PORT OF ADEN MASTER PLAN
ADEN - REPUBLIC OF YEMEN

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1- INTRODUCTION

1.1 Terms of Reference

Yemen Ports Authority (YPA), under the Ministry of Transport, is responsible for the development of Yemen’s ports in the Gulf of Aden. The Port of Aden is a prime national asset for Yemen. It provides essential import and export services for oil and dry cargoes, serves a large and growing hinterland around and well beyond the city of Aden and has, since 1997, developed container transshipment services based initially on the Ma’alla Terminal and, following completion of the Aden Container Terminal (ACT) in 1999, at the ACT.

The Master Plan for the City of Aden was undertaken in 2004/2005 as part of the World Bank Port Cities Development Programme for Yemen. The City Master Plan took into account the many elements that will affect the growth of the city, including the significant impact that future port facilities would have on the city.

Since 2001 the Ministry and the Port Authority have worked on various port expansion options, considering at different times an extension of the Ma’alla berths to resolve port congestion problems and building new facilities to the north of these berths in sheltered water east of the ACT. During its close involvement with the consultants developing the City Master Plan, YPA concluded that future expansion of the port should take place along the North Shore, west and north of the ACT. The north shore area lies in a bay largely protected from the SW monsoon and extends around 9 km west from the ACT access road towards Little Aden. The distance north-south between the inner harbour approach channel and the shore varies between 3 and 6 km.
An agreement for consultancy services was signed between the “Yemen Ports Authority – Port of Aden” and “Ebeido” Consulting Civil Engineers in order to prepare a master plan for the port. This will take into account the many factors that will affect the port during the study period and provide the basis for the allocation of areas for new specialized and general purpose quays, yards and other port-related facilities.

The objectives of this study are:

(A) To present recommendations on the proposed port layout. The port development shall be described in three stages showing how the port could logically expand to provide quays and working areas for all types of cargoes to be handled, stored, and transported.

(B) To provide outline plans for each of the above stages, showing breakwaters, quays, storage areas, cargo sheds, channels, access roads, service buildings and port roads. Drawings shall indicate the type of proposed new breakwaters and quay walls but shall not be presented in detail.

(C) To review existing borehole and geotechnical data and assess, as far as possible, likely ground conditions in the proposed area covered by the Master Plan. Recommendations shall be given on additional geotechnical investigations that need to be carried out.

(D) To advise on the potential impact on the environment of carrying out the proposals shown in the Master Plan including noise, dust,
and all other environmental impact associated with a project of this nature.

1.2 **Outline of Report**

This report is organized as follows:

**CHAPTER (2)**

Discusses, existing port layout and approaches and existing port facilities and services including:

- Ma’alla Multi-purpose Terminal.
- The Aden Container Terminal (ACT).
- Bunkering Berths.
- Aden Fisheries Harbour and other Facilities.
- Inner Harbour Buoy Berths.
- Aden Oil Harbour.
- Outer Harbour and inner Harbour Anchorages.
- Marine Services.
- Ship Repair.
- Other Port Services and Requirements.
- Dredging and Port Access Channels.
- Road Access.
- Cargo Tonnage and Number of Ship Calls.
- Other main entities affecting the port.

**CHAPTER (3)**

Deals with the conditions regarding both soils and environment in the region of Port of Aden including: soils and surface geology, geography, meteorology, and oceanography.

**CHAPTER (4)**

Discusses the proposed stages of the port development.

**CHAPTER (5)**

Concerns with the potential impact on the environment of carrying out the proposals shown in the Master Plan.
2- EXISTING PORT LAYOUT, APPROACHES, FACILITIES AND SERVICES

2.1 Port Layout

The Port of Aden, in Latitude 12° 47’N and Longitude 044° 58’E, is situated in a bay sheltered by the promontory and hills of Shamsan to the south and east, the shoreline to the north, and the Little Aden or Bureiga hills and promontory to the east. The area of sheltered harbour north of a line from the Little Aden Oil Refinery breakwater and Ras Tarshayn is around 60km², making Aden one of the largest natural harbours in the world. South of this line an additional 75km² lies inside port limits.

The division between the inner harbour and outer harbour for port charging purposes is along a line from Ras Marbut bearing 128° 40’. Port limits are defined from Ras Abu Qiyamah in a direction 166° for 1.76 miles to Lat 12° 42.00’ N, Long 44° 54.00’E, then to Lat 12° 42.00’ N, Long 45° 00.00’E, then on a bearing of 007° for a distance of 3.15 miles to Round Island. Fig. 2.1 shows general layout of Port of Aden.

2.2 Port Approaches

Approaches to Aden from the east, south and west are free of obstructions. The sea bed slopes at a rate of around 1 in 560 meters from the inner harbour entrance to the 15 meter contour, then 1:340 from 15 to 20 meters, and 1:170 from 20 to 30 meters, with the slope increasing again to the 50 meter contour, then to depths of 200 meters within 10 miles of the pilot station. The sea bed is very stable and with low current and tidal
velocities there is virtually no siltation. Recent hydrographic surveys of the present port show that depths in undeveloped parts of the harbour are similar to those recorded in the first survey in 1835.

The deviation to reach the Aden pilot station from the main east-west shipping route between the southern entrance to the Red Sea at Bab el Mandeb to Singapore is four miles. From the pilot station, channels to the oil harbour have been dredged to a current depth of 14.7 meters, and 15.0 meters to the inner harbour. From the pilot station to the inner harbour breakwater is 4 miles, or 7.5 km. (see UK Admiralty Charts 7, 3660, 3661 and 4705).

2.3 Existing Port Facilities and Services

2.3.1 Ma’alla Multi-purpose Terminal

Historically Aden discharged and loaded its dry cargo at stream berths in the inner harbour, using barges to move cargo to and from the ships. This method is still used occasionally when no berths are available at the Ma’alla Terminal, particularly for loading salt from barges, but it requires double handling of the cargo.

In 1954 the Home Trade Quay (HTQ) was constructed at Ma’alla to allow smaller ships employed in coastal trade in the Red Sea and Gulf of Aden to be loaded and discharged at alongside berths. By 1986 containers were becoming more important in world trade and there was pressure to increase bulk and general cargo handling rates to improve ship turnaround time in port. Following extensive sea bed geotechnical investigations, channel and turning area, the Ma’alla Terminal was designed to handle
containers, bulk and general cargo. The Terminal was completed in 1991 on the same line as the quay wall of the HTQ and gave Aden, for the first time, the ability to handle large ocean-going ships at alongside berths.

The Terminal has proved to be a highly successful development for the port and has been effective in reducing the cost of imports and exports for the country by increasing cargo handling speed and efficiency since 1991. Ships can now berth alongside and use either their own cranes or derricks to work cargo or, in the case of most bulk cargoes, shore-based unloading equipment. The port is a major and important source of employment for Yemen, both of YPA container handling stevedores and head office personnel, and of stevedores working for the Joint Stevedoring Company which handles non-container cargo at Ma’alla.

The most heavily used dry cargo berths are the four deepwater berths 1 to 4, as draught and length limits restrict the size of ship that can dock at Berths 5 and 6 and the RoRo Berth. Statistics, shows that the tonnage of dry cargo handled at Aden, primarily at these four main berths, has increased from around 960,000 tones in 1997 to over 3 million tonnes in 2004. This has primarily been achieved by handling higher numbers of bulk carriers and general cargo ships, and by handling them more efficiently. Bulk handling rates for grain and cement have increased in some cases from 1,500 tonnes/day to 8,000 or more tonnes/day. Ships’ sizes have also been increasing as larger consignments have been delivered to Aden.

At the eastern end of the Ma’alla Terminal are extensive shallow water quays used by barges bringing cargoes from ships moored at the buoy berths, LASH barges and other shallow-water craft. Dhow sometimes use these quays, while larger dhows use the HTQ.
A new 300 metre long jetty for the Hayel Saeed Anam company was brought into operation to serve the company’s bulk wheat storage and flour mills at the western end of the Ma’alla Terminal. This has a depth alongside of 14.0 metres on the north side and 12.0 metres on the south side to handle large bulk vessels at the deeper berth, and allow transshipment of bulk grain to smaller ships across jetty. The south side will also be used for bran exports. The company will install automated bulk handling equipment to raise efficiency further. The jetty will release space on the Ma’alla quay for consignments brought in by other traders, reducing the current congestion that keeps ships waiting at the anchorage for up to 4 days for a berth at Ma’alla at present.

However, the two container berths, 1 and 2, at Ma’alla are due to come under the control of a concessionaire who is expected to be awarded the concession for all container handling in Aden. The concession for Ma’alla is likely to last for seven years only, after which time container handling at Ma’alla would be terminated. From next year YPA will operate only Berths 3 and 4, perhaps the RoRo berth, and the shallower HTQ berths.

2.3.2 The Aden Container Terminal (ACT)

The ACT was designed in 1996, and built by a concessionaire between 1997 and 1999. Bottom material was used to reclaim around 35 hectares for the terminal, to provide a stockpile of material for future terminal expansion to the west and to reclaim a further 80 hectares north of the rubble mound as working area within the port. The quay wall has a depth of 16 metres, is 710 metres long and stepped down at each end to allow extensions east and west. South and east of the ACT is a turning area 700 metres in diameter so that ships of 400 metres in length or more could be turned.
The primary purpose of the ACT is to handle container transshipment business. With virtually zero deviation from the main east-west shipping route, Aden is well positioned for this, particularly as world fuel costs rise. Container throughput at Aden grew by 40% per year between 1995 and late 2002, when the Limburg incident caused a massive rise in war risk premiums charged on ships calling Yemeni ports. Aden’s container throughput is again rising rapidly and base load or local cargo has grown from 9,000 TEU in 1995 to the present figure of about 150,000 TEU. This reflects the increasing importance of Aden to Yemen’s traders as ocean freight rates to the port have fallen. This fall results from increasing volumes handled, leading to greater competition between more shipping lines, and efficiency gains with lower costs in container operations.

The ACT is currently operated by Overseas Port Management (OPM) following the withdrawal of Yeminvest and the PSA Corporation in 2003. The Government wishes to sign a concession agreement with a larger operator capable of investing in additional quay length, yard space and handling equipment, and of attracting more major lines to use Aden for transshipment purposes. The ACT could be extended to a length of well over 3,000 meters and there is ample space within the port area to build many times this length of quay in other parts of the harbour to handle any foreseeable volume of containers for regional distribution.

2.3.3 Bunkering Berths

Aden was a major ship bunkering port in the 1960’s, 2nd only in the world to New York, and handled over 5 million tonnes of bunkers and over 5,000 ship calls per year at
that time. Aden’s location mid-way between Europe and the Far East made it a favoured port of call at a time when the range of a typical 10,000 GRT cargo ship carrying 600 tons of bunkers was 12-15 days. For many years the port was dredged to 1 foot deeper than the Suez Canal so that westbound ships could take on a full load of bunkers at Aden and be at their deepest possible draft for the Canal transit, with a maximum tonnage of cargo on board.

The closure of the Canal in 1967 for 8 years damaged Aden’s bunker business and when it re-opened world trading patterns and ship design had changed. Container shipping was developing, Rotterdam and Singapore were becoming major bunker ports and ships were designed with larger bunker capacity so that a call to a middle-distance bunker port had become less important for many ships.

Aden’s 13 bunker berths have now been reduced to the three piled dolphin berths installed by BP and the Port Authority in 1963/4 to replace buoy berths and increase bunkering speed. Two of these are operated the Aden Bunkering Department of the Aden Refinery, and one by an independent company. One additional buoy berth, the Yemen-Kuwait berth, is currently being refurbished. The pattern of bunkering has changed in most ports and offshore bunkering locations. Ships preferring to bunker as they work cargo at the berth or wait at anchor, thus saving the cost and time required to move to a bunker berth. Over 200 bunker barges now operate in Singapore and offshore bunkering at Fujirah reports an annual volume of over 9 million tonnes. Future bunker operations at Aden may well be a mix of bunker berths and bunkering at cargo berths from barges and small tankers.
The two dolphin berths on the south side of the harbour are also used by passenger ships, who transfer passengers to and from the tourist pier in Tawahi using their own boats and sometimes passenger carrying boats provided by YPA.

### 2.3.4 Aden Fisheries Harbour and Other Facilities

The Ministry of Fish Wealth of Yemen operates the Aden Fisheries Harbour on the south side of Aden inner harbour. The harbour provides important facilities for handling foreign and Yemeni trawlers and other large fishing boats that operate in the Gulf of Aden. It has a depth alongside of 7.8 metres on a quay 470 metres in length, dredged in 1987. It provides repair facilities, including the 1,500 tonne capacity floating dock operated by the National Dockyard Company in a 6-metre deep pocket close to the shore, workshops, cranes etc.. A large cold store for frozen fish is available, and fish landed at the harbour can also be loaded directly into reefer containers for export from Aden.

Smaller fishing boats and dhows use landing facilities close to the Ma’alla Terminal, where an active local fish market operates. Proposals for building a larger fisheries harbour at a new site inside Aden inner harbour to handle vessels fishing in the western Indian Ocean have been suggested by international fisheries consultants.

### 2.3.5 Inner Harbour buoy berths

The buoy or ‘stream’ berths are used for several purposes. These include cargo handling, mainly for discharging timber, bulk grain and bagged flour to barges, and for loading bagged salt from the Aden Salt Works on the NE side of the harbour from barges.
that use a channel crossing the shallow part of the inner harbour to the works site. Ships temporarily laid up also use the berths. Berth 8 in by the fisheries harbour is being prepared for bunkering.

2.3.6 Aden Oil Harbour

The Oil Harbour was built in 1955 to serve the Aden Refinery, which has a current refining capacity of around 5.5 million tonnes/year. It is reached by a channel that separates from the main channel to the inner harbour 2.0 km from the pilot station. This channel is 2.7 km long to the oil harbour breakwater. In the 1980’s the 4 oil berths were refurbished and new dredging works completed to provide a depth in the channel and turning area of 14.7 metres, and 15.8 metres at the largest berth, No. 1. In the 1990’s the two dry cargo, bitumen, LPG and RoRo berths were extended and rebuilt to give an alongside depth of 11 metres. The main part of the oil harbour can now handle tankers of up to 110,000 TDW fully loaded.

2.3.7 Outer Harbour and Inner Harbour anchorages

Ships anchoring at Aden can use two main areas. South of the harbour approach channels anchorage is available in good holding ground in water depths from 12 to 40 metres inside port limits. Weather conditions in this part of the anchorage for large ships do not present any problems at any season. Smaller ships can anchor to the north of the oil harbour approach channel in water of 5 to 10 metres in depth, where shelter from the SW
monsoon during summer months is available. Strong currents do not affect either of the anchorages.

2.3.8 Marine Services

YPA is responsible for providing pilotage, towing and mooring services for all ships entering the inner harbour and pilotage services at the oil harbour. Aden Refinery operates two tugs at the oil harbour and provides mooring boats. YPA tugs are sometimes needed to supplement the Refinery tugs.

Tugs, pilot boats and mooring boats are berthed and operated from the buoys and pilot bunder inside the inner harbour breakwater, giving them convenient access to all areas of the port. YPA also operates a small grab dredger, floating crane, mainly for lifting buoys, hydrographic survey boat and work boats.

2.3.9 Ship Repair

Ship repair services have been provided in Aden for many years. At present these are provided by the National Dockyard Company (NDC). The NDC operates a 1,500 tonne floating dock located in the fisheries harbour, which is in need of maintenance and can no longer lift its full capacity. The NDC yard is located at Hedjuff, between the Ma’alla Terminal/Hayel Saeed Anam grain silos complex and the fisheries harbour. Plans have been put forward on several occasions to upgrade the facilities and improve staff skills. Other plans to re-locate the repair facilities at a site which has fewer restrictions in terms of water depth, road access, and especially space for expansion, have also been put
forward. The current container handling concession proposals include proposals for the concessionaire to take over the NDC and modernize it.

Other long-established repair facilities, primarily for YPA craft, were set up inside the inner harbour breakwater at the YPA Technical Department. This has a large slipway for the floating crane, YPA dredger, and some tugs. Smaller slips serve pilot boats, mooring boats, work boats, the hydrographic survey boat etc.. Machinery and electrical workshops, casting shop, buoy repair yard and diving services support the repair and maintenance operations. A study of proposals for significantly upgrading the facilities available to YPA, and other users, at the Technical Department is due to be carried out shortly.

Minor slipways and repair shops are also operated at Hudjeff, close to the NDC, for repairing and maintaining barges used to move cargo from the stream berth to Ma’alla.

2.3.10 Other Port Services and Requirements

A long-established naval base to the east of the YPA Technical Department is currently being refurbished. Requirements for any changes in naval facilities should be considered.

A base for coast guard patrol boats has been built at Tawahi next to the passenger pier.

Yachts calling Aden generally anchor in the area off the passenger pier and coastguard base, refuel at the Aden Bunkering Department facilities and take on water and stores at the pier.
A power station intake for cooling water on the North Shore should remain unobstructed.

2.4 DREDGING AND PORT ACCESS CHANNELS

Natural depths in the inner harbour basin were 6-7m when the first extensive survey of the harbour was undertaken in 1835, with depths increasing to 40m plus at a distance of 5 miles south of the inner harbour entrance. As ship size increased dredging to greater depths became essential and was started in 1890 to improve the depth to 8.2m (26 feet), with a short access channel leading to water of the same natural depth in the outer harbour that was well inside the 6 fathom (36 feet) line. Depths increased with ship size and with deepening of the Suez Canal, with Aden inner harbour being maintained 1 foot deeper than the Canal so that westbound ships could bunker in Aden, complete the Red Sea passage and transit the Canal with maximum cargo load.

In 1953-54 Aden Oil Harbour was built and land for the refinery and harbour was reclaimed from sandy materials. The Canal closed in 1967, and in 1975, when the Canal reopened, the access channel to the inner harbour was dredged to 11.9m (38 feet) and extended to the same natural depth in the outer harbour. In the late 1980’s Aden Oil Harbour channel, berths and turning area were deepened to 14.7m or better and the outer end of the channel extended to a natural water depth of 15.0m.
In 1988-90 the Ma’alla Terminal was built, with over 3 million m³ of materials being dredged and/or used for reclamation. The remaining spoil was taken to the dumping area outside port limits.

The most recent channel dredging programme was carried out in 1997-1999, when the approach channel to the inner harbour was deepened from 11.9m to 15.0m. The width of the main section of the channel remained at 183m. The width is 220m over the outer section of the channel, to equal the width of the oil harbour channel, and 220m in the section from the inner harbour breakwater to the 700m diameter turning area off the ACT.

YPA anticipates that the channel will be widened and deepened to improve access for very large container ships and for bulk carriers, and possibly to provide the capacity for two way traffic, i.e. for inbound and outbound ships at the same time.

However, the length of channel from the pilot station to inner harbour breakwater is only 4 miles and its longest straight section is 2 miles long. Aden was handling over 5,000 ship calls/year in the 1960’s with a single lane channel, thus the advantages or otherwise of a two-way system should be carefully investigated. Some realignment of the channel to take into account likely expansion of the port to the west, and to provide a straight run into any new basin, will need to be studied.

A further factor in making a port attractive to a shipping line, and its insurers, is an absence of obstructions in port approaches. Wrecks and other obstructions are a particular point of concern. During the 1997-1999 dredging programme two wrecks were removed from the inner harbour area, consisting of a barge on the edge of the south side of
the approach channel inside the inner harbour breakwater, and a fishing boat causing an obstruction on the northern side of new turning area.

The dredging programme was preceded by an extensive magnetometry survey by a specialist company to identify metal objects and potential explosives on the sea bed. No explosives were found, but a number of metal objects were discovered, such as old cars, anchors, chains, concrete blocks, tires etc. In general these obstructions were removed by the cutter suction dredger, either by pumping them up in the case of small items, or by cutting a hole in the sea bed to push the object into, then continue dredging.

There are six wrecks lying inside Port of Aden limits between the pilot station and the floating dock east of the turning area. These six wrecks are: (1) a wreck of the naval patrol boat sunk in 1986; (2) a wreck of the small RoRo vessel “Soloda” sunk in 1999; (3) a wreck of the “Cosmos” sunk in 1984; (4) a wreck of the floating dock “Al Yemen”; (5) a wreck of a wooden sailing boat sunk in 2003; and (6) a wreck of a flat-top barge.

Wreck number “1” is a wreck of a naval patrol boat sunk in 1986 which is roughly in line with the channel entrance at a natural depth of 19.5m. Depth over the wreck was 14.6m. in 1997, and when the channel was deepened from 11.9m. to 15.0m. it was essential to increase the depth to at least minimum channel depth. Yemen Ports Authority arranged for this to be done and explosives set by divers reduced the height of the wreck’s super structure to give a current clear depth of 15.3m. This wreck now lies inside the 0.5 mile radius circle at the pilot station centered on 12° 44.0’ N, 044° 57.0’ E (see U.K. Admiralty Chart No.7). Yemen Ports Authority has sketches of the wreck which is reported by divers to be in three sections.
Wreck number “2” is a wreck of the small RoRo vessel “Soloda”, that sunk in water 5m. deep in 1999 and settled in an upright position on the sea bed. It lies northwest of and 7 cables clear of the approach channel (see U.K. Admiralty Chart No.7 and No. 3660). It does not present a hazard to navigation, but lies at the eastern edge of the anchorage area for small vessels. Yemen Ports Authority has details of this wreck.

Wreck number “3” is a wreck of the “Cosmos”, that sunk in 1984 in Berth 1A inside the inner harbour breakwater in water from 10.0 to 11.0m. deep. It lies on the south side of the slope of the inner harbour channel with its stern just 15m. south of the inner harbour access channel (see U.K. Admiralty Chart No.7 and No. 3660). The ship lies on its side and is visible at all states of tide. An attempt was made to remove the wreck by cutting it into sections in 1993 – 1994, but this process was not completed.

Wreck number “4” is a wreck of the floating dock “Al Yemen”, lifting capacity 4500 tonnes lying in 3.5m. of water immediately east of the turning area (see U.K. Admiralty Chart No.7 and No. 3660). The wreck is collapsing as it corrodes and needs to be removed to allow any extension of the quay wall or turning area eastwards.

Wreck number “5” is the wreck of a wooden sailing boat about 40m. in length that sunk in 2003. This wreck is close to the north of the pocket dredged in 1998 for the NDC floating Dock.

Wreck number “6” is the wreck of a flat-top barge, around 20m. x 8m. x 2m., sunk in 2-3m. of water. This wreck is located south of the inner harbour turning area, south of the north cardinal buoy and east of the Jerama Beacon. Its position is marked by a small unit buoy.
2.5 ROAD ACCESS

The Ma’alla Terminal is an integral part of the City of Aden, and as such is responsible for generating a good proportion of traffic on the roads of Ma’alla, Khormaksar and Tawahi as cargo is discharged and moved to or through these areas, adding to traffic congestion. Much of the imported cargo now leaves Aden on the road leading to Taiz and the north, or the coast road to the east. Grain imports, and the distribution of grain and flour from the western end of Ma’alla, further increases truck traffic, while loaded and empty containers returning to the Terminal are a further burden on the road capacity.

After extended discussions with the parties involved, the Aden City Master Plan does not recommend any further expansion of cargo handling facilities in the Ma’alla area. The 6 lane road which is being built to provide an efficient link from Aden to Sanaa, via Taiz, will be routed to the central part of the north shore of Aden harbour, west of the ACT and Free Zone. The alignment was changed from the original proposed connection with
Aden on the eastern side of Sheikh Othman, and the new corridor is intended to be compatible with the probable expansion of port facilities to the west of the current port development. The concept is that cargo handling at Ma’alla will gradually move to new berths away from the city, in the North Shore area, as these are built and brought into operation.

2.6 CARGO TONNAGE AND NUMBER OF SHIP CALLS

The major impact on demand for berth space from non-container cargoes is expected to be rock exports. A quarry 120 km from Aden supplied one ship load in 2002 of high quality limestone. With CaO >54.5% and Silica <0.3%, the stone is very suitable for steel making in India. The quarry contains an estimated 650 million metric tonnes of economic reserves. However, the 2002 project failed because of logistical problems, in particular the need to use barges and thus double handling to load the ship. YPA has now given outline permission for an exporter to build a temporary berth close to the eastern end of the rubble mound, allowing loading direct from quay to ship. This berth is due to become operational in 2007 and the exporter predicts that other berths will be required within two years as world demand for limestone of this quality, and for other types of rock, such as feldspar, expands the business.
The other major change in cargo volume and number of ship calls at Aden would be through container handling. A concession is due to be awarded to expand the ACT and allow Aden to reach its potential as a major regional transshipment center. If Aden is provided with berths, equipment and manpower to allow it to grow, and can offer customers efficient and cost effective services within a secure environment, container volumes can be expected to rise very rapidly.

2.7 OTHER MAIN ENTITIES AFFECTING THE PORT

On the north side of the Port Aden Free Zone has an area of some 1,500 Hectares that are due to be developed. Regular shipping services and easy access to container berths and general cargo berths are important for successful Free Zone development.

The approaches to Aden Airport lie over the area of proposed port expansion. New construction would probably occur at a distance of around 3 km from the closest point to the end of the runway. This may limit the height of structures permitted close to the runway line.

2.8 TYPE OF QUAY WALLS IN THE PORT

Construction in the port using either mass concrete or piling has taken place since the early days as favorable sea bed structures support both methods of construction. Most recently the concrete quay wall for the Aden Container Terminal (ACT) provides a depth of 16.0 meters alongside the berth.
2.9 Main Activities And Volume of Unloaded Merchandise in Port of Aden For The Period 2002-2005

Tables 2.1 and 2.2 show statistical data regarding main activities in Port of Aden and volume of unloaded merchandise in the port for the period 2002-2005.

2.10 Container Throughput in The Port of Aden

Tables 2.3 and 2.4 show container throughput at Ma’alla Terminal and Aden Container Terminal for the period 1999-2005.

2.11 Monthly Revenue, Cost, Ebitda Performance of Aden Container Terminal For Years 2004 and 2005

Tables 2.5 and 2.6 show monthly revenue, cost, and Ebitda performance at Aden Container Terminal for years 2004 and 2005, respectively.

Table 2.1 Main Activities In Port of Aden For The Period 2002-2005

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<tr>
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<th>Unit of Qty.</th>
<th>Year</th>
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### Table 2.2 Unloaded Merchandise In Port of Aden For The Period 2002-2005

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Table 2.4 Container Throughput at Aden Container Terminal For The Period 1999-2005

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## Table 2.5 Monthly Revenue, Cost, Ebitda Performance of Aden Container Terminal During 2004

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### Monthly Revenue, Cost, Ebitda Performance of Aden Container Terminal During 2004

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### Operating Expenses In U.S. Dollars

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Table 2.5 (Cont.) Monthly Revenue, Cost, Ebitda Performance of Aden Container Terminal During 2004

<table>
<thead>
<tr>
<th>Gross Profit in U.S. Dollars</th>
<th>828454</th>
<th>523593</th>
<th>645948</th>
<th>746643</th>
<th>778900</th>
<th>620867</th>
<th>610190</th>
<th>747825</th>
<th>622813</th>
<th>728589</th>
<th>492928</th>
<th>390262</th>
</tr>
</thead>
</table>

### Overheads In U.S. Dollars

<table>
<thead>
<tr>
<th>IT Expenses</th>
<th>28219</th>
<th>25500</th>
<th>35065</th>
<th>26736</th>
<th>26154</th>
<th>560</th>
<th>3566</th>
<th>26665</th>
<th>3010</th>
<th>34539</th>
<th>1880</th>
<th>125903</th>
</tr>
</thead>
</table>

Final Report
## Table 2.6 Monthly Revenue, Cost, Ebitda Performance of Aden Container Terminal During 2005

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Throughput Handled (TEUs)</td>
<td>19277</td>
<td>17252</td>
<td>20757</td>
<td>25172</td>
<td>26992</td>
<td>21244</td>
<td>26477</td>
<td>26001</td>
<td>24429</td>
<td>25728</td>
<td>19315</td>
<td>26714</td>
</tr>
<tr>
<td>Container Services Revenue In U.S. Dollars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
### Table 2.6 (Cont.) Monthly Revenue, Cost, Ebitda Performance of Aden Container Terminal During 2005

<table>
<thead>
<tr>
<th>Gross Profit in U.S. Dollars</th>
<th>839663</th>
<th>493229</th>
<th>562349</th>
<th>697059</th>
<th>720533</th>
<th>663215</th>
<th>788496</th>
<th>709792</th>
<th>665003</th>
<th>699664</th>
<th>480990</th>
<th>867629</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operating Expenses In U.S. Dollars</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## PORT OF ADEN MASTER PLAN
### ADEN - REPUBLIC OF YEMEN

<table>
<thead>
<tr>
<th></th>
<th>24837</th>
<th>6837</th>
<th>15019</th>
<th>11974</th>
<th>20898</th>
<th>14550</th>
<th>14824</th>
<th>14467</th>
<th>21855</th>
<th>14755</th>
<th>14561</th>
<th>18521</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IT Expenses</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td>12323</td>
<td>9341</td>
<td>10832</td>
<td>10358</td>
<td>10731</td>
<td>10773</td>
<td>9823</td>
<td>8823</td>
<td>9823</td>
<td>11823</td>
<td>12288</td>
<td>10587</td>
</tr>
<tr>
<td><strong>General Expenses</strong></td>
<td>4775</td>
<td>5221</td>
<td>4628</td>
<td>7077</td>
<td>5238</td>
<td>10274</td>
<td>6921</td>
<td>8442</td>
<td>6699</td>
<td>6068</td>
<td>5772</td>
<td>27630</td>
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<tr>
<td><strong>Insurance Premiums</strong></td>
<td>28910</td>
<td>20003</td>
<td>27066</td>
<td>26981</td>
<td>27270</td>
<td>20996</td>
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<td>27079</td>
<td>27061</td>
<td>25885</td>
<td>25885</td>
<td>25885</td>
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<tr>
<td><strong>Marketing Fee and Expenses</strong></td>
<td>10000</td>
<td>10000</td>
<td>10000</td>
<td>10000</td>
<td>10000</td>
<td>10000</td>
<td>10000</td>
<td>10000</td>
<td>10000</td>
<td>10000</td>
<td>10000</td>
<td>11436</td>
</tr>
<tr>
<td><strong>Management Fee (Expense)</strong></td>
<td>160000</td>
<td>150000</td>
<td>150000</td>
<td>150000</td>
<td>150000</td>
<td>150000</td>
<td>150000</td>
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<td>150000</td>
<td>150000</td>
<td>150000</td>
<td>150000</td>
</tr>
<tr>
<td><strong>Total Overheads in U.S. Dollars</strong></td>
<td>228846</td>
<td>207505</td>
<td>217645</td>
<td>218390</td>
<td>224074</td>
<td>222543</td>
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<td>219811</td>
<td>225438</td>
<td>218531</td>
<td>218503</td>
<td>244059</td>
</tr>
<tr>
<td><strong>Total Operating Expenses in U.S. Dollars</strong></td>
<td>666037</td>
<td>516055</td>
<td>514802</td>
<td>555196</td>
<td>564662</td>
<td>559438</td>
<td>820205</td>
<td>874352</td>
<td>609002</td>
<td>607606</td>
<td>550865</td>
<td>635381</td>
</tr>
<tr>
<td><strong>Ebitda</strong></td>
<td>310817</td>
<td>285724</td>
<td>344804</td>
<td>480669</td>
<td>505459</td>
<td>340672</td>
<td>587575</td>
<td>489981</td>
<td>442885</td>
<td>481133</td>
<td>282487</td>
<td>413570</td>
</tr>
</tbody>
</table>
3- EXISTING CONDITIONS OF SOILS AND ENVIRONMENT
Aden is located on the southern coast of Yemen in the Gulf of Aden approximately 95 nautical miles east of the strait of Bab Al-Mandeb at the southern entrance to the Red Sea. It therefore lies at the cross roads of the Middle East. The Port of Aden is situated between the high promontories of Aden (Jebel Shamsan, 553m) and Little Aden (Jebel Muzalqam, 374m). It is protected from the NE and SW monsoons by these hills, and along the northern boundary by land, enabling it to operate without restriction all year. Siltation is negligible so that dredging is limited to regular cleaning of channels and basins from shoals causing by normal vessel maneuvering. However, this chapter shall describe the conditions regarding both soils and environment in the region of Port of Aden.

3.1 SOILS AND SURFACE GEOLOGY

The only available soil investigation within the port area is that of the “Aden Flour Mill Jetty” executed in 2002. Eight boreholes were executed. The boreholes (BH1, BH2, BH3, BH4, BH5, BH6, BH7, and BH8) were drilled in order to investigate the ground conditions at the project area. The locations of boreholes are shown in figure 3.1. All boreholes were drilled offshore. The boreholes extended to depths ranging between (-12.90) and (-49.45) meters measured from the Chart Datum. The details of the borehole logs shall be presented for the first two boreholes (BH1 and BH2). Figures 3.2 to 3.8 shows detailed soil profiles for boreholes number BH1 and BH2.

The above mentioned soil investigation is not enough to assess likely ground conditions in the proposed area covered by the Maser Plan for two reasons. The first reason is that the locations of executed boreholes are not so close to the area covered by the Master Plan and therefore it is not possible to assess the ground conditions in the area.
covered by the Master plan based on such boreholes. The second reason is that the area covered by the Master Plan is too large (about 8.0 km. by 5.0 km.). Therefore, it is recommended that additional extensive geotechnical investigation should be carried out to cover the whole area of the Master Plan in order to assess the ground conditions within such area. Then, the type of construction for new quay walls shall be determined.

3.2 ENVIRONMENT

3.2.1 Geography

Aden is located on the southern coast of Yemen in the Gulf of Aden approximately 95 nautical miles east of the strait of Bab Al-Mandeb at the southern entrance of the red sea. The Port of Aden is situated between the high promontories of Aden (Jebel Shamsan, 553m) and Little Aden (Jebel Muzalqam, 374m).

3.2.2 Meteorology

3.2.2.1 Climate

The climate of Yemen is hot and humid along the coastal strip mild at the mountainous heights and desert weather in the desertous area.
(1) **Temperature**

The southern region of Yemen is hot and arid with a coastline of about 1200 km. The average annual temperature is about 27.7°C. The mean monthly maximum and minimum temperature for the period between 1941-1970 are 39.0 °C and 15°C respectively (see Table 3.1).

**Table 3.1 Maximum and Minimum Temperature During The Season 1941/1970**

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean Daily Max., °C</th>
<th>Mean Daily Min., °C</th>
<th>Mean Monthly Highest, °C</th>
<th>Mean Monthly Lowest, °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>27</td>
<td>19</td>
<td>30</td>
<td>16</td>
</tr>
<tr>
<td>February</td>
<td>28</td>
<td>20</td>
<td>31</td>
<td>17</td>
</tr>
<tr>
<td>March</td>
<td>29</td>
<td>21</td>
<td>32</td>
<td>18</td>
</tr>
<tr>
<td>April</td>
<td>31</td>
<td>23</td>
<td>34</td>
<td>20</td>
</tr>
<tr>
<td>May</td>
<td>33</td>
<td>25</td>
<td>36</td>
<td>23</td>
</tr>
<tr>
<td>June</td>
<td>35</td>
<td>27</td>
<td>38</td>
<td>24</td>
</tr>
<tr>
<td>July</td>
<td>33</td>
<td>25</td>
<td>35</td>
<td>23</td>
</tr>
<tr>
<td>August</td>
<td>33</td>
<td>25</td>
<td>35</td>
<td>22</td>
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<tr>
<td>September</td>
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<td>October</td>
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<td>19</td>
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<tr>
<td>November</td>
<td>30</td>
<td>21</td>
<td>32</td>
<td>18</td>
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<tr>
<td>December</td>
<td>29</td>
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<td>31</td>
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<tr>
<td>Mean</td>
<td>31</td>
<td>23</td>
<td>39</td>
<td>15</td>
</tr>
<tr>
<td>Extreme Values</td>
<td></td>
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<td>44</td>
<td>14</td>
</tr>
</tbody>
</table>
(2) **Humidity**

The mean monthly relative humidity is shown in Table 3.2

**Table 3.2 Humidity During 1941/1970**

<table>
<thead>
<tr>
<th>Month</th>
<th>Mean Monthly Relative Humidity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>60</td>
</tr>
<tr>
<td>February</td>
<td>63</td>
</tr>
<tr>
<td>March</td>
<td>67</td>
</tr>
<tr>
<td>April</td>
<td>67</td>
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<td>May</td>
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<tr>
<td>June</td>
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<tr>
<td>July</td>
<td>67</td>
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<td>August</td>
<td>70</td>
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<tr>
<td>September</td>
<td>75</td>
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<tr>
<td>October</td>
<td>66</td>
</tr>
<tr>
<td>November</td>
<td>58</td>
</tr>
<tr>
<td>December</td>
<td>56</td>
</tr>
<tr>
<td>Yearly</td>
<td>66</td>
</tr>
</tbody>
</table>
(3) **Wind**

The wind conditions over the area are predominantly of the Monsoon type, with south-westerly winds blowing during the period May – September and north-easterly winds during November – March. In Months April and October the wind direction varies. During the period 1927 - 1973 vessels passing through the sea area have made observations of the wind conditions. The observations show that the south west Monsoon is fairly strong with wind forces averaging 8-12m/s. The north east monsoon is weaker with average velocities of 4-8m/s. In April and October, the months of transition between the two monsoons, the average wind force is about 2-5m/s. The highest wind velocity during 1 day in 10 years can amount to at least 25m/s. The stronger winds come from the Southwest. Storms and cyclones occasionally pass the region. The cyclones normally approach the coast from east to southeast.

The mean monthly wind speed, the prevailing wind direction from true north and the highest mean wind speed at Aden during 1941 to 1970 are shown in Table 3.3
Table 3.3 Wind At Aden 1941 to 1970

<table>
<thead>
<tr>
<th>Month</th>
<th>Wind speed (knot)</th>
<th>Wind Direction and % Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
</tr>
<tr>
<td>January</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>February</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>March</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>April</td>
<td>14</td>
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</tr>
<tr>
<td>May</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>June</td>
<td>14</td>
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</tr>
<tr>
<td>July</td>
<td>17</td>
<td>1</td>
</tr>
<tr>
<td>August</td>
<td>18</td>
<td>0</td>
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<tr>
<td>September</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>October</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>November</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>December</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Means</td>
<td>15</td>
<td>42</td>
</tr>
</tbody>
</table>

3.2.3 Oceanography

(1) Tide

The water levels are almost entirely controlled by tidal conditions. The characteristic tide levels within the project area, shown below in Table 3.4, have been derived from measurements.
Table 3.4  Water Levels

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HAT</td>
<td>+1.60</td>
</tr>
<tr>
<td>MHHW</td>
<td>+1.60</td>
</tr>
<tr>
<td>MLHW</td>
<td>+1.0</td>
</tr>
<tr>
<td>MSL</td>
<td>+0.65</td>
</tr>
<tr>
<td>MHLW</td>
<td>+0.05</td>
</tr>
<tr>
<td>LAT</td>
<td>-0.50</td>
</tr>
</tbody>
</table>

In Gulf of Aden the tide is generally diurnal, with an extreme range of about 2.7m at Aden, and of about 3.0m at Djibouti. The tidal streams in Gulf of Aden are irregular, weak, and frequently masked by current. On the N side of the Gulf, as far E as longitude 54° 42' E, the flood tidal stream sets SE. Between this longitude and Ra's al Junayz (22° 24' N , 59° 51' E), The flood tidal stream sets NE. In Al Mukalla Bay tides at springs there is often only one high and one low water every 24 hours; at neaps there are two tides but their times are irregular.

(2) Current

Seasonal reversals of Indian Monsoon current over the Arabian sea and Gulf of Aden tend to be the strongest. Figures 3.9 and 3.10 show the typical pattern of currents for January and July, the months when the NE and SW Monsoons
respectively, with their associated currents are fully developed. Even during these months there is a good deal of variability in currents, so that occasionally sets may be encountered in directions very different from those depicted.

Currents in Gulf of Aden are generally weaker and more variable than in the Arabian Sea. In general, W-going sets prevail during the NE Monsoon, but contrary sets occur at times, more especially off the N coast of Somalia. The reversal of current associated with the change from NE to SW Monsoon is later and more gradual than in the Arabian Sea. During April, W-going currents still predominate over E-going, though the later are encountered with increasing frequency.

During May there is no predominance with currents generally weak and variable in direction. The pattern associated with the SW Monsoon becomes clear only in June, with the predominance of E-going sets.

During the SW Monsoon, rates are less than in the Arabian Sea, rate of 3 knots. By September the association of currents in Gulf of Aden with the SW Monsoon becomes very tenuous; E-going sets mainly confined to the area N of latitude 13° N, and currents to the S are very variable.

During October W-going sets, typical of the NE Monsoon, become the most common.

(3) Waves

In winter a moderate swell from NE is encountered; a heavy swell develops in these waters after a spell of fresh winds. In summer, very rough sea is frequent when the SW Monsoon reach maximum strength. The swell from SW, also increase
along this route, and heavy swell develops at times. Wave heights and periods have been observed by vessels. The observations made in deep water indicate that average significant wave height of from 7.5 to 8.0 meters may occur during one day in 50 years.

(4) **Sea Surface Temperature**

The average seasonal values for the Gulf of Aden are shown in Figures 3.11 to 3.14. The temperature of the water is uniform in May and November over the Arabian Sea, while the normal latitudinal range prevails in winter.
(FIG. 3.9) Typical Pattern of Currents - January
(FIG. 3.10) Typical Pattern of Currents - July
FIG. 3.11) Mean Sea Surfaces Temperature “°C” - February
(FIG. 3.12) Mean Sea Surfaces Temperature “°C” - May
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(FIG. 3.13) Mean Sea Surfaces Temperature “°C” - August
(FIG. 3.14) Mean Sea Surfaces Temperature "°C" - November
4- PROPOSED PORT MASTER PLAN

4.1 General

The development of Port of Aden was studied extensively considering several options for the port development and reaching to the most suitable development scheme. Previously, since 2001 the Ministry of Transport and the Yemen Ports Authority have worked on various port expansion options, considering at different times an extension of the Ma’alla berths to resolve port congestion problems and building new facilities to north of these berths in sheltered water east of the Aden Container Terminal (ACT). Discussions with the Yemen Ports Authority (YPA) and studies performed have revealed that future expansion of the port should take place along the North Shore, west and north of the ACT. The north shore area lies in a bay partially protected from the SW monsoon and extends around 9 km. west from the ACT access roads towards Little Aden. The distance north-south between the inner harbour access channel and the shore varies between 3 and 6km.
Usually, the preparation of a Port Master Plan should be considered as a long-term job. The emphasis is on setting a rational development framework into which successive construction projects can be fitted as the traffic increases. Therefore, the Port development shall be described in stages showing how the port could logically expand to provide quays and working areas for all types of cargos to be handled, stored, and transported. The study covers three stages of development. Outline plans for each of the three stages shall be presented showing the following:

(i) New Breakwaters.
(ii) Access Channels and Turning Areas.
(iii) Container Berths.
(iv) General Cargo Berths.
(v) Raw Materials and Dry Bulk Berths.
(vi) Liquid Bulk Berths.
(vii) New Ship Repair Facilities.
(viii) Storage Areas.
(ix) Transit Sheds.
(x) Access Roads and Gates.
(xi) Port Roads and Parking Areas.
(xii) Service Buildings.
(xiii) Workers Residential Area.
(xiv) Bridges.

It should be noted that the preparation of the Port Master Plan was influenced by two main factors:
1) The region near the north shore is environmentally-protected and therefore an area having a width about 700 meters from the shore line to the south was left clear along the north shore.

2) There is a power station intake for cooling water on the north shore should remain unobstructed.

Figures 4.1, 4.2, and 4.3 show proposed Port of Aden Master Plan for stages (I), (II), and (III), respectively.

4.2 **New Breakwaters**

Based on a study of the wave actions at the port location it was observed that there is insufficient natural protection within the area of the proposed port development. Unless breakwaters are constructed, the wave activity could cause major problems within the area of the port development. Likely problems are wave reflections, ship maneuvering difficulties, unacceptable ship movement at the berths leading to excessive downtime or even making the berth untenable at times. It is of fundamental importance to the area of port development to form an enclosed protected port by constructing new breakwaters. Therefore, it was decided that it is necessary to construct new breakwaters in order to deflect, reflect or absorb the energy of swell and storm waves which would otherwise enter the port development area, and thus provide an area of relatively sheltered water throughout the year.
Two new breakwaters are proposed in the Port Master Plan as shown in figures. It is suggested that the first breakwater is to be constructed through the first stage of the port development as shown in fig. (4.1), whereas the second breakwater is to be constructed through the second stage of the Port development as shown in fig. (4.2). The first breakwater is in the form of an arm projecting from the shore. The breakwater starts from ‘Ras Tarshayn’ and has a length of about 1800 meters in the south-west direction. The breakwater lies in an average water depth of about 10.0 meters measured from the Chart Datum. The second breakwater is located to the west of the proposed port development area starting about 700 meters east of the oil harbour breakwater and extends in the north east direction a distance of about 2600 meters. The breakwater lies in an average water depth of about 9.0 meters measured for the Chart Datum.

The construction of the proposed new breakwaters leads to the formation of two entrances for the port development area one to the east and the other is to the west. Both entrances have a clear width of about 700.0 meters. There are many types of breakwaters available. The most common types are the vertical wall breakwater and the trapezoidal rubble mound breakwater. The selection of a particular type of breakwaters depends on many factors such as the availability of materials, labour, and plant. It was found that a vertical wall breakwater will place different demands on these factors than that in the case of a trapezoidal rubble mound breakwater. The only disadvantage of rubble mound breakwater is that it will require more material because of its shape. Yemen has an ample supply of rock strata capable of providing large primary rock armouring. Therefore rubble mound breakwaters are suggested for the port development. Figure (4.4) shows a typical cross-section in a rubble mound breakwater. The breakwater shall consist of:
- Base layer of rocks (natural stones) normally weighing between 0.5 kg and 25kg.

- Core layer of rocks (natural stones). Based on a preliminary design the weight of rocks shall be between 5kg and 300kg.

- Filter layer of rocks (natural stones). Based on preliminary design, the weight of rocks shall be between 4 ton and 6 ton.

- Main Armour Layer. It shall not be suitable to provide natural stones for the main armour layer because in this case the weight of rocks needed shall be very large and shall not be available. Therefore, artificial concrete armour units are suggested to be employed. The type of armour units proposed is the concrete “Dolos” blocks as shown in Fig. (4.5).

4.3 Access Channels and Turning Areas

The existing access channel of Port of Aden to the inner harbour and the turning area is 15.0 meters deep. The outer section of the channel is 220 meters wide, the middle section 183 meters wide, and the inner harbour section 220 meters wide. Yemen Ports Authority (YPA) is currently preparing the Tender Documents for deepening the existing access channel and the 700m. diameter turning area off the ACT from 15.0 meters to 18.0 meters. The proposed project considers also widening of the access channel to a width of 240 meters. The current situation of access channels in the Port of Aden also includes the access channel to Aden oil Harbour having a width of 220 meters. Such access channel was deepened in the late 1980’s to 14.7 meters. The proposed extensions of the existing access channels are shown in Figures 4.1, 4.2, and 4.3. The basic aim in the design of the proposed extension was the safe passage of all vessels requiring to call at the port from the
sea to the berthing area. A major consideration was that the channel should be wide enough to improve access for very large container ships and for bulk carriers, and possibly to provide the capacity for two way traffic, i.e. for inbound and outbound ships at the same time. It was decided to widen the channel to provide a two-way access in order to offer unrestricted access to the area of the port development. Another reason for this consideration is that if there is an accident in one lane of the channel, access to the port will still be possible and so there will be less disruption of traffic to and from the port.

Based on that it was decided to perform the following modifications to the existing access channels to account for the proposed development of the Port of Aden:

(i) Widening of the outer section of the existing access channel starting from the pilot station having a length of about 1600 meters from 220.0 meters to 400.0 meters.

(ii) Widening of a part of the middle section of the existing access channel having a length of about 3300 meters from 183.0 meters to 400 meters.

(iii) Widening of the access channel to Aden Oil Harbour having a length of about 2500 meters from 220.0 meters to 400.0 meters.

(iv) Constructing new channel to access the new turning area for the new berths east of the port development area starting from the middle section of the existing access channel, having a length of about 1800 meters and a variable width as shown in the Figures.

(v) Constructing new channel to access the new turning area for the new berths west of the port development area starting from the end part of the access channel to Aden Oil Harbour, having a length of about 1500 meters and a variable width as shown in the Figures.
In the immediate approaches to berths, vessels usually have to make more complicated manoeuvres than are necessary in the access channel. Consequently, appropriate water areas must be provided and in most cases the assistance of tugs will be required. The most basic of these manoeuvres is turning the vessels and it may be taken as a general indication of the space required to turn a vessel that a circle with a diameter four times the ship’s length is required where there is no assistance from tugs. Where assistance of tugs is available, a circle with a diameter two times the ship’s length is adequate. Therefore, it was decided to provide two new turning circles each having diameter of 800 meters, one for the new berths east of the port development area and the other for the new berths west of the port development area, as shown in Figures.

It is suggested that the extensions for existing access channels, the construction of new access channels, and the construction of the new turning areas are to be included through the first stage of the port development.

### 4.4 Container Berths

A review of the statistics and negotiations with Yemen Port Authority revealed that the port development should account for the rapid traffic increase in the container vessels that means the importance of the construction of specialized berths for containers. The rapid spread in container operations has been very fully documented. Soon the last major trade routes between highly industrialized countries will have been containerized. At the same time, there is already an increasing trend towards containerization of certain specific services linking developing and developed countries. Therefore, the development scheme of Port of Aden should consider the probable development towards containerization and the changes in port planning, management and operations which such development bring
with it. Large container vessels will not call the port without specialized container terminals offering a specialized level of service.

As shown in figures 4.1, 4.2, and 4.3 the Port of Aden Master Plan offers container berths of a total length of 12600 meters. The construction of these berths shall be in stages. The Port Master Plan for stage (I) includes the construction of three container berths. The first berth is an extension of the existing Aden Container Terminal (ACT). The length of the first berth is 3800 meters. The second berth is parallel to the first one and has a length of 3000 meters. The third berth shown in the Master Plan (Stage "I") has a length of 1200 meters. It should be noted that the second berth shall be operated as general cargo berth in stage (I) and stage (II) and then the function of the berth shall be modified in stage (III) to be a container berth. Therefore, the total lengths of container berths in the Port Master Plan (stage "I") is 5000 meters.

A container berth was added in the Port Master Plan (stage "II"). The berth has a length of 4600 meters. The total lengths of container berths in the Port Master Plan (stage "II") is 9600 meters.

In stage (III) the function of the prementioned general cargo berth having a length of 3000 meters shall be modified to be a container berth. Therefore, the total lengths of container berths in the Port Master Plan (stage "III") is 12600 meters.

4.4.1 Container Handling Systems

The three most commonly used container handling methods in operation are the trailer storage system, the straddle carrier system, and the gentry-crane system, the gantry
crane being either rail-mounted or rubber-tyred. The straddle carrier system is recommended herein. Straddle carrier can stack containers three or four high, move them between the berth crane and storage area, and load or un-load them to or from road transport. The use of straddle-carrier is advantageous due to its flexibility and its ability to meet peak requirements. It is also possible to use tractor-trailer units for the transfer between berth and storage areas, and the use of straddle carriers only within the storage area for stacking and selecting containers.

4.4.2 Container Storage Area

The planning of new container berths shown in the Port Master Plan offers large storage areas for container stacking. All these areas shall be reclaimed and divided into storage areas each having dimensions of 50 meters by 100 meters. Roads between storage areas were provided in both directions with a width of 15 meters. In addition, the Port Master Plan also shows areas for empty containers, Container Freight Station (CFS), vehicle parking, container repair, container reefer, staff, administration, maintenance, and dangerous goods storage facilities.

4.5 General Cargo Berths

General cargo berths is to provide efficient handling facilities for a variety of cargoes such as flats, pre-slung cargoes, large units of iron and steel, large units of packaged timber, as well as cars and heavy machinery, together of course with a basic load of break-bulk cargo, increasingly palletized.
The Port of Aden Master Plan shown in Figures 4.1, 4.2, and 4.3 offers general cargo berths of a total length of 8870 meters. The construction of these berths shall be in stages. The Port Master Plan for stage (I) includes the construction of a container berth having a length of 3000 meters which will be utilized as a general cargo berth in stages (I) & (II). General cargo berths were added in the Port Master Plan (Stage "III") having lengths of 8870 meters and the function of the prementioned berth shall be changed to be a container berth. Thus, the total lengths of general cargo berths in the Port Master Plan is 8870 meters.

Transit sheds are shown in the Master Plan. For each transit shed an area of 100m. by 200m. is provided. Transit sheds were placed at the rear of the berths beyond the open storage areas so that tracks can be served alongside the sheds without interfering with the transfer operations. Open storage areas are also planned in pieces each having dimensions of 100 meters by 200 meters, closer to the berths for any form of general cargos.

4.6 Liquid Bulk Berths

Liquid bulk includes vegetable oils, molasses, rubber latex, juices, ….etc. The Port of Aden Master Plan shown in Figures 4.1, 4.2, and 4.3 includes the construction of one liquid bulk berth. The berth has a length of 800 meters. The liquid bulk berth is included in stage (I) of the Port Master Plan. A rear area is proposed for the construction of tanks.

4.7 Dry Bulk And Raw Materials Berths

The Port of Aden Master Plan shown in Figures 4.1, 4.2, and 4.3 offers dry bulk and raw materials berths having a total length of 8500 meters. The construction of these
berths shall be in stages. The Port Master Plan for stage (I) includes the construction of one berth having a length of 2200 meters. Two berths were added in the Port Master Plan for stage (II). The first berth has a length of 1500 meters. The second berth has a length of 1600 meters. Therefore, the total length of dry bulk and raw materials berths in the Port Master Plan (Stage "II") is 5300 meters. In the Port Master Plan (Stage "III") another two berths were added each having a length of 1600 meters. Therefore, the total length of dry bulk and raw materials berths in the Port Master Plan (Stage "III") is 8500 meters. The planning of new dry bulk and raw materials berths offers large storage areas. All these areas shall be reclaimed and divided into storage areas each having dimension of 100 meters by 200 meters. Roads between storage areas were provided in both directions with a width of 30 meters.

4.8 Type of Berths Construction

A review of the previous berth constructions in the Port of Aden revealed that the use of either mass concrete or piling has taken place since the early days as favourable seabed soil conditions support both methods of construction. Most recently the concrete berth for the Aden Container Terminal (ACT) provides a depth of 16 meters alongside the berth. However, in order to decide which type of construction is suitable within the area of the port development, an extensive soil investigation program is required including large number of boreholes.
4.8.1 Concrete Blocks

This type of construction shown in Figure 4.6 requires good soil conditions, preferably rock or dense sand. Such berth can be built up from individual blocks, usually placed under water. Among the possible variations are the solid-block work, in which blocks are laid in horizontal courses. Concrete caissons can be used for berths by floating pre-formed boxes into place and sinking them. The suitability of each of these gravity walls depends greatly on ground conditions.

4.8.2 Reinforced Concrete Platforms on Piles

One of the most widely used forms of berths construction is in the form of reinforced concrete platforms supported on piles, as shown in Figure 4.7. This form of berth construction may include, in addition to normal vertical piles, racking piles and/ or tie rods connected to anchor blocks placed some distance behind the berth. A variety of construction techniques are available in steel and concrete. The most economical pile spacing has to be established by examining different solutions. Where there is heavy vertical loading, such as container cranes, large diameter concrete cylindrical piles shall be used. In addition, the spacing of crane rails may influence pile spacing and should be taken into account.

4.9 New Ship Repair Facilities

A new ship repair facilities are proposed in the Port of Aden Master Plan as shown in Figures 4.1, 4.2, and 4.3. The suggested type is a mechanical shiplift having the
capacity of lifting vessels of length up to 250 meters from the water to the land. The suggested shiplift is located at the north-east corner of the port development area. The facility is provided with a transfer area on land leading to fifteen repair lanes on land. Each repair lane has a length of 250 meters. The repair facility is provided with two repair berths. The first berth has a length of 300 meters whereas the second has a length of 545 meters. Figures (4.1, 4.2, and 4.3) show areas for workshop, administration building, car parking, control building, repair shed and other facilities.

4.10 Roads

A main road is suggested for the port development area parallel to the north shore having a width of 30.0 meters and a length of about 13500 meters. The new main road connects at its eastern end with the existing road leading to Aden Container Terminal (ACT). The main road also connects at its western end with the existing main road. In order not to obstruct the power station intake for cooling water on the north shore it is suggested that three sections of the new main road be constructed in the form of bridges as shown in figure (4.3). The length of each bridge shall be 700 meters. Two additional access to the port is suggested to the north through the construction of two bridges that connect the port to the existing roads. The length of the first bridge is 700 meters whereas the length of the second bridge is 900 meters. Many gates are suggested for the port entrance. Each gate is provided with a port entrance building. An internal road network was also provided in order to access all parts of the new port development area. Access to the berths is controlled by means of gate houses. Parking areas are provided in many locations within the new port development area.
4.11 Service Buildings

Service Buildings were provided within the new port development area. The buildings shall be provided in stages as shown in Figures (4.1, 4.2, and 4.3). The buildings shall include the following:

(A) Terminal Administration Buildings.
(B) Harbour Masters Office and Customs.
(C) Workshops.
(D) Ambulance Buildings.
(E) Fire Fighting Buildings.
(F) Police Station Buildings.
(G) Restaurant Buildings.
(H) Restroom Buildings.
(I) Labour Amenities Buildings.
(J) Wharf Superintendents Offices.
(K) Prayer Courts.
(L) Quarantine Buildings.
(M) Power Stations.
(N) Fuel Stations.
(O) Communication Centers.
(P) Workers Residential Area.

4.12 Coordinates of Main Points
The following Table shows the coordinates of the main points of the port new development area. However, it is recommended that a detailed survey should take place before starting execution of the works included in the Master Plan.

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<th>Latitude</th>
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5. **ENVIRONMENTAL IMPACT ASSESSMENT**

This chapter assesses the environmental impacts expected from the proposed project. It is concerned with the impacts during the construction phase, the residual impacts that will arise after applying the mitigation measures, and impacts during operation.

5.1 **OCEANOGRAPHY**

The construction of the proposed project is not expected to change the tides, the currents or the unity of the Sea. However, there is a potential for localized impacts due to the construction of the project. Minor impacts are expected during the construction of the project. A list of mitigation measures is included herein to reduce the significance of those impacts.

5.2 **HYDROLOGY**

The proposed project have a confined activity that is not expected to have any impact on the hydrology or runoff patterns on the regional or the local scales.

5.3 **WATER QUALITY**

During construction of the project it may be expected that the quality of water obstructed will be affected by construction activities, in particular a higher
suspended sediment load is likely to occur due to local increases in turbidity. This is not expected to have an impact on any water intake in the area.

During construction activities, suspended sediment caused by works may adversely affect the quality of water at the location of the project. The increased concentration of suspended materials reduces the efficiency of the primary production by phytoplankton and may as well hamper efficient grazing of plankton. This negative impact, however, will occur only during limited period. The use of protective screens may reduce this negative effect. All quarry stones used, shall be washed first before placing it.

5.4 CLIMATE

It is expected that no change to the climate will result as a direct consequence of the construction of the project.

However, global climate change and sea level rise are uncertain events that may impose a negative impact on the project. Water level variation should be considered during the detailed design stage. A more conservative maximum water level should be used in the detailed design stage to account for any sea level rise.

5.5 AIR QUALITY AND NOISE

The hindrance resulting from construction activities will be very limited. However, there will be emissions to the air and rise of the noise level.
5.5.1 *During Construction*

It is expected that increased vehicle movements will be generated due to construction activities at the site. Due to the transport of construction materials, or the works, this will lead to increased vehicle emissions (including nitrous oxides, carbon monoxide, carbon dioxide, and hydrocarbons) and dust and will also be accompanied by increased noise levels due to the traffic and works.

This source of noise is likely not to cause nuisance to inhabitants. Noise sources, (including fixed and mobile) should be screened as far as possible to reduce the impact of noise. Fixed noise sources such as temporary generators should be enclosed wherever possible to reduce the noise levels they emit. All construction equipment should be operated in accordance with the manufacturers intent, and all noise reduction accessories (for example enclosures, covers, silencers, air filters, etc.) should be in place and well maintained. Construction activities should be carefully monitored to prevent nuisance from occurring.

Generation of dust due to increased vehicular movement especially on non-paved service roads and construction activity may also occur. Dust being carried by the wind could cause nuisance to people. Roads to the site should be fenced out to avoid any vehicles to move in a random fashion on unpaved roads. This is considered a mitigation measure to limit the noise and pollution due to vehicle transportation. Designated areas as dumping sites should also be planned and monitored during construction activities.
Dust from the construction activities should be swept off the main road, to prevent material being carried along this thoroughfare and causing nuisance to pedestrians or workers. Damping down surfaces, which are susceptible to wind blow, or the use of proprietary dust control chemicals, should control dust. Occasional incineration of solid waste may be practiced at construction site.

It is expected that there will be hardly any change in the safety situation, because real hazardous, risk full equipment or substances that could damage the environment shall not be used during construction. This will change positively during operation.

5.5.2 During Operation

During operation air quality and noise shall be controlled during various activity phases to comply with limits and regulations implemented by laws concerned with environmental protection.

Screening of noise sources would help to limit adverse impacts. Air quality during the operational phase is unlikely to differ from that currently experienced. However, there may be greater potential for odor nuisance associated with the fumes of vessels engines. Odor nuisance is not expected to be a problem.

5.6 Fauna And Flora
The construction of jetties, breakwaters, quay walls, and other marine structures often involves loss of natural habitat. On the other hand, the presence of a solid structure in an area otherwise devoid of hard substratum can be beneficial ecologically. Such structures rapidly become colonized by sponges, bryozoans and other encrusting biota, which in turn provide food or refuges for organisms including fish.

The assessment upon the biotic aspects is based upon an estimation of the impacts on the terrestrial and marine ecosystem components. A change in habitat area and in habitat quality will be reflected in the structure and species composition of the communities. Usually in stress situations, special and sensitive species disappear.

It is not expected that a significant impact is likely not to occur as a result of the project.

Habitat will be impacted upon during the construction of the project, and the habitat will undergo significant change. However, the habitat provided by the new project is likely to develop an interesting and diverse biota in time.

Disposal of bilge water, accidental spills during operation may cause the following:

1. Reduced oxygen;
2. Reduced sunlight penetration;
3. Increase in nutrients;
4. Altered bottom biota;
5. Disposal of contaminants;
(6) Release of heavy metals to the surrounding; and

(7) Contamination of fisheries.

Vessels traffic during operation may cause increase of noise, and air pollution.

5.7 Social And Economical Impacts

With a gross national product per capita of US $460, Yemenis 20.0 million people and approximately 25 percent are unemployed or underemployed. One of the challenges facing Yemen is to reduce its dependence on its rapidly depleting oil reserves by turning to non-oil sectors.

Another important challenge for Yemen is attracting private investment. Based on this the beneficial social impacts may be summarized as follows:

- Promotion of regional development.
- Increase of employment opportunities and income generation.

5.7.1 Regional Development

The construction of the new proposed project is a strategic economic factor not only for the local region but also for the country as a whole. The construction
of the new proposed project will enhance the potential of economic development and will directly stimulated the regional economy leading to economic growth.

During the construction phase the construction industry and supplying industries will prosper. The effects will be nation-wide; companies from all over the country will offer their services and construction material will be brought to Aden from wherever they are produced, parts require exceptional expertise that will require collaboration with international partners. International firms are providing for the special technical know-how while local firms contribute their technical/construction services.

5.7.2 Employment Opportunities

Corresponding to the regional economic development the project will have a positive impact upon the regional employment. An increase in employment opportunities is expected in:

(1) Activities related to the project function.

(2) Existing and potential future industries located in the area.

(3) Construction and supplier industry.

A shift is expected from lesser skilled to higher skilled workers due to the new technologies introduced.

Additional employment opportunities will arise from the regional economic development. These are expected through the new location of industrial enterprises
as well as through the expanding suppliers. The demand for skilled as well as unskilled labor will increase.

During construction phase temporary employment opportunities will arise for skilled and unskilled staff of which some will be recruited locally. It is highly likely that some skilled staff will be recruited from abroad for construction management and supervision.

The nation-wide unemployment rate has more than halved in recent years. Nevertheless, a shortfall of the labor market in the recruitment of staff is not expected.

The overall employment effects for the project region may be summarized as follows:

(1) Increase of employment opportunities during construction.

(2) Increase of employment opportunities during operation.

(3) Shift from unskilled to skilled labor force.

5.8 **Archaeology And Cultural Heritage**

As there is no archaeological sites at the project location, there will be no impact relating to this aspect.

5.9 **Landscape And Visual Impacts**
There will be no loss of land on the contrary a land will be gained by reclamation. This gain of land is considered a positive impact.

There will be an impact on the quality of the landscape and views during construction caused by modifications to the landform. including stocking of material. Due to the extent of the operations this effect is considered to be high.

5.10 Plan For Environmental Mitigation Measures During Construction

5.10.1 Introduction

During construction of the project the Contractor shall at all times adhere to all statutes regarding the protection of the Environment. Generally, the preservation of the environment at the project proposed location should be a leading priority.

An education program on reef protection, should be developed and carried out together with a monitoring program. It is, therefore necessary to conserve these natural habitats. These areas may be subjected to degradation in the following ways:
(1) Degeneration of communities during the construction phases due to filling inhabited areas with sediments or due to destruction of the substrata by mechanical means.

(2) Regression of communities at a distance from the work sites, due to increased turbidity caused by raised sediments. This increased turbidity will result in attenuation of light energy necessary for photosynthesis, and will cause damage to filter feeders such as barnacles, corals, etc. The damage may be temporary, followed by recovery, or it may permanently affect the growth rate and reproduction of these species.

(3) Pollution of sea water by oil, sewage, and heavy metals, as well as by excessive heat and brine from desalination plants. Certain species are tolerant, but only for a limited period of time; others are irreparably damaged.

5.10.2 Mitigation Measures For The Project

The construction of the project will help to address issues by centralizing potential hazards into an area where they may be centrally managed. Thus marine pollution, in particular are addressed. The laws covers the standards for marine pollution discharge limits. (The original document of the law and its appendices should be fully consulted for complete coverage of these issues).

5.10.3 Marine Pollution
Fuel storage and oil spills are potentially significant concerns for the project. The Law addresses the problem of marine pollution by requiring the following factors to be addressed:

(1) Means undertaken for spills clean up;
(2) Use of dispersant;
(3) Probable source of spills;
(4) Rate of spill (if continuous);
(5) Velocity and direction of wind;
(6) Tidal conditions;
(7) Threatened shore sites;
(8) The nature of the region, coral reefs, marine specie;
(9) Source of spills reporting.

The project management should put together a spill response plan that addresses these issues. This response plan must be in co-ordination with the regulations of the Yemeni Environmental Association. In particular spill response means that equipment for containment and cleanup of the spill must be available on site, to ensure a rapid response to any incident that might occur. It is recommended that spill response procedures be worked up in liaison with any Non-Governmental Organization (NGO) so that the particular vulnerabilities of coral and sea-grass communities are taken into account.
Chemical and detergents to combat oil spillage must be used only with great care and understanding. The manual or mechanical method is still the most appropriate in the majority of circumstances. Some mechanical appliances for tackling petrol spillage and contamination are helpful. One that is effective is the Self-Leveling Unit for Removing Pollution (SLURP) 11.8,9. It is the size of a large suitcase and weighing 28 kg, it floats and can be used with any on-shore tank and self-priming pump. Such devices would be available on the site for fast deployment in the event of a spill, together with absorbent booms and pads. All such equipment must be regularly checked and maintained to ensure that it is in good working order.

5.10.4 Dredging And Reclamation

The construction of the project shall involve dredging, and reclamation works. The disposal of waste during construction should be brought to a landfill, which is carefully selected where the wastes are deposited in a carefully controlled manner and then covered with acceptably clean soils.

Some dredged materials may be suitable for reclamation. The general suitability of dredged materials can only be determined during the dredging activity.

The quarry material to be used for the construction of the project should be tested, cleaned and washed from fines and dust before placing.

5.10.5 Mitigation During Construction Activities
The review of practices at local construction and operating site activities of similar developments during site visits suggests the following recommendations:

(1) Supervision on contractor activities must be centralized. Strict regulations have to be set in site and imposed on all contractors or sub-contractors. It will be the owner and the contractor responsibility to provide the site, from the first beginning, with portable sewage treatment units and to be located in designated areas for workers.

(2) It is also important to recycle certain waste materials and provide for their timely collection. The following materials should be considered for recycling: paper products, cans, bottles and vegetarian waste. If a recycling area is provided they should be convenient, clean, frequently emptied and well marked. A common location for a recycling of all development solid waste should be placed on shore against wind direction.

(3) The allocation of workers camps should take into account the following:
   (a) Minimum disturbance to the surroundings by allocating them at an appropriate distance;
   (b) Provision of adequate utilities as water, sanitation, and electric supplies;
   (c) Providing safe fire fighting precautions;
   (d) Encouraging solid waste sorting and separation at the origin (glass, plastics, cardboard and paper, organic waste, and metals). Solid waste transport truck may be equipped with partitions to collect each type separately.
(4) Storage of fuels and lubricants shall be practiced through the use of barrels. The waste material are to be stored and recycled through oil companies managing oil residue to prevent local contamination with oil at the site. Storage of chemicals and other hazardous materials should be practiced in controlled and adequately ventilated stores. Chemical wastes, such as discarded batteries, gas oil filters, should be collected properly. Contract should be established with a contractor to ensure that environmental sound discharge and processing will be established.

(5) To mitigate the potential environmental impacts from bilge water discharge, it is a good practice to place absorbent pads in the bilge area to soak up oils and fuels.

(6) Noise control should also begin at the planning stage during which thought should be given to locating noise sources away. The Contractor and the Engineer can have a considerable contribution towards the reduction of noise at the construction site. Detailed designs should consider whether there are alternatives, which will involve less noise in construction. Mufflers should be used in all equipment during construction.

(7) Special Environmental Precautions: Certain essential precautions must be taken against accidental pollution. The principal element should take the form of a floating (inflatable) boom, which can quickly be installed in the case of fuel spillage. As a secondary measure, additional booms may be needed along the breakwaters as fuel may pass through the structures.

(8) Additional provisions may be adopted. These include power saving systems, the use of low power consumption bulbs for illumination, decreasing cistern capacities for fresh water conservation, etc. It is strongly recommended that the Yemeni Environmental Association representative should attend and monitor the construction work.
5.10.6 Soil Conservation

All reasonable precautions shall be taken to prevent the erosion of soil from any land used or occupied by the Contractor and of the bed and banks of any beach, river or stream and the deposition of excavated or eroded materials in any beach, river or stream that may result from the execution of the Works, except so far as is absolutely necessary for the execution of the Works.

Soil conservation measures on excavated surfaces of filled material which form part of the Works shall be performed in accordance with relevant specifications.

All soil conservation measures shall be carried out in the earliest possible season to ensure that the required protection is established by the time of completion of the Works.

The project management shall exercise care in preventing wastage of suitable material needed for embankment or fill construction.

5.10.7 Safety Precautions

The project management shall comply with any safety instruction given by the relevant authorities. In the performance of the Works, the project management shall exercise every reasonable precaution to protect from injury, persons or property. All necessary temporary fencing, barriers, signs and lights and fire alarms, fire extinguishers and fire fighting services at strategic points on the site
shall be provided. The project management shall adopt and enforce such rules and regulations as may be necessary, desirable or proper to safeguard the public, all persons engaged in the Works and its supervision.

The project management shall be responsible for watching the Works and for the flagging and control of traffic and they shall comply with the requirements of the Police and the Competent Authority in these matters.

5.10.7.1 Safety Officer

The project management shall employ a Safety Officer, qualified in safety, and familiar with the type of work being performed, and his assignment shall include initiation of measures for the protection of health and the prevention of accidents and he shall see, by personal inspection, that all safety rules and regulations are enforced. The project management shall hold regularly scheduled safety meetings at least once each month with their engineers, supervisors and foremen.

5.10.7.2 Safety Measures

Temporary Fencing - The project management shall furnish, erect and maintain suitable an approved temporary fencing to enclose such areas of the permanent Works and areas of land occupied within the Site. Where any temporary fencing has to be erected alongside a public road or footpath, it shall be of the type required by and shall be erected to the satisfaction of the Government authority concerned.
**Lighting** - The project management shall provide sufficient lighting to ensure that, in all places where work is in progress safe working conditions are provided for all personnel in the site.

All moving equipment or plant used during night operations shall be equipped with sufficient lights and reflectors to ensure safe working conditions.

**Accident Reports** - The project management shall report to the relevant authorities in the form to be prescribed, all accidents involving death or serious injury to staff or workmen, and furnish monthly reports of all accidents to staff or workmen.

The project management shall provide all necessary signs for the works. These shall include, but are not limited to:

- standard road signs
- warning signs
- danger signs
- safety signs
- direction signs

Wording on all signs shall be in Arabic and English languages. The size, colour, lettering and location of all signs will be subject to approval of the relevant authorities, and attention shall be paid to international signs.

The project management shall provide sufficient safety helmets and life jackets for all personnel at the Site.
5.10.7.3 First Aid and Medical Services

The project management shall be fully responsible for ensuring necessary first aid and medical services to all personnel at the site, including transport for injured personnel to hospital or other appropriate accommodation as and when required.

The project management shall supply, maintain and keep stock of medicines and medical equipment of a scope, quantity and standard deemed by a physician to be sufficient for first-aid. A qualified nurse shall be present on Site throughout the execution of the Works.

The project management shall obtain the advice of a physician on all such matters as water supply, sanitation, refuse and sewage disposal, and provisions of fly-screens and anti-malarial precautions and industrial health and hygiene. A proportion of the employees, normally 1 man per gang, shall be trained in first aid.

5.10.8 Preservation of Flora and Fauna

5.10.8.1 Flora

The project management shall restrain all employees from destroying, removing or clearing trees, timber, scrub and other flora to any extent greater than that being necessary for the execution of the Works.

The project management shall refrain from disposing waste materials amongst vegetation within or outside the Work site. Any and all waste materials disposed amongst vegetation for any purpose or reason shall be recovered.
5.10.8.2 Fauna

The project management shall take such measures as may be necessary to prevent employees from hunting, disturbing, capturing or destroying stock and such fauna as may be protected by relevant statutes.

5.10.9 Pollution Control

5.10.9.1 Dust Control

The project management shall make all efforts to minimise the generation of dust at the Works by constructional equipment and related activities. The project management shall provide suitable spraying equipment for regular spraying of water over the existing roads used and over completed as well as incomplete road and other barren areas of the site.

The project management shall provide for the prompt removal of all dirt and other materials spilled from vehicles on public roadways over which such materials are hauled or on to which such materials are dumped, washed or otherwise deposited by reason of his work or carelessness in execution of the Works and avoid interfering with drainage or creating a traffic hazard to vehicles or impeding the passage of pedestrians.

5.10.9.2 Noise

All work shall be carried out without unreasonable noise disturbance. The project management shall indemnify and keep indemnified the relevant authorities from and against any liability for damages on account of noise or other disturbance
created while or in carrying out of the Works and from and against all claims
demands proceedings damages costs charges and expenses what so ever in regard
or in relation to such liability.

The project management shall ensure that all equipment and machinery are
in proper working condition so as to minimise the amount of noise generated. The
project management shall replace any machinery, that to their discretion, is
emitting excessive noise.

The project management shall comply with the general recommendations
set out in BS 5228 Code of Practice for Noise Control on Construction and
Demolition Sites.

5.10.9.3 Oil and Grease

The project management shall refrain from disposing used oil and grease
from equipments and machinery into the sea, streams, drains or pools or vegetation
in the area.

The project management shall provide for the prompt removal of oil and
grease spillage from vehicles and equipment.

The project management shall take such measures necessary to collect and
store used oil and grease from vehicles and machinery in a manner deemed proper
by the relevant authorities for the prevention of pollution to adjacent watercourses
and groundwater.

In case of pollution of watercourses, due to oil and grease from the Works
the project management shall indemnify and keep indemnified the relevant
authorities from and against any liability for damages on account of water pollution or other nuisances created and against all claims, demands, proceedings, damages, costs, charges and expenses whatsoever in regard or in relation to such liability.

5.10.10 Utility

5.10.10.1 Water Supply

The project management shall design, supply, install, operate and maintain a system for supply of potable water to the construction facilities in the Works area including site offices, accommodation facilities and accommodation for workmen and staff. The supply shall be taken from sources approved by the relevant authorities.

Potable Water shall comply with the requirements of World Health Organisation standards.

5.10.10.2 Sanitary Facilities

The project management shall supply, construct, operate and maintain temporary toilet facilities at sufficient locations on the sites of the Works. Facilities shall be complete with adequate water closets, urinals and hand-basin, septic tanks, absorption trenches or other sewerage disposal installation.

The temporary toilet facilities shall meet the requirements of the Government health authority. The location of these facilities and their construction shall be as approved by the relevant authority.
Sewerage from temporary facilities shall be disposed of in a hygienic manner as approved by the relevant authorities.

All persons connected with the Works shall be obliged to use these conveniences. Any employee found violating this requirements shall be liable to immediate discharge and be refused further employment on the Works or access to the site.

5.10.10.3 Garbage Disposal

The project management shall undertake the collection and disposal of garbage from the Works area. Garbage collections shall be made at least twice a week and the services shall be continued until completion of the Works.

The project management shall also dispose off any non-combustible or waste construction materials.

5.10.10.4 Fire Fighting Services

The project management shall be responsible for all fire-prevention measures, fire protection and fire fighting on the Site.

The project management shall be guided by the recommendations of the relevant statutory authorities.

The project management shall provide, regularly maintain and operate all the fire fighting equipment including, but not limited, to water pumps, lines,
hydrants, hoses and chemical fire extinguishers adequate for the protection of all buildings or works under construction.

The project management shall provide and train an adequate fire fighting force under the direction of a nominated Fire Officer. The Fire Officer's duties shall include training fire fighting personnel, inspection of the supervision of maintenance of fire fighting equipment and taking control in case of emergency.

5.10.11 **Explosives**

The project management shall regulate the use of explosives, explosive powered tools or the like in the Works for the safety of persons or property or to safeguard the Works.

No blasting shall be carried out in any part of the Works without the written permission of the relevant authorities. Such permission shall not absolve the project management from any of their obligations or liabilities and they shall take all necessary precautions including the use of blasting nets to avoid damage, loss or injury to persons and to public or private property.

The project management shall keep the relevant authorities fully informed of all times when blasting is proposed to be carried out and of any details that may be required concerning strength of charges and their positions.

Explosives shall not be used within fifteen meters of any existing structure, pipeline, electric cable overhead power, telephone line etc.

The project management shall obtain the necessary licences for the use, handling, transporting and storage of explosives and shall provide a secured store
or stores suitable for explosives in accordance with local regulations and will be held strictly responsible for and shall settle at their own expense any claim for damage or injury resulting.

The project management shall at all times make full liaison with and inform well in advance and obtain such permission as is required from all government authorities, public bodies and private parties whatsoever concerned of affected or likely to be concerned or affected by blasting operations.

The amounts and number of charges used in various parts of the works shall be fixed in relation to the nature of the work with due regard to danger to work people and shall be subject to the approval of the relevant authorities. The times when blasting shall take place and the system of warning shall be approved by such authorities.

Proper buildings or magazines, with separate compartments for detonators, in suitable positions for the storage of explosives in manner and quantities to be approved shall be provided. The prevention of any unauthorised issue or improper use of any explosive brought on the Works shall be the responsibility of the project management and only experienced and responsible men shall be employed to handle explosives for the purpose of the Works.

The project management shall at all times take every possible precaution in and shall conform with all regulations and applicable laws relating to the handling transportation, storage, safe custody and use of explosives. The design and construction of the explosives stores shall be to the approval of the relevant
authorities and shall be in accordance with the requirements laid down by the such authorities.

Explosives shall be used in the quantities recommended by the manufacturers. Blasting shall be restricted to such periods as the authorities may prescribe.

If blasting is carried out close to properties or roads, appropriate safety rules shall be strictly adhered to. Where necessary or as directed by the relevant authorities, heavy mesh blasting mats shall be used to ensure that no damage is caused to persons or property on or off Site. Special care shall be taken in wet ground to ensure that individual explosions are reduced to such size as to preclude damage to any buildings or structures. Plaster shooting will not be permitted within 400 meters of any building or structure.

For rock blasting, the project management shall have technical personnel specialized in commercial blasting and shall use solid explosives (plastic or dynamite) and electrical detonators. An appropriate metering device shall be provided by the project management to show that the electrical circuit is connected to all the explosive elements in the holes before blasting, but without causing an explosion. An electrical source (detonating dynamo) shall be used for detonation.

5.10.12 MONITORING PROGRAMME, RECORD KEEPING AND REPORTING

General operation and management of the project should be on a daily basis. The continuous monitoring and maintaining of all services in perfect working
order. Before commencing operation of the project, it will be essential to establish the operation plan setting out exactly how it will be administered and operated, defining the rules and regulations to be adhered to and defining protocols to handle emergency situations.

Monitoring of the following parameters should commence prior to construction activity starting:

(1) Monitoring the shoreline around the project location. This activity should take place before construction and after construction.

(2) The seabed at the project location should be re-surveyed within 12 months following the start of operations to determine the rate of sedimentation.

(3) Water quality in the sea (Oxygen, Suspended Solids, Phosphates, Nitrates, Biological Oxygen Demand, Chlorophylla), immediately after construction.

(4) Effluent treated for disposal. Water should comply with the standards given above.

(5) Measurements of sources of noise not to exceed the standards in the executive regulation of Law. This is particularly important during construction, any source found to be operating above the required standards should be closed down and not restarted until repairs are made to allow standards to be met or a replacement found.

(6) Monitoring of turbidity of water every week or two weeks in the near-by edge reef using a Secchi disc. Distance of visibility to be measured in metres.
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(7) Weekly monitoring of sediment plume entering the water from the construction. The same vantage point should be used each week and photographs taken to establish the extent and direction of any plume.

(8) Reports to be made to the Yemeni Environmental Association, and others, including the Governorate Environmental Management Unit, and the owner to enable mitigation measures to be implemented if effects are severe. It should be noted that if effects are severe construction activity may need to be suspended until environmental conditions improve.

The project management should also keep records:

(1) Of fuel analyses to demonstrate that the sulphur content of the fuel used is at or below the specified levels mentioned in Law.

(2) To demonstrate equipment is operating within manufacturers specifications.

(3) Of significant environmental matters, including monitoring data, water quality, shoreline changes, accidents and occupational illnesses, and spills, fires and other emergencies.