. When elevated levels have been experienced they were attributed to the emissions from Power and



Desalination Plant and the industrial estates of Jeddah. In general, air quality at the site appears to be normal, due to the lack of pollution sources and the prevailing sea breezes.

### **3.4 Marine Physical information including current, waves and tides**

#### **3.4.1 Water Levels and Tides**

The circulation in the Red Sea is predominantly wind driven. The northerly wind drives surface water south for about four months during the summer at a velocity of 12-50  $\text{cm s}^{-1}$  while in the winter flow is reversed, with water entering the Red Sea through the strait of Bab Al Mandab from the Gulf of Aden. The water balance in the Red Sea is negative in the sense that the annual precipitation is 10mm, while the evaporation is about 2m  $\text{year}^{-1}$ . The balance is made up by the winter flow entering the Red Sea as it is greater than the summer outflow (UNEP/PERGSA)

The tide in the Red Sea is semidiurnal and the mean range in increases from an amphidrome located near Jeddah to 1.7m in the Gulf of Aden. The Mean Sea Level (MSL) in late summer is between 0.3m to 0.5m lower than in the winter due to seasonal differential evaporation of the Red Sea and the prevailing regional atmospheric and associated wind conditions. The maximum seasonal variations of MSL are +0.23 in December, and -0.38 in August.

#### **3.4.2 Currents**

The main water direction in the Jeddah Area is towards the south east. The direction, however, is not consistent. South east currents exist for approximately 60% of the time. These observations, made generally from vessels in the area, may not be fully representative of near shore currents. Regional winds, local winds, and sea bed morphology conditions in the Red Sea variable surface flows. As tidal currents are so low, these variable flows are relatively significant. In general at offshore locations, a SSE flow prevails from March to October (7 months) and NNW drifts from October to March (5 months). The former reaches over 10  $\text{cm/s}$  and the later generally below 5  $\text{cm/s}$ .

Current measurements at the project site have been undertaken by the Client, these measurements shows that the current were typically lower than 0.1  $\text{ms}^{-1}$  but the maximum value was greater than 0.25 $\text{ms}^{-1}$ . The current were mainly shore parallel and were prone to reversal with the dominant directions being 330 and 150°N. The results indicated that the tidal component only represents a small part of the total current and that the currents are mainly influenced by meteorological factor (wind). The most dominant flow during the study was towards the NW which is at odds to the prevailing wind direction. This highlights the variable nature of current in the Red Sea especially inshore.

#### **3.4.3 Waves**

Storm winds of 17.5  $\text{m/s}$  or greater occur on average less than 4 days/year and during these periods the significant offshore wave height (average of the upper thirds of all observed waves) of 5m can be build up. This means that maximum wave height of 8m can occur. For the Red Sea north of 20°N, waves higher than 5m can occur in January, February and March during 0.1% of the time i.e. 8 hours a month. Wave heights of 3.5 to 4.5m can occur throughout the year, with the highest frequency in March of 1%, i.e. 3 days (SWCC 1996).



### 3.5 Water Quality Information

#### 3.5.1 Temperature and Salinity

The monthly average sea water temperature in the Jeddah Area varies from about 25°C in February to about 31°C in September. The extreme surface water temperature in open seas is 19°C in January and February, and more than 34°C in July to September. Shallow water in the vicinity of the fringing reefs often has temperature between 1.5 and 2.0°C higher than surrounding deeper waters. Temperature stratification is generally absent in the area, mainly due to surface mixing by waves and wind drift current, and the absence of significant fresh water inflows (SWCC 1996).

The salinity of the Red Sea near Jeddah varies only slightly over the year, with means of about 38.5‰ in the winter and 39.8‰ in summer, without rapid change between the two seasons.

#### 3.5.2 Dissolved Oxygen and Nutrients

The measured dissolved oxygen concentration on the surface water of the Red Sea is near saturation level (UNEP/PERGSA, 1997). The saturation values are in the range 4.8 to 6.5 ml of oxygen per litre depending on temperature and salinity values. The saturated layer extends to about 100m. Below 100m in the Red Sea, the dissolved oxygen concentration values drop to only 10-25% saturation levels.

#### 3.5.3 Analysis of Seawater Samples

In order to have a baseline data of seawater within the project's site, three (3) sampling locations were identified by MTEV with coordinated (N1400, E800), (N1200, E400), (N1800, E2000) and water samples and analysis was conducted by SARCO through RGF on January 7, 2009. The laboratory chemical analysis of the seawater is as follows:

**Table 3.5.3A (Seawater Chemical Analysis No.1)**

Project		Shoaiba Steam Power Plant Extension Stage III		
Sample Location		N-1400,000, E 800.000		
RGF Lab. Ref. no.		CHJ-08/144 (SW)	Date of Report: 07Jan2009	
No.	Chemical Test	Result	Unit	Standard
1	Temperature	--	°C	2550-B
2	Dissolved Oxygen	6.50	mg/l	4500-O-C
3	pH at 25°C	8.11	--	4500-HB
4	Salinity	42.000	ppt	2540-C
5	Turbidity	1.30	N.T.U.	2130-B
6	Total Suspended Solids	1.80	mg/l	2540-D
7	Bio-chemical Oxygen Demand	11.50	mg/l	5210-B
8	Chemical Oxygen Demand	36.0	mg/l	5220-B
9	Total Coliform	None Isolated	Nos/100ml	9221-B&C
10	Total Petroleum Hydrocarbon	<0.1	mg/l	D-3921
11	Ammonium (NH <sub>4</sub> )	0.20	mg/l	4500-NH <sub>4</sub> -C



METALS				
12	Arsenic (AS)	N.D. < 0.05	mg/l	3113-B
13	Mercury (Hg)	N.D. <0.001	mg/l	3112-B
14	Cadmium (Cd)	<0.01	mg/l	3111-B
15	Copper (Cu)	<0.05	mg/l	3111-B
16	Lead (Pb)	<0.05	mg/l	3111-B
N.D. not detected				
The test was conducted by the standards method for examination of water and waste water APHA, AWWA, WPCF (17 <sup>th</sup> Edition) and ASTM				

**Table 3.5.3B (Seawater Chemical Analysis No.2)**

Project		Shoaiba Steam Power Plant Extension Stage III		
Sample Location		N-1200,000, E 400.000		
RGF Lab. Ref. no.		CHJ-08/144 (SW)	Date of Report: 07Jan2009	
No.	Chemical Test	Result	Unit	Standard
1	Temperature	--	°C	2550-B
2	Dissolved Oxygen	6.70	mg/l	4500-O-C
3	pH at 25°C	8.07	--	4500-HB
4	Salinity	42.500	ppt	2540-C
5	Turbidity	1.15	N.T.U.	2130-B
6	Total Suspended Solids	1.85	mg/l	2540-D
7	Bio-chemical Oxygen Demand	12.0	mg/l	5210-B
8	Chemical Oxygen Demand	37.0	mg/l	5220-B
9	Total Coliform	None Isolated	Nos/100ml	9221-B&C
10	Total Petroleum Hydrocarbon	<0.1	mg/l	D-3921
11	Ammonium (NH <sub>4</sub> )	0.15	mg/l	4500-NH <sub>4</sub> -C
METALS				
12	Arsenic (AS)	N.D. < 0.05	mg/l	3113-B
13	Mercury (Hg)	N.D. <0.001	mg/l	3112-B
14	Cadmium (Cd)	<0.01	mg/l	3111-B
15	Copper (Cu)	<0.05	mg/l	3111-B
16	Lead (Pb)	<0.05	mg/l	3111-B
N.D. not detected				





The test was conducted by the standards method for examination of water and waste water APHA, AWWA, WPCF (17<sup>th</sup> Edition) and ASTM

**Table 3.5.3C (Seawater Chemical Analysis No.3)**

Project		Shoaiba Steam Power Plant Extension Stage III		
Sample Location		N-1800,000, E 200.000		
RGF Lab. Ref. no.		CHJ-08/144 (SW)	Date of Report: 07Jan2009	
No.	Chemical Test	Result	Unit	Standard
1	Temperature	--	°C	2550-B
2	Dissolved Oxygen	6.50	mg/l	4500-O-C
3	pH at 25°C	8.13	--	4500-HB
4	Salinity	42.000	ppt	2540-C
5	Turbidity	1.33	N.T.U.	2130-B
6	Total Suspended Solids	2.00	mg/l	2540-D
7	Bio-chemical Oxygen Demand	12	mg/l	5210-B
8	Chemical Oxygen Demand	37	mg/l	5220-B
9	Total Coliform	None Isolated	Nos/100ml	9221-B&C
10	Total Petroleum Hydrocarbon	<0.1	mg/l	D-3921
11	Ammonium (NH <sub>4</sub> )	0.12	mg/l	4500-NH <sub>4</sub> -C
METALS				
12	Arsenic (AS)	N.D. < 0.05	mg/l	3113-B
13	Mercury (Hg)	N.D. <0.001	mg/l	3112-B
14	Cadmium (Cd)	<0.01	mg/l	3111-B
15	Copper (Cu)	<0.05	mg/l	3111-B
16	Lead (Pb)	<0.05	mg/l	3111-B
N.D. not detected				
The test was conducted by the standards method for examination of water and waste water APHA, AWWA, WPCF (17 <sup>th</sup> Edition) and ASTM				

### 3.6 General Geology and Sediment Transport in the Area

The shoreline at Shoaiba is backed by wide areas of flat coastal plains. Some of the shoreline consists of mainly cap rock which is not covered by sediment with the remainder consisting of sandy beach. Inorganic (plastics) and organic (dead seaweeds, wood) is commonly found fringing the shoreline.



Coastal structure in the area e.g. Desalination Plant outflow, shows no sign of littoral drift material on either side and hence either the transport rate or availability of sediments has to be low. The reef back, consisting of coral rock, little sediments is found due to permanent wave action. Only in deep levels and caverns on the coral rock coarse sediments are found, indicating that some littoral transport takes place there, mainly during large waves conditions.

Offshore of the reef face, the whole seabed is covered with coral and shell debris of varying size, being coarser at the sloped foot of the reef, where large coral branches are lying. Sediments in water depth of up to 20m can be moved during storm conditions with large waves.

Surface waters in the area have very low suspended sediment concentrations during normal meteorological conditions. With increased storm, bed sediments in crevasses on the reefs, and in the shallower portion of the channel may be temporarily suspended and transported. Offshore winds in excess of 3.25m/s will transport sand from the onshore area towards the reef, this sand will then settle on the reef.

Chemical Analysis of sediments was conducted by RGF on January 20, 2009 in the three selected areas around the project site as follows:

**Table 3.6A: Chemical Analysis of Sediment No.1**

Project		Shoaiba Steam Power Plant Extension Stage III		
Sample Location		N-1440,000, E 800,000 (depth = 1.0m)		
RGF Lab. Ref. no.		CHJ-08/144 (sediments)	Date of Report: 20Jan2009	
No.	Chemical Test	Result	Unit	Standard
1	Volatile Solids	4.25	%	ASTM 3976
2	Chemical Oxygen Demand (COD)	360	ppm	5220-B
3	Total Kjeldhal Nitrogen (TKN)	17.2	ppm	4500-N-B
4	Oil & Grease	0.60	ppm	5520-B
5	Mercury (Hg)	<0.001	ppm	3112-B
6	Lead (Pb)	0.03	ppm	3111-B
7	Zinc (Zn)	0.21	ppm	3111-B
8	Arsenic (As)	<0.10	ppm	3113-B
9	Cadmium (Cd)	<0.10	ppm	3111-B
10	Chromium (Cr)	<0.10	ppm	3111-B
11	Copper (Cu)	0.30	ppm	3111-B
12	Nickel (Ni)	<0.10	ppm	3111-B
N.D. not detected				
The test was conducted by the standards method for examination of water and waste water APHA, AWWA, WPCF (17 <sup>th</sup> Edition) and ASTM				



**Table 3.6B: Chemical Analysis of Sediment No.2**

Project		Shoaiba Steam Power Plant Extension Stage III		
Sample Location		N-1200,000, E 400,000 (depth = 1.5m)		
RGF Lab. Ref. no.		CHJ-08/144 (sediments)	Date of Report: 20Jan2009	
No.	Chemical Test	Result	Unit	Standard
1	Volatile Solids	2.48	%	ASTM 3976
2	Chemical Oxygen Demand (COD)	148	ppm	5220-B
3	Total Kjeldhal Nitrogen (TKN)	12	ppm	4500-N-B
4	Oil & Grease	0.03	ppm	5520-B
5	Mercury (Hg)	<0.001	ppm	3112-B
6	Lead (Pb)	0.06	ppm	3111-B
7	Zinc (Zn)	0.14	ppm	3111-B
8	Arsenic (As)	<0.01	ppm	3113-B
9	Cadmium (Cd)	<0.10	ppm	3111-B
10	Chromium (Cr)	<0.10	ppm	3111-B
11	Copper (Cu)	0.12	ppm	3111-B
12	Nickel (Ni)	<0.10	ppm	3111-B
N.D. not detected				
The test was conducted by the standards method for examination of water and waste water APHA, AWWA, WPCF (17 <sup>th</sup> Edition) and ASTM				

**Table 3.6C: Chemical Analysis of Sediment No.3**

Project		Shoaiba Steam Power Plant Extension Stage III		
Sample Location		N-1800,000, E 200,000 (depth = 1.0m)		
RGF Lab. Ref. no.		CHJ-08/144 (sediments)	Date of Report: 20Jan2009	
No.	Chemical Test	Result	Unit	Standard
1	Volatile Solids	4.81	%	ASTM 3976
2	Chemical Oxygen Demand (COD)	384	ppm	5220-B
3	Total Kjeldhal Nitrogen (TKN)	28.0	ppm	4500-N-B
4	Oil & Grease	0.80	ppm	5520-B
5	Mercury (Hg)	<0.001	ppm	3112-B
6	Lead (Pb)	1.40	ppm	3111-B
7	Zinc (Zn)	6.0	ppm	3111-B
8	Arsenic (As)	1.08	ppm	3113-B

9	Cadmium (Cd)	0.34	ppm	3111-B
10	Chromium (Cr)	<0.10	ppm	3111-B
11	Copper (Cu)	4.0	ppm	3111-B
12	Nickel (Ni)	1.30	ppm	3111-B
N.D. not detected				
The test was conducted by the standards method for examination of water and waste water APHA, AWWA, WPCF (17 <sup>th</sup> Edition) and ASTM				

### 3.7 Biological Environment

#### 3.7.1 Coral Reef

It should be note that coral reefs play an important role in the coastal ecosystem and provide the habitat for a wide variety of marine species and plant. In the Red Sea, coral reef communities generally form extensive and productive reef flats which create protected areas for many juvenile species as well as lagoons which also serve this purpose.

Bleaching of coral reefs due to high sea temperatures occurred during 1998 which resulted in high mortality, particularly near Rabigh where bleaching killed 65% of coral . Significant levels of coral mortality were observed along the southern Red Sea where some sites (e.g. Abalat Islands) where live coral declined from 80% in 1993 to 10% in 1999. Mean monthly temperatures were found to be unusually high (>32 Centigrade) in the 3 months prior to the first reports of coral mortality.



Coral reefs are tropical and sub-tropical of shallow water ecosystems. These ecosystems consist principally of hard floor, typically carbonate rock, where corals are prominent. Growth of corals requires clear, warm, aerated and nutrient-rich conditions. It produces a coastal barrier against wave action and erosion and which are a potential tourist attraction. Some living resources have direct commercial value, e.g. certain fishes and shellfish. Both pelagic and shallow reef-associated fish which form the major part of existing fisheries are at risk from coastal and offshore contaminants. The area supports resident and breeding populations of waders, terns and boobies and at least in the northern parts, is the



migration route of many species. The susceptibility of the communities to pollutant may vary with the geographical location within the Red Sea.

Coral reefs offer many environmental benefits; their structure allows them to withstand and dissipate



strong wave action, thus protecting land, island and beaches from wave damage and shoreline erosion., coral reefs are important in food production. They provide habitat for animals and plants thereby accumulating nutrients for rather complex food webs. Fish, invertebrates and other animals are collected directly from the reefs for human consumption and finally there are some medicinal drug and marine natural products being produced from coral reef organisms.

Coral reefs are sensitive biological systems that are threatened by human activities and are therefore more threatened by the high population density in coastal areas. Coral reefs can also be damaged by development activities such as dredging and fill operation for port development and construction and operation of tourist resorts.

Due to the critical condition of many coral reef systems and their environmental and economic importance technology is available to help prevent further damage to the reefs. For example, sewage outfalls can be placed below the level of coral growth and thermal effluent can be discharged in deep water with carefully engineered diffuser systems. Projects in areas where coral reefs have been destroyed should consider the construction of artificial reefs (materials may consist of cement and stone blocks and newly developed PVC structures).

Artificial reefs quickly replace some of the important reef functions to marine life and restore beach protection (Johannes, 1967 and UNEP 1995).



**Soft Coral**

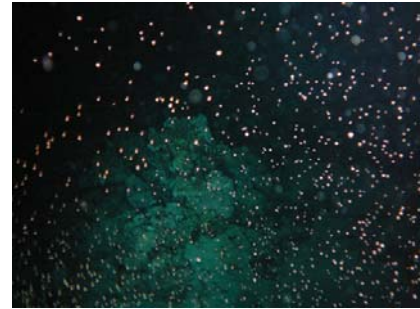
A study was done by (IUCN, 1984) which divided the coast and offshore of Jeddah islands into fourteen sectors. The coastline of Sector 8 for which the Rabigh development is part of is low-lying and dominated by coral sand and terrigenous beach sands. This part of the Red Sea coast also contains several large mersas, sharms, i.e. embayment, which support extensive sea grass beds.

### 3.7.2 Plankton and bottom Algae

High productivity in the Red Sea is limited to the shallow reef area. Virtually all shallow water life depends either directly or indirectly on localized photosynthesis. There are two main factors that limit the productivity levels. Firstly, when the reef are steep sided, this limits the area of the sea bed in the active photosynthetic zone. Secondly, the production of planktonic and benthic algae is severely

limited by the availability of nutrients. Nutrients are not effectively recycled from the bottom of the waters due to generally weak upwelling currents and a well developed thermo cline and halocline.

Nearly 500 species of algae have been recorded for the Red Sea. Most species of algal turf in the Red Sea are macroscopic, non-calcareous forms of greens, brown and reds. Two of the most common species are the brown Sphacelaria Tribuloides and Turbinaria Elantesis (Sheppard et. al, 1992). Quantities of abundant in the Gulf of Aden water in the southern Red Sea.. Summer populations were dominated by diatoms whereas dinoflagellates are found in the highest concentrations during winter.



### 3.7.3 Bottom Invertebrates

The densities of aquatic benthic macro-invertebrates are considered to be low in the Red Sea coral reef areas, and are particularly severely diminished in the shallow water coastal reef.

### 3.7.4 Shallow and Deep Water Fish

Studies of fisheries have indicated that there is a general trend for increased productivity from the north (in the Gulf of Aqaba) to the south towards the border with Yemen. Over 74% of the annual Red Sea landing comes from the southern section between Al Lith and the Yemeni border, 23% from the Al Lith to Yanbu and 3% from Yanbu to Jordanian border. Until 1981, Saudi Arabia's fishery was exploited almost exclusively by artisanal fishermen from small boats. After 1991, an industrial fishery began, which has grown to a point where the largest company, Saudi Fisheries, currently lands around 1,500 tones of shrimp and a similar amount of fin fish.

Red Sea coral reef fish include butterflyfish (Chaetodontidae), angelfish (Pomacanthidae), damselfish (Pomacentridae), surgeonfish (Acanthuridae), parrotfish (Scanrdidae), wrasse (Labridrige), emperors (Lethrinidae) and snappers (Lutjanidae).

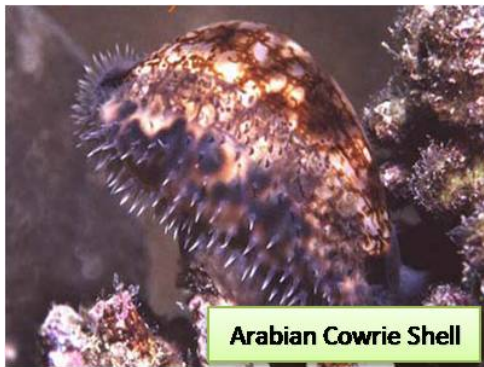




**Coral Crab**



**Arabian Doctor Fish**



**Arabian Cowrie Shell**



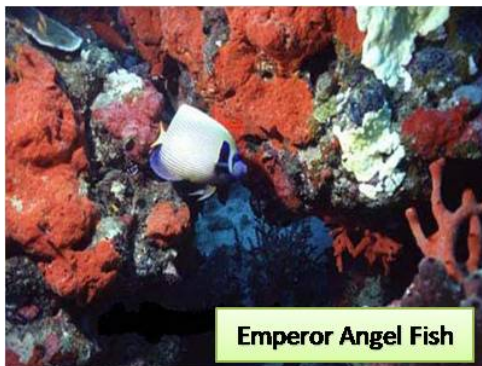
**Damsel Fish**



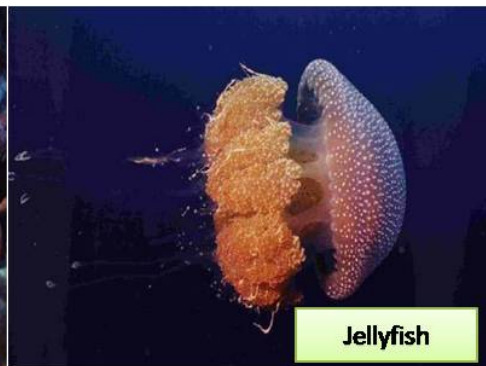
**Blue Spotted Stingray**



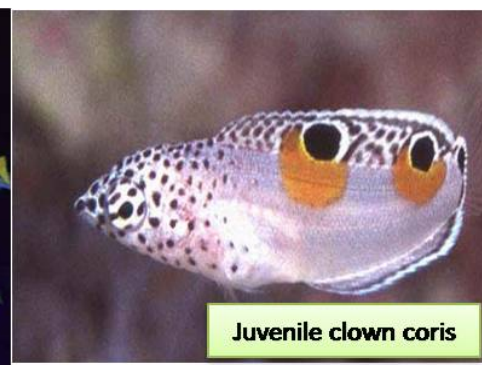
**Christmas Tree Worm**



**Emperor Angel Fish**



**Jellyfish**







**Yellow saddle goat fish**

**Emperor Angel Fish**

### 3.7.5 Coastal and Marine Birds

The Red Sea is an important region for both resident and migratory birds. Hundreds of species either breed, or use of coastal areas as a stop-over on their migrations. Wading birds are evident on the shoreline in the vicinity of the site, including flamingos.

(Sea Birds Colonies of Red Sea)



الاسم العربي: النحام الكبير  
 الاسم اللاتيني: *Phoenicopterus ruber*  
 الاسم الإنجليزي: Greater Flamingo



الاسم العربي: الغلق الكبير  
 الاسم الإنجليزي: *Phalacrocorax carbo*  
 الاسم اللاتيني: Great Cormorant



الاسم العربي: بلشون الصخور  
 الاسم اللاتيني: *Egretta gularis*  
 الاسم الإنجليزي: Reef Heron



الاسم العربي: البلشون الرمادي  
 الاسم اللاتيني: *Ardea cinerea*  
 الاسم الإنجليزي: Grey Heron

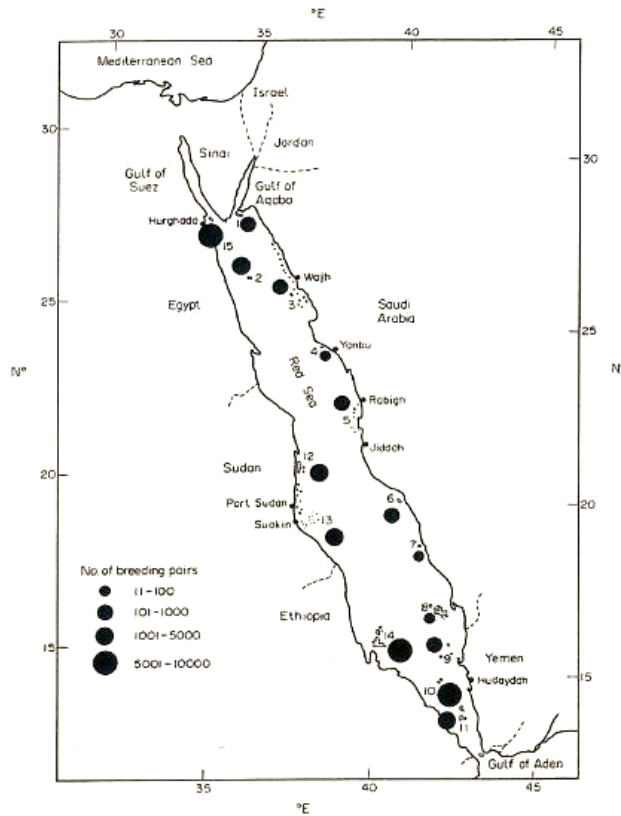


Fig. 5 . Seabird colonies of the Red Sea, amalgamating data on all breeding species, from several sources. The numbered islands are 1 – Tiran Island, 2 – Perim and Brothers Islands, 3 – Islands on the Wajh Bank, 4 – Islet north of Yanbu al Bahr, 5 – Jiddah and Rabigh, 6 – Janabiyat, 7 – Kutunbol, 8 – Farasan Islands, 9 – Islands near Al Hudaydah, 10 – Zubayr Island, 11 – Hanish Islands, 12 – Muhammad Qal and associated islands, Mukawwar, Mayetib and Taiba, 13 – Suakin Archipelago, 14 – Dahlak Archipelago, 15 – Islands near Hurgada (Mugawish, Orm Qamar, Abu Mingar and Shadwan).

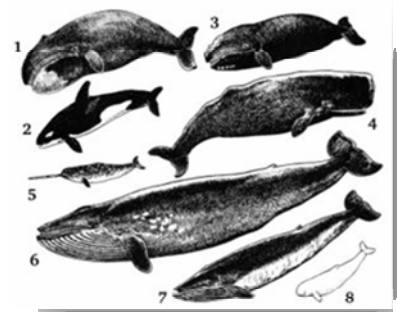
### 3.7.6 Sea Mammals

Dugongs: are not known to be common in any part of the Red Sea, which is in any case peripheral to the main distribution of the species and ecologically unsuitable over much of its coastline. The dugong is a large animal, totally aquatic, with no externally visible back legs. Adult animals may reach a length of 3 meters, weighing some 320 kg. The skin is chiefly grey in color, with scattered single hairs about 2 cm apart. Dugongs are completely restricted in diet to marine higher plants (sea grasses). The Red Sea dugong may taxonomically distinct from that of the rest of the Indo-Pacific, but the evidence is scanty. The physical features of the Red Sea are fundamental to the distribution, numbers and prospects for this rare and endangered animal. Dugongs are restricted to live in shallow silty areas where sea grasses flourish, and coral reef do not provide a favorable environment. In the largely coral-lined Red Sea, suitable shallow areas of marine vegetation are not abundant, but when occurring are generally landward of offshore reefs. Records of dugong sightings exist particularly for the better-studied areas, the Gulfs of Suez and Aqaba, the Port Sudan- Suakin area. The adjacent southern coast of Arabia has almost no record of dugongs but they do occur on the



southern shores of the Gulf of Aden and in the Arabian Gulf (Betram and Betram, 1973). There seems to be no recorded special hunting of dugongs in the Red Sea, probably because of their natural rarity.

Whales, Dolphins and Porpoises, are the most strictly aquatic of the mammals, having secondarily returned to living in the sea. Despite their relatively large size, our knowledge of cetaceans in the Red Sea is extremely fragmentary. Only seven to eight species have been recorded regularly and it is unlikely that more intensive investigation would reveal many others. A number of reasons probably contributed to the low species diversity compared with the Indian Ocean, with 44 species. These include the enclosed nature of the sea (with a very shallow sill at the southern end and the relatively recent Suez Canal at the northern end), its high salinity and its relatively low primary productivity.



Risso's Dolphin: has a worldwide distribution in tropical to temperate seas. It is not uncommon throughout the Red Sea and even into the Gulf of Aqaba where it has been recorded off the south-west point of Tiran Island and the west side of Ras Muhammad.



Spotted Dolphin: It is probably the most common dolphin in the Red Sea, and although most records are from the northern end and Gulf of Aqaba, it is likely to be as abundant in the less well known parts of the Red Sea further south (Frazier et al., 1987).

False Killer Whale: This pelagic deep water species has occasionally been recorded in the Red Sea. There are at least two records of individuals in and around the Gulf of Aqaba.



### 3.7.7 Marine Turtles

Marine Turtles: There are five species of pantropical marine turtles occur in the Red Sea (refer to the below figure). These are *Eretmochelys imbricata* (the hawksbill turtle), *Chelonia mydas*, *Lepidochelys olivacea* (eschscholtz, the olive ridley turtle), *Caretta caretta* (the loggerhead turtle) and *Dermochelys coriacea* (the leathery turtle). There are signs of ancient and incredibly heavy exploitation of sea

turtles on several Red Sea islands. However, little has been documented about Red Sea turtles, and the first detailed studies were not done until the late 1970's.



*Eretmochelys imbricate* (the hawksbill turtle): this evidently the most abundant of the Red Sea turtles with record from every country of the Red Sea coastline. This species is most restricted to tropical waters; its foods seem to be sponges, soft corals and other sessile soft-bodied invertebrates that grow in the nooks and crannies of coral reefs. Nesting spoor, probably of this species, has been seen on islands along the coast of Saudi Arabia (Frazier et al. 1987).

*Chelonia mydas* (the green turtle): this is the second most common species in the Red Sea. Specimens have been seen or collected in the Dahlak Archipelago, Port Sudan, the Egyptian coast and islands, Sinai and Yemen. There are unconfirmed reports of *C. mydas* nest spoor on Saudi Arabian islands and this turtle probably also nests on Yemeni islands.



*Lepidochelys olivacea* (Eschscholtz), the olive ridley turtle: smallest sea turtle, this is an uncommon turtle throughout the western Indian Ocean; there are only five records of this species from the Red Sea: one specimen each from Massawa, Eritrea, Suakin, Sudan and Ras Katib, north Yemen; and also two specimens in southern Sinai. The animal is typically found in water with low salinity, high turbidity and high organic content where mangrove and shrimp fisheries abound. These features are uncommon in the Red Sea.

*Caretta caretta*, the loggerhead turtle: this is the rarest of all the Red Sea's turtle. It is known only from the shores of eastern Sinai.



*Dermochelys coriacea*, the leathery turtle: this is the largest of all turtles, reaching weight of over half a tonne. There are several records from Sinai area, Gulf of Suez and at the southern end of Gulf of Aqaba. There is no evidence of *D. coriacea* nesting in the Red Sea. This species nests in only a few places in the Indian Ocean.

The most important predator on marine turtles is Man, who exploits them throughout their range of life cycle for meat, oil and eggs. Turtle eggs and meat are usually consumed by peoples of the Red Sea.

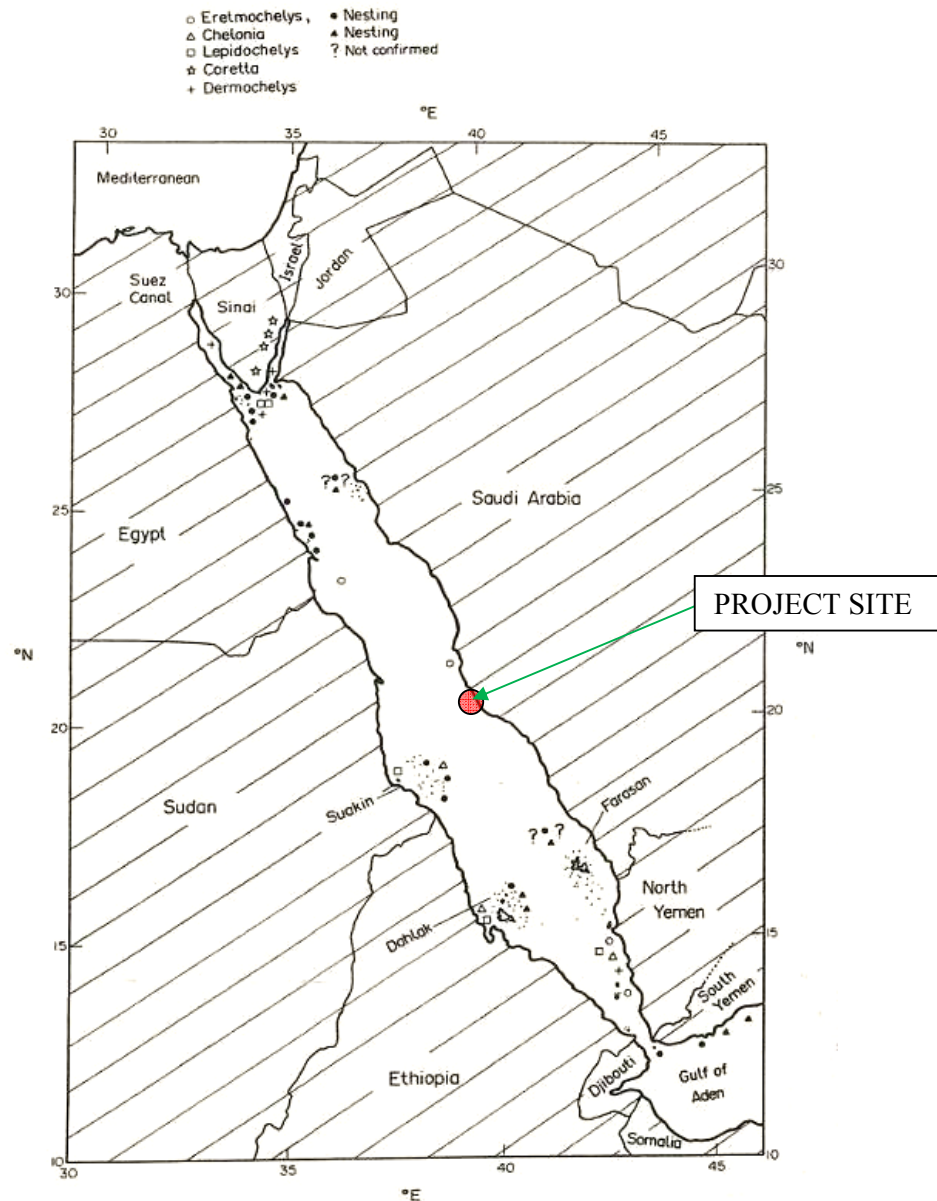


Fig. 6 . The Red Sea showing localities of sea turtle records and nesting areas.

Figure shows that there is no turtle nesting areas in the vicinity of Shoaiba project site.

## 4.0 Significant Impact Assessment

### 4.1 Impact Assessment Methodology

The EIA study has predicted few environmental effects and assessed their significance based on the well accepted methodology. The general approach is described below. The criteria for assessing the significance of effects were based on the current legislation, standards and guidelines in the Kingdom where these were available.

#### Impact Magnitude

The magnitude of effect is the degree to the state of an environmental resource resulting from the proposed development. An appropriate scale was developed for each environmental topic, ranging from negligible impact (no change or imperceptible change) to high impact. The evaluation of impact magnitude considers the duration (short/medium/long term), probability, magnitude, spatial extent, reversibility and the likelihood of indirect effect. Impact can be either adverse or beneficial.

#### Receptor Sensitivity

Each potential receptor (e.g. human population, habitats, and water resources) was assigned a level of sensitivity to change, ranging from negligible sensitivity to high sensitivity. This level of sensitivity was based on the perceived value of the receptor (e.g. local, district, regional, national or international significance) and its sensitivity to a change in existing conditions. These judgments were informed by legislation or guidelines where these were available or were otherwise based on typical practice during EIAs of similar developments.

#### Impact Significance

The significance of an impact is the product of the magnitude of impact and the sensitivity of the receptor. Impact significance can be adverse or beneficial. A standard significance table was used for all environmental topics, Table 4.1A

Table 4.1A General Impact Significance Assessment Matrix

Receptor Sensitivity	Magnitude of Impact			
	High	Moderate	Low	Negligible
High	Very substantial	Substantial	Moderate	Minor
Moderate	Substantial	Moderate	Minor	Negligible
Low	Moderate	Minor	Negligible	Negligible
Negligible	Minor	Negligible	Negligible	Negligible

Any moderate, substantial or very substantial effect was considered likely to be significant for the purposes of this EIA. For such impacts, mitigation measures were proposed with the goal of reducing the significance of the impacts as far as possible

### 4.2 Scoping of Significant Issues for Impact Assessment

Based on the Methodology Report and subsequent gathering of information about the project, the potentially significant impacts which may arise from the project were identified. These are summarized in Table 4.2A and form the basis of further study under the impact assessment topics in this Chapter. It should be noted that these are potential impacts. Section 5.0 summarizes the impacts which were actually identified, and the proposed mitigation measures.



Table 4.2A: Potential Significant for Impact Assessment

<b>Activity Causing Impact</b>	<b>Predicted Impact</b>	<b>Receptor</b>	<b>Magnitude of Impact</b>	<b>Significance of Impact</b>
Dredging	Direct removal of reef area	Reef	High	Substantial
	Carryover of silt plume from the dredging	Bio-system in the area	Moderate	Moderate
	Reduced water quality and Increase in turbidity and Oxygen Depletion due to suspension of sediments	Reef, Flora & Fauna, Bio-system or benthic community in the area	High	Substantial
	Fine fraction of the sediments can travel over significant distances	Ecological and marine life	Moderate	Substantial
	Nutrients availability and level change	Marine life	Moderate	Moderate
	Dispersion of contaminants during dredging and disposal	Marine life	Moderate	Substantial
	Impact from noise (surface/underwater) from equipment	Marine Habitat	Negligible	Negligible
	Air contaminants due to transport and reclamation works of dredged materials generated from dust	Nearby populated community	Negligible	Negligible
	Over-spill from split barge that handles dredged material	Bio-system or benthic community in the area	Negligible	Negligible
	Workplace hazard	Workers	Moderate	Minor
Operation	Re-colonization build-up of benthic communities to channel structures	Benthic communities	Negligible	Positive
	Entrainment and impingement of marine organism at the intake structure	Marine life	Moderate	Substantial
	Water quality due to	Marine life	Moderate	Substantial



	temperature increase, thermal pollution and dispersion of potential contaminants from discharge channel			
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**4.3 Factors influencing the potential Marine Environmental effects during dredging and disposal**

- Magnitude and frequency of the dredging activity.
- Method used for the dredging and disposal.
- Channel size and depth.
- The size, density and quality of the material.
- Intertidal area.
- Background levels of the water and the sediment quality, suspended sediment and turbidity.
- Tidal range.
- Current direction and speed.
- Rate of mixing.
- Seasonal variability and meteorological conditions, affecting wave conditions and freshwater discharges.
- Proximity of the marine habitat to the dredging or disposal activity.
- Presence and sensitivity of animal and plant communities (including birds, sensitive benthic communities, fish and shellfish invertebrate).

Prediction of the potential effects that might be caused by dredging and/or dredged material disposal in a marine environment cannot be made with any degree of confidence if these parameters are not known on a site-by-site basis. Generally, the potential impacts of the dredging and dredged material disposal can be summarized as follows:

- Removal of sub-tidal benthic species and communities.
- Short-term increases in the level of suspended sediment can give rise to changes in water quality which can effect marine flora and fauna, both favorably and unfavorably, such as increased turbidity and the possible release of organic matter, nutrients and or contaminants depending upon the nature of the material in the dredging area.
- Settlement of these suspended sediments can result in the smothering or blanketing of sub-tidal communities and/or adjacent intertidal communities, although this can also be used beneficially to raise the level of selected areas to offset sea level rise or erosion (short-term impact vs. long-term gain).

The potential impact of the dredged material disposal depends largely on the nature of the dredged material, if it is inorganic, organically enriched and/or contaminated and the characteristics of the disposal area accumulative or dispersive areas. The potential impacts of the disposal of maintenance dredging material if it is on the marine environment, such as the disposal of heavily contaminated sediments, can be minimized to some extent, through the PME licensing process by the regulation and conditions imposed.





The evaluation of the environmental effects of dredging and restricting the area of disposal of the dredged material to be disposed both the short-term and the long-term effects that may occur both at the site of dredging and/or disposal area (near field) and the surrounding area (far field). The guide below provides a useful table that illustrates the temporal and spatial scales in which various environmental effects of dredging might be realized (see table 4.3A below). Near field effects are simply defined as phenomena occurring within the geographic bounds of the activity, or less than approximately 1 km from the activity, and far field effects are occurring more than approximately 1 km from the activity. However, we suggest that caution should be used when adopting an arbitrary distance to distinguish between near and far field effects, due to the site-specific nature of the potential effects that arise from dredging which includes quantity and quality of material to be dredged and disposed, technology and methods used during dredging and disposal, all other site specific's such as the department of dredging and water conditions which are all need to be considered and discussed to reach the real potential impacts to near and far fields from the dredging site.

**Table 4.3A: Time–space matrix of potential effects associated with dredging and dredged material placement (IADC/CEDA 1998)**

	<b>Near-field Environmental Effects (&lt;1km)</b>	<b>Far-field Environmental Effects (&gt;1km)</b>
<b>Short-term Environmental Effects (&lt;1 week)</b>	<b>Dredging</b> Turbidity Smothering/removal of organisms Reduced water quality	<b>Dredging</b> None generally expected
	<b>Disposal</b> Smothering of organisms Turbidity Reduced water quality Acute chemical toxicity	<b>Disposal</b> Offsite movements of chemicals by physical transport
<b>Long-term Environmental Effects (&gt;1 week)</b>	<b>Dredging</b> Disturbance by shipping traffic Removal of contaminated sediment	<b>Dredging</b> None generally expected
	<b>Disposal</b> Altered substrate type Altered community structure Chronic chemical toxicity Bioaccumulation	<b>Disposal</b> Offsite movements of chemicals by physical transport and/or biota migration

the environmental effects that may occur as a **direct** result of dredging and disposal activities, we must also consider the environmental effects that may occur as a result of the physical changes to the bathymetry and the hydrodynamic processes during dredging. Although such changes may occur as a result of dredging, they are more commonly associated with capital dredging activities. These changes can be summarized as follows:

- Alterations to coastal or estuary morphology, for example alteration of the sediment pathways and changes to siltation patterns, which may affect the coastal habitats and species as well as marine environment,



- 
- Alterations to water currents and wave climates, which might effect navigation and conservation conditions and interests, and
  - Reduction or improvement of water quality.

Each of the potential effects from dredging and disposal are discussed in details in the following sections. It should be stressed that there are only few dredging and disposal operations in marine environment where all of these potential effects will be realized.

Figure 4.3A: is a conceptual diagram illustrating the impact of dredging

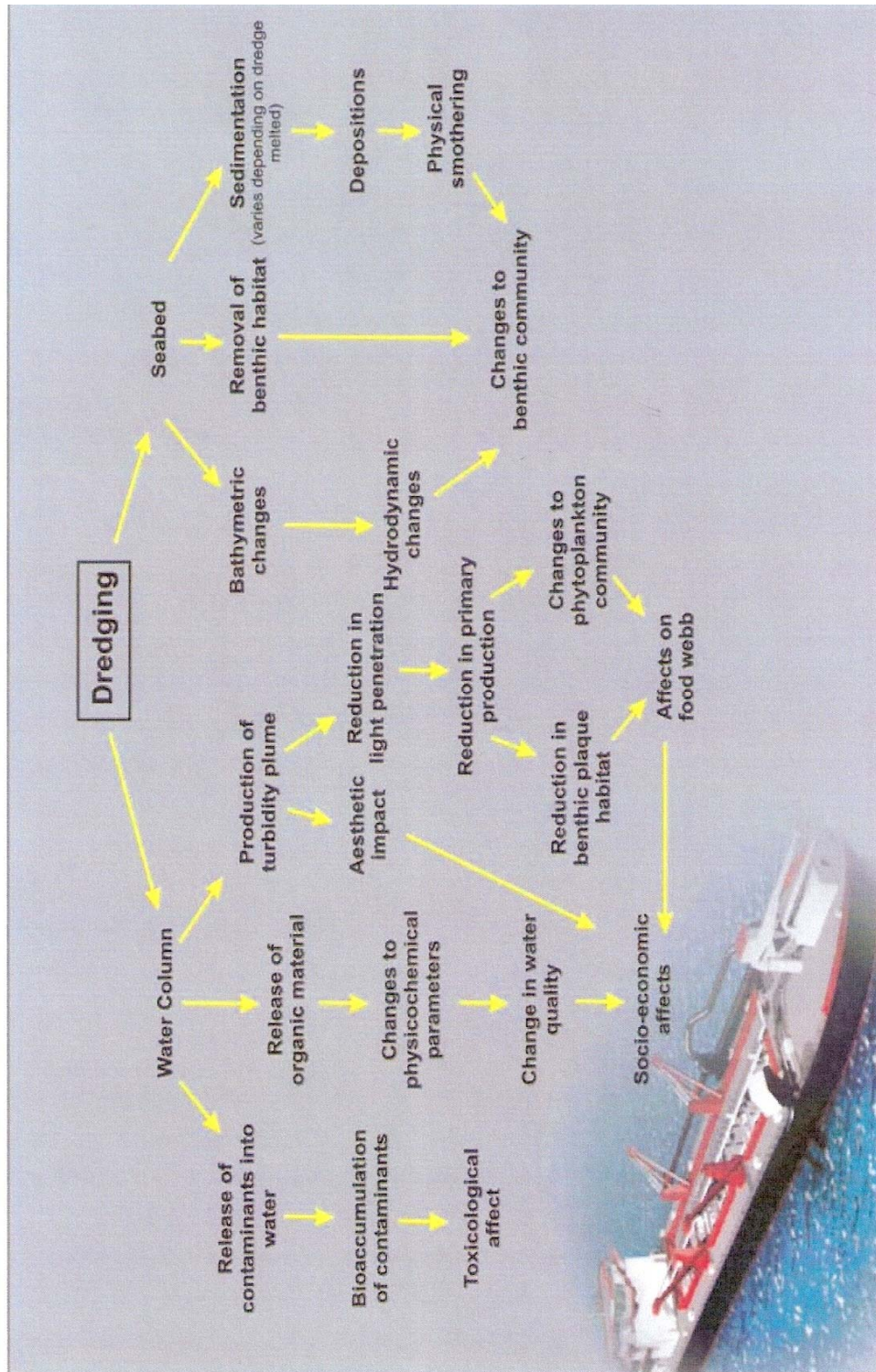
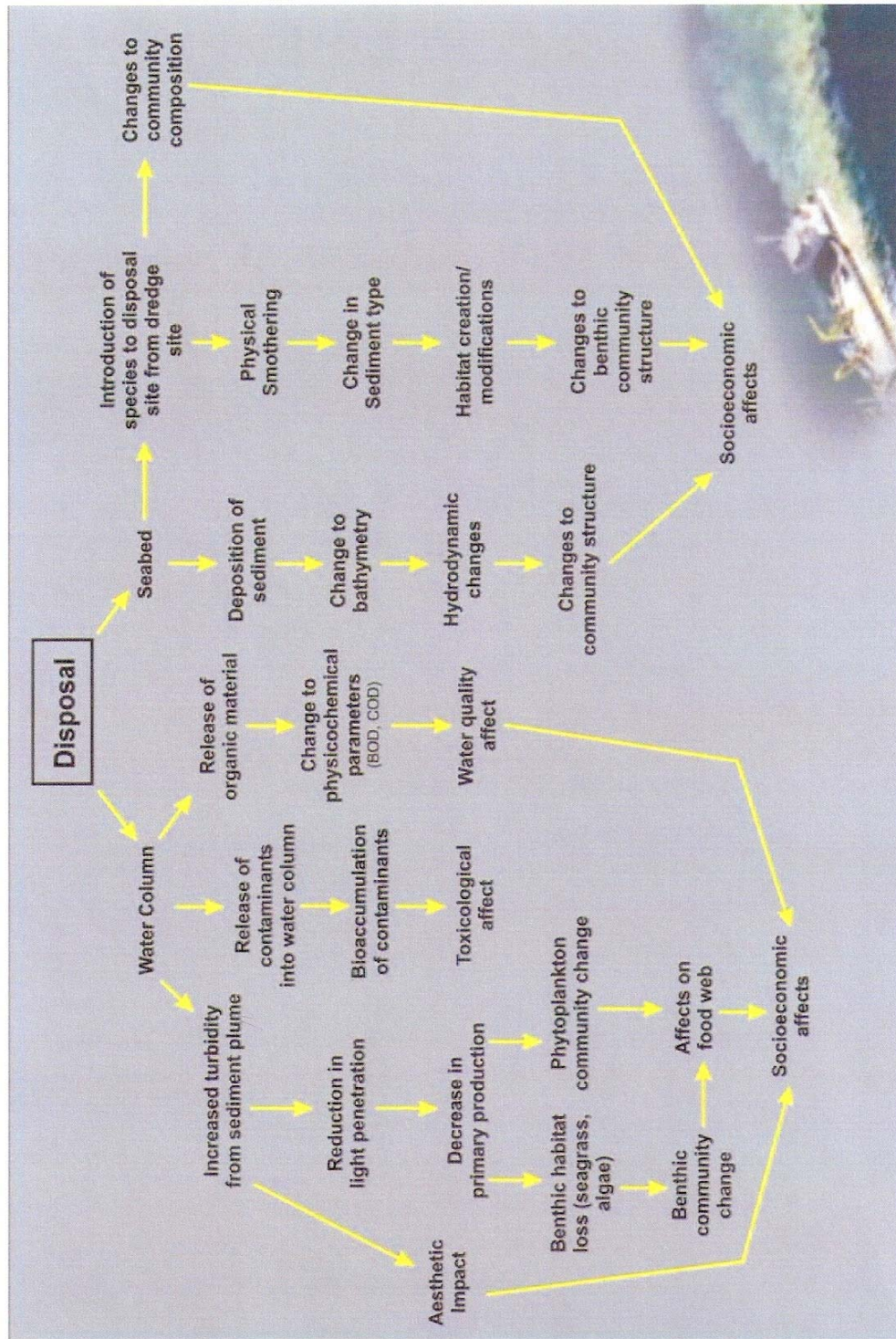


Figure 4.3B: is a conceptual diagram illustrating the impact of disposal



#### **4.4 Dredging: Removal of benthic animals**

##### **4.4.1 Recovery of benthic communities following dredging activities**

During all dredging operations, the removal of material from the seabed also removes the animals living on and in the sediments (benthic animals). With the exception of some deep burrowing animals or mobile surface animals that may survive a dredging event through avoidance, therefore, dredging may initially result in the complete removal of animals from the excavation site.

Where the channel or berth has been subjected to continual maintenance dredging over many years at least nine years in this case, it is unlikely that well-developed benthic communities will occur in or around the area. It is therefore unlikely that their loss as a result of regular maintenance dredging will significantly affect the marine ecology. However, certain marine species and communities are more sensitive to disturbance from dredging than others. For example, during dredging if maerl beds (calcified seaweed) or *Sabellaria* reefs (reef forming marine worms) are present it may result an irreversible damage of these sensitive, slow growing species. These are important habitats, generally associated with the habitat of sub-tidal sandbanks. It is, however, unlikely that such sensitive marine communities would develop in close proximity to the disturbed habitat of a regularly maintained navigation channel.

The recovery of the disturbed habitats following dredging ultimately depends upon the nature of the new sediment at the dredge site, sources and types of re-colonizing animals, and the extent of the disturbance. In soft sediment environments, recovery of animal communities generally occurs relatively quickly and a more rapid recovery of communities has been observed in areas exposed to periodic disturbances, such as maintained channels.

##### **4.4.2 Recovery of benthic communities following dredging activities**

A review of dredging works in coastal areas world-wide showed that the rates of recovery of benthic communities following dredging activities in various habitats varied greatly with the benthic sediments characteristics which are indicated as follows:

**Table 4.4A: Benthic Habitat Recovery Rate**

<b>Habitat type</b>	<b>Recovery time</b>
Disturbed Muds	4 weeks
Channel muds	6 months
Lagoon muds	>11 months
Sands-gravels	1-2 years
Muds-sands	18 months
Gravels	>2 years
Sands	3 years
Shells-sands	10 years

Recovery rates were most rapid in highly disturbed sediments in estuaries that are dominated by opportunistic species. In general, recovery times increase in stable gravel and sand habitats dominated by long-lived components with complex biological interactions which controlling community structure.



Benthic studies which suggest that dredging has only a short term effect on the animal communities of silty and clay sediments. Although almost complete removal of organisms occurs during dredging activities, however recovery begins within 1 month after dredging and within 2 months the communities were reported to be similar to pre-dredge conditions.

Other studies suggest that dredging impacts are relatively short term in areas of high sediment mobility (Hall, Basford & Robertson 1991).

In view of this previous studies on benthic communities, since the habitat type in this project is mostly sands and gravel, it is anticipated that a full recovery of the benthic community will be established within 1 -2 years after the dredging activities

#### **4.5 Dredging and Disposal: Suspended sediments and turbidity**

During dredging activities and dredged waste disposal of non-contaminated fine materials in estuaries and coastal waters, the main environmental effects are the suspended sediments and the increases in water turbidity. All methods of dredging release suspended sediments into the water column, during the excavation itself and during the flow of sediments from hoppers and barges. In many cases, the locally increased suspended sediments and turbidity associated with dredging and disposal is very obvious from the turbidity 'plumes' which may be seen trailing behind the dredgers or disposal sites.

The increase in suspended sediments and water turbidity levels from dredging activities and disposal operations may under certain conditions have adverse effects on marine animals and plants by reducing the light penetration into the water column and by physical disturbance.

For maintenance dredging, the extents of these environmental effects are near-field only and temporary and generally only lasting as long as the dredging operations are taking place.

##### **4.5.1 General effects of increased suspended solids and turbidity levels**

Increased suspended sediments can affect filter feeding organisms, such as shellfish, through clogging and damaging their feeding and breathing apparatus. Similarly, young fish can be damaged if suspended sediments become trapped in their gills as increased fatalities of young fish have been observed in heavily turbid water. Adult fish are likely to move away from or avoid areas of high suspended solids, such as dredging sites, unless food supplies are increased as a result of increases in organic material.

Increases in turbidity results in a decrease in the depth that light is able to penetrate the water column which may affect submerged seaweeds and plants, such as eelgrass *Zostera* species, to temporarily reducing productivity and growth rates. The tolerance of eelgrass to high turbidity is indicated by the survival of a very sparse bed near the turbidity. Although this demonstrates that eelgrass can survive in estuaries with high levels of suspended sediments, this bed declined greatly during the construction of channels which is associated with the adverse effects of smothering by the same sediments.

Background suspended solid and turbidity levels in marine environment are highly variable and dependent on the site conditions. In many estuaries background turbidity levels are high. Organisms in these environments are normally able to tolerate continuous exposure to high suspended sediment concentrations, for much longer time than if it would occur in most other dredging operations.

However, marine plants and animals living in areas where the waters are normally clear may be especially vulnerable to the effects of increased suspended sediments.

The degree of re-suspension of sediments and water turbidity from dredging activities and disposal depends on four main variables:

- the sediments being dredged (size, density and quality of the material),
- method of dredging (and disposal),
- hydrodynamic regime in the dredging and disposal area (current direction and speed, mixing rate, tidal state), and
- the existing water quality and characteristics (background suspended sediment and water turbidity levels).

Dredging activities often generate no more suspended sediments and/or water turbidity than commercial shipping operations, bottom fishing or turbidity generated during severe storms. Furthermore, natural events such as storms, floods and large tides can increase suspended sediments over much larger areas and for longer periods of time than dredging operations. It is therefore often very difficult to distinguish the environmental effects of dredging from those resulting from natural processes or normal navigation activities.

In most cases, sediment re-suspension is only likely to present a potential problem if it is moved out of the immediate dredging location by tidal processes. Therefore when dredging activities are in an enclosed areas, such as within locks or dock basins where, there is little likelihood that material will be transported to a wider environment and effect the marine features, the impact is very minimum normally. In general, the effects of suspended sediments and turbidity are generally short term (<1 week after activity) and near-field (<1km from activity). One would generally only needs to be concern if sensitive species are located in the vicinity of the dredged channel.

#### **4.6 Dredging and dredged waste disposal: Organic matter and nutrients**

The release of organic rich sediments during dredging or dredged waste disposal could cause the removal of oxygen from the surrounding water in the near field area around the dredging activities. Depending on the location and the timing of the dredging it may lead to the suffocation of marine animals and plants within the localized area around dredging or may deter migratory fish or mammals from passing through. However it is important to stress that the removal of oxygen from the water is only temporary, as tidal exchange would quickly replenish the oxygen supply. Therefore, in most cases where dredging and dredged waste disposal is taking place in open coastal waters, estuaries, bays and inlets, this localized removal of oxygen from water has little, if any, effect on marine life. However, despite the temporary nature of the effect, if oxygen depletion were to occur during an important life stages of sensitive species, such as the peak spring migration, the effects could be adverse.

The re-suspension of sediments during dredging and dredged waste disposal may also result in an increase in the levels of organic matter and nutrients available to marine organisms. This can result in two main effects:

- In certain cases, such as a localized area which is adapted to low nutrient conditions or it is sensitive to the effects of eutrophication which can simply be described as a nutrient enrichment

process leading to the formation of algal blooms. These blooms can reduce the surrounding water quality by causing the removal of oxygen from the water during the blooms break down or by (occasionally) by the release of toxins which may disturb marine wildlife. The potential formation of algal blooms in coastal and estuarine areas is generally limited by high turbidity levels and tidal flushing.

- In other cases, increased organic material, nutrients and algal growth may provide more food for zooplankton and higher organisms, with possible knock-on effects on the productivity of the marine ecosystem. For example, there is evidence of increased productivity of benthic communities that receives considerable amounts of dredged materials. The beneficial effects are reported to be a result of organic enrichment from the dredged material and also due to the stabilization of sediments through the incorporation of fine organic matter. Increased suspended sediments as a result of dredging operations may have resulted in increased numbers of filter-feeding brittlestar and fan worm. However, if the communities that are present in the vicinity of the disposal sites rely on low nutrient levels then any nutrient enrichment is unlikely to be beneficial.

#### **4.7 Dredging and Dredged Waste disposal: Contaminated sediments**

Although generally not heavily contaminated, much of dredged material is subject to some contamination. A variety of harmful substances, including heavy metals, oil, TBT, PCBs and pesticides, can be effectively ‘locked into’ precipitated into the seabed sediments in areas of close to shoreline. These contaminants can often be of historic origin and from distant sources. The dredging and disposal processes can release these contaminants into the water column, making them available to be consumed by animals and plants, with the potential to cause contamination and/or poisoning. The likelihood of this occurring depends upon the type and the degree of the sediment contamination; however, some remobilization of very low levels of pollutants should be expected during any dredging project.

The highest levels of contaminants generally occur in silts which are most dredged from industrialized estuaries. If low level contaminants are released into the water column during disposal, they may accumulate in marine animals and plants and transfer up the food chain to fish and sea mammals.

#### **4.8 General Effects of Contaminants on Marine Life**

- When found in sufficient quantities in the food chain, contaminants may cause morphological or reproductive disorders in shellfish, fish and mammals.
- Generally young shellfish and crustaceans (oysters, shrimp, crab and lobsters) are much more susceptible to the toxicity of contaminants than adults.
- Concentrations of heavy metals in most estuaries are too low to cause adverse effects on eelgrass *Zostera*.

Although almost all dredged silts will contain some contaminants arising largely from the past industrial activities typical of many coastal shoreline locations, fortunately, the occurrence of very contaminated sediments is rare. The PME assessment process prevents the disposal of highly contaminated sediments in the marine environment at the first place, therefore generally avoiding the occurrence of direct toxic effects on marine animals and plants.





In table 4.13, absolute thresholds of acceptable sediment contamination levels are set, in addition to guidelines or legislative standards, the levels of contamination in the sediments are also compared with the existing background levels in the local area.

Where elevated concentrations of contaminants are identified in the assessment process, Saudi Archirodon and MTEV's environmental specialist will investigate the potential for direct biological effects on the marine communities near the disposal site and may impose conditions on the dredging license to minimize or avoid such impacts. When very contaminated sediments are found the means of managing and controlling the situation will be discussed and agreed with the licensing authority and the national environment agencies-PME.

#### **4.9 Dredging and Dredged Waste disposal: Settlement of suspended sediments**

Sediments dispersed during dredging and dredged waste disposal process may resettle over the seabed and the animals and plants that live on and within it. This blanketing or smothering of benthic animals and plants may cause stress, reduced rates of growth or reproduction and in the worse cases the effects may be fatal. Generally sediments will settle within the vicinity of the dredged area, where they are likely to have little effect on the recently disturbed communities, particularly in areas where dredging is a well-established activity. However, in some cases sediments are distributed more widely within the estuary or coastal area and may settle over adjacent sub tidal or inter tidal habitats possibly some distance from the dredged area.

The sensitivity of marine animals and plants to siltation varies greatly and will be discussed briefly below. In areas with high natural loads of suspended sediments, the relatively small increases in siltation away from the immediate dredging area are generally considered unlikely to have adverse effects on benthic populations. Assessment of the effects of siltation from other previous dredging process concluded that some smothering of benthic animals was inevitable. *It was also suggested that given the area is subjected to dredging of channels and that the adjacent sub tidal and inter tidal areas appear to be productive, we can draw conclusion that it is unlikely that the effects from the proposed dredging program will have anything more than temporary and fairly localized impacts.*

Post-dredging surveys of the intake and discharge channel's similar to our case project site, indicated that with appropriate care, substantial dredging works can be undertaken with no adverse effects on shell or other fisheries.

#### **Examples of the varying sensitivity of marine animals and plants to siltation**

- Animals with delicate feeding or breathing apparatus, such as shellfish can be intolerant to increased siltation, resulting in reduced growth or fatality.
- Maerl beds (calcified seaweed) are reported to be sensitive to smothering due to channel dredging
- In important spawning or nursery areas for fish and other marine animals, dredging can result in smothering eggs and larvae. Shellfish are particularly susceptible to dredging in the the spring during spawning period.
- When smothering of intertidal areas occurs, there may be subsequent effects on the availability of the feeding areas for the animals and plants.

#### **4.10 Dredging and disposal: Changes to hydrodynamic regime and geomorphology**

General statements about the impact of dredging on the hydrodynamics and geomorphology of a site cannot be made as these effects are very site specific, and very difficult to isolate from other 'forcing effects', such as sea level rise or reclamation, which are often little understood. Although all dredging activities can cause some change to the hydrodynamic flow, the magnitude and the type of effect are often related to the overall size of the excavation compared to the overall size of the whole system in that area. Most reported adverse effects of dredging operations on hydrodynamics and geomorphology of coastal and estuarine areas were associated with capital dredging operations.

The overall effect of maintenance dredging on the hydrodynamics and geomorphology of a site has all the complexity of a capital scheme but the actual impacts are much smaller. In many cases the magnitude of dredging related to hydrodynamics & geomorphology alterations may fall well within the range of naturally occurring phenomena and probably impose little or no additional stress to marine features.

Choosing the disposal site could, however, cause a regular removal of sediment from the transport system which could affect the erosion and sedimentation processes and ultimately the form of the estuary, possibly depriving downstream coastal areas of sediment required to maintain coastal stability. Equally important, if the sediment is placed back within the same system, although the net change is insignificant the locations of maximum sediment concentration may change promoting additional siltation in specific areas. Increased erosion of mud and sand sections may have numerous implications on the ecology of marine habitats and species. For example a reduction in the lower intertidal area may lead to the reduction of site intertidal communities and a subsequent loss of bird feeding grounds, this can be of a possible benefit, however, of better fish breeding grounds. By contrast, careful design of disposal can result in intertidal areas being increased.

#### **4.11 Disposal: Discharge of dredged material at the disposal site**

When the dredged waste material is disposed of at sea they will have a blanketing and smothering effect on benthic organisms in the immediate disposal site. The continual disposal of dredged waste material at the disposal sites may prevent the development of stable benthic communities, and a partial or complete loss of benthic re-production is an adverse effect sometimes has to be accepted within regularly used disposal sites.

With the exception of the initial smothering of benthic communities at the disposal site which is inevitable, the potential for other effects to possibly occur as a result of disposal operations will be site specific, depending on the characteristics of the dredged material and the hydrodynamic conditions at the disposal site. These potential effects at the disposal site are minimized under the PME licensing and regulations process, irrespective of whether it is in or adjacent to a marine environment, which is regulated by PME and other government agencies.

The finer the material, which is associated with greater energy at the disposal site, the greater the possibility of increased suspended sediments and cause far-field effects. However, as mentioned previously, these far-field effects of turbidity and smothering are generally only of high concern in areas of low background levels of suspended solids. Adverse effects may only occur if these dredged materials are to settle out over communities which are adapted to and dependant upon clear conditions, such as clean swept gravels which supporting rich sponge communities.



Disposal sites located in shallow and low energy areas may accept small amounts of fine dredged material occasionally, which is dispersed by tides and waves, ensuring that material does not build up at the site or causing any effects on adjacent communities. However, if the disposal site is overloaded with large quantities of dredging over a short period, shallowing of the disposal site can occur and smothering can adversely affect areas of adjacent sub tidal habitat. In contrast, disposal of dredged material may have beneficial effects through the creation of new sub tidal or inter tidal habitat, depending on the location of the disposal site.

Just as dredging within highly turbid environments has little effect on the tolerance of benthic communities, disposal of dredged sediments in suitable locations within such estuary systems can also have minimal effects. For example, the disposal of between 5-10 million tones each year of fine dredged sediments in highly turbid environment is reported to have little if any physical or biological effects as the sediments are re-deposited within the estuary. By choosing a proper disposal site for this project and following disposal procedure using chart, quantity and location of the disposed material suggest that little if any physical or biological effect will occur.

#### **4.12 Disposal: Intertidal recharge**

Although as previously mentioned, that intertidal recharge schemes can provide long-term benefits of environmental enhancement and protection, the process of placing material over the existing intertidal habitats can cause short-term impacts, suspended sediments and smothering more environmentally the susceptible and sensitive environments of the estuaries, inlets and bays. However, despite the short-term problems, intertidal recharge is often the only practical means to combat erosion of intertidal habitats, which is caused by coastal squeeze and rising sea levels.

Recharge of intertidal habitats with dredged materials which are coarser than the present intertidal sediments, such as a mixture of sand, gravel and rock could be used to protect salt marshes from wave attack and erosion. Although this technique has many benefits for flood defense purposes, the use of coarse sediments to recharge intertidal mudflats could changes their nature considerably in terms of sediment action processes and animal and plant communities. A reduction in typical mud dwelling animals may result in the reduction of food supplies for feeding birds and foraging fish, but conversely the new material may provide alternative habitats for breeding and roosting birds. A major benefit of using coarser sands is that most of the sediment stays in its place, with little or no sediment re-suspension, and therefore no siltation of adjacent areas.

The potential of the long term benefits vs. the short term adverse effects associated with the disposal of fine materials over intertidal habitats are summarized below.

#### **Examples of short-term impacts and long-term benefits of intertidal recharge schemes using fine sediments**

##### Short-term impacts



- Smothering of benthic animals and plants at the recharge site, particularly if the sediment is deposited on the intertidal at a high rate. Smothering can occur during the initial deposition of material or due to a gradual accumulation.
- Risk of material being lost from the recharge site through re-distribution of sediments. Redistribution of sediments may potentially cause an increase in suspended sediments and smothering of nearby sensitive communities, such as shellfish beds. However, these effects may be no worse than may occur naturally during severe storms.

#### Long-term benefits

- The sediments can be retained within the estuary system and recycled into the intertidal habitats, replacing lost intertidal area.
- Clean fine dredged materials are able to support productive benthic communities, similar to natural intertidal flats and can be re-colonized by fauna at the recharge site and adjacent areas.
- With appropriate planning and time the recharged intertidal habitat can be closely resemble the natural intertidal flats, both in appearance and function.

It is worth pointing that providing short-term and/or long-term or permanent structures to protect a newly recharged site from wind and waves in moderate to high energy areas may be the only way for the sediments to be stabilized and used as a habitat. Experience from other trial schemes indicates that gravel bunds or other protective mechanisms can be used to retain fine sediments at the recharge site. Using coarse bunds are most suitable in situations where mudflats exist which are important for their bird or salt marsh habitats which are being rapidly eroded, with no realistic prospect of replacement by shoreline re-alignment, or in areas where a relatively soft defense is required to protect the terrestrial asset which cannot be relocated. The material used to create the bund should be carefully selected so as to retain some limited mobility where placed. This allows it to be a flexible structure, capable of responding gradually to changes, rather than being like small-scale rock armor.

Other protective structures that may be used to retain material in place and to reduce redistribution of sediments to adjacent habitats, include sand bags, straw bales, brushwood fences and water or sediment filled geo-textile tubes.

Each proposed intertidal recharge scheme needs to be considered on a site by site basis weighing up the potential short-term adverse impacts against long-term environmental gain. A long-term view will be taken in assessing such proposals and its contributions to the short-term damage which could be accepted when considering its long-term benefits, in terms of sustainable management of the broader areas of the intertidal habitats. This assessment may involve the country's conservation agencies, licensing authorities and the environmental agencies.

In view of the above, this project indicates little short-term impact with positive long-term benefits.

#### **4.13 Thermal Pollution**

The discharge of heated water from the power plant can elevate seawater temperature and this can affect fish larvae and other minute organisms near the outfall. However, impact is predicted to be localized and insignificant. The outfall with diffuser is efficient, as demonstrated by plume centerline temperatures that fall below the mixing zone limit in all cases of different maximum tidal velocity before discharged water reaches the surface. World Bank Standards requires "temperature of

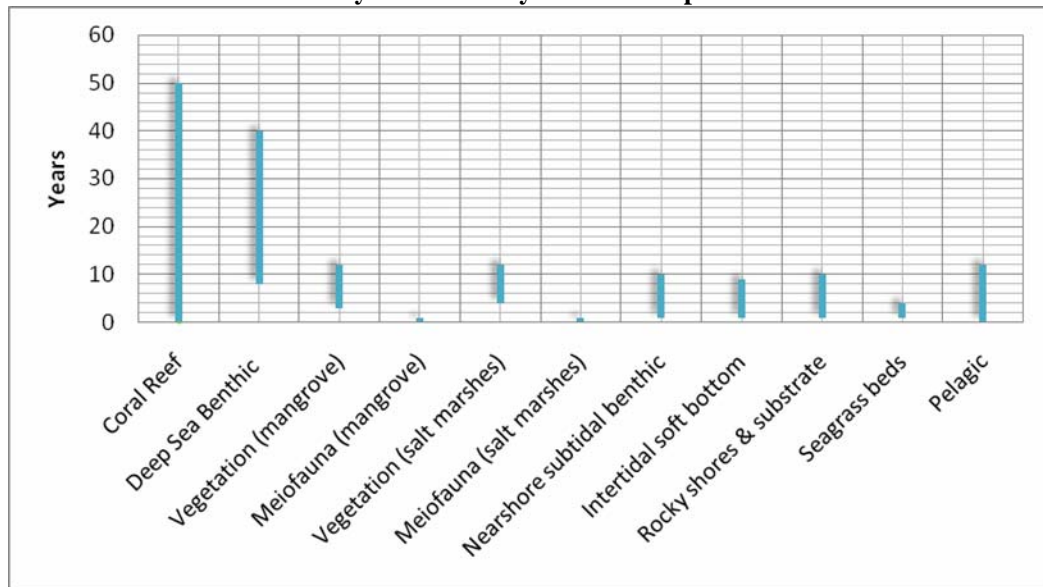
wastewater prior to discharge does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone which takes into account ambient water quality, receiving water use and assimilative capacity among other considerations.”

Analysis of thermal discharge modeling using 3D Code TRIMDI (developed by ENEL) ref. doc. 00-P-M-30042 provided by SARCO shows that during a high current condition scenario parallel to the shoreline and oriented in the NNW direction and by winter season condition of the seawater parameters, resulted as follows:

- Plume direction at the surface level is strongly affected by the environmental current but the plume dilution is greatly favored by it, so the plume extension is limited and the isothermal line correspondent to +1.0 °C is no more than 2km from the discharge point. At the discharge bottom level, no thermal effect can be detected as far as 1.5km from the discharge point as shown in Appendix 15.
- The temperature field at the vertical section centered on the discharge point shows that the plume floats and the mixing effect quickly reduces its vertical extensions (see appendix 16)

Therefore, by design, the water discharge and plume modeling near the outfall indicates that the impact is predicted to be very localized and that the effect to seawater temperature and marine life would be insignificant

**Below table indicates the ecosystem recovery time after a pollution event:**



(from Neft, 1987)

In accordance to World Bank document “Pollution Prevention & Abatement Handbook” and PME Guidelines for direct discharge liquid of effluent threshold for industrial estate development are as follows:

**Table 4.13A** Direct Discharge Liquid Effluent from Industrial Estates  
(Milligram per liter, except for pH and temperature)

Parameter	World Bank	PME
<b>pH</b>	6-9	6-9
<b>Turbidity</b>	-	75 NTU (max)
<b>Biochemical Oxygen Demand</b>	50	25
<b>Chemical Oxygen Demand</b>	250	150
<b>Total Suspended Solids</b>	50 (20 if toxic metals are present at significant levels)	15
<b>Total Kjeldahl Nitrogen (TKN)</b>	-	5
<b>Total Chlorinated Hydrocarbon</b>	-	0.1
<b>Oil and Grease</b>	10	8
<b>Cadmium</b>	0.1	0.02
<b>Chromium</b>		
Hexavalent	0.1	
<b>Total</b>	0.5	0.1
<b>Copper</b>	0.5	0.2
<b>Lead</b>	0.1	0.1
<b>Nickel</b>	0.5	0.2
<b>Zinc</b>	2.0	1.0
<b>Phenol</b>	0.5	0.1
<b>Chlorine Residual</b>	-	0.5
<b>AOX</b>	1	-
<b>Mercury</b>	-	0.001
<b>Benzene</b>	0.05	-
<b>Benzo (a) pyrene</b>	0.05	-
<b>Sulfide</b>	1	-
<b>Total Coliform</b>	-	Allowable effluent 30-day ave. 1000 MPN per 100 ml.
<b>Temperature Increase</b>	≤ 3°C (a)	-
<b>(a) The effluent should result in a temperature increase of no more than 3°C at the edge of the zone where initial mixing and dilution take place. Where the zone is not defined, use 100 meters from the point of discharge</b>		

According to the threshold given in table 4.13A above, these standards is to be taken into great consideration in the design stage and modeling of water discharge properties of the power plant. Whereby monitoring devices need to be installed and be recorded to ensure compliance with the given standards.

### Water Use

It is possible to reduce the fresh water intake for the cooling systems by installing evaporative recirculation cooling systems. However, such systems require a greater capital investment, but they may use only 5% of the water volume required for once-through cooling systems. Where once-through cooling systems are used, the volume of water required and the impact of its discharge can be reduced by careful design of intakes and outfalls, by minimizing the use of biocides and anticorrosion chemicals (effective non chromium-based alternatives are available to inhibit scale and products of corrosion in the cooling water systems), and by controlling discharge temperatures and thermal plumes. Wastewaters from other processes, including boiler blow down, demineralizer backwash, and



resin regenerator wastewater, can also be recycled, but again, this requires careful waste management and treatment for water reuse. Water use can also be reduced in certain circumstances through the use of air-cooled condensers.

The design and operation of the above power plant's intake and discharge channels indicate minimum effect to marine environment. The plant's environmental management plan (EMP) is to encourage recycling and re-using of waste water as much as possible to reduce impact outside the plant. The monthly report will indicate all the chemicals used in the plant as well as the procedure in place of re-using waste water and/or ways of their disposal with any impacts if any to marine and/or inland environment.



## **5.0 Analysis of Significant Impact, Mitigation Plan & Control Measures**

### **5.1 Means of minimizing potential impacts of dredging and promoting benefits**

Although historically the primary objective was to optimize dredging operations and its economic benefits with little regard to the environment, today in most cases dredging projects are evaluated and managed on the basis to minimize adverse environmental effects however, whilst still maximizing economic and environmental benefits. There are now existing procedures and regulations in place which are generally considered to effectively avoid and/or minimize the environmental impact potential of dredging and disposal operations cause, particularly the requirements of the PME licensing process. In addition, in recent years, dredging has become a more of a scientific process with greater emphasis being placed on continuous survey on the channels design to minimize dredged volumes. Positive changes in dredging practices and port operations have greatly reduced the amounts of material dredged over the past decade. Improved dredging technology and position fixed equipment allows more precision techniques which has resulted in real reductions in the amounts of materials dredged and deposited.

In most cases, existing regulations and careful dredging practice techniques are sufficient to avoid the potential impacts discussed above and further steps need to be taken. Where adverse effects are identified on the site or as a precautionary approach is considered necessary, the following actions may be taken to avoid or minimize impacts, many of which are already in place in the dredging operation:

- Managing and informing contractors with regards to site specifics,
- Timing of dredging and disposal operations,
- Selection of Best Available Technique (BAT) dredging methods
- Reducing amounts of dredging,
- Promotion of beneficial use,
- Selection of best possible disposal sites, and
- Monitoring and record keeping.

#### **5.1.1 Managing and informing contractors**

It is important that the contractors are fully briefed with the dredging and disposal procedures by the Client's management prior to the commencement of dredging and disposal works. The procedure of briefing the contractors may include the requirement of the method statements and risk assessments for the operations to be provided by the contractors. These procedures should be agreed and approved by the relevant Government Agencies before the works are allowed to proceed. When renewing the contracts of contractors, contracts should be considered of those companies who has demonstrated good performance on similar projects and that they are competent to carry out the work required. When briefing the contractors consideration should be given to the factors indicated below.





## **Issues to be considered when briefing contractors about dredging works in marine environment**

When briefing a contractor consideration should be given to:

- Providing information on the marine environment and the features for which the site was designated for and if appropriate outlining the areas which are particularly sensitive to dredging at specific times of the year.
- Best timing of the operations,
- Hydrodynamic conditions at the excavation and disposal location,
- Best Available Technique (BAT) regarding dredging methodology, and
- Particular areas of the dredging and/or disposal site which are sensitive where any contractor's error can cause adverse effects on marine features.

Dredging Contractor should follow proper safety procedures to avoid accidents and spills as per SARCO's Health, Safety & Environment (HSE) manual, and the ports and harbor's authorities need to ensure that other vessel users are provided with adequate information and instruction to avoid conflict with the dredging operations. In order to reduce the potential of contractor's error which could result in adverse environmental affects, ports and harbors authorities should endeavor to regularly monitor the operations of the contractor during dredging and disposal activities. Within the last ten years of education and training on the environmental issues has resulted in risen up the issue on the agenda. With regard to dredging, knowledge of the most effective techniques can only be gained through experience. Therefore it is suggested that the relevant labor force should be educated on marine environmental matters to minimize the detrimental effects on marine species as a result of the dredging and disposal process.

### **5.1.2 Timing**

Since the problems resulting from the increases in suspended sediments have been identified in a marine environment, the timing of dredging and disposal operations may be planned, where practical, in order to avoid and reduce any adverse impacts on sensitive marine features. Timing can be considered both in terms of the local hydrodynamics, with the aim of minimizing sediment dispersion and the extent of/or the area affected, and the ecology of the system to avoid sensitive periods. Recognizing that timing restrictions can add considerably to dredging costs, a closer look needs to be taken of the social and economic consequences of timing restrictions.

When planning the timing of the dredging operations common sense needs to be applied. In addition to the ecological considerations, operational factors also need to be addressed such as peak recreational and commercial periods in the area and seasonal weather conditions. Therefore, a balance between nature conservation and operational interests needs to be found on a site by site basis when planning dredging activities.

In order to reduce the movement of suspended sediment from the dredging area, dredging should be undertaken at the most favorable points in the tidal cycle. This will vary from site to site, with local hydrodynamic characteristics and the various methods of dredging undertaken. To limit the dispersal of suspended sediments, dredging operations may also be timed to divert the movement of any suspended sediments generated from sensitive areas. For example, in order to reduce impacts to sensitive communities upstream of the dredging activities, such as shellfish beds, dredging operations can be limited to ebb tide. Conversely, where appropriate, by dredging on flood tides timing can be

used to ensure that suspended sediment is retained within the system, instead of being washed out to sea. The disposal of dredged material may be timed to either maximize or minimize the removal of sediments from the disposal site depending on the nature of the site and the sensitivity of the surrounding habitats.

In order to limit the levels of suspended sediments released during sensitive periods to animals and plants near the dredging and disposal areas, the dredging program can be planned to avoid important breeding, migrating and spawning times, egg, larval and juvenile stages or periods of greatest growth. These sensitive periods vary with different animals and to some extent from site to site. Examples of some general sensitive periods are summarized in the table below.

**Table 5.1A: Simplified examples of general sensitive times for selected marine animals and plants**

Type of organism	Sensitive stage in life cycle	Period
Benthic animals	Spawning	Summer
	Highest growth rates (shellfish)	Early summer
	Highest numbers of eggs and larval stages (shellfish)	Early summer
Fish	Migration of salmon and young sea trout (smolt) from rivers to the sea	Spring and early summer
	Highest numbers of eggs and larval stages	Early summer
Microalgae (phytoplankton)	Highest growth rates (highest potential for algal bloom formation)	Summer

It is important to be aware that the sensitive periods for different marine animal and plant species vary and in some cases, such as when considering sensitive periods for overwintering waterfowl, this could restrict dredging periods to impossibly small windows of opportunity. In such cases consideration will be required to find out what is the most important period throughout the year to avoid and the measures that may be recommended to mitigate the residual effect. Local country conservation agencies and other environmental organizations and country wildlife trusts, can also advise on critical breeding, rearing and migration periods that should be avoided in order to minimize potential adverse effects on marine organisms in each marine environment. In most cases, such advice should be coordinated by the country conservation agency so that competing factors can be evaluated and a rational judgment reached which can be fully explained to the dredging contractor.

## 5.2 Air Quality

With respect to air quality, we have identified the potential sources of air pollutant releases from the construction and operational phases of the proposed scheme but consider that these would be of relatively minor significance given the nature of the works.

The operational phase of the scheme is not associated with any significant increase in the air pollutant emissions that is likely to impact upon land-based receptors. However, vessel engine emissions associated with the dredging and disposal works during the construction phase could potentially give rise to impacts on ambient air quality close to the activities.



The overall impact on the air quality at the nearest receptor location to the dredging activity would be expected to be of negligible significance. Hence no mitigation measures are required and the residual impact would be negligible.

The potential for an impact on air quality during the reuse of the dredged material for land reclamation is largely associated with the exhaust emissions from the mechanical equipment (bulldozers and excavators) used in the reclamation work following pumping ashore. The release and dispersion of emissions from construction plant are typically localized on site. Furthermore the nature of the work would require that the materials would be wetted on a continuous basis, so the release of significant quantities of dry sand and/or dust into the air would be minimize effect would very unlikely and, therefore, no impact is predicted. No mitigation measures are required other than a routine wetting procedure of the ground in the dredged area and there would be no residual impact.

### 5.3 Marine Water Quality

#### 5.3.1 Methodology for Impact Prediction and Assessment

Baseline data on water quality were collected through the chemical water sampling and analysis by RGF commissioned by the Client. The chemical water analysis are attached, the chemical analysis includes;

1	Temperature
2	Dissolved Oxygen
3	pH at 25°C
4	Salinity
5	Turbidity
6	Total Suspended Solids (TSS)
7	Bio-chemical Oxygen Demand
8	Chemical Oxygen Demand
9	Total Coliform
10	Total Petroleum Hydrocarbon
11	Ammonium (NH <sub>4</sub> )
	METALS
12	Arsenic (AS)
13	Mercury (Hg)
14	Cadmium (Cd)
15	Copper (Cu)
16	Lead (Pb)

Water sampling at the three locations, at site coordinates (N1400, E800), (N1200, E400), (N1800, E200) around the dredging area were taken at depths ranging from 1 to 1.5m, and laboratory analysis of these samples were conducted for turbidity and TSS (total suspended solids). Samples were taken on January 07, 2009. Result of the analysis can be seen on section 3.5.3 of this study.

#### 5.3.2 Predicted Impacts

The potential impacts from dredging and construction are likely to be as follows.

##### 5.3.2.1 Construction impacts



Dredging will increase suspended sediment loads and turbidity in the water near the dredging area and at the reclamation or disposal site. The extent of the increased suspended sediment will depend on the dredging practices adopted. The impacts will depend on the sensitivity of the reef and other marine life to suspended sediments and turbidity and the timing of the dredging.

These impacts are likely to occur to at least some extent, but can be minimized by appropriate practices. By adopting the best management practices during dredging, the effects on adjacent reef systems of the dredging should be minimum short term and reversible.

Oil or fuel spillages from marine equipment, while unlikely, would have serious consequences for local marine life. The risk of such spillages would be low, and in view of this the potential impact is assessed as moderate and the impact significance as moderate.

#### **5.4 Aquatic and Terrestrial Ecology**

This section provides an assessment of the potential impact of the dredging on the proposed site on the near-shore marine and coastal environment of the area.

##### **5.4.1 Marine ecology**

The existing near-shore marine and coastal environment has been discussed in Section 3. The macro benthic fauna and flora in the area of the new dredging project is generally of low species, diversity and abundance. There is also very low floral and faunal species diversity compared with other non-developed or non-operational areas further offshore.

The relative low species diversity can be attributed to infill, sedimentation, sewage and eutrophication. These are reported as amongst the major environmental pressures for the area in the IUCN reports and further aggravated by the accumulative continued discharge of sewage.

The significant impacts facing this project are as follows:

- Impacts on marine ecology during dredging and construction, due to direct removal of areas of reef and possible sedimentation and turbidity
- Impacts on marine ecology during operation, mainly through the risk of pollution from operational activities and the (very small) risk of a major spill incident
- The impact on wildlife species inhabiting the project area and the vicinity will mainly be the noise generation resulting from the operation of equipment during site development and the dredging operations and the loss of small areas of habitat for water birds. The impact is, however, considered short-term and therefore no long-term impacts on wildlife species are expected
- Chemical wastes from the maintenance and servicing of the construction plant, equipment and vehicle (for instance, cleaning fluids, solvents, lubrication oil and fuel) are a possible issue. Chemical waste arising during the construction phase could pose environmental and/or health and safety hazards if these are not stored and disposed of in an appropriate environmental friendly manner.

##### **5.4.2 Methodology for impact prediction and assessment**



Studies were commissioned, for the purposes of the ecological impact assessment; an ‘ecologically significant’ impact is defined as an impact (adverse or beneficial) on the integrity of a defined site or ecosystem(s) and/or the conservation status of habitats or species within a given geographical area.

Unlike the approach for other environmental issues, impacts are determined as being ‘ecologically significant’ and do not consider the value of the receptor or the planning context. The consideration of the ecological value and planning context are undertaken separately following the determination of the impact’s ecological significance.

The first stage of the assessment process is to consider the impact of the ‘scheme’. The ‘scheme’ includes those measures which are integral to the project design and whose impacts are therefore relatively certain.

Any additional mitigation measures for which there is less certainty to occur, or which represent an enhancement, are presented separately as mitigation proposals. Following the determination of the ecological significance of the mitigated scheme’s impacts there follows a descriptive consideration of the nature of any potential impacts (beneficial or adverse). The ecological value of the resource and the planning policy and legal context are described and used to determine the scale at which the impact should be considered to be of concern.

Finally, the predicted residual impact of the scheme is presented, assuming that the additional mitigation measures described are implemented.

**5.4.3 Baseline conditions**

There are no rich feeding grounds for seabirds in the area, together with the lack of breeding places, means that there is an overall low density of bird population in the area. According to the baseline environmental information presented earlier, the following conclusions can be made of the ecology in the vicinity of the proposed site:

- The local ecology is quite impoverished. It comprises slight opportunistic colonization of the reclaimed land by hardy halophytes and a benthos dominated by gastropods and bivalves that can tolerate the existing levels of contaminants from discharges from the power plant
- There are no resident bird species, but some seabirds and migrating birds may be temporarily seen in the area.

The following Table 5.4A summarizes the baseline information

Marine habitats	There are no known significant or sensitive habitats as identified by IUCN or NWDC
Marine flora and fauna	No significant marine flora is known to be present. A field survey of the corals is required to confirm this.  Fish are present in the port areas, however no data are available to enable identification of particular species and there is no evidence to suggest that these are protected or rare species.  No information is available to suggest the presence of shellfish,



	invertebrates or benthic communities and it is unlikely that these are present in the dredged area Sea mammals are not present in the project area.
Terrestrial habitats	There are no known significant or sensitive habitats as identified by IUCN or NWDC
Terrestrial flora and fauna	There are no known significant or sensitive habitats as identified by IUCN or NWDC

#### 5.4.4 Predicted impacts

As previously discussed, the near-shore marine environment in the immediate vicinity of the existing area is considered to be of low ecological value and sensitivity. Based on current information regarding the project area, there is an absence of protected marine species and of sensitive habitats. However as a means of best practice, coral and fish communities have been identified as potential receptors.

##### 5.4.4.1 Coral reefs

The sensitivity of the coral reefs to pollution has been well documented internationally. Corals generally have a higher biomass productivity and greater species diversity than other marine ecosystems and tend to be more sensitive to the effects of dredging than other ecosystems. As all corals can survive for about 24 hours of burial there are no acute tolerances levels for sediments, only chronic limits.

Dredging can have the following potential effects on coral ecosystems:

- Re-suspension of fine sediment into the water column
- Affect or reduce the turbidity of the water
- Have biological implications on corals and associated organisms
- Lethal affects
- Sub-lethal effects
- Decreased light values that suppress calcification (sub-lethal effect)
- Stimulate energy consuming sediment rejection
- Unfavorably influence the planktonic food supply due to suspended sediment
- Reduce species diversity with some species absent
- Reduce the number of live corals
- Increase the relative abundance of species more tolerant to sediment smothering and reduce light efficiency
- Smaller coral colonies may develop
- An upward shift in depth zoning patterns may result
- Can cause greater abundance of branching forms.

High levels of sedimentation can lead to a decreased growth rate, fewer coral species, fewer live corals, greater abundance of branching flora, decreased recruitment, decreased net productivity and slower rates of accretion. Sedimentation can also have adverse effects on the organisms living in this ecosystem, altering interactions between reefs and reef fish. Threshold levels are especially useful when evaluating effects of the water quality environment on individual organisms. Any potential changes in abundance and spatial arrangements should be considered.

Studies have shown that sedimentation particles can smother reef organisms and reduce the light available for the photosynthesis which is so important in a reef ecosystem. Mean sediment rates and suspended sediment concentrations that do not lead to anthropogenic stress are < 1 to ca 100mg/cm<sup>2</sup>/d and < 10 mg/l (0.15 kg/mg/d).

Other studies have suggested sedimentation rates of 15mg/sqcm/day as high sedimentation rates, which will significantly affect corals.

#### 5.4.4.2 Reef fish

Generally there is a lack of literature available on the effects of dredging on fish in Red Sea waters. However it is necessary to review international studies which are similar to the situation of the Red Sea to determine possible effects.

Dredging can affect physical biota by:

- Increasing suspended solids (solid or colloidal particles which are held in suspension in a liquid)
- Can increase the rate of sedimentation above a value that is acceptable
- Can increase the turbidity of the water
- Can reduce the amount of dissolved oxygen in the system.

Table 5.4B: Definition of possible effect on fish

Lethal effects	These kill individual fish, cause population reduction and damage the capacity of the ecosystem to produce fish – fish will die through clogging of the gills and oxygen starvation
Sub lethal effects	Tissues may be injured or the physiology of the organism may be changed but death will not occur
Behavior effects	The organism may show a change in activity patterns or behavioral change, not normally encountered in an undisturbed environment

#### 5.4.4.3 Summary of Impact Significance

It is unlikely that suspended solids released during dredging for the channel will have any significant impact on the ecology of the area, since fine material would not be expected to have a travel distance of more than 200-300m maximum, besides the suspended solid will be displaced and redistributed by the effect of tidal wave.

Table 5.4C: Summary of Potential Significant Impact

Activity Causing Impact	Predicted Impact	Receptor	Magnitude of Impact	Significance of Impact
Dredging	Direct removal of coral reef from channel dredging	Reef	High	Substantial
	Carryover of silt plume form the dredging	Bio-system in the area	Moderate	Moderate
	Dredging of the channel	Bio-system or Benthic community in the area	Low	Minor

	Impact from noise (surface/ underwater)	Loss of habitat to existing fauna	Negligible	Negligible
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#### 5.4.4.4 Mitigation Measures and Residual Impact

Mitigation measures proposed and the anticipated impacts are shown in table below:

Table 5.4D: Mitigation Measures and Residual Impact

Impact	Nature (adverse or beneficial)	Significance	Mitigation	Residual Impact Significance
Direct removal of coral reef from channel dredging	Adverse	Substantial	Location of channel to minimize coral loss	Minor
Carryover of silt plume from the dredging	Adverse	Moderate	Methods of dredging Method of land reclamation Avoid overspill, use silt curtains if necessary	Minor
Impact from noise (surface / underwater)	Adverse	Negligible	None required	Negligible

## 5.5 Noise and Vibration

### 5.5.1 Potential Significant Issues

The scoping process identified the following potentially significant issues in relation to noise:

- Impacts of construction noise on nearby sensitive receptors. These may include noise from dredging works, piling, compaction, general construction works and construction traffic.

Vibration is not considered to be a significant issue as there are no vibration sensitive receptors, such as sensitive buildings or residential users, near to the project site. The nearest community (accommodation compound) of SARCO's staff is about four (4) km away from the site.

Construction and Operational workers are directly affected by the noise produced by the dredging equipments, but noise is a typical a workplace hazard only. Workers will have access to personal protection equipment hence, sensitivity is assessed as moderate. No other nearby sensitive receptors is determined.

## 5.6 Occupational Health & Safety

SARCO should also have a strict requirement for ensuring that all contractors and subcontractors are properly trained, since this minimizes occupational illnesses and accidents. SARCO has a very well





developed Health, Safety & Environmental (HS&E) procedure manual which needs to be activated and implemented during this project. As normal practice, examples of the in-house or external courses offered by SARCO that successful contractors would be expected to attend are detailed in Table 5.6A below:

Subject	Main Contractor	Sub-contractor
How to conduct toolbox meeting	Supervisors	Foreman, Supervisors and Managers
Safety Concepts	Selected staffs and supervisors	Safety representatives, foreman, supervisors and managers
Walk and Talk Audit	Selected staffs and supervisors	Safety representatives, foreman, Supervisors
Hazard Awareness	Selected staff and supervisors	Safety representatives, foreman, Supervisors
Incident reporting/investigation	All staff	Safety representatives, foreman, supervisors and managers
Fire prevention	Basic – all staff	All supervisors
Office safety	Office staff	Office Staff
Job safety analysis and risk assessment	Supervisors	Foremen and selected staff
First Aid	Selected staff	Selected staff

### 5.7 Summary of Proposed Mitigation

Significant impacts are considered to be those for which “impact significance” is anticipated prior to any mitigation was assessed or implemented. Impacts which are anticipated to be beneficial have also been included in the table below:

Table 5.7A: Summary of significant impact and mitigation measured proposed

Activity causing impact	Predicted Impact	Significance	Proposed Mitigation and Enhancement Measures	Residual Impact Significance
Dredging	Direct removal of coral reef	Substantial	Benthic study and choosing the best location of channels to minimize coral reef damage or loss	Minor
	Carryover of silt plume from the dredging and disposal operation	Moderate	<ul style="list-style-type: none"> <li>▪ Method of dredging</li> <li>▪ Emphasis on using best available technology (BAT)</li> <li>▪ Use of Silt curtains to minimize spreading of silt plume</li> <li>▪ Best equipment and barge used in the operation</li> <li>▪ Limit the volume of</li> </ul>	Minor



Activity causing impact	Predicted Impact	Significance	Proposed Mitigation and Enhancement Measures	Residual Impact Significance
			offshore disposal and instead plan to use large volume inland productively, i.e. for beautification , land reclamation, and backfilling	
	Reduced water quality by increase in turbidity and reduced dissolved oxygen due to re-suspension of sediments	Substantial	<ul style="list-style-type: none"> <li>▪ Daily and monthly Environmental Monitoring</li> <li>▪ Avoid sensitive areas</li> <li>▪ Avoid trenching activities where there is nearby aquaculture</li> <li>▪ Use of appropriate geo-textile curtains to control spread of sediments</li> <li>▪ Use of silt curtain</li> <li>▪ Proper planning and scheduling on the dredging and disposal to avoid strong wind, current and tides that will further add to widen the effect of spreading of sediments</li> <li>▪ Used of best available method</li> <li>▪ Testing and analyzing the water column at upstream and downstream from all the dredging activities</li> </ul>	Negligible
	Water contamination during dredging and disposal	Substantial	<ul style="list-style-type: none"> <li>▪ Method of Dredging and Disposal</li> <li>▪ Daily and monthly Environmental Monitoring</li> <li>▪ Sampling of sediment and water of the dredging site to determine compliance</li> </ul>	Negligible



Activity causing impact	Predicted Impact	Significance	Proposed Mitigation and Enhancement Measures	Residual Impact Significance
			with the World Bank and PME standards before and during dredging <ul style="list-style-type: none"> <li>▪ Apply environmental management plan (EMP)</li> <li>▪ Ensure that all necessary permit prior to dredging and disposal works has been acquired by SARCO</li> </ul>	
	Impact of noise (surface/underwater) from equipment	Negligible	<ul style="list-style-type: none"> <li>▪ High maintenance standard of equipment</li> <li>▪ Installation of noise suppressors in all the equipments</li> <li>▪ Provision of silencer and muffler</li> <li>▪ Limit the hours of operation</li> <li>▪ Apply health and safety and environment manual (HSE)</li> </ul>	Negligible
	Air contaminants due to transporting and reclamation works of dredged materials	Moderate	<ul style="list-style-type: none"> <li>▪ Watering of pavement to minimize dust</li> <li>▪ Use of Personal Protective Equipment (PPE) as per health &amp; safety guidelines</li> </ul>	Negligible
	Potential over-spill from split barge that handles dredged material	Negligible	<ul style="list-style-type: none"> <li>▪ Limit the capacity to avoid overloading</li> <li>▪ Good housekeeping</li> <li>▪ Use of well maintained barge</li> <li>▪ Daily monitoring and inspection</li> </ul>	Minor
	Workplace hazard	Negligible	<ul style="list-style-type: none"> <li>▪ Good housekeeping</li> <li>▪ Applying and enforcing the company's HSE system</li> </ul>	Negligible



Activity causing impact	Predicted Impact	Significance	Proposed Mitigation and Enhancement Measures	Residual Impact Significance
			<ul style="list-style-type: none"> <li>Safe operation through the use of safety management system, protective equipment daily site inspection and safety training</li> </ul>	
Operation	Re-colonization build-up of benthic communities on channel structures	Negligible	No need for any mitigation	Positive Impact
	Entrainment and impingement of marine organism at the intake structure	High	<ul style="list-style-type: none"> <li>Maintaining intake velocity rate</li> <li>Use of velocity caps to reorient flow pattern</li> <li>Fitting of screens at the bottom ceiling of the intake</li> <li>Frequent cleaning</li> </ul>	Moderate
	Reduced water quality due to temperature increase from power plant discharge, thermal pollution and dispersion of potential contaminants	High	<ul style="list-style-type: none"> <li>Modeling design parameter of maximum <math>\leq 3^{\circ}\text{C}</math> temperature increase from the ambient temperature at 100 meters of the discharge point</li> <li>Constant monitoring to make sure that the temperature increase is within <math>\leq 3^{\circ}\text{C}</math> from the ambient marine temperature at 100 meters from the point of discharge</li> <li>Increase retention time in the channel to reduce the temperature before discharge</li> <li>Use of diffusers (as appropriate)</li> <li>Installation of sensors to continuously record the temperature at the discharge point to</li> </ul>	Moderate



Activity causing impact	Predicted Impact	Significance	Proposed Mitigation and Enhancement Measures	Residual Impact Significance
			ensure compliance with World Bank standards ▪ Periodic sampling and analyzing of water at the discharge channel at appropriate points to comply with PME and World Bank standard related to direct effluent discharge	

### 5.8 Residual Impact

Residual impacts are those impacts remaining after all recommended mitigation has been applied. Residual impacts from the project are summarized below, with comment.

- Loss of coral and marine life in the proposed dredged channel. This is an adverse impact, although it could be mitigated by artificial reef creation, or enhancement of reefs elsewhere.
- Risk of spillages of silts from accidents or collisions of split barges. This is an impact of low probability but high consequence, which should be managed through adherence to regulations and best management practices.
- Landscape impacts, this can be mitigated by beautifying the area after the project is done
- There will be an enhancement to the local and national economy as a result of the increased revenue from the new power plant and provision of additional capacity to serve the power requirements of the City and elsewhere.



## **6.0 Environmental Management Plan and Monitoring Procedure**

This section is intended to sets out a proposed strategy for monitoring the potential effects of the dredging activities. The monitoring strategy has been developed to focus on those aspects that are predicted to be affected by the proposed project and/or which are considered to be of particular importance.

Once the scheme has received the final consent from PME, the details of the methodology for the management and monitoring plan will be discussed and agreed with PME prior to implementation. In addition, at that stage it would be important to agree on the points at which action would be triggered and the most appropriate action to take accordingly in view of the findings of the monitoring plan.

The following sections are, therefore, intended to set out the scope of a proposed monitoring program and the principles of such monitoring.

The frequency and the type of monitoring is dependent on the sensitivity of the environment including:

- Water quality
- Ecology
- Coastal dynamics
- Bathymetry to monitor the extent of the dredging and natural changes
- Periodic analysis of benthos and sea bed sediments along the repeated transects
- Identification of control (reference) points on the site to understand natural variability
- Preparation of monthly reports

### **6.1 Environmental Monitoring Protocol**

This section is to set forth the construction and operational monitoring activities and the documentation required for tracking and evaluating the changes to the environment and the effectiveness of the EMPs in place. Monitoring activities include:

- **Construction** - Construction staff and environmental managers will conduct weekly inspections and prepare monthly reports of the work status, along with daily reporting of any incidents or events of potential environmental significance on site. This will include inspections of sediment control measures, assessment of dredged spoil disposal and dewatering areas.
- **Turbidity** - Testing of the water column upstream and downstream from all dredging activities will be performed on site testing daily during dredging and full laboratory testing monthly on the three designated point mentioned.
- **Terrestrial Habitat** – Weekly survey will be conducted by an environmental specialist during dredging period, and the finding will be included in the monthly report of which a copy will be sent to PME.
- **Marine Water Quality Monitoring** – Monitoring of the two dredging locations (intake and discharge channels) to qualify the marine quality through observation and laboratory testing.



All the finding and data collected will be included in the monthly report and a copy will be presented to PME.

- **Waste Management** - Environmental managers on site as well as the environmental specialist will monitor and document the effectiveness of the management practices, procedures and record keeping, as well as management decision and resolution of any unusual situations for all the waste generated (water, soil, hazardous etc.), during both construction and operation phases on a weekly basis, and will be recorded and included in the monthly report.

## 6.2 Water quality and suspended sediment concentrations

As an ongoing plan for establishing an environmental management database for the site of dredging would include a routine sampling and analysis of the water quality (from the three (3) designated locations) during the dredging and disposal activities. In the construction phase an additional program for sediment sampling and analysis should be also taken in the dredging areas.

For the water quality survey, locations should be evenly spaced identified by GPS and should be within the area of the dredging. Water sampling should be conducted at the mid-water depth only.. The sampling should be done on a monthly basis. During the scoping period, three (3) strategic locations for water and sediment sampling has been identified to be used as a reference point during dredging, the coordinates of these locations are (N1400, E800), (N1200, E400), (N1800, E200). Measurements could be taken by using a portable, laser monitoring device. The following parameters could be measured:

- Temperature (°C)
- Dissolved oxygen (mg/l)
- pH
- Salinity (ppt)
- Turbidity (Nephelometric Turbidity Units (NTU))
- Ammonium
- Depth (m).

In addition, a water sample representative from the same locations should be taken and analyzed in a locally approved PME laboratory for the full suite of physical-chemical and biological parameters at least once a month. The sampling and analytical methods should be explained through the monthly report. Each sample and should have a correspondent chain of custody that should be available for auditing purposes should the need arise. The following laboratory analysis shall be conducted on each water sample:

- Total Suspended Solids (TSS)
- Biological Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Total Coliforms
- Total Petroleum Hydrocarbons
- Heavy Metals, arsenic, mercury, cadmium, copper, lead.



Data should be compared with the national standards, however, in the absence of such standards, a suitable international standards shall be chosen.

### **6.3 Sediment Characteristics**

Sediment quality analyses shall be undertaken at representative locations paying particular attention to the locations where excavation and trenching may occur when assessing the impact of any sediment removal and disposal works. Three (3) strategic locations have been identified during scoping to be used as reference points for this monitoring practice.

This will be a necessary part of the environmental monitoring program for the course of the construction work as it will be particularly important to understand the nature of the sediments that will be disturbed. Accordingly, a representative number of sediment samples shall be taken from the areas of proposed excavation and trenching and analyzed in the laboratory for a suite of parameters.

These locations were chosen to be used as the reference points during the scoping period. Methods of sampling and laboratory analysis should meet the requirements of the PME. Each sample should have a chain of custody that should be available for auditing purposes should the need arise. The following laboratory analysis should be conducted on each sediment sample:

- Total petroleum hydrocarbons;
- Total coliforms;
- Heavy metals, arsenic, mercury, cadmium, copper and lead.

The samples collected for laboratory analysis should also be subjected to a standard grain size analysis to determine the nature of the sediments and the percentage of fine material deposited. The method should conform to the standards of the international practices. The data should be transmitted to an environmental specialist who is monitoring of the work during the construction stage in order to establish the relationship (if any) between the faunal communities and the environmental parameters.

### **6.4 Material disposal monitoring at the disposal site**

The distribution of the deposited sediment must be monitored to avoid any build up beyond the 2.0m cap. The even distribution of the material is the contractor's responsibility and to confirm that the dredging along with an even deposition of spoil material are done correctly by the contractor and would be subjected to be reviewed by the PME. To ensure an even spread of materials, the contractor must submit to the Site Environmental Specialist, on a quarterly basis, a detailed deposition plan which need to be approved. This plan must contain the following

- 1) A clear grid pattern which divides the deposition site into 6 equal size areas.
- 2) Deposition location using GPS, all barge shall be equipped with GPS devices
- 3) The previous quarter's dumping statistics (e.g track plots, exact amounts, location (GPS) and date).
- 4) The results of the latest surveys.
- 5) The proposed deposition plan which takes into consideration of the results of the previous quarter.

The Contractor/SARCO should keep daily records and submit a monthly report to the Environmental specialist, outlining how the objectives stipulated in the quarterly report are being met. The





Environmental Specialist must be authorized to stop disposal activities if the deposition plan is not being adhered to.

## **6.5 Environmental Monthly Monitoring Report**

To accumulate relevant data during the dredging and the disposal activities, MTEV environmental specialist and SARCO environmental staff shall witness such activities and record the data by using “Environmental Monitoring Report” form (see appendix 17). This collected information shall be used to create an overall Monthly Environmental Report that will be produced by MTEV and submitted to PME for their review and approval.

MTEV’s environmental specialist is planning to visit the dredging site at least twice (2x) per week to monitor, supervise and consult on the dredging procedures and management plan.

Monthly Environmental Report shall include the following sections as a minimum:

1. Project Profile (Introduction)
2. Weather and Marine Conditions
3. Description of Dredging & Disposal works
4. Accumulated volume of dredged materials and disposals to date
5. Hard-copy of all the Environmental Monitoring Reports
6. Hard-copy of all the Water and Sediment Sampling Laboratory Analysis Report
7. HSE Accident/Incident Report
8. Maps (as appropriate)
9. Site Photographs
10. Risk Assessment
11. Conclusion and Recommendation

MTEV have selected three (3) points to be used as reference point for contamination during dredging



## **7.0 Recommendation and Conclusion**

### **7.1 Recommendation**

Fine sediments are likely to be released into the water column during the dredging and embankment. These will be transported by the waves and currents and deposited onto the coral reef under certain environmental conditions.

The sediments will be suspended (either partially or fully) and dispersed over a substantial area due to magnitude of the sheer stress of waves and currents.

It is highly recommended that silt curtains to be used, which will form as a physical barrier to the transport of fine sediments. The use of best equipment and barges will also minimize this impact dramatically. Timing is also plays an important role in controlling the transport of sediments as the impact will multiply when the waves are strong. Complete mitigations and recommendations are discussed in section 5.7 of this study.

For the embankment works, the use of protective bunds would limit the transport of silts from the areas that are being filled. Using proper geo-textile materials in making the bunds from materials that cannot be transported by waves and currents and are positioned at the edge of area being embanked is highly recommended.

These structures then act as a physical barrier to the silt which is released into the water column in areas that are being filled. The use of bunds could significantly reduce the environmental impact of silt disposition on the shallow reef areas.

The construction of bunds can introduce direct (bund on the coral reef) and indirect (fine material release and sedimentation on reefs) impact during the establishment; therefore special care needs to be applied in constructing and placing these bunds.

The quality and quantity of the discharged material could cause an impact to the marine life if it is not monitored and applied the proper means to eliminate or at least to minimize the impact. Proper monitoring sensors need to be put in place to monitor the temperature of the discharged water. Also by increasing the retention time by installing proper diffusers at the discharge point would help in reducing the temperature in the channel as well as minimizing the impact at the discharge point to the marine environment. Constant monitoring is to make sure that the temperature is within  $\leq 3^{\circ}\text{C}$  temperature increase limit from the ambient marine temperature at 100 meters the point of discharge is recommended.

In order to enforce and satisfy the monitoring and mitigation measures recommended in this study, MTEV environmental specialist is planning to visit the site at least twice (2X) per week during the dredging and construction phase as mentioned in the scoping paper submitted to PME.

During the site visits, MTEV's environmental specialist along with SARCO staff will monitor all the dredging activities to make sure that a full compliance with this EIA findings and recommendations, as well as PME's and World Bank standards are applied.



MTEV will provide a monthly report to PME which will include the parameters mentioned above to satisfy the mitigations measured mentioned in this EIA for review and approval.

In view of this EIA study, SARCO has to apply all the mitigation measures discussed with regards to impact and to follow and implement the environmental monitoring plan and monthly reporting during the marine dredging and disposal activities to ensure full compliance with the World Bank’s and PME’s Standards.

## 7.2 Conclusion

This EIA Study has identified that the marine dredging activities will have a number of environmental impacts, both positive and negative. The significant impacts have been summarized in Table 5.7A, and set out in details in the individual impacts sections. Mitigation measures were addressed for each of the impacts and recommendations were given to eliminate and or minimize the impact.

If the recommended mitigation techniques detailed in Table 5.7A, the environmental management and monitoring recommendations given in section 6.0 are to be followed, it is anticipated that the negative impacts will not lead to any significant effects.

Significant impacts are considered to be those for which will be anticipated to create a negative “impact significance” prior to any mitigation was assessed and/or proposed. Impacts which are anticipated to be beneficial have also been included in the table below.

Table 5.7A: Summary of significant impact and mitigation measured proposed

Activity causing impact	Predicted Impact	Significance	Proposed Mitigation and Enhancement Measures	Residual Impact Significance
Dredging	Direct removal of coral reef	Substantial	Benthic study and choosing the best location of channels to minimize coral reef damage or loss	Minor
	Carryover of silt plume from the dredging and disposal operation	Moderate	<ul style="list-style-type: none"> <li>▪ Method of dredging</li> <li>▪ Emphasis on using best available technology (BAT)</li> <li>▪ Use of Silt curtains to minimize spreading of silt plume</li> <li>▪ Best equipment and barge used in the operation</li> <li>▪ Limit the volume of offshore disposal and instead plan to use large volume inland</li> </ul>	Minor



Activity causing impact	Predicted Impact	Significance	Proposed Mitigation and Enhancement Measures	Residual Impact Significance
			productively, i.e. for beautification , land reclamation, and backfilling	
	Reduced water quality by increase in turbidity and reduced dissolved oxygen due to re-suspension of sediments	Substantial	<ul style="list-style-type: none"> <li>▪ Daily and monthly Environmental Monitoring</li> <li>▪ Avoid sensitive areas</li> <li>▪ Avoid trenching activities where there is nearby aquaculture</li> <li>▪ Use of appropriate geotextile curtains to control spread of sediments</li> <li>▪ Use of silt curtain</li> <li>▪ Proper planning and scheduling on the dredging and disposal to avoid strong wind, current and tides that will further add to widen the effect of spreading of sediments</li> <li>▪ Used of best available method</li> <li>▪ Testing and analyzing the water column at upstream and downstream from all the dredging activities</li> </ul>	Negligible
	Water contamination during dredging and disposal	Substantial	<ul style="list-style-type: none"> <li>▪ Method of Dredging and Disposal</li> <li>▪ Daily and monthly Environmental Monitoring</li> <li>▪ Sampling of sediment and water of the dredging site to determine compliance with the World Bank and PME standards before and during</li> </ul>	Negligible



Activity causing impact	Predicted Impact	Significance	Proposed Mitigation and Enhancement Measures	Residual Impact Significance
			dredging <ul style="list-style-type: none"> <li>▪ Apply environmental management plan (EMP)</li> <li>▪ Ensure that all necessary permit prior to dredging and disposal works has been acquired by SARCO</li> </ul>	
	Impact of noise (surface/underwater) from equipment	Negligible	<ul style="list-style-type: none"> <li>▪ High maintenance standard of equipment</li> <li>▪ Installation of noise suppressors in all the equipments</li> <li>▪ Provision of silencer and muffler</li> <li>▪ Limit the hours of operation</li> <li>▪ Apply health and safety and environment manual (HSE)</li> </ul>	Negligible
	Air contaminants due to transporting and reclamation works of dredged materials	Moderate	<ul style="list-style-type: none"> <li>▪ Watering of pavement to minimize dust</li> <li>▪ Use of Personal Protective Equipment (PPE) as per health &amp; safety guidelines</li> </ul>	Negligible
	Potential over-spill from split barge that handles dredged material	Negligible	<ul style="list-style-type: none"> <li>▪ Limit the capacity to avoid overloading</li> <li>▪ Good housekeeping</li> <li>▪ Use of well maintained barge</li> <li>▪ Daily monitoring and inspection</li> </ul>	Minor
	Workplace hazard	Negligible	<ul style="list-style-type: none"> <li>▪ Good housekeeping</li> <li>▪ Applying and enforcing the company's HSE system</li> <li>▪ Safe operation through the use of safety management</li> </ul>	Negligible



Activity causing impact	Predicted Impact	Significance	Proposed Mitigation and Enhancement Measures	Residual Impact Significance
			system, protective equipment daily site inspection and safety training	
Operation	Re-colonization build-up of benthic communities on channel structures	Negligible	No need for any mitigation	Positive Impact
	Entrainment and impingement of marine organism at the intake structure	High	<ul style="list-style-type: none"> <li>▪ Maintaining intake velocity rate</li> <li>▪ Use of velocity caps to reorient flow pattern</li> <li>▪ Fitting of screens at the bottom ceiling of the intake</li> <li>▪ Frequent cleaning</li> </ul>	Moderate
	Reduced water quality due to temperature increase from power plant discharge, thermal pollution and dispersion of potential contaminants	High	<ul style="list-style-type: none"> <li>▪ Modeling design parameter of maximum <math>\leq 3^{\circ}\text{C}</math> temperature increase from the ambient temperature at 100 meters of the discharge point</li> <li>▪ Constant monitoring to make sure that the temperature increase is within <math>\leq 3^{\circ}\text{C}</math> from the ambient marine temperature at 100 meters from the point of discharge</li> <li>▪ Increase retention time in the channel to reduce the temperature before discharge</li> <li>▪ Use of diffusers (as appropriate)</li> <li>▪ Installation of sensors to continuously record the temperature at the discharge point to ensure compliance with World Bank standards</li> </ul>	Moderate



Activity causing impact	Predicted Impact	Significance	Proposed Mitigation and Enhancement Measures	Residual Impact Significance
			<ul style="list-style-type: none"> <li>▪ Periodic sampling and analyzing of water at the discharge channel at appropriate points to comply with PME and World Bank standard related to direct effluent discharge</li> </ul>	

The most significant impacts occurring during the construction of the project will be during the dredging phase. However, these impacts are anticipated to be short term and, providing that the full mitigation measures that were discussed earlier were to be applied, the impacts significance will not be severe.

Beneficial socio-economic impacts was also concluded resulting from the new additional capacity of the Power Plant, both to the residents of Jeddah, and throughout Saudi Arabia, which will be in terms of improving their standards of living, creating more jobs to local residents and allowing the development of the infrastructure in the area through building more facilities, factories and governmental and private institution.

By applying all the mitigation measures and the Environmental Monitoring Plan (EMP) and the reporting procedure throughout the dredging and disposal activities, the proposed marine dredging activities is anticipated to have a controlled and minimum impact on the marine environment.

MTEV will monitor the dredging activities on site through their environmental specialist to make sure that all the mitigation measures and monitoring plan are implemented on site to satisfy the World Bank and PME’s standards for dredging and deep sea dredged material disposal procedures.

*In view of this EIA study, the main environmental impacts due to the dredging projects are:*

- 1. Direct removal and/or destruction of the coral reef in and around the dredging site.*
- 2. Carry-over of silt from the dredging and disposal activities.*
- 3. Reduced water quality and reduced dissolved oxygen due to the increase of turbidity and suspension of sediments.*
- 4. Increased water temperature at the discharge point due to high power plant water discharge*
- 5. Water contamination during dredging and deep sea disposal of dredged material*

*Through our mitigation plan, site works procedure recommendations and monitoring plan, all the above impacts have been addressed. It was concluded that the above impacts can be controlled and localized and their environmental effects would be minimum. The recovery of the ecosystem on the dredging site will take anywhere from 2 to 5 years after completion of the project.*