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EXECUTIVE SUMMARY
EXECUTIVE SUMMARY

This report represents a Draft Final Environmental Impact Assessment Report for the Water Supply and Sanitation Project developed for the Greater Mukalla Region in the Republic of Yemen. The report is issued in parallel to the draft feasibility study submission by the Engineering Consultant for the Project (AAW being the Environmental Consultant). The report is issued at this stage as to consider its output during the final design of the project components according to World Bank procedure.

In order to assess the environmental impacts of the project, several steps were undertaken through this project for illustrating the legal aspects controlling the implementation of such project, a description of the project components, an assessment of the possible impacts of the project on the environment, and a plan for mitigation actions and operation monitoring.

The local Policy, Legal Framework and Administration Framework related to the Project were investigated including the organization of Governmental Authority, the National Water and Sanitation Authority (NWSA), and the Local Corporation for Water Supply and Sanitation In Hadramout Governorate – Coastal Areas (LCWSSHG-CA) that is the executing authority of the current project. Relevant Organizations and other relevant authorities as the Environmental Protection Agency as well as the relevant Environmental Legislation have also been highlighted.

The report highlights the current project objectives illustrating the real need for its prompt implementation. The project covers the need of the increased population along the project time horizon, while requires several sites for hosting the different project components.

A baseline study was included showing the present state of the Environment as a background prior to project implementation. This addressed both natural and man made environment including: climate, geology, groundwater hydrology, aquifers, topography, land resources and land uses, water resources, water supply works, distribution network, sanitation system and a summary of the diagnostics of the current systems.

An assessment of potential Environmental Impacts was herein conducted through evaluation of the activities to be conducted during construction and operation of the different project components. The expected potential impact of the different components of the project on the different physical and biotic elements of the environment were identified in order to assess their impacts relative to the background status of the environment; considerations for mitigation measures have also been proposed. The general approach in environmental impact assessment was the prediction of impacts compared with the baseline, consider
who or what is affected by positive or negative impacts, evaluate the significance, and develop specific mitigation measures.

Socio-economic impact assessment revealed that benefits are likely to be obtained from the implementation of the current project through enhancement of public health and reduction in household repairs and or protective works against sewage inflow. The wider range of goods and services available will benefit many businesses and make it easier for them to operate and to focus on their core business, e.g. fisheries, tourism and commerce.

The current project in implemented in land plots that are either governmental properties (for pipelines routing) or abandoned sites, some of them are deserted land of no current activities or uses. It was concluded that little or no people will be affected by its intended use through the current project. The construction of works may have positive impacts on economics and landscape value of the land. The water supply and sanitation project in the area will not result in the loss of any archaeological or cultural features.

Construction activities impacts from traffic accessing the construction sites shall result in noise, possible spillage of fuel, lubricants and hydraulic fluid. This impact is temporary except where permanent damage occurs to land or resources. In the absence of adequate measures to manage construction activities it is to be an impact of moderate significance. During site preparation and construction, noise will be generated from a number of sources including: jack hammers, loaders, generators, etc. and in many instances these will be operating in immediate proximity to residential areas. Unmanaged air pollution, especially of particulate and gaseous emission from construction machinery, and some of the unpaved access roads may create nuisance and in extreme cases direct adverse health impacts or damage property. However, these impacts are not severe.

Groundwater at the project area may be affected by contamination from minor spillage at contractor camps or construction materials on site, increased chances of seepages of faecal material and other contaminants due to disturbances in soil physical properties, or increased potential mixing of contaminated surface flows with those of the shallow aquifer water table. With appropriate and effective mitigation in place the negative impacts may have a very short-adverse impact on local groundwater quality, but no adverse consequences are anticipated.

Assessment of the wastewater treatment plants impact initiated with the examination of the proposed layouts and design criteria and the possible modifications to be considered from the environmental point of view. Possible impacts were identified and the issues related to safe disposal of treated wastewater and produced sludge were addressed. The implementation of the current project especially the sanitation components are expected to improve the present state of the marine life within the project area.
With appropriate and effective mitigation in place, the different impacts of the project can be adequately managed. Air quality and noise levels can thus be reduced to low significance, the negative visual impacts shall also be reduced to low significance. In addition, the impact of solid wastes should also be low, however, failure of mitigation will carry a high risk of much greater impacts.

The philosophy of the Environmental Management Plan addressed in this report includes the physical plan, land use zoning, protection of archaeological sites, social and economic planning, training and education strategies, economic strategy, and construction code of practice. Monitoring of essential parameters were suggested in order to ensure a sustained and environmentally sound operation of the facilities especially the wastewater treatment facility.

Finally, the participation of the public and stakeholders represents a milestone as the Consultants and Authority should consider the public points of concerns relative to the implementation of the current project. The different Public Consultation Meetings held along the project were listed illustrating the consultation process and the output obtained from these meetings.
CHAPTER (1)

INTRODUCTION
CHAPTER (1)
INTRODUCTION

1.1 Background

With the continuous efforts for boosting development activities in the Republic of Yemen, several national projects are implemented in the field of infrastructure, aiming at raising the quality of life of Yemeni population and responding to the increased needs for infrastructure services including water supply and sanitation facilities. These projects, while enhancing public health of the served populations, help in the development of more activities in the served areas that will also have its impact on the social life of people.

Al-Mukalla water supply and sanitation project is one of these major projects implemented in the Greater Al-Mukalla region to provide the required water supply and sanitation services for the project area till a development planning horizon covering the year 2020. The project will be executed on phases where Phase I shall provide the required facilities for a planning horizon till 2007.

The executing authority of the project is the Local Corporation for Water Supply & Sanitation in Hadramout Governorate – Coastal Areas (LCWSSHG-CA), and has appointed an Engineering Consultant (Dar Al-Handasah) for conducted the required engineering works for the project that is funded through a World Bank loan. Meanwhile, AAW Consulting Engineers was appointed as the Environmental Consultant for the Project.

1.2 Project Area

The project area is located in the Governorate of Hadramout that has two main Directorates: Al-Mukalla (comprising two cities and five villages) and Ghail Bawazir (comprising one city and two villages). The cities and villages included in the project area extend from Rayyan village in the east to Fowah City in the west (65-km) and from the Sea Shoreline in the south to major Wadis in the north (4-km).

Al-Mukalla lies between rugged mountains and an attractive shoreline. The climate, although hot in summer, is potentially suitable for tourists during the months of September to May. Al-Mukalla can be reached by roads, sea and air. An international airport is located at Rayyan village (35 km far from the city). The area has the potential to attract investors and to become a major commercial, tourists and industrial center, and as such, a development program for the water supply and sanitation sectors is needed to create a suitable environment.

1.3 Project Components

The Development Programme of the Greater Al-Mukalla Region was conducted by the Engineering Consultant in order to estimate the development requirement
and phasing of the water supply and sanitation project components. Estimation was pointed to achieve the following objectives:

A. Increase the present quantities of water to meet population requirements.
B. Improve water quality to meet world health organization standards.

The required facilities for water supply, revealed that rehabilitation of existing wells is required in addition to the construction of a new wellfield capable of providing the progressive demand of water along the project phases. In addition, new water transmission pipelines shall be installed and the overall water storage capacity shall increase through the construction of new ground and elevated water reservoirs.

The produced water shall be distributed to the different consumers via the existing and newly constructed distribution networks serving existing and newly developed areas. The works will make the possible use of the existing utilities and expand in the new areas through the installation of new pipelines.

The need for sanitation facilities is more pronounced in the project area as several unsafe practice are currently in use for the disposal of raw sewage collected from residential areas through local sewerage system. Such practice results in the formation of wastewater ponds very close to residential areas thus imposing health risks which is definitely highly pronounced during flooding periods.

The current status of sanitation service at the project area shall be ameliorated through the implementation of the sanitation component of the current project. Sanitation facilities will include gravity sewers collecting the generated raw sewage from residential areas and conveying it to intermediate or final pumping station sites. The collected sewage shall thus be pumped either to other conveying facilities or finally to the sites of the wastewater treatment plants.

Two wastewater treatment plants (WWTP) were suggested for the project area. The first WWTP have a small capacity (approx. 150 m$^3$/d) and shall be installed temporary at Ghail Bawazir area as a compact treatment unit and shall be further relocated during the second phase of the project to Rayyan village upon completion of the gravity sewerage network serving Ghail Bawazir and An-Naga'a area.

The second WWTP is a permanent installation near Wadi Fowah with a capacity of (14,000 m$^3$/d) constructed in two trains (with a third train of 7,000 m$^3$/d to be added in a later project stage). The treatment plant is of the stabilization ponds type with the additional use of chlorination facility and sand filters to produce a treated effluent suitable for further reuse.

1.4 Objectives under the EIA

The task of the Environmental Consultant is to review the different environmental aspects related to the implementation of the different components of the project and provide recommendations for further
consideration during the final engineering design stage of the project conducted by the Engineering Consultant. In addition, the Environmental Consultant has to review and assess the impact of the project which include water supply and sanitation services on the environment, and recommend mitigation measures and monitoring plan to be catered for while constructing and operating the various project components.

EIA study will solve many problems such as:

- The sewage networks are mostly designed un-adequately resulting in some lines.
- Ejector station are not functioning resulting in by-passing raw sewage to the sea.
- Outfall and its PS includes only Screens and Grinders (not functioning), allow all solid waste to discharge directly into the Sea. This practice has a very bad effect on the quality of the seawater and its surrounding environment.
- The location of the outfall PS is at a very strategic location in Old Al-Mukalla, which is enlarging the scale of the pollution, health hazards and nuisance problems.
- Septic tanks and/or cesspools are not properly sized resulting in ground water contamination and local flooding, which induces high risk to public health.
- Direct discharge of sewage into nearby wadis resulting from the poor initial standards of construction of the individual septic tanks and cesspools and the virtual absence of cleaning and maintenance, which contribute to a non-effective system percolation and consequently to a flooding situation. This practice cause contamination of shallow groundwater by seepage. Especially, where the water table is high and the underground water is considered as the only main source feeding the Project area.

EIA study Could help in:

- Elimination the local flooding problems, especially at wadi Al-Ayga.
- Limitation of sea pollution.
- Prevention of ground water contamination.
- Improvement of residents public health and socio-economic conditions
- Improvements of the environmental conditions for tourist purposes.

Impacts on the environment will include:

Natural environment and made environment as well as cultural and socioeconomic environment specifically water resources, land resources, atmospheric conditions and Bio-ecological parameters shall be assessed.

This is conducted in order to attain the least negative impacts of the project on the surrounding environment while maximizing the positive impacts on both the environment and the served population.
1.5 Organizational Structure of the EIA.

This report comprises eight chapters that address the different environmental issues related to the project as follows:

- **Chapter 1:** **INTRODUCTION**, Presents a general introduction of this Draft Environmental Impact Assessment Report.
- **Chapter 2:** **POLICY, LEGAL, AND ADMINISTRATION FRAMEWORK**, Addresses the different Policies, Legal and Administration Frameworks Related to the Project.
- **Chapter 3:** **PROJECT OBJECTIVES AND DESCRIPTION**, Describes the Project objectives addressing the need for implementing the current Project.
- **Chapter 4:** **BASELINE STUDY**, Introduces the Baseline Study (present state of Environment) including natural environment, climate, geology, ... etc.
- **Chapter 5:** **ASSESSMENT OF POTENTIAL ENVIRONMENTAL IMPACTS AND CONSIDERATION FOR MITIGATION**, Presents an assessment of potential Environmental Impacts of the different components of the project and the considerations of mitigation measures to be undertaken.
- **Chapter 6:** **ENVIRONMENTAL MANAGEMENT PLAN**, Introduces the Philosophy of the Environmental Management Plan for the current project; and
- **Chapter 7:** **PUBLIC CONSULTATION MEETINGS**, Describes the Public Consultation Meetings held along the project design and assessment works to develop the Draft Environmental Impact Report.
- **Chapter 8:** **IMPLEMENTATION OF THE ENVIRONMENTAL MONITORING AND MITIGATION PLAN.**
CHAPTER (2)

POLICY, LEGAL AND
ADMINISTRATION FRAMEWORK
CHAPTER (2)
POLICY, LEGAL AND ADMINISTRATION FRAMEWORK

2.1 Introduction
The policies, legal and administrative aspects of the project promoters, the funding agencies and the statutory government agencies play a major role in complying with recommendation of the Environmental Studies. Sustained success of Environmental Management practice depends upon the structure and effectiveness of such components. Existing policies, legal and administrative framework with respect to EIA and the framework within which this project has been carried out are described below.

2.2 Governmental Organization
The Republic of Yemen (ROY) was formed on 22nd May 1990, after the unification of the Yemen Arab Republic (YAR) and the People's Democratic Republic of Yemen (PDRY).

According to the Constitution of the Republic of Yemen, which is valid and in force since unification of Yemen, the Cabinet is the Central Government of the Republic. Under the Constitution each Minister shall undertake all the affairs of his Ministry and shall direct its Departments and Branches in ROY. The Minister is responsible to implement the general policy of the Government in his Ministry.

Part of the constitution provides for the local authority organization whereby the ROY is divided into administrative units, which have legal entity and are integral part of the state authority.

The Republic of Yemen is divided into 18 Governorates, each Governorate has a Governor who implements Cabinet resolutions and is responsible and accountable to the Cabinet.

Various agencies active in the sectors of Water Supply, Sanitation and Environment are described hereafter in the sub-section.

2.2.1 National Water and Sanitation Authority (NWSA)
NWSA was established in 1973 as an autonomous body under the Ministry of Electricity and Water with responsibility of development, operation and maintenance of water supply and sanitation facilities in urban areas of erstwhile North Yemen.

Public Water Corporation (PWC) active in erstwhile South Yemen was unified with NWSA. NWSA at present has 30 branches all over the country. In 1997, Yemeni Government adopted a major resolution allowing decentralization of operating and financial responsibilities of the branch offices to be achieved by Year 2000. Each branch office is responsible for the operation and maintenance in their respective urban areas.
2.2.2 Local Corporation for water supply and Sanitation

The Local Corporation for Water Supply and Sanitation in Hadramout Governorate - Coastal Areas (LCWSSHG-CA) is responsible for any existing and planned water supply and wastewater drainage services in the project area.

2.3 Stakeholders

The different stakeholders concerned with the current project are summarized in Table 2.1.

Table (2.1): Stakeholders Concerned with the Current Project

<table>
<thead>
<tr>
<th>Authority</th>
<th>Subject</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministry of Public Works and Urban Development (MPWUD)</td>
<td>Land Use and Zoning Data</td>
<td>Office of Public Works and Urban Development / Director’s Office</td>
</tr>
<tr>
<td>University of Hadramout for Science &amp; Technology (UHST)</td>
<td>Available Data of the Sea Physical Characteristic in the Area</td>
<td>Faculty of Environmental Science &amp; Marine Biology / Dean’s Office – UHST</td>
</tr>
<tr>
<td>Fisheries Research Center (FRC)</td>
<td>Available Fisheries Data</td>
<td>General Director’s Office – FRC</td>
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<tr>
<td>University of Hadramout for Science &amp; Technology (UHST)</td>
<td>Available Bio-Diversity and Natural Habitats Data for the Study Area</td>
<td>Faculty of Environmental Science &amp; Marine Biology / Dean’s Office – UHST</td>
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<td>Authority:</td>
<td>Meteorological / Weather Station Authority in Sana'a</td>
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<tr>
<td>Subject:</td>
<td>Meteorological Data for Project Area</td>
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<tr>
<td>Location:</td>
<td>Office of Weather Station in Sana'a</td>
<td></td>
</tr>
<tr>
<td>Authority:</td>
<td>Ministry of Public Works and Urban Development (MPWUD) / Mukalla</td>
<td></td>
</tr>
<tr>
<td>Subject:</td>
<td>Available Maps for the Study Area and the Urban Development Master Plan</td>
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</tr>
<tr>
<td>Location:</td>
<td>Office of Public Works and Urban Development / Director's Office – MPD</td>
<td></td>
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<tr>
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<td>Municipal Affairs and Environmental Health (MAEH) / Ghail Bawazir</td>
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<td>Subject:</td>
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<td>Authority:</td>
<td>General Surveying Department (GSD) / Mukalla</td>
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<tr>
<td>Subject:</td>
<td>Geodetic Information/Coordinate System/Existing Maps</td>
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<td>Location:</td>
<td>Director's Office – GSD</td>
<td></td>
</tr>
<tr>
<td>Authority:</td>
<td>Office of Real Estate and Government Properties (REGP) / Mukalla</td>
<td></td>
</tr>
<tr>
<td>Subject:</td>
<td>Road Layout of Al-Mukalla City</td>
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</tr>
<tr>
<td>Location:</td>
<td>Director's Office – REGP</td>
<td></td>
</tr>
<tr>
<td>Authority:</td>
<td>Ministry of Agriculture and Irrigation (MAI) / Fowah</td>
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</tr>
<tr>
<td>Subject:</td>
<td>Available Agricultural/Irrigation Data and Potential New Dams Sites</td>
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</tr>
<tr>
<td>Location:</td>
<td>General Director's Office – MAI</td>
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<tr>
<td>Authority:</td>
<td>Surveying Consultants</td>
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<tr>
<td>Subject:</td>
<td>Available Mapping / Local Coordinate System / Geodetic Data</td>
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<tr>
<td>Location:</td>
<td>Al-Ommal Zone (Private Office)</td>
<td></td>
</tr>
</tbody>
</table>
Table (2.1) Cont’d: Stakeholders Concerned with the Current Project

| Authority: | Municipal Affairs and Environmental Health (MAEH) / Al-Mukalla Municipality |
| Subject: | Solid Waste Disposal Data for the Study Area |
| Location: | Head’s Office – MAEH |
| Authority: | General Corporation for Electricity – Coastal Areas (GCE) |
| Subject: | Available Data on Power Plants, Transmissions, and Networks |
| Location: | General Director’s Office – GCE |
| Authority: | Soft Drink Co. LTD. (SDCL) / Ghail Bawazir |
| Subject: | Canada Dry Factory – Required Data |
| Location: | General Manager Office – SDCL |
| Authority: | Mukalla Fish Canning Factory (MFCF) / Mukalla |
| Subject: | Mukalla Fish Canning Factory – Required Data |
| Location: | General Manager Office – MFCF |
| Authority: | “Tuna” for Canning & Packing Fisheries (TUNA) / Al-Rayyan |
| Subject: | Fish Canning Factory – Required Data |
| Location: | General Manager Office – TUNA |
| Authority: | Al-Amoudi Marine Products Co. LTD. (SABAA) / Fowah |
| Subject: | Saba Fish Canning Factory – Required Data |
| Location: | Directive Manager Office – SABAA |
| Authority: | Hadramout Industrial Complex (HICO) / Al-Rayyan |
| Subject: | Sponge, Oil, and Plastic Factories – Required Data |
| Location: | General Manager Office – HICO |
| Authority: | General Survey / Sana’a |
| Subject: | Geodetic Information / Coordinate System/Existing Maps |
| Location: | Director Office |
| Authority: | Environmental Protection Council (EPC) / Sana’a |
| Subject: | Available Environmental Data for the Study Area |
| Location: | General Director Office – EPC |
Table (2.1) Cont'd: Stakeholders Concerned with the Current Project

| Authority: | General Corporation for Surveying and Mineral Resources |
| Subject:   | Ministry of Oil & Minerals Resources (MOMR) / Fowah     |
| Location:  | Available Geological/Hydrogeological Data and Maps     |
|           | General Director's Office - MOMR                       |

| Authority: | Central Statistical Organization (CSO) - Hadramout Bureau / Mukalla |
| Subject:   | Available Population Statistics                          |
| Location:  | General Manager's Office - CSO                         |

Other Stakeholders
- Fishermen.
- Farmers.
- Local community of areas receives wastewater, connections.
- Agriculture land owners.
- Local community of the wastewater plant area.
- NGOs and civil community in Al-Mukalla city.
- NGOs and civil community in Ghail - Bawazir.
- Religious men in the former areas.

2.4 Environmental Protection Agency (EPA)

After unification of Yemen, the Environmental Protection (EPC) was formed under the Prime Minister Decree 94/1990 replacing the existing two councils in the former YAR and PDRY.

Recently this organization has been changed to the Environmental Protection Agency (EPA) which is responsible for the protection of the environment after enactment of Environmental Protection Law (26/1995). It is attached to the Minister of State reflecting its importance as the policy making agency. The objectives and aims of EPA include:

- Formulation of environmental policies and strategies
- Enhancement of environmental education and awareness
- Co-ordination and organization of information in the field of environment among the different concerned agencies
- Co-ordination with related agencies at regional and international levels.
2.4.1 Relevant Environmental Legislation

1. Law No.5 of 1973 regarding Mines and Quarries 4.8.1973
2. Law No. 1 of 1975 regarding Wood Wealth & Greening 5.1.1975
3. Law No.1 of 1989 regarding Municipalities 1989
4. Republic Decree in Law No.50 or 1991 regarding Mines and Quarries 14.4.1991
5. Taking ownership for Public Interest Law No.25 of 1992
6. Cabinet decree concerning the adoption of EIA Report for Projects, Law No.89 of 1993
7. Prime Minister Decree in Law No.24 or 1994 regarding regulations of Hygiene and Environmental Health violations and penalties thereof 19.4.1994.
CHAPTER (3)

PROJECT OBJECTIVES AND DESCRIPTION
CHAPTER (3)
PROJECT OBJECTIVES AND DESCRIPTION

3.1 Introduction

This section presents an overview of the need of the project, existing system scheme and plans to be implemented under various phases of the proposed water supply and sanitation project as identified in the Development Programme Report. The main objective of the project is to improve the quality of life of the population in the project area through the provision of adequate means of water supply and sanitation. The project area is located in the Governorate of Hadramout that has two main Directories Al-Mukalla (comprising two cities and five villages) and Ghail Bawazir (comprising one city and two village). Table 3.1 presents areas to be served in the project.

Table 3.1 - areas to be served in the project

<table>
<thead>
<tr>
<th>Governorate</th>
<th>Directorate</th>
<th>City/Village</th>
<th>District</th>
<th>Neighborhood</th>
</tr>
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<tbody>
<tr>
<td>Hadramout</td>
<td>Al-Mukalla</td>
<td>Al-Mukalla City</td>
<td>Old Al-Mukalla</td>
<td>Al-Shaheed khalid</td>
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<td>Al-Ommal(AI-Sharj)</td>
<td>Al-Ommal</td>
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<td></td>
<td>Fowah City</td>
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<td>30 November</td>
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<td>Ghail Bawazir</td>
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<td>Al-Mustaqbal</td>
<td>Al-Moustaqbal</td>
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<td>Al-Wihdah</td>
<td>22 May</td>
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<td>Al-Naga'a</td>
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<td></td>
<td></td>
<td></td>
<td>Al-Rayyan</td>
<td></td>
</tr>
</tbody>
</table>

3.2 Need for the Project

As the population increases in the project area, a rising demand for water potable water occurred and is expected to persist as a result of development activities in the served communities. Meanwhile, water supply for the served areas dropped as a result of several factors as the lack of maintenance for the current water
production wells, high leakage rates resulting from corrosion of the cast iron distribution system, internal scaling of the pipes as a result of high calcium carbonate levels of the raw water, etc.

Low pressures experienced in some regions and air entrapment in pipelines in some locations further imposed difficulties for providing the required water supply service. Water pipelines that were often laid above ground, or with very shallow cover depths, were consequently at risk of damage. Pipes laid above ground along wadis risked being washed away or ruptured during rainy events. The temperature of water flowing through the above ground pipes increased leading to greater depositions within the pipes due to the hard nature of the water.

According to the Local Corporation for Water Supply and Sanitation in Hadramout Governorate – Coastal Areas (LCWSSHG-CA) records for water production and considering the Unaccounted for Water (UFW), the maximum quantity of water reaching those consumers residing at lower elevations within the system was no more than 50 liters per capita per day. In some other areas, consumers are not supplied with water and they had to rely on water tankers.

In addition, the sanitation service is far lagging the progress in water supply works, as only 20% of the population are served with a sewerage network. Higher percentage is connected to on-site sanitation facilities as septic tanks. The individual sewerage networks were installed mainly to provide a temporary solution for sanitation problems and were not all incorporated into a Master Plan that serves future purposes, however, some of these networks would still serve within the new approach for providing sanitation service for the project area.

Furthermore, the collected sewage from the different served areas is discharged into open dump areas or ponds due to the lack of final treatment and disposal facility at the project area. The presence of such ponds near the residential areas and subject to uncontrolled discharge of sewage represents a real threat to public health and thus needs immediate intervention.

The existing water supply and wastewater services in the project area are in poor conditions and have become grossly inadequate and malfunctioning as:

• Most of the existing networks are over 35 years old.
• Most of the water supply pipes are laid above ground or at a very shallow depths.
• Most of the existing pipes are laid arbitrarily to serve local requirements without appropriate design and specifications.
• At some locations, buildings may interfere with pipes route.
• Some pipes are laid in narrow streets that are not accessible for pipes installation and maintenance equipment.
• Some pipes are laid in wadis or over mountains, which make them difficult to be accessed for maintenance. In addition, these pipes are susceptible to the intrusion of vegetation roots which renders them liable to damage.
• At some locations the houses are old and can be damaged by pipe bursts.

Poor coverage with water and sanitation services and malfunctioning of damaged system lead to health hazards and aesthetic nuisance. Thus the existing system needs urgent renovation through rehabilitation and expansion works to cope with the required water supply and sanitation services along the planning horizon of the project.

3.3 Project Description

3.3.1 Project Location

The project area is located in the Governorate of Hadramout that has two main Directorates: Al-Mukalla (comprising two cities and five villages) and Ghail Bawazir (comprising one city and two villages). Figures (3.1a) & (3.1b) show the cities and villages included in the project area that extends from Rayyan village in the east to Fowah City (including fish packing plant) in the west (65-km) and from the Shoreline in the south to major Wadis in the north (4-km).

Al-Mukalla is an active seaport located in a pleasant environment on the southern shores of the Republic of Yemen on the Arabian Sea coast. It is the fifth largest district in Yemen and is the seat of Hadramout Governorate.

Al-Mukalla lies between rugged mountains and an attractive shoreline. The climate, although hot in summer, is potentially suitable for tourists during the months of September to May. The sparkling clear waters of Al-Mukalla Bay with it's numerous coral reefs provide a heaven for such holiday activities as sub diving, wind surfing and parasailing while the long stretches of golden sands rival those found in other major tourist destinations. The old City is particularly picturesque with traditional stone built multi-story buildings separated by narrow winding passageways huddled between the sea and the mountains. Recent records show that approximately 8,000 tourists per year visited Al-Mukalla recently with expected significant increase upon completion of a number of hotels currently under construction. A number of local travel agencies have branches in Europe catering specifically for the Al-Mukalla Directorate.

Al-Mukalla can be reached by roads, sea and air. An international airport is located at Rayyan village (35 km far from the city). Al-Mukalla has the potential to attract investors and to become a major commercial tourists and industrial center, and as such, a development program for the water supply and sanitation sectors is needed to create a suitable environment.

The updating of the 1981 master plan has not been completed and that the exact limits of each City/village (Administrative boundaries) have not been defined.

The only available mapping covering the study area is the 1978 Military survey Topographical maps scale 1: 100,000 and the 1981 maps based on Aerial photography scale 1: 10, 000 carried out by MAPS company which covers part of the study area.
3.4. Current and projected populations

3.4.1 Al-Mukalla City

The current population density is 175 Persons per Hectare (PPH). This density is considered between medium and high density. An examination of local area densities reveals that this overall density is distributed unevenly among the different districts. Existing densities range from 475 PPH in Al-Sayyadeen Neighborhood to 25 PPH in 30 November Neighborhood.

Due to the different existing densities within each Neighborhood, their capabilities to absorb future population growth will differ. Some Neighborhoods such as Al-Sayyadeen, Al-Salam, October and Al-Ommal Neighborhoods have reached a near saturation level. The growth will be limited in such Neighborhoods according to movement between Neighborhoods.

The population of Al-Mukalla City is expected to increase around 120,000 from the year 2007 to the year 2020. Approximately 55% of that increase will be in the Rwainat area (Four plots). Even by the year 2020, with population of around 70,000, Rwainat area is not expected to reach its full capacity. The densities of Rwainat area will range from 59 PPH in plot "4" to 98 PPH in other three plots, which results in an overall density of 78 PPH by the year 2020. On the other hand, the reminder of Al-Mukalla population increase will be accommodated in existing populated areas as well as allocated expansion areas specifically in New Khalf area of Al-Shaheed Khalid Neighborhood and Al-Thawrah, Al-Nasr Neighborhoods. A small portion of the population growth is expected to be absorbed in currently saturated areas of Al-Ommal as well as 30 November Neighborhoods. The overall population density of Al-Mukalla City is projected to reach 150 PPH by the year 2020, a gradual decline from the current density of 177 PPH. The densities of Neighborhoods will range from 98 PPH in 30 November to 485 PPH in Al-Sayyadeen Neighborhoods.

3.4.2 Ghail Bawazir City

The current population density of Ghail Bawazir City is 58 PPH, which is considered as a low density relative to the calculated populated area especially within Al-Mustaqaal District. Ghail Bawazir City includes a considerable number of under construction and vacant dwellings. These dwellings have the capacity to accommodate the natural population growth. Projections for the year 2007 produce a population of 26,710 an increase of approximately 6,000 from 2001. The current area produces an overall density of 76 PPH, which remains in the low-density category. So, there will be no need for expansion beyond the current built area until the year 2007. The increase in population in Al-Mustaqaal District constitutes 95% of the overall population growth in Ghail Bawazir City.
Currently, there is a trend of movement from Al-Wihdah and 22 May Districts to Al-Mustaqbal District that accounts for the high percentage of increase in the later.

The increase in the population of Ghail Bawazir City between 2007 and 2020 is expected to be 19,634. In order to maintain a relatively low density, which is the main characteristic of the City, an additional area of 115 Hectares is needed. Since the expansion in both Al-Wihdah and 22 May Districts is limited by topographic factors, the only expansion will take place in Al-Mustaqbal District. This expansion will take place towards the east due to topographic limitations to the north, south and west. As a result, the overall population density of Ghail Bawazir City will become around 100 PPH. Although, Al-Wihdah and 22 May Districts will maintain relatively medium to high densities of 140 PPH to 245 PPH, respectively.

3.4.3 Fowah City

The current population density of Fowah City is 22 PPH, which is considered as very low density. This phenomenon is caused by the rapid construction activity taking place in most areas of city excluding Old Fowah District. The increase in population in Fowah Ibn Sina District and Al-Mutadarrireen Neighborhood constitutes 75% of the overall population in Fowah City. Dwellings currently under construction have the capacity to accommodate the natural population growth beyond the year 2007 with low-density rates of 27 PPH. As a result, there will be no need for expansion beyond the current built area until the year 2007.

Fowah City demonstrated rapid construction activity, which is reflected, in the low densities. The projected population of the city for the year 2020 is expected to reach 39,000 approximately, and increase of 16,500 since 2007. With an approximate populated area of 815 Hectares, the city will not reach its full capacity by the year 2020. The overall population density is expected to be below 50 PPH that remains in the low-density category. As a result, there will be no need for expansion even some years beyond 2020.

3.4.4 Villages within Al-Mukalla and Ghail Bawazir Cities

Table 3.2 provides data on the population served according to 1994 census. The total current population of these villages is 14,149, which ranges from 4,557 in Roukob Village to 495 in Al-Rayyan Village. Using the 4.33% annual growth rate, the total projected population becomes 18,246 by the year 2007, which ranges from 5,877 in Roukob Village to 639 in Al-Rayyan Village. The current population densities range from 89 PPH in Al-Eiss to 17 PPH in Buwaysh Village. With the exception of Al-Eiss and Al-Naga'a Villages, the projected population for 2007 can be accommodated within the current built areas with densities below 100 PPH ranging from 80 PPH in Harshiyyat to 21 PPH in Buwaysh Villages. So, Al-Eiss and Al-Naga'a Villages are the only two Villages.
that will need expansion areas (additional Four and Five Hectares, respectively) to accommodate the projected population.

With the exception of both Roukob and Buwaysh, Villages will require expansion to accommodate projected population for the year 2020. The total population of these villages will grow from 18,250 in 2007 to 31,650 in 2020. As a result, expansion areas (ranging from 9 Hectares in Al-Rayyan Village to 19 Hectares in Al-Naga’a village) are required to accommodate the population growth.

Similar to Fowah City, Both Roukob and Buwaysh Villages currently demonstrated considerable construction activity. The areas covered by existing dwellings as well as dwellings under construction will be sufficient to accommodate their projected population by the year 2020. On the other hand, the additional land have been provided for other Villages thus Population densities range from 60 PPH in Al-Rayyan Village to 91 PPH in Al-Naga’a Village.

Table 3.2: Population Data of Project Area (1994 Census)

<table>
<thead>
<tr>
<th>Source: Central Statistical Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Avg. HHS: Average Household Size</td>
</tr>
<tr>
<td>- Avg. PDU: Average Persons per Dwelling Unit</td>
</tr>
</tbody>
</table>
The population of Hadramout Governorate is projected to grow at 4.33% (CSO) growth rate until the year 2025. Most of the Cities/Villages within the project area will need additional land to accommodate the projected population by the year 2020. The second phase of this project, the natural growth in population will be accommodated at moderately low densities in the range of 100 PPH.

3. 5  Present and Projected water Demand

3.5.1 Existing Water Consumption

Data collected from different sources revealed that water consumption for different purposes increased steadily. Table 3.3 shows the water production from existing wellfields within project area (1999 & 2000)

<table>
<thead>
<tr>
<th>Location</th>
<th>Production m³ year1999</th>
<th>Production m³ year2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>An-Naga (10 wells)</td>
<td>5,645,067</td>
<td>6,710,333</td>
</tr>
<tr>
<td>Fowah (2 wells)</td>
<td>525,854</td>
<td>551,488</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td>7,261,821</td>
</tr>
<tr>
<td>Audaiba (6 wells)</td>
<td>3,356,171</td>
<td>3,262,507</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td>3,262,507</td>
</tr>
<tr>
<td>Thila (4 wells)</td>
<td>671,381</td>
<td>556,761</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td>556,761</td>
</tr>
<tr>
<td>Total</td>
<td>10,198,482</td>
<td>11,081,089</td>
</tr>
</tbody>
</table>

Table 3.4 shows the various areas served, and consumption for each of these areas (cities/villages/districts, 1999& 2000 ) for the overall Project area.

The followings describe the current status of water consumption from the public network:

a) Domestic Water Consumption

The average domestic consumption in year 1999 in Al Mukalla and Ghail Bawazir directorates was respectively 72.6 and 68.3 lcpd (i.e. litre per capita per day). The consumption has increased from year 1998 to year 1999 by 13.1% and 23.0%, respectively in Al Mukalla and Ghail Bawazir. This is mainly because the water supply increased significantly after the completion of Al Mukalla Water Supply Project – 1st Stage - Contract AMWSP 3A&3B.
b) Non-Domestic Water Consumption

Non-domestic water consumption consists of institutional, commercial, industrial, construction and agricultural water consumption. In year 2000, 1.17 MCM of water was provided from An'naga and Audiba wellfields for agricultural use to the adjacent farmers because their water sources have been reduced considerably since the development of the wellfields. However, during discussions with officials from the Ministry of Agriculture and LCWSSHG-CA Planning Department concerning irrigation demand in the project area, we were informed that agricultural water requirements are currently being provided from private sources and that there are no plans to provide it from the water supply system. Therefore, agricultural consumption will not be considered as part of the non-domestic consumption in the current study.

Table 3.4 Water Consumption at Project Area

<table>
<thead>
<tr>
<th>Areas served</th>
<th>District</th>
<th>Consumption m³</th>
<th>Unaccounted for Water Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al-Mukalla</td>
<td>Old Mukalla October Al-Omal</td>
<td>721,341 1,096,909 1,453,880</td>
<td></td>
</tr>
<tr>
<td>Buwaysh</td>
<td>Part of Roukob Other Fowah</td>
<td>230,833 890,857 622,040</td>
<td>For agriculture</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td>5,015,860</td>
<td></td>
</tr>
<tr>
<td>Ghaibawazir</td>
<td>22May Al-Wihda AlMostaqbal</td>
<td>76,640 106,387 379,279</td>
<td></td>
</tr>
<tr>
<td>Al-Gara</td>
<td>Habayer Naga Sheheir Other</td>
<td>121,762 68,001 30,657 513,909 728,100</td>
<td>For agricultural use</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td>2,024,735</td>
<td></td>
</tr>
<tr>
<td>Harshiyal, JouMasha</td>
<td>October, AlOmal</td>
<td>230,832</td>
<td></td>
</tr>
<tr>
<td>Part of Roukob</td>
<td>Fowah</td>
<td>1,577</td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
<td>232,409</td>
<td>Included above An-Naga</td>
</tr>
<tr>
<td>Fowah</td>
<td></td>
<td>622,040</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>7,273,004 3,808,085</td>
<td></td>
</tr>
</tbody>
</table>
The LCWSSHG-CA, Planning Department classified non-domestic consumption as follows:

- Institutional including government & public institutions, schools, colleges & universities, hospitals & health centers, mosques and public standpipes.
- Commercial & Industrial including factories, shops, hotels, restaurants, bakeries and gas stations.
- Construction including buildings under construction.

The analysis presented in the Development Programme revealed the following:

- The institutional type of water consumption is by far the largest non-domestic consumer. In year 2000, institutional consumption constituted 61% and 49% of the non-domestic consumption in Al-Mukalla and Ghail Bawazir directorates, respectively.
- Institutional demand increased by around 105,000 m³ from 1999 to 2000 in each of Al-Mukalla and Ghail Bawazir directorates because some users such as teachers consumption type has been reclassified from domestic to institutional in year 2000.
- The commercial/industrial type of water consumption has increased significantly starting year 1998 especially in Ghail Bawazir.

c) Unaccounted for Water

In year 2000, the percentage of unaccounted for water reached a high of 38.9% and 36.6% in Al Mukalla and Ghail Bawazir, respectively.

3.5.2 Provision of Water and Sanitation Services

Customer Base

Total connections covered virtually 100% of the population (190,154 in 2001) and totaled 28,000 connections in 1999 rising to nearly 30,000 in 2000. Since 1995 new connections have averaged nearly 740 per year. Domestic connections at 23,546 in 1999 accounted for 83% of total connections and 81% of water consumption. The number of persons benefiting from domestic connections was 182,134 at the time, implying average of 7.8 persons per domestic connection.

The project area comprises about 80% of the total connections to LCWSSHG water supply network that had a total of 36,000 connections in April 2001. There are additional 4,838 connections that are classified as abandoned either old building that have fallen into disrepair or recent homes and speculative real estate developments. A further 305 of water consumers are connected to septic tanks, many of which were installed as a part of the 1988 Mukalla sewerage project. The main septic tanks are found in the October, Old and New Fowah, and parts of Al-Ommal and Al-Nasr Neighborhoods.
3.5.3 Future Water Service Delivery Options

3.5.3.1 Water Consumption

The following paragraphs describe the proposed scenarios for water consumption from the public network in year 2020.

a) Domestic Water Consumption

As described previously, the average domestic consumption has increased from year 1998 to year 1999 by 13.1% and 23.0%, respectively in Al Mukalla and Ghail Bawazir directorates. This sharp increase in consumption in year 1999 reflects the fact that the low consumption in the previous years was due to supply limitations rather than other factors. The consumption is likely to increase in the future if more water is made available. Where there are no supply or financial constraints, the average domestic consumption will reach above 100 l/c/d.

In the previous study “Programme for Reduction of Water Losses in Al-Mukalla – Phase 2”, it was recommended to fix the domestic consumption for the year 2022 to 80 lcd for the city of Al Mukalla.

In the current development programme, three scenarios for average water domestic consumption will be considered. The scenarios will assume that the average domestic water consumption from metered connections to the public network will be at the following levels in the year 2020:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Domestic Water Consumption, lcd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low consumption</td>
<td>70</td>
</tr>
<tr>
<td>Medium consumption</td>
<td>90</td>
</tr>
<tr>
<td>High consumption</td>
<td>110</td>
</tr>
</tbody>
</table>

In the low consumption scenario, consumption in 2020 would remain at the level achieved in 1999. In the high scenario, consumption at 110 lcd in year 2020 would be in line with the potential developments expected for Al Mukalla. The medium scenario consumption of 90 lcd is the mid-point between the low and high scenario forecasts.

b) Non-Domestic Water Consumption

Non-domestic water consumption includes institutional, commercial, industrial and agricultural water consumption. However, as discussed in the previous chapter agricultural consumption will not be considered as part of the non-domestic consumption in the current study.

The collected records of institutional, commercial/industrial and construction water consumption in Al-Mukalla and Ghail Bawazir directorates from year 1990 to year 2000 were analyzed. In addition, records for water consumption in the major factories were also collected and analyzed. However, it was not possible to establish a trend for the future increase in non-domestic consumption from the previous consumption records because these records are fluctuating irregularly from month to month and year to year mainly due to limitations on water availability or high cost and/or un-metered connections and other reasons.
addition, the unavailability of a future land use plan makes it difficult to determine the future growth pattern.

The average of the last 11 years non-domestic consumption percentage from the total water consumption is 18% and 21.3% in Al-Mukalla and Ghail Bawazir directorates, respectively. The non-domestic consumption increased sharply in Al-Mukalla in year 1999 after the completion of Al Mukalla Water Supply Project because more water became available. In year 2000 the non-domestic consumption percentage from the total water consumption was 19.2%. The latter percentage is likely to remain constant if water availability remains as it is and increase if more water becomes available in the following years. Therefore, for year 2020, it is recommended to consider the non-domestic consumption for the low, medium and high consumption scenarios respectively as 20, 22.5 and 25 percent of the total consumption, equivalent to 25, 29 and 33 percent of domestic consumption.

Accordingly, the average total domestic and non-domestic water consumption excluding unaccounted for water would be as follows in year 2020:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Domestic &amp; Non-domestic Consumption, lcd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low consumption</td>
<td>87.5</td>
</tr>
<tr>
<td>Medium consumption</td>
<td>116.1</td>
</tr>
<tr>
<td>High consumption</td>
<td>146.7</td>
</tr>
</tbody>
</table>

c) Unaccounted for Water

As described in the previous chapter, the percentage of unaccounted for water from the water produced in year 2000, reached a high of 38.9% and 36.6% in Al Mukalla and Ghail Bawazir, respectively.

Unaccounted for water or system losses are expected to decrease in the future after rehabilitating the trunk mains and distribution network and as a result of the anticipated leak detection programmes and related measures. The rate of decrease depends on the works, which will be completed at the various phases of the project.

For the purposes of the present analysis, it has been considered that network water losses (unaccounted for water) would decrease in year 2007 to a level of 30 percent of total production, equivalent to 43 percent of total water consumption and starting year 2013 to a level of 25 percent of total production, equivalent to 33 percent of total water consumption.

d) Total Water Consumption

According to the above mentioned recommendations, the average total water consumption including unaccounted for water will be as follows in year 2020:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Total Average Consumption, lcd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low consumption</td>
<td>116.7</td>
</tr>
</tbody>
</table>
3.6 **Current Practice for Wastewater Disposal**

With the absence of adequate wastewater treatment process and the partial provision of sewerage collection system (covering only 20% of the project area), the following practices are conducted for wastewater disposal in the different project areas:

3.6.1 **Wastewater Disposal from Al Mukalla City**

In Old Mukalla district, the collected sewage is discharged directly to the Sea through the Harbor Ejector Station in addition to a 150 mm diameter by-pass without any sort of treatment. The Promontory Ejector Station is out of order and the collected sewage conveyed to it is discharged directly into the Sea through a 150 mm diameter by-pass pipeline. The post office pumping station is also not work due to technical problems and the collected sewage is discharged directly to the Sea via a 300 mm by-pass pipeline also without any treatment.

Collected sewage from Al-Ommal sewage collection system is discharged into the Sea through the Sea Outfall Pumping Station where three pumps (one of them reported to be broken) with a discharge capacity each of 100 l/s at 20 m head pump the collected sewage to the sea. These pumps were reported to be overloaded. The pumping station includes 3 screens (2 duty and 1 standby) and 2 grinders which are not functioning and consequently the screens were removed allowing raw sewage to be discharged directly through a 500 mm diameter sea outfall pipeline.

The newly planned and constructed sewer lines in October (Al-Diess) district and Ba-Ja'am area allow the collection and transmission of collected sewage to the Sea Outfall pumping station mainly through a 500 mm trunk line. Similarly, sewage will partially be collected from Ghar Al-Ahmar area and part of Wihdet Sami to the same trunk line then to the Sea.

Most of recently installed pipes were temporarily laid, and partially cover part of the project area not following proper technical design and specifications. This has resulted in flooding of the wadis and caused critical pollution to the surrounding environment.

3.6.2 **Wastewater Disposal from Roukoub City**

In Roukoub city, three different areas are served with sewerage system installed temporarily to provide prompt service with no coordination within a master plant. Thus the southern area of the old city discharges its sewage into Wadi Al-Harshiyat at the seashore, the middle area of the old city discharges the collected sewage is discharged into an open pond near the central mosque of the city. Finally, areas served in the northern part of the city discharge their sewage flow into an open pond located north-east of the old city.
3.6.3 Wastewater Disposal from Fowah City

In the area of Fowah, septic tanks and cesspits discharging into nearby wadis or overflowing into the streets serve most of the district. This is creating health nuisance, odors, and smells. The surrounding Wadis (especially Wadi Fowah) are filled with wastewater ponds.

In addition, the existing sewerage system and the planned collectors all convey the collected wastewater to Wadi Fowah and allow for further direct discharge into the Sea through a 400 mm PVC pipeline.

3.6.4 Wastewater Disposal from Ghail Bawazir

The generated sewage generated in Ghail Bawazir area is mainly discharged to septic tanks and cesspools or into nearby Wadis where numerous ponds are noticed. Open ditches are also used discharging the collected sewage from some part of the village into agriculture lands.

3.6.5 On-Site Wastewater Disposal System

The existing wastewater disposal systems used within the rest of the project area comprise mainly individual septic tanks and cesspits / soakaway or small collecting networks discharging into septic tanks and cesspits or directly into nearby wadis.

However, despite the relatively low per capita domestic water consumption, the poor initial standards of construction of these pits and the virtual absence of cleaning and maintenance contribute to a situation in which most pits are effectively full, and no longer permit effective percolation. This condition is generating a number of problems, specifically:

- Frequent overflow into the streets and wadis within the project area’s cities and villages creating wastewater ponds and consequently health nuisance, odors, and smells.
- Contamination of shallow groundwater by seepage, especially at Al-Naga’a and Ghail Bawazir villages, where the water table is high and the underground water is considered as the main available source of water for the Greater Al-Mukalla.

3.7 Project Components

The Development Programme of the Greater Al-Mukalla Region was conducted by the Engineering Consultant in order to estimate the development requirement and phasing of the water supply and sanitation project components.

Currently the project area is not served by any wastewater treatment plant as the current procedure for wastewater collection and disposal is through septic and holding tanks. Few areas are served with limited wastewater collection system where several local networks were executed through public contributions.
The development program and the feasibility study produced by the Engineering Consultant considered a low water consumption scenario to develop the different components of the water and sanitation project including the wastewater treatment plants capacities. The Feasibility Study Report submitted by the Engineering Consultant contains updated findings after using the aerial photos, thus the consequent modifications and deviations from using the Satellite Images. In addition, it contains calculations for water supply network and sewerage networks in addition location of stabilizations pond wastewater treatment plant, and the compact wastewater treatment unit at An Naga’a.

Estimates for water demand, thus the required facilities for water supply, revealed that rehabilitation of existing wells is required in addition to the construction of a new wellfield capable of providing the progressive demand of water along the project phases. In addition, new water transmission pipelines shall be installed and the overall water storage capacity shall increase through the construction of new ground and elevated water reservoirs.

The produced water shall be distributed to the different consumers via the existing and newly constructed distribution networks serving existing and newly developed areas. The works will make the possible use of the existing utilities and expand in the new areas through the installation of new pipelines.

The need for sanitation facilities is more pronounced in the project area as several unsafe practice are currently in use for the disposal of raw sewage collected from residential areas through local sewerage system. Such practice results in the formation of wastewater ponds very close to residential areas thus imposing health risks which is definitely highly pronounced during flooding periods.

The current status of sanitation service at the project area shall be ameliorated through the implementation of the sanitation component of the current project. Sanitation facilities will include gravity sewers collecting the generated raw sewage from residential areas and conveying it to intermediate or final pumping station sites. The collected sewage shall thus be pumped either to other conveying facilities or finally to the sites of the wastewater treatment plants.

Two wastewater treatment plants (WWTP) were suggested for the project area. The first WWTP have a small capacity (approx. 150 m³/d) and shall be installed temporary at Ghail Bawazir area as a compact treatment unit and shall be further relocated during the second phase of the project to Rayyan village upon completion of the gravity sewerage network serving Ghail Bawazir and An-Naga’a area. The second WWTP is a permanent installation near Wadi Fowah with a capacity of (14,000 m³/d) constructed in two trains (with a third train of 7,000 m³/d to be added in a later project stage). The treatment plant is of the stabilization ponds type with the additional use of chlorination facility and sand filters to produce a treated effluent suitable for further reuse.

Followings are the main components to be implemented under Phase I of the current project.
3.7.1 Rehabilitation of Existing Wellfields

The existing wellfields are currently operating at levels considerably under installed capacity. Project works will comprise the deepening and/or drilling (or replacement wells in the immediate vicinity of the existing facilities), and equipping them with associated ancillary works.

3.7.2 Wellfield at Wadi Flik

It is expected that a wellfield will be constructed at Wadi Flik of 12 wells near (KM-7) to produce an ultimate production capacity of about 260 l/s. Phase (1) contains only 6 production wells.

3.7.3 Water Storage Facilities

The project area can be divided into five major water zones, four in Al-Mukalla directorate and one in Ghail Bawazir directorate. Each zone is served by an independent water system although in one or two cases they are inter-connected at few locations. The following is a brief description of these zones:

- Al-Mukalla southern zone consists of the areas of Al-Mukalla city included in the "Programme for the Reduction of Water Losses in Selected NWSA branch offices - Taiz, Al-Mukalla". This zone is supplied directly from Al-Ommal and Bahush reservoirs but currently it is also supplied from Al-Sadad reservoir because Bahush reservoir level is not sufficiently high to feed the old city upper areas by gravity.

- Al-Mukalla western zone consists of the city of Fowah and the area of Al-Mukalla city west of the southern zone. This zone will be supplied mainly from the proposed Al-Thawrah reservoir but partly from Al-Tawilah reservoir.

- Al-Mukalla northern zone consists of the area of Al-Mukalla city north of the southern zone. This zone is mainly supplied from Bakrain reservoir.

- Al-Mukalla eastern zone consists of the villages and projected developments in the area east of the southern zone including Al-Shaheed Khalid (New Khal±) neighborhood. This zone will be supplied from the proposed Eastern reservoir.

- Bahush Reservoir:

It is not feasible to rehabilitate the existing Bahush reservoir. Therefore, it is recommended to replace it by a new reservoir with a storage capacity of 400 m$^3$ at an adjacent location to serve Al-Mukalla southern zone water system. The most suitable reservoir elevation was found to be 80 m a.s.l. It allows for supplying the area serviced by the reservoir by gravity except for few scattered houses on the area fringes.

- Al-Tawilah Reservoir:

The existing Al-Tawilah reservoir location is suitable because it is close to Fowah wellfield supplying this reservoir but the reservoir storage capacity is only 45 m$^3$. Therefore, it should be demolished and replaced at the same location by a new reservoir with a storage capacity of 400 m$^3$. This reservoir will serve Fowah western side.
• **Proposed Regional Reservoirs:**

Three new regional reservoirs are proposed for Phase I, one of which is near Audaiba existing reservoir (Stage 2: 2500m³) and the remaining two are at new sites one near Buwaysy east of Al-Mukalla city (Stage 1: 1000m³; Stage 2: 4000m³) and one near Al-Thawrah neighborhood (Stage 1: 1000m³; Stage 2: 6500m³). The following is a brief description of these reservoirs:

- **Audaiba Reservoir:**
  This new reservoir is proposed near the existing Audaiba reservoir. It will collect the water transmitted from Audaiba well field and store it to serve Ghail Bawazir zone water system. The reservoir proposed elevation is 135 m.a.s.l. and its recommended storage capacity is 2500 m³. This reservoir will serve Al-Mukalla southern zone.

- **The Eastern Reservoir:**
  The Eastern reservoir is proposed near Buwaysy to serve the areas east of Al-Mukalla city. The reservoir proposed location is at a mountain crest between Buwaysy and Joul Masha, around 700m north of the main road. The recommended elevation for the Eastern reservoir is 90 m a.s.l. because it allows for supplying the eastern areas and Al-Shaheed Khaled (New Khalaf) at the required residual pressure of 25 m during peak hour water consumption. The proposed location is 4500 m away from Thila wellfield. Therefore, this reservoir can be used for the collection and distribution of the water produced from Thila wellfield and from An'Naga'a well field or the proposed well field at wadi Flik. The reservoir recommended storage capacity is 5000 m³. This reservoir will serve Al-Mukalla eastern zone water system.

- **Thawrah Reservoir:**
  This reservoir is proposed uphill of Al-Thawrah neighborhood to serve most of Al-Mukalla western zone water system. This reservoir recommended storage capacity is 7500 m³ and its proposed location is 200 m north of the main road to Fowah. The most suitable reservoir elevation was found to be 80 m a.s.l.

  Storage capacity will fulfill average daily water consumption. The storage will be provided by both the existing reservoirs and the newly constructed ones with the following proposed capacities: (i) 7500 m³ at Al-Thawrah, (ii) 5000 m³ at Eastern area, and (iii) 2500 m³ at Audaiba.

3.7.4 **Water Transmission Lines**

Transmission mains are mainly used to convey water to reservoirs. In some cases if necessary, transmission mains may be used also as distribution mains. In the project area, some existing pipes that were originally functioning as transmission mains are currently being used mainly as distribution mains. The existing transmission/distribution mains that should be integrated into the proposed water system or should be replaced and relocated are discussed below.
Additional transmission/distribution mains are proposed as described in the next paragraphs mainly for the following reasons:

- To connect the proposed reservoirs and existing relocated reservoirs to the water supply network.
- To supply the reservoirs with the projected peak day water consumption in 2020.
- To strengthen the existing water distribution network and allow for a minimum residual pressure of 25.0 m during normal operation and 15 m during a fire outbreak in the distribution networks proposed to be constructed in the next phases of this project.
- To feed the distribution networks directly from existing and proposed reservoirs rather than from transmission mains.

All the works proposed hereunder are included in Stage 1 of Phase I except for the works proposed on the existing transmission line from Buwayesh collector reservoir to Al-Sadad reservoir that are included in Stage 2 of Phase I.

There are five existing transmission and distribution mains in the water supply system. Two of these mains were recently constructed and are expected to remain in good condition till year 2020. They are the one from An Naga'a reservoir to Al-Sadad reservoir and that from Al Sadad reservoir to Al-Ommal reservoir and its related branches. These transmission lines are as follows:

- Transmission main from An Naga'a reservoir to Al-Sadad reservoir:
- Transmission main from Audaiba wellfield to Buwaysh reservoir
- Transmission line from Buwaysh collector reservoir to Al-Sadad reservoir

These lines are subject to some rehabilitation works, some reaches of them shall be abandoned according to the evaluation previously conducted by the Engineering Consultant.

Water distribution mains are recommended to supply the villages of Buwaysh, Roukob and Joul Masha in the eastern water zone. A transmission main is recommended to supply Bahush reservoir to be reconstructed at a new location as described in the previous section. This reservoir is to be supplied from the existing 300 mm transmission line from Al Sadad reservoir. In addition, a distribution main parallel to the transmission main is recommended from the reservoir to the existing 300 mm pipe.

### 3.7.5 Water Distribution Works

Phase I scope of work includes the rehabilitation of Al-Mukalla northern water zone distribution network. These works are to be completed in Stage 1 of Phase I. Al-Mukalla northern zone total area is around 400 hectare and includes the neighborhoods of October, 30 November and Ba'jiman. The existing distribution network requires major rehabilitation works.

Phase I of the project includes the following distribution lines:
• From Eastern reservoir to the villages of Joul Masha and Roukob
• From Bakrain reservoir to October, 30 November and Ba-Ji’man neighborhoods
• From Al-Tawila reservoir to Fowah Ibn Sina neighborhood

3.7.6 Sewage Collection System and Treatment Plants

3.7.6.1 Proposed rehabilitation works

The following rehabilitation works are proposed during the execution of the current project:

The Promontory Ejector Station is now completely out of order and need complete renovation (the compressor is broken, there is leakage from pipe joints, and the underground ejector room is flooded with sewage flow).

Some main collectors are laid temporary without proper technical design and specifications especially at wadi Al-Ayga. This has resulted in flooding of the wadis and critical pollution to the surrounding environment. Relocation or replacement of these pipes is recommended.

Ghail Bawazir city comprising Al-Mustaqbal, Al-Wihdah and 22 May districts, is served by on-site disposal systems constructed in a random way and discharging into septic tanks and cesspools or into nearby Wadis. Constructing well-designed septic tanks is highly recommended.

The Sea Outfall needs rehabilitation since it has a broken pump, its grinders are not functioning, and its screens are removed.

3.7.6.2 Proposed wastewater collection system

Phase I proposed sewage collection systems consist of the followings:

• Al-Mukalla and Fowah collection system consisting of two main collectors, one collecting sewage flows generated from Al-Mukalla city and the second collecting sewage flows generated from Fowah City. The system will discharge collected sewage into a treatment plant located in wadi Fowah, northward the main road leading to Al-Mukalla city.

• Collection system network serving Al-Naga’a village. The collected sewage will be discharged temporarily into a package sewage treatment plant (STP) but at later phases of this project it will discharge into an STP located southwards Ghail Bawazir city near the road leading to Al-Rayyan Airport.

The works were selected to provide the followings:

• Prevent contamination of ground water and pollution of natural streams and sea;
• Collect and dispose sewage from problematic and high density areas;
• Improve and upgrade the tourist areas.

Stage 1 works (of Phase I) include the sewage network and transmission lines of the following areas:
Stage 2 works include the remaining areas of Phase I. The following areas are to be served by the proposed sewage system:

- Fowah City including: Al-Sadah, Al-Mutadarrireen, Old Fowah, and Fowah Sina (Stage 2)

The collection network was at the beginning designed to be laid along the main existing highway to avoid land expropriation. But one problem was faced; sewage flows could not be collected by gravity since the coastal areas have ground levels lower than the road. In order to solve this problem, a new system was proposed to be placed along the new proposed coastal alignment. This area embraces two pumping stations. This system comprises gravity lines greater than 200 mm diameter.

Therefore, the works incorporated in Phase 1 implementation of the current project for sanitation works include:

- Rehabilitation of the sewage networks in Al-Mukalla extension to cover the development of October and November areas to year 2007.
- Construction of transmission lines from Old Fowah to wadi Fowah STP.
- Construction of the transmission line from Al Sadaqah located on the other side of wadi Fowah.
- Construction of the sewage network of the rest of Fowah City. This includes Al-Mutadarrireen and Fowah Ibn Sina areas.
- Construction of two modules (7000 m$^3$/d) of the sewage treatment plant (STP) at wadi Fowah, to serve Al-Mukalla, Old Fowah, and the transmission line from Mukalla to wadi Fowah STP.
- Construction of An Naga’a village sewage network and installation of a package treatment plant of capacity 150 m$^3$/d (2 x 75 m$^3$/d).

### 3.8 Wastewater Treatment Plants

This section addresses the implementation of the treatment plants in the project area providing background information about the current situation, the practice of wastewater disposal, the locations of the suggested wastewater treatment plants relative to the land use planning, reviewing and commenting the design of wastewater treatment facilities, in addition to identifying the impact of the wastewater treatment plant on the project area. The report addresses the proposed mitigation measures of the identified negative impacts and the recommendations for monitoring the performance of the treatment plant.

The project includes the construction of several wastewater treatment plants as follows:
• Construction of two modules (7000 m$^3$/d) of the sewage treatment plant (STP) at Wadi Fowah, to serve Al-Mukalla, Old-Fowah, and the transmission line from Mukalla to Wadi Fowah STP.

• Construction of Al-Naga’a village sewage network and installation of a package treatment plant of capacity 150 m$^3$/d (2 x 75 m$^3$/d).

• Construction of two modules 3600 m$^3$/d of the Ghail Bawazir sewage treatment plant (STP) at southwards Ghail Bawazir to serve Ghail Bawazir city and An’Naga’a village.

The Wadi Fowah treatment plant will be phased in three identical trains each train handling 7,000 m$^3$/d. For the first phase, two trains will be constructed with a capacity of 7,000 m$^3$/d each (total 14,000 m$^3$/d). The treatment plant will be of the oxidation pond type. The plant will have an emergency sea outfall that will be used when no irrigation is needed.

The package treatment plant at Al-Naga’a will comprise 2 units each with a capacity of 75 m$^3$/d. The plant will treat the sewage flow up to a secondary level of treatment. The effluent will be re-used also for irrigation. The plant will be of the package type.

3.8.1 Design of WWTP

This section investigates the currently proposed design criteria and configuration of wastewater treatment plants proposed for the different project areas highlighting the issues of concern from the environmental perspective.

Wastewater Treatment Plant at Wadi Fowah

• General Description

Stage I of Phase I of Al-Mukalla water supply and sanitation project will comprise two modules each with a capacity of 7,000 m$^3$/d while a third module with an additional capacity of 7,000 m$^3$/d will be constructed later on.

The Engineering Consultant proposed – after addressing several treatment processes – to use the oxidation ponds for treating the collected sewage at Wadi Fowah treatment plant. The works comprise large earthen basins providing adequate detention time for sewage treatment.

The proposed oxidation ponds comprise a series of ponds namely anaerobic ponds, facultative ponds, and maturation ponds. Provision of two parallel modules of the proposed ponds allows for flexible operation of the ponds facing emergency cases or operational requirements.

Anaerobic ponds receive the raw sewage and allows for solids settling and for anaerobic bacteria to remove a considerable portion of organic loads received in the raw sewage. The sewage flow thus discharges into facultative ponds where both aerobic and anaerobic bacteria contribute to further removal of organic loads. Anaerobic conditions prevail at the bottom of the facultative ponds while aerobic
conditions are encountered in the upper zone of the ponds as a result of oxygen introduction to wastewater via natural surface aeration and photosynthesis activity of algae. Therefore, the colloidal and soluble organic content of sewage are further stabilized through these ponds. Maturation ponds or aerobic ponds are used to improve the overall performance of the pond system and to further destroy the pathogenic content of sewage.

- **Sewage Flow**

  The Engineering Consultant conducted a survey on actual rates for water consumption in the different district of the project area. This survey included an estimate of water lost through distribution networks and unaccounted for water. Three scenarios for further evolution in per capita water demands were considered and the corresponding rates of per capita generated sewage flows were also estimated as shown in Table (3.5).

  **Table (3.5): Per Capita Generated Sewage Flow**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Projected Net Per Capita Water Consumption (l/c/d)</th>
<th>Estimated Average Generated Sewage Flow (l/c/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Consumption</td>
<td>88</td>
<td>74</td>
</tr>
<tr>
<td>Medium Consumption</td>
<td>116</td>
<td>99</td>
</tr>
<tr>
<td>High Consumption</td>
<td>146</td>
<td>125</td>
</tr>
</tbody>
</table>

  The Engineering Consultant concluded in his study to the use of the low consumption scenario which represents a more realistic view of the evolution in water consumption and sewage generation. However, the project components may accommodate an unexpected shift to the medium consumption scenario. Therefore, the total estimated wastewater flow was conducted using the low consumption scenario in order to size the different components of the project including the wastewater treatment plant.

- **Quality and Characteristics of Raw Sewage**

  According to the Local Corporation for Water Supply and Sanitation in Hadramaut Governorate – Coastal Areas (LCWSSHG-CA) no sampling or testing seems to have been previously conducted within the project area to determine the characteristics of raw sewage, especially at the inlet of Al-Mukalla existing outfall pumping station. In the absence of any previous records for testing / analyses of raw water samples, the Engineering Consultant selected the following criteria to represent raw sewage:

  - **pH**
    - 7.5
  - **Temperature**
    - 24 °C
  - **BOD₅**
    - 500 mg/l
- TSS 750 mg/l
- Total Alkalinity 600 mg/l
- NH₄ 100 mg/l
- Total Phosphorus 40 mg/l
- Total Dissolved Solids 1250 mg/l

**Design Criteria**

The Engineering Consultant provided brief on design criteria used to size the wastewater treatment plant highlighting the maximum permissible limits and the chosen criteria for the design as shown in Table (3.6).

**Table (3.6): Design Criteria for Proposed Treatment Plant at Wadi Fowah**

<table>
<thead>
<tr>
<th>Treatment Unit</th>
<th>Purpose</th>
<th>Max. Design Criteria</th>
<th>Chosen Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaerobic ponds</td>
<td>- Receive and remove high organic loadings</td>
<td>- Volumetric Loading: 400 g BOD₅/m³/d</td>
<td>- Volumetric Loading: 117 g BOD₅/m³/d</td>
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<td></td>
<td></td>
<td></td>
<td>- D.T.: 5 days</td>
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<td></td>
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<td></td>
<td>- η BOD₅ removal: 60%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>- Depth: 5.0 m</td>
</tr>
<tr>
<td>Facultative ponds</td>
<td>- Further reduction of organic loading</td>
<td>- Surface loading: 40 g BOD₅/m³/d</td>
<td>- Surface loading: 39 g BOD₅/m³/d</td>
</tr>
<tr>
<td></td>
<td>through aerobic and anaerobic actions</td>
<td></td>
<td>- D.T.: 10 days</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- η BOD₅ removal: 70%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Depth: 1.50 m</td>
</tr>
<tr>
<td>Aerobic ponds</td>
<td>- Reduction of pathogens</td>
<td></td>
<td>- Depth: 1.50 m</td>
</tr>
</tbody>
</table>

**Wastewater Treatment Plant at An Naga’a**

According to design concept, the treatment plant to be installed at An Naga’a is a compact treatment unit that shall serve temporarily during Phase 1 of the project, then shall be relocated to Al-Rayyan village for further use within the general development plan of the project area. No data were reported in the design documents concerning the type of treatment process (expected to be biological treatment) or the required design criteria for water treatment, effluent disinfection, sludge management, etc. It is expected that such data should be included in the final detailed design of the required facilities.
CHAPTER (4)

BASE LINE STUDY (PRESENT STATE OF ENVIRONMENT)
CHAPTER (4)  
BASELINE STUDY  
(PRESENT STATE OF THE ENVIRONMENT)

4.1 General
According to the major objectives of the environmental impact assessment (EIA) of the present project different environmental parameters were studied by the Consultant including scoping process and public participation that assisted in the identification of the most important environmental parameters that might be affected by the project implementation. In this chapter, the baseline studies concerning the present status at the project area are presented for comparisons of expected project impacts before and after project implementation. The followings address both the natural and man-made environment main parameters and status. Natural environment comprises climate factors, which are very important for water demand and usage, water consumption, recharge of underground water aquifers, and water loss by evaporation. Geological studies including ground water hydrology will be studied to describe the existing water resources. Marine environment shall be addressed to describe how for the present situation could be changed after the completion of the project.

4.2 Natural Environment
4.2.1 Climate
The weather in Yemen is dominated by three main meteorological mechanisms:
(i) The Red Sea Convergence Zone Effect (RSCZ)
(ii) The monsoon Inter Tropical Convergence Zone Effect (ITCZ).
(iii) The Mediterranean Effect.

The Mediterranean effect causes light rainfall events in December and January. This effect reaches Yemen once every few years and consists of ingress of polar air following a depression. RSCZ effect takes place from March to May but can also be observed during autumn and causes the rainfall season in April and May. This effect causes rainfall on the western Escarpment as a result of rapid heating of the land surface then the winds drives the clouds inland to the escarpment. The caused rainfalls are fairly high and of a short duration and with a small area extent.

Between the RSCZ and ITCZ a time of transition takes place in June. In the ITCZ effect the northern and southern trade winds converge. Following the position of the sun, ITCZ moves north and back to south reaching latitudes of Hadramout and dominates the weather from July to September. Warm dry air from northern parts of Hadramout province, where the importance of summer rains decreases.
Temperature in Yemen can be extreme, ranging from a cool 10°C at night to over 50°C in daytime. Rainfall is sparse averaging only 60 mm per year. A dry season occurs from October to March. The weather is dominated by easterly to northeasterly airstreams that change direction near the Red Sea to become a persistent southerly flow across the Tihama province.

4.2.1.1 Climate within the Project Area

The Hadramout plateau, in general, has its precipitation during the seasons of spring and autumn. Most rainfall periods consist of intense but brief showers and followed by light rain. On the southern part of the plateau, the rainfall intensity has an average of 100-300 mm/year as issued in most relevant reports.

In general the weather of the Southern Yemen coast and the Gulf of Aden is hot and arid. Two-monsoon season prevail. The southwest monsoon occurs between the months of May and September while the northeast monsoon occurs between October and April. Although the term "monsoon" often implies heavy seasonal rains, both monsoons are dry in the southern coast of Yemen. Within the study area, there is one meteorological station; the Rayan Airport station that is located at 1435 N Latitude and 4915 E Longitude and at 25 m elevation from Sea level. Although during the period from January to March, the rainfall intensity was less than 50 mm as measured from Rayan Meteorological station, yet most of the rainfall occurred during the month of February for the past 20 years. The temperature rises gradually in April and reaches a maximum of 38.5°C in the shade in June and July, while humidity is in average of 70%.

Table 4.1 Rainfall Intensity in Project Area

<table>
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<th>FEB.</th>
<th>MAR.</th>
<th>APR.</th>
<th>MAY.</th>
<th>JUN.</th>
<th>JUL.</th>
<th>AUG.</th>
<th>SEP.</th>
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<tr>
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<td>21.2</td>
<td>17.3</td>
<td>27.4</td>
<td>85.5</td>
</tr>
<tr>
<td>1998</td>
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<td>11.4</td>
<td>30.2</td>
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<td>0.0</td>
<td>0.0</td>
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<td>0.0</td>
<td>0.0</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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</tr>
<tr>
<td>2002</td>
<td>1.0</td>
<td>2.6</td>
<td>8.0</td>
<td>71.0</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Figure (4.2 b): Hydrological Analysis Showing the Major Watersheds and Wadis for the Region.
LEGEND

- Existing Boundaries
- Expansion Area for 2007
- Expansion Area for 2020

Note: The project area contains a number of scattered proposed settlements which are not highlighted. This figure illustrates the areas shown in green within the project area.

Proposed Expansion Areas for 2007 and 2020
4.2.2 Geology/Stratigraphy

Within the Mukalla city two stratigraphic units of alluvial deposits have been distinguished. Pleistocene conglomerates present the first one rather widely spread in the region and the second one is presented by Holocene gravel-sandy-clayey formations composing the axial zones of valleys (Figure 4.1).

Since the beginning of the Holocene the most wadis are in the stage of erosion caused by the geotectonic uplifting. The latter resulted in erosion and in a sharp reduction of the conglomerate thickness. At present the conglomerates practically everywhere are eroded to the base and are locally preserved within the coastal plain as terraces and in the interfluvies of wadis. Where these compact well-cemented rocks reach a thickness up to 20-30 m. thus, deep erosion of conglomerates and their relatively poor permeability, caused by compact cement, determines its low groundwater potential. The geologic structure, Stratigraphy, the hydraulic properties of the various strata, climate as the source of water available for potential recharges and their proximity to ground surface or major terrain features determine the hydrogeological flow regime.

4.2.3 Groundwater Hydrology

The major hydrological features for regional study area are shown in Figures (4.2a) & (4.2b).

From the groundwater hydrology point of view, the main (productive) aquifers in the Al-Mukalla basin are confirmed to loose wadi deposits. The largest wadis in the region are as follow:

(i) Wadi Khirba-Fowah (Catchement area: 450 sq. Km)
(ii) Himam-Buwaysh (Catchement area: 650 sq. Km)
(iii) Huwayrah (Catchement area: 750 sq. Km)
(iv) Arf-Shihr (Catchement area: 1000 sq. Km)
(v) Khird (Catchement area: 600 sq. Km)

Wadis, upstream deeply cut the plateau which is composed predominantly of carbonate deposits of the paleogene age and more the Precambrian metamorphic rocks and cretaceous sandstone. Approaching the coastal plain the wadis become wider and cut the Oligocene-Miocene deposits (Shihr Formation) which are predominantly composed of weakly permeable deposits-clays, clayey sands, gypsum and red sandstone. The location of the wadis with their morphology and geological structure presented hereafter determines the groundwater formation and occurrence in the area.

4.2.3.1 Groundwater Aquifers

Along the Aden Gulf coast there are a few narrow basins that open to the sea and present rift filled with Oligocene-Quaternary series. Al-Mukalla is one of these basins, the Major aquifers in this arid region are made up by the quaternary series
filling the wadis as well as the Oligocene-Miocene series (Shihr Formation). Shihr Formation is presented by clayey limestone's, conglomerates, sandstone and gypsiferous clays. Hydrogeologically, the coastal plain aquifers possess low permeability and groundwater as a supplementary source of water supply.

4.2.4 Topography

The surface elevations of the regional study area vary from about 1705 m above mean Sea level (mamsl) on the Escarpment to the Coastal plain at Sea level in the south. The coastal plain is sloped from north to the south towards the Arabian Sea coast. The Escarpment is located 40 Km between the coastal plain (south) and third topographic feature in the study area, which is the plateau (north). The surface of the northern plateau is gently sloped to the northeast and deeply incised by wadis (hundreds meters deep) reaching wadi Hadramout at the north.

4.2.5 Land Resources and Land Uses

The project area consists of a number of land uses, varying from predominantly residential and agriculture in the small settlements to a wider and more balanced distribution of activities in the three main Cities: Al-Mukalla, Fowah and Ghail Bawazir Cities. The small settlements within the project area have limited institutional and governmental facilities unlike Al-Mukalla City and to a certain extent Ghail Bawazir and Fowah Cities.

A general examination of the land uses reveals that most of the commercial activity takes place in Al-Mukalla and Fowah Cities and to a certain extent Ghail Bawazir City and Roukob Village. Agricultural activities are spread in Ghail Bawazir City, Jou Masha, Buwaysh and Al-Eiss Villages. There are two main sites allocated for tourism: New Khalf and Rwainat areas in Al-Mukalla City and in Al-Mutadarrireene in Fowah City.

4.2.6 Groundwater

Generally, the quaternary alluvial-proluvial series in wadis is the main source of ground water for the Al-Mukalla water supply. Ground water supply in Al-Mukalla has high calcium carbonate (700-900 mg/l) compared to a WHO maximum permissible concentration of 300 mg/l. The following sub-section describe the exciting ground water:

(i) Wadi Khirba (Fowah wellfield)

Wadi Khirba valley is located in the west (17 Km west of Al-Mukalla) of the region, where Fowah town is located in its mouth. This water supply based on ground water abstraction from the Quaternary alluvial-proluvial aquifer. The main annual flood is 220l/s and its salinity being locally 1.5 g/l and higher. Ions of calcium, magnesium, sulphate and chlorides are predominant.

The water-bearing alluvial-proluvial coarse-grained deposits have thickness of 6-14m and they are underlain by weakly permeable Eocene marls and limestone. The maximum possible rate of ground water abstraction in the downstream has
been estimated by SOGREAH at 35 l/s, recommended rates 10-20 l/s. A more intense abstraction can cause an encroachment of seawater into wells. The groundwater quality in wadi khird, which is the upstream of wadi khirba, as a rule is good.

The extracted quantity from two well is about 17 l/s.

(ii) Wadi Himam-Buwaysh (Thila Wellfield)

Wadi Himam-Buwaysh (30 wells) has a mean annual flood of 155 l/s, the water-bearing alluvial-proluvial deposits (transitivity varies between 0.001 to 0.00001 m²/second). It has a thickness ranges from 5 to 30 m and are underlain by weakly permeable marls and clayey sands of shihr formation. The groundwater salinity in the middle part of valley (1.0 g/l), in the coastal area it increases to 3-6 g/l. Close to the confluence of Wadi Himam and Wadi Thila there is the Buwaysh wellfield at which about 30 wells have been drilled since 1965. Currently the extracted quantity from the wells in operation is about 28 l/s. The Wellfield abstraction can be increased to 100 l/s.

(iii) Wadi Huwayrah

It is the largest one in the region and its mean annual flood is 310 l/s. the middle part of the Wadi upstream presents a narrow and deep canyon with a large flow gradient. The wadi is about 5 Km wide and its area is 100 sq.Km. Towards the sea the valley narrows and has a width within 400m. The saturated thickness usually does not exceed 20m and in the middle part of the thickness reaches 40m. The ground water is brackish and its salinity is 1.5 – 3 g/l. The maximum possible rate of abstraction is 40 – 60 l/s.

(iv) An-Nagaa and Audiaba Wellfields

The main water source for Al-Mukalla is An-Nagaa and Audiaba Wellfields, which are, located 50-Km northeast Al-Mukalla (5Km north of town of Ghail Bawazir).

Wells were completed in fracture networks interpreted to be within limestone of the Jeza Formation. High calcium, sodium and sulphate (425-560 mg/l) concentrations caused the mineralisation. Currently, the extracted quantity from ten wells of An-Nagaa is 180 l/s and from wells of Audiaba is about 106 l/s.

(v) Gbail Bawazir Sinkholes

Recently, these sinkholes have been depleted after operation of A Nagaa Wellfield and the main reason is that there has been no rain for almost 10 years. This resource has also been used to supplement irrigation and the water supply for Al-Mukalla and Ghail Bawazir.

Major Observation:

Water abstractions from the existing groundwater development comes from aquifer storage due to the insignificant recharge (Scarcity of rainfall).
The groundwater levels at An Naga‘a Wellfield are decreasing by meters per year (well effective life-time is about 10 years).

Groundwater development in the project area is at risk due to overexploitation and needs to be controlled.

The number of secured potentials nearby water sources is limited due to overall deterioration.

The general geological and lithological characteristics of the area are expressed as follows, using conventional symbols:

- (Vs): Precambrian metamorphic rocks, outcropping in the vicinity of wadi khirba,
- (Kt): Upper and middle cretaceous: sandstone (500 m thickness),
- (Tu): Paleocene lime stones,
- (Tj): marls (80m), some times interbedded with limestones,
- (Tr): gypsum and marls, of lower and middle Eocene age, forming an interbedded complex about 30 m thick,
- (Ts): Oligomioocene, mainly composed of shales, clay marls, sometimes interbedded with clayey sands and gypsum (650m maximum),
- (Qt): Quaternary deposits, made of more or less cemented conglomerates, boulders and sands (alluvium). Siltstone can be found in the lower reaches of the wadis.

The sedimentary formations lie uncomfortably over the metamorphic basement, and are generally folded, except for (Ts).

The overall structure is monoclinal, dipping southwards and is effected by a faulting system which might be connected to the movement of the Arabian shield. The oligomioocene formations (Ts) are only warped and are separated from the other sedimentary formations by an regular unconformity.

The various wadis all flow seawards and in their lower reaches the water generally becomes progressively more saline.

The resistivity survey included electrical soundings (E.S.) with AB emissive current lines equal to or shorter than 800 m. They are located on deferent wadis and distributed over 30 transverse profiles.

Profile elevation was found by altimetric plotting, using a barometer.

The measurements obtained by such a method are not highly accurate and margin of error of 10 m should be allowed for. On a single profile, the difference in elevation between E.S. station is only estimated.

Qualitative Interpretation

Two borehole logs are available in the study area, giving lithologic columns which should be used in E.S. calibration. Unfortunately, these boreholes are
located on the terraces and cannot be correctly correlated with E.S., executed in
the wadi bed.

However, as a function of the local geology, Water-bearing layers should be
found:

- in the wet alluvium, where the interstitial permeability may be considered a
  favorable factor;
- in the wet gypsum of the (Tr) formations, characterized by a cracking
  permeability, resulting from fractures, doline collapses, etc.;
- Alluvium dry or wet, overlaying a conductive bed-rock;
- Siltstone at the surface, with alluvium laying over a conductive substratum;
- Dry gypsum at the surface, with wet and fractured gypsum under the water table.

Concerning the alluvium, it is of interest to note that when the dry/wet thickness
ratio is considerable.

The water resistivity range from 2 to 16 ohm.m. a resistivity scale of different
formations can be established as follows:

<table>
<thead>
<tr>
<th>Formation</th>
<th>Resistivity Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silt (surface)</td>
<td>4 - 50 ohm.m</td>
</tr>
<tr>
<td>Dry alluvium</td>
<td>150 - 15000 ohm.m</td>
</tr>
<tr>
<td>Wet alluvium</td>
<td>50 - 300 ohm.m</td>
</tr>
<tr>
<td>Gypsum</td>
<td>20 - 150 ohm.m</td>
</tr>
<tr>
<td>Wet gypsum</td>
<td>12 ohm.m</td>
</tr>
<tr>
<td>Clay (Ts)</td>
<td>less than 10 ohm.m</td>
</tr>
<tr>
<td>Sands and clays</td>
<td>30 - 60 ohm.m</td>
</tr>
<tr>
<td>Marls (Tj)</td>
<td>10 - 40 ohm.m</td>
</tr>
<tr>
<td>Limestone (Tu)</td>
<td>resistant layer</td>
</tr>
<tr>
<td>Sandstone (Kt)</td>
<td>conductive layer</td>
</tr>
</tbody>
</table>

The water table level varies from 5 to 8 m below the surface.

Under a covering of dry alluvium and a clay layer, appears a potential aquifer. At
E.S. 18, its high resistivity indicates the presence of conglomerates also found in
borehole.

The underlying deposits, with a resistivity of less than 10 ohm.m, may belong to
the Ts formation. At E.S. 31, the very low resistivity could be due to see water
intrusion.

Ts formations are overlaid by alluvium, the wet part of which seems very resistant
and is probably made up of conglomerates (qw = 6.2, F = 15).

E.S. 21 was disturbed and the thickness of wet alluvium could not be evaluated here.
The wet alluvium becomes more resistive here, due to an increase in the water resistivity ($qw = 6.7$, $F = 30$).

Only dry alluvium appears on the interpretative cross-sections, overlaying a conductive substratum (less than 10 ohm m) attributed to Tj formations.

The water table is situated within the substratum of Tj formation.

Alluvial deposits are totally dry.

Except at the surface, the strata are probably Ts formations with clayey sands interbedded in clay. The western station E.S. 11 should traverse layers with a higher salt content than at E.S. 12 and 13.

The wet fringe appears only on the east side at E.S. 16, the 150 ohm m layer may be considered as a possible aquifer. The Ts formation probably forms the substratum, in the deep part on which sea water may be infiltrated.

This profile is located on the wadi Buwaysh and its tributary the wadi rayzbah.

Wet alluvium of considerable thickness is found below E.S. 4, E.S. 5 and E.S. 10. its high resistivity could be explained by an aquifer having a good permeability ($qw = 6.7$, $F = 30$)

The bed-rock is almost certainly of Tj formation.

E.S.76, which is located close to a gypsum outcrop, shows on its diagram the following variation in resistivity:

- A resistant surface layer,
- A conductive layer (probably clay of Ts formation),
- A second resistant layer (dry gypsum),
- A second conductive layer (wet gypsum under the water table).

Southwards, the E.S 78 diagram reflects the continuity of this succession of layers, although the dry gypsum may be more marly.

Correlation is difficult with E.S. 79, due to a discontinuity in the resistivity distribution.

E.S.77 is located on crushed stone resistive layers. The thin conductive seam of 15 ohm m can attributed either to wet gypsum or Ts formation.

These are also located on gypsum formation, the dry part of which has a resistivity which varies according to the quantity of interbedded marl. the conductive layer under the water table is probably made up of wet gypsum.

The bed-rock could be of Tj formation or profile T and profile u.

4.2.7 Marine Environment

Bathymetric Surveys and Field Measurements have been accomplished for the exploration of the existing outfall, and it was found to be in very poor conditions.
4.2.7.1 General Aspect of Sea Profiles

In Fowah, the seabed slopes down regularly. At a distance of 2000 m from the coast, the water depth reaches 70 m.

In Al-Mukalla, in front of the owed, the slope is low down to -30/-35 then increases to reach 65 m 2500 m from the coast. As one moves to the East, the plateau narrows and the slope increases, with depths of more than 80 m at 2500 m from the coast.

In Roukob, the slope is regular with depths of about 50 m at 2000 m from the coast.

In Rayyan, the wadi also forms a submarine plateau down to -25/-30. Further depths increase rapidly to -70 m.

4.2.7.2 Sea Water Temperature

Seawater temperature has been found homogeneous over the water column in depths less than 20 meters.

Al-Mukalla divers mentioned that the sea water temperature starts decreasing beyond a depth of 35 m (28°C at 40 m against 3°C in the top column).

4.2.7.3 Currents

Currents have been measured within the top 2-meter layer, which is the layer within which the effluent plume is transported. It has been found in the direction of wind as it is expected in a low tidal current environment. This means that due to wind predominant direction, direction of surface currents is very frequently towards land.

4.2.7.4 Marine biology

(i) Sea Grass

The Red Sea and Gulf of Aden Coast of Yemen support large areas of various types of sea grass and mangroves. Although sea grass is patchily distributed along the length of Red Sea and gulf of Aden Coast of Yemen, five principal sea grass regions have been identified — offshore, these area: Cymouocel, Cyil1ouocen, Ertllalus acoroides, Syrinogodium, isoetifolium

The most abundant species, based on the quantitative estimates, are Cymodocea and Thalassia.

(ii) Mangrove

Mangrove is the major coastal plant along the coastline of Sea in Yemen; the following species have been reported: Aricemia mar ma, Druguiucra, Arnhilul borucr, discolllirious.
Grazing of mangroves by camels was observed on various occasions near the coasts.

The most heavily grazed mangrove forest was found north of Al-Mukalla, some small isolated patches of mangroves are covered by drifting.

Coral communities on volcanic rocks around volcanic islands on terraces formed by old lava.

L. Porites is the most common coral in the Red Sea water in Yemen. The other two most common corals are Stylophora pistillata and Platygyrg daedalea, both hardy species found in a great range of habitats.

As per the Report of 'Protection of Marine Ecosystems of the Red Sea, Coast of Yemen' (1999) there are six district clusters of hard coral species in Red Sea of Yemen. The clusters are as follows:

- Clear water communities facing open seas
- Exposed reefs
- Low diversity communities
- Southern fringing reefs
- Semi-protected island reefs and

Clear water communities facing open sea are found only around offshore islands. In and around the coast of Al-Mukalla low density communities are existent.

The communities are characterized by low coral species richness (average 9 spp.) and live coral cover (3%). Macro algae cover is the highest (35%) with Sargassum, Turbinaria. Padina and Dictyota spp being dominated. In most of the site dead standing coral cover is also extensive

- The Red Sea has a diversified fish fauna both in total and in reef-associated fish. Fish species observed on the reefs in the Yemen Sea are reef fish and a number of species of shrimp are fished in Yemen. Widely distributed species is Penaeus semisulcatus, most abundant species of shrimp is Penaeus indicus, referred to tiger shrimp, is widely distributed in the area usually found in deeper waters

- Shrimp production is about 300 tons annually for local boats but difficult to estimate for overseas
- Investment boats as exact data is not available. An estimate of the production annually is 1000 - 1500 tons for all boats in the Yemen.
- Shark is a very important fish for the export of fins and considered as the second to shrimp for fisheries. Queen fish is a particularly sought after species for the market.

Catches of most of the fish associated with coral reefs have increased in recent years. As a result, the total reef catch has also increased.
4.3 Man Made Environment

Pollution of sea water as result of sewage discharge:

The lack in municipal wastewater facilities, e.g. collection and treatment led to uncontrolled discharge of sewage flows into the sea resulting in negative impacts on marine environment as monitored by some researches conducted by environmental scientists in Hadramout Science and Technology University in Al-Mukalla which reported the followings:

1- changes occurring in the quality of seawater.
2- pollution of aquatic micro organisms used as fish food
3- pollution by heavy metals that may cause precipitation in fish tissues, thus leading to reduced nutritional values.
4- decrease in fishing income as complained by fishermen as a result of sea pollution
5- overall noticed deterioration in marine water quality

Present status of tourism activities:

There are numerous tourism facilities (Hotels & Resorts) within the project area along the seashore. It may be stated that the current pollution occurring in the marine environment is one of the reasons of decreased tourism attendance thus less job creation in the field of tourism activity thus reduced income of a category of the population and will impact the national income.

Underground water in the area:

By considering human activities within the project area it is obvious that there is high risk of polluting the underground water from drainage overflows from septic tanks that may permanently affect the water aquifers. Main pollutants are summarized in micro-organisms, heavy metal and chemical pollutants.

The huge increase in the rate of population in the area and the provision of the required water demand for various activities as industrial, agricultural and human activities besides the scarcity of rainwater for the last twenty years led to a considerable reduction in the underground water storage as no renewal of underground water (as may be conducted artificially by barrages) occurred.

This affected badly the surrounding environment and was apparent during field visits. For example Ghail Bawazer area had lost a great number of palms which long provided an economic value for the village farmers and the extra workers during harvesting seasons, Owners of agricultural lands were also affected. Other farming activity that was also affected is the Tobacco sector, other farmlands that were used to cultivate different fruits and vegetables were also affected by the decrease of water levels as noted in the private wells constructed by local farmers for use in irrigation. This obviously led to decreasing job opportunity in the field
of agriculture (that is considered as a job intensive field) and considerably increasing unemployment rates.

Knowing that the increase of green areas provides both aesthetic and moral feelings and significantly reduces the feeling with hot temperature, it is obvious that parts of the project area specially Ghail Bawazir area is deprived from such privilege as a result of continuous loss of cultivated lands due to shortage of water production for use in the purpose of irrigation. Loosing such areas also decrease the grassing opportunities for livestock and would thus decrease the opportunities of investment in such field.

Concentration of salts in underground water will continuously increase due to the oppressive consumption of water and the lack of application of mitigation works as groundwater recharge works leading to a decrease in drinking water quality.

It is to mention that the dependence on underground water for agriculture without additional measures for recharging the aquifer from collected rainwater will magnify the negative effects of the problem.

4.3.1 Water Supply

(ii) Storage Facilities

There are fourteen reservoirs and one break pressure tank (Huwayra) in the water supply system. Seven of the reservoirs (namely: Ghail Bawazir, Buwaysh, Thila, Old Bakrain, Khalf, Al Talayeh and Al Moustashfa) are abandoned because AnNaga'a and Audiaba reservoirs collect respectively the water produced from AnNaga'a and Audiaba Wellfield. The total storage capacity of the remaining seven reservoirs is around 9,000 m3. The reservoirs' name, type, capacity and condition are summarised as follow:

a) An Naga'a Reservoir

This reservoir is located on a hill near AnNaga'a Wellfield at an elevation of 154.7 m a.s.l. AnNaga'a reservoir was constructed in 1997 as part of Al Mukalla Water Supply Project - Contract AMWSP 3A&3B. It is made of reinforced concrete and has a storage capacity of 400 m3. The water is produced from this reservoir by direct pumping from the wells. Then, water is discharged by gravity to Al Sadad reservoir after passing through Huwayra break pressure tank (100 m3). This reservoir is not provided with a chlorination facility.

b) Audiaba Reservoir

This reservoir is located upstream of Audiaba Wellfield. It has been constructed recently from reinforced concrete and has a storage capacity of 400 m3. It collects the water pumped from Audiaba Wellfield and feeds by gravity the Ghail Bawazir area water network via a 300 mm Asbestos Cement pipe that continues to reach Buwaysh collector reservoir. LCWSSHG-CA constructed this reservoir using the same design as AnNaga'a reservoir. Furthermore, in year 2000 they completed the construction of the 300-mm pipe connecting the reservoir with the Audiaba
Well field and the pipe conveying water from the reservoir to the existing 300-mm pipe feeding Ghail Bawazir and Al-Mukalla. This reservoir is not provided with a chlorination facility.

c) Ghail Bawazir Reservoir

This reservoir is located north of Ghail Bawazir City about 3 Km east of Audiaba Wellfield. It is an elevated tank made of steel plates and has a storage capacity of 1135 m3. The reservoir was supplied by the trunk main from Audiaba Wellfield. Currently, the steel plates are corroded and leaking and the support legs (steel construction) are missing some pieces and rusted.

Major rehabilitation works are required therefore the reservoir is currently bypassed. Chlorinating facilities were installed at this reservoir and currently calcium hypochlorite solution is being injected directly into the water line.

d) Buwaysh Reservoir

The Buwaysh collector reservoir is located next to Buwaysh pumping station. It consists of 2 steel cylindrical shape compartments. The capacity of the reservoir is about 440 m3. It was originally designed as an oil storage tank for the harbour but was taken over by LMSSHG-CA in the year 1988. This reservoir was used to collect the water from Buwaysh Wellfield together with the water coming from Audiaba Wellfield. Then, the collected water was pumped to AIMukalla. This reservoir was abandoned in 1998 after the completion of the new transmission line from An’Nagaa to avoid the cost of pump station operation, maintenance and reservoir rehabilitation. Furthermore, currently the Buwaysh and Audiaba Wellfield yield is consumed almost completely in the Ghail Bawazir directorate.

This reservoir is not provided with a chlorination facility.

e) Thila High Level Reservoir

The Thila high level reservoir has a capacity of 455 m3 and is located at the crest of a mountain at an elevation of 146.27-m a.s.l. It is at a distance of about 4 to 5 Km from Buwaysh pumping station and does not have an access road.

This steel structure reservoir has been disconnected for a long time because it is completely corroded. This reservoir is not provided with a chlorination facility.

f) Al Sedad Reservoir

Al Sedad reservoir was constructed in 1998 as part of Al-Mukalla Water Supply Project - First Stage - Contract AMWSP 3M3B. It is made of reinforced concrete and has a storage capacity of 1200 m3. It is located on a small hill at the northeastern edge of Al-Mukalla October district at an elevation of 98.0-m a.s.l. The reservoir serves as a regional reservoir that supplies the remaining storage reservoirs downstream. Chlorinating facilities were installed at this reservoir and are currently operational.
g) Bakarin Reservoir

The Bakarin reservoir is the largest reservoir in Al-Mukalla with a storage capacity of 4,546 m³. It is located in the district of October at an elevation of 58 m a.s.l. It is supplied from Al Sedad reservoir and feeds the October district distribution network. It was constructed in the year 1981/82 of steel plates in the shape of a cylinder. It was rehabilitated in 1999 by sand blasting the steel plates and painting its lower parts with epoxy. Chlorinating facilities were installed at this reservoir but currently they are not in operation because the water is being chlorinated upstream at Al Sedad reservoir.

h) Old Bakarin Reservoir

The Old Bakarin steel reservoir has a capacity of 455 m³. It is located next to the Bakrain reservoir but has been disconnected because its structure is completely corroded.

i) Bahush Reservoir

The Bahush reservoir is located at the border of the district of Al-Salam and the district of Al-Ommal. It is made of steel plates and has a capacity of 455 m³. The reservoir is acting as the storage reservoir for the Old Town area (including Khalf area). The reservoir is located at an elevation of 53.46-m a.s.l. and does not have an access road. It is in a very bad condition and not feasible to rehabilitate. Therefore, it is more economical to replace it at a higher and more suitable location that can be accessed by car.

j) Al-Ommal Reservoir

Al-Ommal reservoir was constructed in 1998 as part of Al-Mukalla Water Supply. It is located on a high hill on the northern border of Al-Ommal district at an elevation of 68.8-m a.s.l. It is made of 2 steel cylinders and has a total storage capacity of 2000 m³. It is supplied from Al Sedad reservoir and feeds the distribution network of Al-Ommal district and western areas. This reservoir is internally sealed using a rubber jacket. This reservoir is not provided with a chlorination facility.

k) Khalf Reservoir

Khalf reservoir has been constructed in 1998 as part of Al-Mukalla Water Supply. It is located in the Khalf area (Old Town district), next to the harbour at an elevation of 40.11-m a.s.l. It has a storage capacity of 500 m³. This reservoir functions as a balancing reservoir that is fed directly from the distribution network during low demand hours. It requires minor rehabilitation works and fencing for protection. Currently, this reservoir remains empty most of the time mainly because most of the water is being consumed in the network before reaching the reservoir and because the last section of the pipe feeding the reservoir is only 100 mm in diameter, which constricts the water flow into the reservoir.
l) Al Talayeh Reservoir (Fuwah)

Al Talayeh reservoir was the main reservoir of Fowah and is located about 500 m Southwest of Al-Tawila reservoir. It has a capacity of 504 m³ and is made of masonry. The reservoir is leaking at an unacceptable rate, however it is not feasible to rehabilitate it because of high cost and because its elevation is not suitable to serve the new urban developments in the area northern side.

Therefore, this reservoir was put out of service.

m) Al-Tawila Reservoir (Fuwah)

This reservoir is located about 4 km east of the Fuwah Wellfield. It is made of masonry and has a capacity of about 45 m³ (bottom water level: 66.03 m a.s.l.).

When this reservoir gets full, pumping into the network from the Wellfield will be stopped.

n) Al-Moustashfa Reservoir (Fuwah)

This reservoir is located about 400 m west of Fuwah Wellfield. It is built of masonry and has a capacity of 136 m³ (bottom water level: 46.62 m a.s.l.). The reservoir was supplying the new part of the town of Fuwah as well as the hospital of Fuwah. Currently, this reservoir is bypassed because its low elevation hinders the network operation and prevents supply to the new developments in the area northern side.

(ii) Trunk Mains

Trunk mains are used to convey water from Wellfield into the city of Al-Mukalla and to connect the reservoirs. The following is a description and initial assessment of the water supply system trunk mains.

a) Trunk main from An Nagaa reservoir to Al-Sadad reservoir

The trunk main from An Nagaah reservoir to Al-Sadad reservoir was completed in the year 1998 as part of Al-Mukalla Water Supply. Water is conveyed by gravity via a 500 mm pipe 12 km long to Huwayra break pressure tank then via a 600 mm pipe 33 km long to Al-Sadad reservoir. The pipe material is mainly asbestos cement (AC) but ductile iron (DI) was used where the pressure in the pipe is high in parts of the section preceding Huwayra break pressure tank. This pipe route runs along the wadi outskirts from An Nagaah until reaching Huwayra break pressure tank. Thereafter, it runs along Al-Mukalla - Seiyun road until reaching Al Sadad reservoir. Recently some connections were made directly from this trunk main: one to an army camp, one to the industrial complex in the Riyyan area and one to a 150 mm main pipe in Buwaysh feeding the villages of Buwaysh, Al-Eiss and part of Roukob, and others.

b) Trunk main from Al Sadad reservoir to Al-Ommal Reservoir and its related branches.
The trunk main from AI Sadad reservoir to AI-Ommal reservoir, its branch to Bahush reservoir and the main from AI-Ommal reservoir to the trunk main from Fuwah were also completed in year 1998 as part of AI Mukalla Water Supply. In addition, this trunk was connected to the existing 300-mm pipe feeding Bakrain reservoir. The above-mentioned main material is mainly Asbestos Cement except at very few locations where Ductile Iron was used. The total length of the trunk main to AI-Ommal reservoir is 7 km. Its first section upstream of the connection to Bakrain is 3.4 km long and 500 mm in diameter. The second section downstream is 3.6 km long and 400 mm in diameter. The branch to Bahush reservoir is 1.5 km long and 300 mm in diameter. The trunk main from AlOmmal reservoir to the existing 300 mm main from Fuwah is around 1.1 km long and 400 mm in diameter.

The latter main feeds the distribution network of AI-Ommal district and the areas to the west.

c) Trunk main from Audiaba Wellfield to Buwaysh reservoir (35 km)

The trunk main from Audiaba Wellfield to Buwaysh collector reservoir was completed in the year 1988 and is called the emergency pipeline. This pipe was constructed by LCWSSHG-CA without any expatriate consultancy. Machinery for trench excavation was not available during the construction therefore the pipe is above ground (85%) or at a shallow depth. The trunk main was constructed to convey the water from Audiaba Wellfield to AIMukalla. Currently the Wellfield yield is consigned almost completely in the Ghail Bawazir directorate. This AC pipeline is 300 mm in diameter and passes by the towns of Ghail Bawazir and Shuheir. Then, it continues along the main road by the Riya airport until reaching Buwaysh collecting reservoir. The pipe is extremely endangered by traffic loads of the main road used frequently by heavy trucks and because the AC pipe may not withstand heavy traffic loads for a long time if the pipe bedding is inadequate. Several leaks have been reported in the pipe in the early nineties. Fittings and valves were not protected and are affected by corrosion.

The pipe is susceptible to be washed away by storm water at wadi crossings.

Maintenance works were conducted recently under the "Programme for Reduction in Water Losses in selected NWSA Towns".

d) Trunk main from Buwaysh collector reservoir to Al-Mukalla (11 km)

This AC pipeline (dia. 300 mm) is laid from Buwaysh collector reservoir up to the crest of the mountain where Thila high-level reservoir is located then continue to AI Sadad and Bakrain reservoirs. Drawings showing this pipe alignment are not available. The trunk main was constructed to convey water from Audiaba Wellfield and Buwaysh Wellfield via a booster pumping station to the town of Al-Mukalla and feed Bakarin reservoir. In 1998 after the completion of the new transmission line from AnNagaa this was stopped to avoid the cost of pump station operation and maintenance. Currently water is pumped directly into this trunk from Buwaysh Wellfield but the amount reaching Al Sadad reservoir is negligible. The first section of the pipeline up to the crest of the mountain (around 4 km long) is very difficult to maintain because there is no access road.
The remaining section of the pipe is susceptible to be washed away by storm water at wadi crossings.

e) Trunk main from Fuwah to Al-Mukalla (17 km)

This AC trunk main ranging from 200 mm to 250 nun in diameter is passing through the town of Fowah and following the main road from Fowah to Al-Mukalla. The trunk main was transporting water from Fowah Wellfield to Al-Mukalla. Currently, it is supplying Al-Ommal district and part of the western areas from AlOmmal reservoir via the 400 nun trunk main from that reservoir, which was connected to it near the school of A'isha. This main is around 20 years old and shallow.

(iii) Distribution Network

The distribution network in the current project area, except in Al-Ommal district, is mostly over 30 years old. The pipe material used in the existing network is Asbestos Cement for pipes ranging in diameter from 100 to 300 nun and galvanised steel for pipes ranging from 12.5 nun to 150 nun. The use of PVC pipes started recently. In year 2000, a 600-m long 100-mm PVC pipe has been installed. Currently, a 7-km long PVC pipe ranging in diameter from 200 to 100 min is being installed along the main road from Joul Masha to Khalf.

The following are the major works completed by LMSSHG-CA in year 2000 in the current project area:

The construction of a 300 mm AC pipe to connect the newly constructed Audiaba reservoir with the Audiaba Wellfield and a 300 mm AC pipe to convey water from the reservoir to the existing 300 mm AC pipe feeding Ghail Bawazir and Al-Mukalla.

The installation of a 100 mm DI pipes 2 km long to feed the village of Al-Eiss.

The installation of 2 km of pipes ranging in diameter from 80 min to 100 min to provide water for various areas.

The rehabilitation of the existing network by installing 1 km of new pipes ranging in diameter from 100 to 300 mm and installing around 15 km of pipes 80 mm and less.

The only recent project to rehabilitate the distribution network "Programme for the Reduction of Water Losses in Selected NWSA branch offices -Taiz, Al-Mukalla" commenced in 1996 and is still ongoing. This project is being financed by the German agency KFW. The first phase of this project was completed and handed over in year 2000. The following is a summary of the completed works:

- In the district of Al Ommal about 14,000 m of ductile iron pipes ranging in diameter from 80 to 200 min and some 20,000 m of 25 to 100 min galvanized seamless steel (GS) pipes were laid. In addition, about 2,600 house connections were installed.

- The installation of 3,000 house water meter and 11,000 m of 12.5 min GS pipes.
• The installation of around 1 km of DI pipes ranging in diameter from 80 to 200 mm outside Al Ommal district.

The construction of 2-tanker filling station.

• The replacement of valves and bulk water meters.

In general, about 25-30% of the distribution system in Al-Mukalla City has been rehabilitated. Under Phase 2 of the above-mentioned project the following are the major activities to be completed.

(iv) Consumer Connections

The total number of house connections in year 2000 in Al-Mukalla and Ghail Bawazir directorates was respectively 22,480 and 7,359 (source: LCWSSHG-CA, Planning Department). During year 2000, 7,606 meters were disconnected because customers did not pay their bills and 4,453 meters were reconnected. It should be noted, however, that 80% of the existing water meters are out of order and need replacement.

(v) Water Quality

Chlorinating facilities were installed at the reservoirs of Al Sadad, Bakrain and Ghail Bawazir in 1997 as part of Al-Mukalla Water Supply Project – First Stage - Contract AMWSP 3A&3B. Currently the Bakrain reservoir facilities are not operated because the water is being chlorinated 3.5 km upstream at Al Sedad reservoir. Calcium hypochlorite solution is being injected directly into the water lines mechanically at Al Sedad and Ghail Bawazir. Tests of water samples are being conducted regularly to ensure that the residual concentration is around 0.2 mg/l. The groundwater supplying Al-Mukalla is high in calcium Carbonate. Laboratory tests have shown total hardness (CaCO3) as 700-900 mg/l, compared to a WHO maximum permissible concentration of 300 mg/l. The groundwater otherwise meets the WHO requirements for drinking water.

4.3.1.1 Existing Water Consumption

(i) Domestic Water Consumption

The average domestic consumption in year 1999 in Al-Mukalla and Ghail Bawazir directorates was respectively 72.6 and 68.3 lcd (liter per capita and capita per day). The consumption has been increase from year 1998 to 1999 by 13.15 and 23% respectively in Al-Mukalla and Ghail Bawazir. This mainly because the water supply increased significantly after the completion of Al-Mukalla water supply.

(ii) Non-Domestic Water Consumption

Non-Domestic water consists of institutional, commercial, industrial construction and agricultural water consumption. The institutional type of water consumption is by far the largest non-domestic consumer.
(iii) **Unaccounted for Water**

In year 2000 the percentage of unaccounted for water reached a high of 38.9% and 36.6% in Al-Mukalla and Ghail Bawazir, respectively.

### 4.3.2 Existing Sewerage System

The project area, as described in the previous sections, includes cities / villages of Al-Mukalla and Ghail Bawazir directorates. As previously mentioned only 20% of the population within the Project area are served with a sewage network. These are located in Al-Mukalla, Fowah, Roukob and Ghail Bawazir Cities. The rest of the areas are served by random on-site disposal systems comprising septic tanks and cesspits.

#### 4.3.2.1 Al-Mukalla Sewerage Collection System

The first Al-Mukalla Sewerage Project, designed by "John Taylor and Sons Consulting Engineers" and funded by "DANIDA", was completed in 1988. This comprised the provision of a sewage network for Old Mukalla district and for large section of Al-Ommal district. The total area covered by the existing sewerage networks is 119.05 ha serving a population of 37167 Inhabitants. Since Al-Shaheed Khalid Neighbourhood has reached saturation, it is assumed that 80% of the population of Al-Shaheed Khalid are settled in "Al-Shahid Khalid" and 20% are settled in "Old-Khalaf. The remaining part of Al-Mukalla city, which includes the whole October district, AP Thawrah neighbourhood, part of Al-Nasr neighbourhood and Baja'aman area, are still un-sewered. There exist some random sewage collection systems that discharge into septic tanks and cesspools or into nearby Wadis.

### (i) Old Mukalla District Collection System

A part of Ba-jaman area, the whole existing sewage network system of Old-Mukalla district, comprising Al-Shaheed Khalid, Al-Sayadeen and Al-Salam neighbourhoods, consist of two Ejector stations, one pumping station and about 16,000 meters of PVC pipelines with different diameter ranging between 100 mm and 300 mm. The two Ejector Stations; the first called "Harbour Ejector Station" and the second called "Promontory Ejector Station", are constructed within the Al-Shahid Khalid neighbourhood and designed to collect sewage flows from low levelled areas and lift them to a higher level allowing them to discharge by gravity into the Post Office Pumping Station constructed on the Coast near the Old Al-Mukalla Post Office and within Al-Salam neighbourhood. In turn the Post Office P.S. pumps sewage flows collected from the above Ejector Stations and from other gravity systems. Serving AP Sayadeen and Al-Salam neighbourhoods, to a man hole located near the Palace from where a main trunk pipeline, with diameter ranging between 300 mm and 600mm, collects the entire district sewage flow and conveys it by gravity to the sea out fall pumping Station.
4.3.2.2 **Roukob Sewage Collection System**

The local inhabitants and the local municipality constructed the existing collection system of "Roukob" city in a random way without any proper technical design and specifications.

In "Roukob" area, there are three existing gravity sewage collection systems as follows:

(ii) **AI-Ommal Collection System**

AI-Ommal Neighbourhood and part of Al-Thawrah and Al-Nasr Neighbourhoods are served by sewage net work collection systems discharging by gravity into the Sea Outfall Pumping Station constructed on the coast within AI-Ommal Neighbourhood.

The remaining part of the district is served by on-site sewage disposal systems discharging into septic tanks and cesspools. AI-Ommal collection network consists of about 26,100 meters of clay and PVC pipelines with different diameters ranging from 100 mm to 600 mm. The system comprise secondary and tertiary branch pipelines, with diameters ranging from 100 mm to 150 mm, discharging by gravity into the main collectors with diameters ranging from 200 to 600 mm, that in turn discharge into the Sea Outfall Pumping Station. After the unexpected rapid growth in the Al-Mukalla population that happened after the Golf war and during the last 10 years, some of the tertiary and secondary branches were extended randomly, without reinforcing the main collector pipelines (such as the coastal 200-mm diameter pipeline). This overloaded the existing system and as a result, blockages and flooded ponds are formed along these extended lines.

(iii) **Newly constructed and under construction Collection Systems**

A temporary small project financed by the Social Development Fund for the main collectors of October (Al-Diess) district and Ba-jaman area is presently under construction. This project includes the following main collectors: A main gravity collector "S", to be laid along the western bank of Wadi Al-Ayga and Northwards of its main Bridge. The up-stream part of this collector which starts North east of the central Stadium, near the "22 May" Girls' School and up to its crossing with wadi "Sugum" (about 500m length) consist of 250 mm and 300 mm diameters PVC (constructed but not operational yet) to serve part of "Wihdat Sami" area. The down-stream part consists of 350 mm diameter pipeline (not yet constructed) and which is to be laid along the western bank of Wadi Al-Ayga and connected to the main collector "k" laid along its eastern bank after crossing the Wadi upstream of the bridge. Moreover, the Project considers an extension of this collector, Northwards of its lower part to collect effluent from the existing 250mm diameter collector laid along the main road leading to Jaul Al-Shifa area and parallel to Wadi "Sugum" water stream. It should be noted that most of these recently constructed pipes are temporary laid, and partially cover the area not following proper technical design and specifications. This has resulted in flooding of the wadis and caused critical pollution to the surrounding environment.
• The first collection system serves the southern area of the old city, starting from the central mosque and up to the seashore. This collection system consists of PVC pipelines with diameters ranging between 200 mm and 250 mm and discharging into Wadi Al-Harshiyat at the seashore.

• The second collection system serves the middle area of the Old city, starting from the natural crest contour line crossing the main road of the old city, and southwards. This collection system consists of two PVC pipelines with diameters 150 mm and 250 mm discharging into an open pond located near the central mosque of the city.

• The third collection system flows by gravity from the above mentioned natural crest contour line, and northwards. This collection system consists of PVC pipelines with diameters ranging between 200 mm and 250 mm and discharging into a 250 mm diameter PVC collector which in turn discharges, into an open pond located north-east of the Old city.

4.3.2.3 Fowah Sewage Collection System

The only existing sewage collection system in Fowah is that constructed for the 196 apartments" area located in front of Fowah University and within Al-Sadaqah Neighborhood.

Septic tanks and cesspits discharging into nearby wadis or overflowing into the streets serve the remaining part of the district. This is creating health nuisance, odors, and smells. The surrounding Wadis (and especially wadi Fowah) are filled with wastewater ponds. This collection system consists of about 2500 m of 150 mm, 200 mm and 250 mm diameters PVC pipelines. It discharges into wadi Fowah located eastward of the branch road leading to the Old Fowah neighborhood. An under construction 250 mm diameter new PVC trunk line will extend the above mentioned network to allows for a direct discharge into the Sea.

4.3.2.4 Ghail-Bawazir Sewage Collection System

A part from two small existing network collection systems, Ghail-Bawazir city comprising Al-Mustaqbal, Al-Wihdah and 22 May districts, is served by on-site disposal systems constructed in a random way and discharge into septic tanks and cesspools or into nearby Wadis where numerous ponds are noticed.

• The first collection system of Ghail-Bawazir city serves Al-Salhiyat neighbourhood (which is part of Al-Mustaqbal district), and consists of about 3025 m of 150 mm and 200 mm diameter PVC pipelines discharging into three septic tanks of 12 m x 8 m x 2.5 m each located outside the settled area.

• The second collection system serves part of the old town area located within Al-Wihdah district and consists of about 850 m of 150 mm and 200 mm diameters PVC pipelines discharging into an open ditch, which discharges in turn into open agriculture lands.
4.3.2.5 On-Site Wastewater Disposal System

A part from the above, the existing wastewater disposal systems used within the rest of the project area comprise mainly individual septic tanks and cesspits/soakaway or small collecting networks discharging into septic tanks and cesspits or directly into nearby wadis.

However, despite the relatively low per capita domestic water consumption, the poor initial standards of construction of these pits and the virtual absence of cleaning and maintenance contribute to a situation in which most pits are now effectively full, and no longer permit effective percolation. This condition is generating a number of problems, specifically:

Frequent overflow into the streets and wadis within the project area's cities and villages creating wastewater ponds and consequently health nuisance, odors, and smells.

Contamination of shallow groundwater by seepage, especially at An Naga'a and Ghail Bawazir villages, where the water table is high and the underground water is considered as the main available source of water for the Greater Al-Mukalla.

Buildings of the coastal cities in Fowah and Rayyan, constructed directly on the seashore, discharge their wastewater effluent directly into the Sea. The main industries located within the project area are six. The first three located at Fowah, Khalf and Rayan produce canned fish. The fourth one located at Ghail Bawazir produces soft drinks (Canada dry). The fifth and sixth are the Hadramout Industrial complex and the Plastic Industry at Joul Masha. Industries of Fowah, Khalf and Rayan discharge their industrial wastewater into septic tanks overflowing into the sea without any pre-treatment except Rayyan's can fish industry, which has a grease removal tank. That of Ghail Bawazir, being far from the sea, discharges its industrial wastewater into a septic overflowing into cesspits. De-sludging of the septic tanks is done either by the municipality or by private trucks hired for this purpose. The de-sludged material is taken to disposal sites. The low permeability soil in Ghail-Bawazir City renders the lifetime of cesspits very short. The local Municipality has reported that before the construction of the collecting system Al-Mustaqaibal district (at Al-Salhiya area) overflows from cesspits flooded the lower apartments.

4.4 Diagnostics of Water Supply and Sanitation Systems

4.4.1 Diagnostics of Water Supply Systems

Based on what has been previously presented above, the following are the major findings concerning the existing water supply system:

1. The trunk mains require major rehabilitation works or replacement except those completed recently as part of Al Mukalla Water Supply Project –Contract AMWSP 3M3B.
2. The distribution networks require major rehabilitation works or replacement except those completed as part of the "Programme for the Reduction of Water Losses in NWSA Towns" and some of the recently constructed pipes by LCWSSHG-CA.

3. The currently available storage capacity is not adequate and additional storage should be provided. In addition, the existing Bahush reservoir should be abandoned and replaced by a new reservoir to be constructed at an adjacent more suitable location.

4. The percentage of unaccounted for water from the water produced is high over 35%. Therefore, leak detection programmes and related measures should be taken to determine the causes and provide economical solutions to reduce the losses.

4.4.2 Diagnostics of Sanitation System

Areas served with Network:
• Less than 20% of the Project area.
• Inadequate hydraulic design resulting in flooding for some lines.
• Ejector station not functioning resulting in by-passing raw sewage to the sea.
• Outfall and its PS are in very poor condition resulting in pollution of the coast.
• The location of the outfall PS is in a very strategic location with Old Mukalla.

Areas not served with Network:
• Septic tanks are not properly sized resulting in ground water contamination.
• Flooding and un-hygienic conditions.
• Lack of maintenance.

Summary of capital cost

This sub-section presents a summary of the capital costs by the main components of expenditure covering phase 1 totals separated into the IAP and the balance of the investment has been split into two stages due to the funding constraints of $25 million indicated from world bank sources (IDA) in respect of the IAP.

A total of $25 million for the IAP but only when the Flik transmission pipeline is excluded. It is expected that additional funding will be secured to implement this pipeline in order to utilize the development of Flik wellfield included within the base $25 million of the IAP.

The costs are in constant prices and include additional provisions of 12% for contingency (5%) and the services of design and supervision (7%). The main points to note regarding the schedule of phase 1 investments are:

• The total investment is $51.4 million of which $31.1 million relates to the IAP when the cost of the Flik transmission line is included.
• Rehabilitation requirements comprise $12.2 million with over 80% incurred under the IAP.
• Expenditure on wellfield and the water supply networks constitute respectively 13% and 39% of the phase 1 total.

• Investment requirements for the sewerage system correspond to nearly 50% of the investment due to the limited extent of the existing network. About $17 million (excluding contingency, design and supervision) is scheduled for network expansion and $5 million for rehabilitation of the existing network.
CHAPTER (5)
ASSESSMENT OF POTENTIAL ENVIRONMENTAL IMPACTS AND CONSIDERATIONS FOR MITIGATION
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AND CONSIDERATIONS FOR MITIGATION

5.1 Impact Identification

Three phases of the project are considered:

a) The planning and design phase.

b) The construction phase.

c) The operation phase.

Components of each phase are evaluated relative to their expected potential impacts on different physical and biotic elements of the environment. The impact identification process is based on the exhaustive lists of components and activities of each phase of the project. It is also based as well, on detailed lists of both biotic and abiotic elements of the existing environment at the project site.

Review of the lists of biotic and abiotic elements of the existing environment at the project site revealed that certain environmental elements were obviously more sensitive than others and were found to merit detailed examination. The marine environment in general, and coral reefs and associated marine life and biotic communities in particular, were identified; as the most sensitive elements of the environment and hence the impacts of the project components and activities on marine environment were therefore analyzed in more detail.

Exhaustive lists of project components and activities containing numerous items were examined thoroughly. Only some of these items appeared to pose potential threats to the items identified to be of potential impact along with relatively sensitive elements of the environment, were considered in the next impact prediction process.

5.2 General Methodology and Approach

The general approach in environmental impact assessment is:

• To predict the impacts of a development based on a comparison between the baseline, or without development situation, and with development situation.

• To consider who or what is affected by those impacts and how they are affected, i.e. positive or negative impacts.

• To develop specific mitigation to address those negative effects, and magnify positive effects.

• To evaluate the significance of any residual effects which remain after mitigation.

Some impacts cannot realistically be predicted or if they can this can only be undertaken at very high cost. The assumption is then made that there are potential impacts and that mitigation may be needed to deal with these. This applies particularly where a wide range of variable affects both the baseline situation and
the impacts from the development and is likely to change over time with these variable. In this situation it is generally appropriate to focus on a robust set of mitigation measures, which is able to cope with any level of impact.

5.2.1 Significance

For all impacts the following levels of significance are used:

- **Not significant**, i.e. the development of the project has no significant effects on the environment in respect of the impact under consideration.

- **Of low significance**, i.e. the development of the project has a significant effects on the environment but this is of low concern, e.g. because it affects a small number of people and because it is more of an inconvenience rather than a serious problem.

- **Of moderate significance**, i.e. the development has a moderate effect on the environment. These concerns will not generally be sufficient to justify stopping the development but will be acceptable where the development gives rise to clear benefits, which outweigh the impact.

- **Of high significance**, these are impacts, which by themselves are sufficient to bring the development into questions, they will often raise national or international concerns.

Less significant impacts may combine to result in cumulative impacts of higher significance.

The above levels of significance apply to negative or adverse impacts; matching levels of significance for positive or beneficial impacts will mirror each of the levels of significance for adverse effects.

5.2.2 Format

For all subject areas, the following format is followed:

- A summary of the method used for the assessment including the criteria used to judge significance, these may be based on the value of a resource, the scale of an impact, the probability of an impact, the number of people affected, etc.

- A description of the likely impacts including, where possible a prediction of these impacts in comparison with the baseline, without development, situation.

- Who or what is affected by the impacts.

- How they are affected and the significance of this.

- A summary of potential mitigation measures; residual effects after mitigation.

5.3 Potential impacts of (Phase 1) design and planning :

(a) **Potential impacts of alternative design and development proposals**: Alternatives development proposals are mainly defined in developing and the different issues considered water resources, components of the water supply system and components of the sewerage system.
Water resources development is considered as one of the important alternatives to meet the demand of the population within the area of the project for the next years. The work as reported in the feasibility study comprises the rehabilitation of the existing wells fields.

Works of rehabilitation will comprise increasing the depth of the existing wells and drilling new well in the immediate vicinity of the existing wells. Engineering Consultants reported that these activities could secure a rate of 315 l/s which is enough for the future development.

Possible impacts are:

Drilling and increasing the depth processes could affect the terrestrial ecosystem in the area, including different flora and fauna species, wastes of drilling like mud may cause some negative impacts.

Transportation of drilling equipment may require the construction of roads to the new proposed wells.

Impacts from such activities:

One of the most important possible impacts is the dryness of the wells or at least increase of calcium carbonate concentrations which is already higher than the permissible limits of world Health Organization.

Who or what is affected:

Human being, flora and fauna of the area.

Significance:

Possible impacts except that of wells dryness are not significant, impact from ground water decrease and deterioration in water quality is significant.

(b) Impacts of the proposed improvement in distribution networks and in the reduction of the unaccounted water:

It is reported in the feasibility study that water supply and distribution system (reservoirs, transmission lives and distribution networks) are to be reconstructed.

Possible impacts of constructing new.

Reservoirs or reconstruct the existing reservoirs could summarized as:

- negative impacts of civil work on the flora and fauna.
- negative impacts of storing building materials, on.
- negative impacts of noise from the equipments and machines.
- Positive impacts of the reduction of water loss from leakages of the distribution networks.
(c) potential impacts of increasing water supplies on wastewater disposal:

Increasing water supply to different areas will increase wastewater produced from the different consumers, this will need more effort for collection, transmitting, treatment and disposal of wastewater.

Negative impacts possibly existed in each step, where collection needs more energy, transmitting crude wastewater to treatment plant need more pipes, more land, so ecological system, agricultural land, and roads could be affected.

Mitigation measures should be taken to reduce energy consumption, avoid digging in agricultural land and roads as will as residential areas.

(d) potential impacts of improved and extended wastewater collection services:

Improving and extending wastewater collection services to include all residential areas will produce positive impacts which are expected to improve public health, and the quality of life, eliminating of pathogenic factors and vector diseases, increasing the value of lands near the residential areas, and protecting roads and residences from the negative impacts of wastewater.

(e) potential impacts of improved on site wastewater disposal facilities:

Improving on site wastewater facility will produce positive impacts on

- Reducing of the cost of disposal, people pay much money for emptying septic tanks.
- Decreasing potential human exposure to diseases which accompany traditional disposal facilities.
- eliminating effluent discharge, which harm people and their properties.
- reduction of household expenditure on sanitation.

(f) potential impacts of a risk reduction in ground water pollution:

as we mentioned in the introductory part of this report, ground water resources in the area are threatened from cesspits and effluent discharges of crude wastewater infiltration. The risk of polluting ground water will be reduced to a great extent after the implementation of the new facilities of collection.

(g) potential impacts of reduced or eliminated wastewater disposal in surface and sea-water we do think that this will be a high positive impact which will be reflected on:

- Recreation, and tourism.
- Labor market, especially those related fishing and recreation.
- Marine biology and fishing.
- Attraction of new investors to the area, especially in the field of marine works.
(h) Potential impacts of treated wastewater/sludge reuse for agricultural purposes:

All the previous studies and reports indicated that there is a scarcity of water, so the reuse of treated wastewater is highly recommended to decrease water consumption in irrigation.

According to the expected wastewater quality, it will be very useful to use this water for irrigation purposes for non-edible crops like tobacco which cover great areas in the agricultural lands. Increasing soil fertility, plant growth rate and crop production are highly expected. In that respect, design of treatment works should consider treatment processes which produce treated effluents with quality meeting the guidelines of the World Health Organization (WHO) for using treated wastewater for irrigation.

(I) Potential impact of discharging treated wastewater into the sea in view of established objective on degree of treatment:

We recommend that Engineering consultant and the LCWSSHG – CA make use of all the reclaimed water for the irrigation purposes. Most of the land resources in the project area are considered as desert which could be cultivated with non-edible plants and wood production plants. Implementation of such ideas will prevent the potential impacts of discharging wastewater into the sea.

Emergency By-pass

As previously mentioned, the treated effluent will be re-used for irrigation. However, and in case no irrigation is needed specially at the early stages of the project until the irrigation scheme is formulated, the effluent will be diverted to the sea via a sea outfall.

The irrigation pumping station will be designed to either pump the effluent to the irrigation scheme or pump it to a sea outfall located in the sea.

The recommendations are to have an STP at Wadi Fowah (between Fowah and Mukalla) with re-use of effluent for irrigation. In case irrigation does not consume all effluent or does not need it, a by-pass to the sea must be available to take care of the effluent.

The treatment plant will have two 7000 m$^3$/day modules in Phase I, plus an additional 7000 m$^3$/day module in later phases for an ultimate total of 21000 m$^3$/day.

This corresponds to a daily average 243 l/s, or to a peak discharge of 365 l/s with a 1.5 discharge coefficient.

For an outfall at sea just offshore of a public beach, the dimensioning parameter of an outfall length is the discharged bacteriological load.

The treatment plant will be of the oxidation type with three ponds in series (anaerobic, facultative then aerobic). When operated properly, such a treatment releases an effluent with a low coliform concentration, of $10^4$ FC/100 ml or less.
However, concentration at outlet may rapidly increase by a factor of 10 or more in case of treatment plant mal-functioning (overflow, heavy rain).

**Bacteriological mortality:** Enteric bacteria die when released in the marine environment. For the clear and warm waters of the coast of Mukalla, a rate of decay of 1 hour may be retained from values at similar sites. This means that after 1 hour, 90% of bacteria have disappeared.

**(e) Oceanographic conditions**

Due to the homogeneous density of sea water in the top 40 m ocean layer, the effluent plume discharged by the by-pass pipe will rise to the surface and will follow the surface water movements.

Along the coast of Mukalla, there are permanent long-shore currents, but surface currents within the first kilometers closest to the coast are wind driven. For the return of plume towards the coast, worst conditions occur in Summer when strong sea breeze blows from south-west.

**(f) Land acquisition:**

Most of stretches of water mains and sewer lines are proposed to be laid along the blanks of the existing roads and within the right-of-way under government control.

Most of the work will be carried out within the public properties.

Reuse of treated water in establishing green belts around the residential areas could change the empty desert uninhabited land to green areas and increase agricultural land resources. Potential impacts will be positive as it will improve the present status of land uses.

5.4 Impacts During Operational Phase

**Socio-Economic Impact Assessment**

**Method:**

The assessment considers the changes in socio-economic status that will be brought about as a result of the development of the project. Indicators covering existing employment base, economic activity level, social status, educational status and housing situation represent a baseline against which the changes are judged.

The following indicators of positive impacts can be used in this subject area:

- The number of jobs potentially created in general regarded as a positive impact
- Improvement in the range of job opportunities, and training opportunities.
- The change in employment take up by women. High participation by women in employment resulting from the project would be regarded as a positive impact.
- Widening of the economic base of the area. Introduction of new industries and activities not currently present in the area will widen the economic base.
• Improvement in the range of training opportunities. Training opportunities outside the predominant sectors will particularly help in this regard.

Economic multiplier effects in the local area: Where new industries and activities are established, particularly in the manufacturing sector these industries will make some local purchases of goods and services.

Furthermore their employees will add to the domestic spending power in the local economy which will increase economic activity.

Better services and facilities: Increased economic activity can help raise the level and quality of social and community facilities such as schools, health centers, cultural facilities, etc.

• Improvement the quality of life.

The following indicators can be used for negative socio-economic impacts:

(i) Changes in established sectors, and (ii) New businesses may compete with existing businesses for a limited market. Table (5.1) shows and identification of positive socio-economic impacts of the current project.

Table (5.1): Identification of Positive Socio-Economic Impacts of the Current Project

<table>
<thead>
<tr>
<th>Socio Economic Impacts</th>
<th>Time Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>During Construction</td>
</tr>
<tr>
<td>New job opportunities</td>
<td>Few new jobs for construction sector</td>
</tr>
<tr>
<td>Better job opportunities</td>
<td>Non, as all jobs taken by skilled workers</td>
</tr>
<tr>
<td>New activities</td>
<td>Few initial activities are in a traditional fields</td>
</tr>
<tr>
<td>Training opportunities</td>
<td>Initial numbers small due to lack of critical mass to support training</td>
</tr>
<tr>
<td>Better services</td>
<td>Minor but increasing</td>
</tr>
<tr>
<td>Better quality of life</td>
<td>Minor but increasing</td>
</tr>
</tbody>
</table>
Who or What is Affected?

Local people from: Al-Mukalla City, Fowah City, Harshiyat, Joul Masha, Roukoh, Buwaysh, Al-Eiss, Ghail Bawazir City, Al-Naga’a, and Al-Rayyan will generally be affected by both positive and negative impacts.

They should benefit from new and better job opportunities; however they may be unable, e.g. by reason of education or skill levels, to take advantage of these opportunities. They should benefit from a stronger local economy.

A wider range of services can be supported which will benefit those who can afford to use them. Some established local firms may be able to develop their business in response to stronger local market demand.

Income and Employment. Secondary employment opportunities generated by a growth in the local informal and formal sectors of the economy, most notably in the commercial sectors that will stem from the improved physical environment of affected areas and the reduction in the proportion of household expenditure on sanitation. At present, degraded sanitary conditions are claimed by local business owners to seriously impact turnover. In areas prone to sewage flooding, turnover is reported to decline by more than 50 percent during flood events.

Putting into consideration the following baseline situation which reveal that:

- Most of the existing network is over 35 years old.
- Most of the pipes are laid above ground or at a very shallow depth.
- Most of the existing pipes are laid haphazardly to serve local requirements without appropriate design and specifications.
- At some locations buildings are constructed above the pipe route.
- Some pipes are laid in narrow streets that are not accessible to pipe construction equipment.
- Some pipes are laid in Wadis or over mountains, which make them difficult to be accessed for maintenance. In addition, these pipes are susceptible to the intrusion of vegetation roots which renders them liable to damage.
- At some locations the houses are old and can be damaged by pipe bursts

It is argued that further benefits are likely to be obtained from the reduction in household repairs and or protective works (against sewage inflow). Approximately 30% of households in Al-Mukalla claimed to have spent money either protecting their property incursion or in repairs to damage done. The estimated total value of the works was put over $300,000. The wider range of goods and services available will benefit many businesses and make it easier for them to operate and to focus on their core business, e.g. fisheries, tourism and commerce.
Workshops within the project area will be equipped with modern technology which is necessary for meeting quality production needs and for training of workers. Administration will be fully aware of the importance of training and willing to finance it. They must have the willing to train local workers.

- **Evaluation of Significance:**
  
  Significance is highly depended on wider economic situation. A downturn in the economy can stall socio-economic benefits. In the longer term the overall impacts of the development should be positive and of high significance but a programme of mitigation actions is essential to increase the chance of success without these actions, benefits are less likely to result.

- **Potential Mitigation Measures:**
  
  - Training strategy to improve the local skill base and working with new technology to be used.
  - Education strategy: working with technical primary and secondary schools in Al-Mukalla City, Ghail Bawazir City and Fowah City and with particular focus on women, and young workers.

5.5 **Land Resources Impact Assessment**

- **Method:**
  
  The assessment considers the changes in landscape character that will be brought about as a result of the development of the present project. The focus is at several levels:
  
  - At the strategic level within the region
  - At a district level within the surrounding area.
  - Locally within the development itself.
  
  The existing land use and landscape character represents the baseline against which the changes are judged.
  
  Three criteria can be used to judge significance under this subject area:
  
  - The contribution of the land to the landscape character of the area. Where land has no character it is assumed that impacts will be low. Where land is originally landscaped it is assumed that impacts will be highly significant.
  - Areas of acquired land: Small areas of land taken will be less significant than large areas of land taken.
  - The proximity to areas or places of high landscape value/where the land is part of the area, against which a major landscape features can be important.

  Significance has been based on a subjective judgment supported by a description of the impacts.

- **Land Requirement and Availability:**
Land requirement for the different project components is represented in areas required for the followings with the estimated land requirement:

- New groundwater well fields
- Routes of water supply pipelines
- Locations for additional water storage capacities
- Routes for implemented sewers
- Areas for allocating sewage pumping stations
- Wastewater treatment plants sites
- Corridor for emergency sea outfall pipeline
- Agriculture land for effluent reuse activities

Criteria to be used to judge significance under this subject area are:

- Loss of large areas of valuable lands.
- The presence of land that has archaeological or cultural features.

Significance is determined by judging the value of the land taken and measuring its area. Loss of large areas of valuable land may be of national significance; loss of small areas of land will generally be of local significance only.

There is also a positive dimension to this subject. Land resources may be enhanced by development where deserted land of lower value land is replaced by land of higher value. These positive impacts are however recognized by benefits to people which are counted under the socio-economic subject heading.

- **Impacts:**

Most stretches of water mains and sewer lines are proposed to be laid along the flanks of the existing roads and within the right-of-way under government control. Certain stretches of water mains are to be laid across land under private control. Such land are under minor agricultural use, and since pipelines are buried deep the surfaces will be restored.

Most of the works will be carried out within existing public properties, so all components of the study could be constructed without any new requirement for additional land acquisition or property take, nor they need any new requirement for population relocation or resettlement.

Similarly, there will be almost no productive loss, and no loss of employment or other loss of income from any actions from constructing any of the study components.

Using an empty, desert, uninhabited land for the present project will improve the existing situation of the land use in the area. The land at the present time is considered as not used, not landscaped and has no character. But after the completion of the project the occupied land will be changed into useful sites, landscaped where possible with characteristic modern features.
The assessment considers the changes in land resources that will be brought about as a result of the development of the project.

The focus is on:

Improvement of environmental conditions and air quality which will result from the green areas around and inside the wastewater treatment plant.

• Effects on any beneficial land uses outside the site which may be affected by the development.

Who or What is Affected?

Though land and property markets in the study area may not be that responsive to changes in urban environmental quality, some increase in land and property values may be expected from this development. The household survey results indicate that 63% of the respondents considered connection to a sewage network would substantially increase their property values.

All of the land taken is understood to have been an abandoned, some of them are desert land of no value for any other use some are agricultural. It is therefore assumed that no people will be affected by its loss. Note that the buildings of the plant may have economic and positive landscape value and assessment of this is undertaken under economic subject.

• Evaluation of Significance:

The loss of existing land resources is considered not significant.

• Potential Mitigation Measures:

None required.

• Residual Effects after Mitigation:

None.

5.6 Archaeology and Cultural Heritage Assessment

• Method:

The assessment considers the changes in archaeology and cultural heritage that will be brought about as a result of the development of the project. The focus is on:

Loss or damage to any archaeology and cultural heritage present within the site of the project.

Effects on any archaeology and cultural heritage outside the sites which may be affected by the development.

The existing archaeology and cultural heritage on the sites and in the local area represent the baseline against which the changes are to be judged.

Three criteria can be used to judge significance under this subject area:
The reflection of air quality improvement through using the abatement facilities will be of positive significance impact.

Extent of damage to or loss of archaeological or cultural features. The rarity of the feature both locally and at a national international level will be significant. Where damage is minimal the significance may be low particularly if the feature is a minor one. Extent of damage to setting of archaeological or cultural features here the land is part of the backbone against which an archaeological or cultural feature is seen this can be important.

Significance has been based on a subjective judgment supported by a description of the impacts.

Impacts:
The project of water supply and sanitation for the served area will not result in the loss of any archaeological or cultural features.

The principal heritage and cultural values of the study area lie in occasional isolated examples to traditional architecture. However, no sites of specific scientific, cultural or heritage or significance were identified that may be directly affected by the different activities of the project works. The rich cultural and archaeological heritage of the old city is entirely unaffected by project works.

Moreover, virtually all project activities will occur within existing rights of way that have already been subject to development. It is considered very unlikely therefore that any buried site will be encountered in construction.

The project will result in highly significant positive impact on the surrounding buildings where the improvement of environmental conditions will be amended.

Who or What is Affected?
Changes in air quality due to mitigation measures could result in protection to the buildings of other activities could existed.

Changes on the quality of environment could affect their value as archaeological and cultural features; this may be particularly important for buildings of Al-Mukalla and Ghail Bawazir.

Evaluation of Significance:
The positive impact of restoring the buildings will be considered highly significant.

Potential Mitigation Measures:
None.

5.6 Atmosphere, Odor and Noise Assessment

Method:
The assessment considers the potential impacts on air quality and on noise levels from operations located within the proposed site. Impacts during construction are
dealt with under the Construction Impacts Assessment. Comparison of the present state and the changes in air quality and noise in the surrounding area will be the method of identifying impacts. In this section the focus is on identifying impacts and setting out the key concerns which a management plan needs to address.

- **Impacts:**

Unmanaged air pollution, especially of particulate and gaseous emission from construction machinery may create nuisance and in extreme cases direct adverse health impacts or damage property. However, while some impacts can be expected throughout Project areas, the quantity and nature of the machinery to be used is such that these impacts need not be severe.

Construction traffic may potentially generate substantial quantities of dust in and around active construction areas and on some of the unpaved access.

- **Roads:**

This issue is linked to that of heavy traffic use and access and safety in minor roads within the cities. It is also possible that offsite facilities, in particular aggregate processing plants may generate sufficient dust to be of nuisance.

- **Noise and Construction Disturbance:**

During site preparation and construction, noise will be generated from a number of sources including: jack hammers, loaders, generators, etc. and in many instances these will be operating in immediate proximity to residential areas.

Certain levels of noise disturbance are unavoidable. In excess, however, they can be a nuisance to neighboring residents and, in extreme cases, can become a health hazard to workers and residents. Typically, operational noise will be broad-band but intermittent, and is in a wide range from 50dB(A) to 90 dB(A). Without exception, night operations will exceed standards and day operations are uniformly excessive up to 20m. It is therefore inevitable, without mitigation, that significant disturbance will be experienced by a substantial element of the population.

During the construction phase, there may be an increased risk of accidents involving local populations especially children. These may result from one or a combination of the following:

- Unauthorized access to a construction site.
- Absence of control over access to construction sites
- Conflict with construction vehicles.
- Poor site safety.
- Inadequate site management.

By their very nature construction activities generate elevated levels of accident risk. However, three factors suggest that the impacts from these projects may he further increased.
• It is evident that a number of construction sites in Yemen lack proper management and in some cases are clearly dangerous and equally importantly that off site activities, such as construction traffic, are as poorly controlled.

• Widespread construction within the urban area: Extensive Linear construction sites along urban streets will expose large sections of the population, especially children who use streets as play areas, to risk.

• The nature of the urban development is such that access routes for construction traffic will be poor; often comprising relatively narrow streets and lanes with no pedestrian facilities, blind corners etc.

• Access and Construction Traffic:
  All points of contact between a heavy construction traffic and existing traffic will be a potential source of accidents. Three factors will contribute to this:
  • Increased number of turning movements of heavy construction traffic gaining access to and exiting from the primary road.
  • Relatively low speed of the construction traffic, and the mixing of traffic types and speed.
  • Possibility of damage to road surface from the increased level of heavy traffic and, more likely, modification of road surface conditions by mud, chippings, surface oil and other foreign matter.

Access to the construction sites: which may require the use of local access roads that would generally not be considered suitable for use by heavy vehicles will also be a potential source of concern. Use by construction traffic of such roads may cause damage to the road surface or in other cases to structures, delays to non-construction traffic and increased risk of accidents.

For off site facilities where some choices in siting are available, direct access to the primary network should be a major criteria in location.

• Negative Impacts Could Occur From:
  • Particulate emissions from preparing, transporting and storing materials, burning fuel or other processes which result in dust.
  • Gas emissions from any activities through combustion, stationary engines, evaporation of solvents, etc., and
  • Odor from use or processing of strong smelling substances.
  • Noise of machines, electric generators and other facilities.

Who or What is Affected?

Revisions in air quality will affect:

• Archaeology and cultural heritage.

• Other activities and plants nearby the plant or other construction sites.
People living in the area surrounding Cities.

Increases in Noise Levels will Affect:

- Workers within work sites, exposure to high noise levels over long periods can cause deafness.
- Other businesses in the zone, particularly office uses which require quiet conditions may potentially be affected by noisy works.

Evaluation of Significance:

In overall terms the impact on air quality is potentially of moderate significance and is largely dependent on the management of emissions to the atmosphere by the different works and on traffic volumes. In an extreme situation, i.e. the development of a highly polluting process with weak controls over emissions, this could increase to high significance.

In overall terms the nuisance from higher noise levels is potentially of minor significance and is largely dependent on facilities to control noise levels, the extent to which these are attenuated by the containment by buildings, walls and distance and on traffic volumes. Locally this could increase to moderate significance, e.g. where a noisy works was located next to an office development or where a busy road passes a sensitive land use.

Potential Mitigation Measures:

- Air quality management plan.
- Waste management plan.
- Toxic and hazardous substances management plan.
- Landscape design and implementation.
- Noise reduction at source, e.g. quieter processes, and noise attenuation through barriers, e.g. walls and green belts.

Principle of Reducing air Pollution:

The removal of pollutants from gaseous discharge is often complicated by the fact that the contaminants are generally present in small concentrations with a large excess of inert diluents gases.

This means that processes must be found that either remove the pollutant at these low concentrations or concentrate it in another phases. An effective program for prevention of air pollution can be implemented through the followings:

1. Physical examinations.
2. Periodic examinations.
3. Education and knowledge of the potential hazards caused by the exposure to the pollutant gases.
4. Personal protective devices such as face shields and respiratory equipment.
5. The presence of an occupational medical officer in the work sites with knowledge of the principles of occupational medicine and all the medical services that are available to the exposed workers.

6. Extend the activities of the "Medical Insurance Program" and situation in which the physician is unaware of the work environment or the existing hazards.

- Residual Effects after Mitigation:
  With appropriate and effective mitigation in place, the potential impacts of the development on air quality and noise levels should be reduced to low significance.

5.7 Toxic and Hazardous Substances and Solid Waste Assessment

- Waste Material:
The alluviums in which the greater majority of the project works will be constructed will contain horizons that may not suit the use as selected bedding material unless detailed geotechnical investigations provides recommendations in this aspect.

- Method:
The assessment considers the potential impacts of the transport, use and storage of toxic and hazardous substances and of the management and disposal of solid waste impacts and setting out the key concerns which a management plan needs to address.

- Impacts:
The main activity in the plant which has potential impacts in this area is the solid wastes from industrial activities and municipal wastes from the workers, no toxic or hazardous wastes could be generated.

- Generally, Solid Waste May be:
  - "inert" i.e. it is not toxic or hazardous and does not degrade;
  - "biodegradable" for example food vegetable and wood wastes, but not toxic or hazardous;
  - "toxic" for example containing heavy metals;
  - "hazardous" for example acidic or alkaline substances which can burn skin and inflammable substances.

Solid waste can fall into one or more of these categories. Note that solid waste include wastes which arise during construction.

Who or What is Affected?
The presence of solid wastes is a risk to:
- Other activities in the area and on their employees.
- Occupations of the public services in the area.
- Archaeological sites and buildings
- People living or otherwise present in the area and visitors.

Disposal of solid waste will potentially affect:
- Other businesses in the area, particularly where waste is left lying in the street.
- Occupations of land uses close enough to any disposal area could be adversely affected.
- Natural and cultural resources present where waste is deposited.

**Evaluation of Significance:**

For solid substances the significance of the potential impact is dependent on the risk of an incident. The severity of an incident is in turn dependent on the substance involved, the quantity of the substance stored and the location of the incident.

In overall terms the impact of solid waste disposal is more certain in that it is a necessary and continuing activity. In the absence of adequate measures to control and dispose of solid waste properly it is likely to be an impact of at least moderate significance.

**Potential Mitigation Measures:**

Sites of works will be provided for materials stockpiles. These sites are not yet identified, but may be at the Client's headquarters site. The materials for stockpile at this (or other defined) site will be exclusively non-hazardous and should not require application of any exceptional handling and storage measures.

**Borrow Material and Aggregate Washing and Screening:**

Borrow material and aggregates may be required during construction and shall be obtained from appropriate sources after approval from the concerned authorities.

At all of site facilities it will be important that contractors maintain and manage sites to high standards, that health and safety regulations are in force, that appropriate means for waste control and disposal are applied and that all temporary project sites are cleaned up and made good. Possible residual wastes of concern at each facility are shown in Table (5.2).

Waste collection system including transportation and disposal shall be upgraded by the authority or kept adequately ready to manage the waste generated through the implementation of the current project.

Presently, this service is undertaken by the municipality. Open dumps and street litter spread throughout the area as well as poorly-prepared collection shall be avoided. Accumulated waste is transported by the municipality at a very low and inefficient frequency. There is a need to develop a comprehensive system of waste in-source reduction.
Table (5.2): Typical Residual Wastes of Concern During Construction Activity

<table>
<thead>
<tr>
<th>Waste Material</th>
<th>Source</th>
<th>Impact Type / Environment Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spent oils</td>
<td>Maintenance yard</td>
<td>Immediate temporary contamination: Shallow aquifer, Soil,</td>
</tr>
<tr>
<td>Batteries</td>
<td>Stockpile site</td>
<td>Long term persistent contamination: Soil and water,</td>
</tr>
<tr>
<td>Scrap metals</td>
<td>Construction Site(s)</td>
<td>Long term persistent: Soil and water</td>
</tr>
<tr>
<td>Waste pipes</td>
<td>Maintenance Yard</td>
<td>Negligible / Unsightly Variable / Unsightly, safety concern, especially children</td>
</tr>
<tr>
<td>Surplus fill</td>
<td></td>
<td>Urban. Immediate temporary contamination: Shallow aquifer, Soil</td>
</tr>
<tr>
<td>Spent oils</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Mitigation Measure:**
  - Waste management plan.

- **Residual Effects after Mitigation:**
  With appropriate and effective mitigation in place, the potential impacts of the use of solid wastes should reduce to low significance.
  However, this is an area where failure of mitigation will carry a high risk of much greater impacts.

5.8 Construction Activities Assessment:

- **Method:**
  The assessment considers the potential impacts during construction activities.
  These activities result in:
  - Construction traffic to and from the area.
  - Disposal of surplus material either within the site or off-site.
  - Building and civil engineering operations within the site including in particular machinery operations.

- **Impacts:**
  Impacts during construction include:
  - Impacts from traffic from and to the site.
  - Noise from the use of machinery.
  - Spillage of fuel during re-fuelling of machinery and vehicles where this could takes place on-site.
• Spillage of lubricants and hydraulic fluid during servicing of machinery and vehicles where this takes place on site.

• Spillage of building materials to streets, particularly during loading and unloading of vehicles, and failure to contain construction materials within the site.

• Visual impacts of construction activities.

Who or What is Affected?

Construction activities may affect:

• Existing occupations of neighbors and adjoining areas as a result of, for example, noise from construction machinery.

• People living or otherwise present in the area.

Evaluation of Significance:

The impact of construction activities is temporary except where permanent damage occurs to land or resources. In the absence of adequate measures to manage construction activities it is to be an impact of moderate significance.

Potential Mitigation Measures:

• Code of environmental practice for construction.

• Waste management plan.

Residual Effects after Mitigation:

With an effective code of environmental practice for construction in place the potential impacts during construction should reduce to low significance.

5.9 Environmental Assessment of WWTP

While conducting the Environmental Impact Assessment (EIA) of the proposed project, an assessment of the impact of the wastewater treatment plants to be implemented during the current project are of prime importance as they play the main role in wastewater purification prior to disposal to the surrounding environment either through reuse or for final discharge.

Contaminants as suspended solids, organic loads and pathogens are removed along the different steps of the treatment process in order to reach an acceptable quality of the treatment effluent for further management through reuse or disposal. Therefore, the selection of the treatment process and the sizing of the different units shall impact the treated effluent quality.

In order to identify the impact of the wastewater treatment plant to be implemented within the current project on the surrounding environment, it is necessary first to consider the case of no-action, the studied alternatives, and the currently selected design in order to accentuate both its positive and negative impacts. This section discusses this issue while identifying the impact of the treatment plant either along the construction or operation phases on the
surrounding environment as a prerequisite to identify mitigation measures for any adverse impact.

In the following sections, specific discussions are related to the design and operation of the wastewater treatment plant which is one of the most important components of the project, thus the previous format is not adhered to.

5.9.1 No Action

The current practice of collected wastewater disposal in the different areas included in the project poses health concerns great enough to urge for the need for an intervention that provides a long term solution for the problem of water impounding and the possible spread of diseases through vectors and insects.

The waste collected from septic and holding tanks is extremely aggressive. It is anaerobic and probably very acidic having a strong adverse impact if disposed of directly to existing, main or interceptor sewers or directly to the environment.

Therefore, the current practice for removal and disposal of liquid waste is considered as a health hazard and should no longer be accepted on a large scale for the project area. It is thus important to start acting based on the phasing requirements of the project to start implementing the water supply and sanitation project in order to supply the required service while keeping good hygienic conditions within the project area.

5.9.2 Studied Alternatives and Selected Process

Within the procedure of selecting the treatment process to be implemented, the Engineering Consultant went through studying different alternatives including the followings processes:

• Activated Sludge (Complete mix or extended aeration).
• Trickling Filters.
• Rotating Biological Filters.
• Oxidation Ponds.

All the considered processes being based on the biological treatment process will offer high ability to biodegrade the municipal wastewater received by the sewage collection system which is organically biodegradable in nature. Each system would offers some advantages and disadvantages relative to numerous issues as construction cost, operation cost, land requirement, efficiency of contaminants removal, operators skills requirement, etc. The Engineering Consultant finally recommended the use of oxidation (stabilization) ponds followed and disinfection process for implementation aiming to achieve an effluent quality suitable for further reuse.

5.9.3 Environmental Issues Related to Current Design Approach

This section concerns the identification of the impact assessment of the wastewater treatment plant on the surrounding environment. The treatment plants
are considered as a core element in this project as they play the most important role in contaminants removal and the production of a treated effluent that can be reused in other useful purposes rather than leaving the project area with inadequate measures of raw sewage treatment and the consequent health hazards that can emanate from.

The assessment addresses three different issues namely the environmental issues related to the design of the process, the impact of the construction phase, and the impact during the operation phase of the treatment plants. The measures to be considered applies to all planned treatment facilities either in Fowah, in Ghail Bawazir or at An’Nagaa village compact treatment unit.

5.9.3.1 Design Phase

- General Layout:

For the proposed location of stabilization ponds, provide information about soil type, groundwater location, the need of preventing sewage infiltration to groundwater and its cost implication. It is expected with the final design that a full calculation sheet for the wastewater treatment plant be submitted to the Client indicating the efficiency of each stage in the removal of the different contaminants thus justifying the selected sizing of the units.

The Engineering Consultant proposed the construction of storm water collection channels in order to protect the plant from surface runoff of water. However, the Environmental Consultant suggests that other configuration of the ponds would be proposed in order to reduce the required overall length of the treatment plant specially that the areas subject to higher floods at the end of the treatment plant include the main buildings at the plant and the chlorination facilities. The relocation of such buildings is also recommended.

- Anaerobic Ponds:

Anaerobic ponds are able to support high organic loadings, a detention time of 5 days was proposed for the plant, and a volumetric organic loading of 117 g BOD₅/m³/d was also suggested. This suggestion implies that only a BOD₅ generation rate of 37 gram/capita/day is assumed to result in 500 mg/l BOD₅ with a corresponding wastewater discharge of 74 l/c/d water consumption. This assumption may be lower than acknowledge generation rates and may need to be reconsidered unless similar records for raw sewage in similar areas in Yemen confirm this issue, otherwise this will have adverse impact on the required sizing of the treatment units.

However, even with doubling the per capita organic load discharge the volumetric loading acquired in the design would still be in the acceptable limit but the efficiency of BOD₅ is expected to be lower thus affecting the sizing of the facultative ponds.
• **Facultative Ponds:**

Facultative ponds shall allow further removal of organic loading through both aerobic and anaerobic actions of bacteria where the settled solids at the bottom biodegrade under anaerobic conditions thus reducing the amount of sludge accumulated with time while the results of decomposition would lead to some conversion of solids into both liquid and gases forms.

Further biodegradation of organic waste shall occur in the aerobic region of the ponds that predominates the distance to the water surface where the simultaneous effects of biological degradation of waste through aerobic bacteria and algae photosynthesis action create a balance between oxygen demand provision and consumption of gases biodegradation products. The reduction of organic biodegradable waste is coped with an increase in both bacterial and algal cells count, these mainly settle within the facultative ponds though some solids may still remain and further settle in the following (polishing) ponds.

• **Aerobic (Polishing) Ponds:**

Pathogens reduction may occur at low rates in both anaerobic and facultative ponds, but are generally remove at higher rates in the polishing ponds. The role of polishing pond provided in the current demand needs to be more highlighted regarding its role in pathogen reduction, incorporating the effect of using higher number of ponds in series, specially that the continuous operation of the sewerage collection system would result in an influent pathogens concentration far higher than those currently detected in some transferred septage to disposal lagoons as the effect of long term storage may result in a reduction in pathogens concentration.

Therefore, the expected concentration of pathogens and microorganisms in the raw sewage upon continuous operation of the sewerage system should be added to the characteristics of raw sewage, consequently, the removal efficiency through the different ponds and the target effluent concentrations should be highlighted illustrating their effect on sizing the polishing ponds. However, as both filtration and disinfection processes are used downstream the facultative ponds, it can be expected that these will remove the excess pathogens still remaining in the treated effluent in order to reach an acceptable limit of discharge as mandated by water reuse requirements.

Another challenge that may face the proper function of polishing ponds is the need to provide shallow depths of water stream for UV effect to properly take place. Thus increased depth will involve excessive excavation works while not profiting from an increased disinfecting effect from UV. On the other hand, reduced depth will impact the overall residence time of the ponds unless larger areas of the ponds are selected. The Environmental Consultant see that an optimization should be conducted through the Engineering design of the plant specifying target pathogen reduction for sizing the ponds taking into considerations the role of the downstream filtering and disinfecting units and the
optimum depth of the ponds. This optimization may result alternative configuration of the treatment plant upon which the Engineering Consultant may further compare and select.
• **Disinfection:**

The reduction of pathogens in the treated effluent is an important issue that was considered in the current design of the wastewater treatment plant. The removal of solids is of prime importance in reducing the amount of disinfectant (chlorine) required to achieve the aimed reduction in pathogens and microorganisms.

• **Sludge Management:**

Sludge is expected to accumulate specially at the bottom of the anaerobic ponds at rates that can be estimated from previous international experiences of using ponds for sewage treatment (typical values of 4 liters/capita/year are cited in some references). The accumulated sludge will need to be periodically withdrawn from the bottom of the ponds in order not to consume the available ponds volume required for treatment and to prevent excessive solids escape to the following facultative ponds thus disturbing its function.

The current design of the treatment plant does not provide facilities for sludge management as sludge drying ponds or drying beds. The design has to take into considerations or clarify the means of sludge withdrawal and drying. Additional measures for sludge management as stabilization prior to disposal or composting for reuse purposes need also to be addressed. Though it is expected that sludge drying and long term storage prior to use (in addition to sludge composting if found feasible) would enhance the produced sludge quality and enables safe handling and reuse of sludge.

### 5.9.3.2 Construction Phase

In general, the construction of new works for wastewater treatment plants using the stabilization ponds process involves major earthworks in addition to requirements for infrastructure facilities as access roads, corridors provision for rising main and emergency effluent pipelines, power supply, in addition to materials supply for the construction of the main and service buildings in the treatment plant.

Therefore, the major impacts due to construction activities related to the construction of the treatment plant site would be related to the followings:

• The need to construct an access road to the site of the wastewater treatment plant

• The need to optimize earthworks at the site of the plant as to match cut and fill requirements.

• The need to assess the suitability of the excavated materials for use as a backfill material through appropriate geotechnical investigation at the site.

• Through geotechnical investigation and hydro-geological data, identifying the need for lining material in order to protect groundwater from pollution.

• Identifying land requirement and location for effluent reuse activity.
• Investigating the options for power supply to the site based on demands from different service and other buildings.

The works shall avoid interference with other utilities as storm drainage system, roads, others properties, and existing utilities. In some cases, the diversion of some utilities is necessary for the proper construction and installation of the proposed project components. Therefore, it is expected that the construction of the wastewater treatment plant at Wadi Fowah using the stabilization ponds process would incorporate the followings:

• Finalizing adequate sizing and layouts of the treatment plants for land acquisition purposes.

• Based on final layouts, optimizing major earthworks (cut and fill) through the proper selection of beds bottom levels and embankment slopes.

• Selecting land plots required for effluent reuse practice based on actual rates of water consumption in agriculture.

• Minimizing interference with storm drainage streams and provision of adequate storm drainage channels.

• Routing, design, and construction of infrastructure facilities, e.g. access roads, electric power supply facilities, corridors for raw influent and emergency effluent pipelines, etc.

The construction of the proposed wastewater treatment plants will require the installation of temporary facilities for contractors working on site. It is expected that the following would occur during the construction of the wastewater treatment plants:

• Increased traffic due to conveyance of construction materials, pipelines, equipment, etc.

• Generation of waste materials, either liquid or solid, from temporary workers camps (if separate camps are used in the site of treatment plants)

• Accumulation and transport of excess excavation materials or required borrow materials

• Dust generation during excavation works

• Waste generation for machinery used at site (as spent oil, gasoline, etc.)

5.9.3.3 Operation Phase

Upon construction of the works, the start up and continuous operation of the treatment plants will result in some adverse impacts on the surrounding environment that needs adequate consideration while operating the facilities. The preliminary negative impacts for the construction of the treatment plants can be viewed mainly in the followings as discussed herein in details:

• Odor emissions
• Effluent re-use and disposal
• Sludge disposal
• Increased activities due to daily operation practice

Odor emissions may be encountered at the inlet works and the anaerobic ponds of the wastewater treatment plant. The anaerobic ponds have a large area compared with inlet works and represent a higher potential for being a source of odor emission. However, it is normal for anaerobic ponds receiving municipal wastewater discharge that oil and grease accumulation occurs on the top of the ponds. The source of oil and grease would be discharge from residential areas within the accepted limits for wastewater discharge into public sewerage networks. Treated effluent characteristics as expected through the engineering design are as follows:

- BOD<sub>3</sub> 30 mg/l
- S.S. 30 mg/l
- Faecal coliform <200 / 100ml

It is expected that detailed design will show the progressive removal of each of these contaminants along the proposed treatment units in order to further optimize the required sizes of each treatment unit.

The potential areas for using treated effluent in agricultural purposes are usually located downstream of wastewater treatment plants. The wastewater treatment plant proposed at Fowah is located near Wadi Fowah where part of the site is at risk of flooding from small flood streams discharging into the main Wadi stream.

From actual land uses in the project area, no current activity can be distinguished around the proposed site of wastewater treatment plant at Wadi Fowah. As this would offer an advantage of not having a negative impact on the land uses planned in the future, the nature of terrain around the site will imply the potential of water reuse in the vicinity of the plant or the requirement for further transfer of treated effluent to more suitable areas for conducting agricultural activities.

Treated effluent is considered as a value added to the water resources in the area where its use shall be prudent in order to achieve the maximum benefit of using this additional water resource while maintaining good hygienic conditions in the project area. Treated effluent offers the advantage of being available year round as a result of continuous water uses and wastewater discharges from residential areas. Thus, perennial crops can be considered to get advantage of the available irrigation water resource year round.

In general, open channels used for gravity discharge of treated effluent to the sea result in the establishment of natural wetlands (as is experienced in other Yemeni cities) which may further polish the discharged effluent. However, this can still expose the shore water to pollution load from solids in effluent and few decaying vegetation which would create aesthetic problems for shore water. The land use
map indicates that close to the proposed emergency outfall location some areas are
assigned for tourism activities. This necessitates that the design of sea outfall shall
consider the most stringent precautions as to safeguard the future investments to
be carried out in the region to stimulate tourism activities taking advantage of the
marine environment and the beauty of the nature and beaches within the project
area.

5.9.4 Compact Wastewater Treatment Plant

The selection of compact treatment plant location shall serve the future plans for
sewerage system implementation in the project area and incorporate the prevailing
conditions as wind direction and soil condition in the design and implementation
phases. Where compact treatment units are planned for future relocation to serve
in other sites, construction shall take into consideration the ease of dismantling the
mechanical parts for further installation in other locations with proper
management of remaining civil works along the termination phase of the compact
units operation.

5.10 Highlights on Main Issues

While the negative impacts are individually addressed as reported in the
concluding tables of this chapter, some issues are hereby highlighted:

(A) Water resources

Although the current project maintains supplying the inhabited areas with it’s
needs of water along the project target year, there is high risk of affecting
available water resources due to the over consumption and increased the salt
concentrations in groundwater thus impairing the sustainable uses of such
resources, therefore, the followings are suggested:

1- Establishing an integrated program for water quality monitoring in the wells and
measuring the daily salt concentration in it.

2- Establishing a long run plan for developing other sources of water such as sea
water desalination or further development of other wellfields as were studied in
the project options though there implication on the cost of cubic meter of water
supply that may not match the social conditions of the served population and
poses more overburdens on the financial capabilities. Pilot projects for water
desalination may be initiated from private sector investors specially those
concerned with the supply tourism establishments along the coastal areas with
water.

3- Study the storm water drainage pattern within and surrounding the project area
and studying the construction of dams to catch, store and infiltrate rainwater to the
ground in order to recharge the aquifers.

(B) Operation of treatment works

The treatment operations implies the use of some chemicals especially in the
disinfection process, and due to the probability of the existence of some negative
impacts from transportation and storage operations, protective arrangements should be taken to prevent such impacts, these arrangements should consider safety operations and training people to deal with it prudently, providing safe means of transportation, and providing safe storage locations, keeping appropriate records for entry / exit and transport of such substances, and ensuring the safety of all projected population.

(C) Treated wastewater

As recommended previously, the use of treated wastewater should be oriented towards farming of timber tree (forestry) that would be a value added to the desert areas near the treatment plants where such activities will be implemented. The potential of sludge reuse after appropriate considerations is also of value since it will reduce the need for using fertilizers and increase plants growth rates through higher uptakes of nutrients such as nitrogen and phosphorus.

Such approach shall reduce the occurrence of negative impacts from the implementation of these facilities and which might occur following uncontrolled discharges of wastewater into the sea, therefore, the following are suggested:

• Preparing an integrated study about desert areas where forestry activities could be applied using treating effluent in order to specify the areas to be used and the end users of treated effluent.
• Preparing an economical study for the cost of implementation of the necessary irrigation nets, the planting cost and the expected economical revenue from these farms.
• Preparing a study to present the lands, which could be used in this purpose to the private sector investors in addition to providing the necessary technical support.
• Studying successful experience in this field from other countries having similar experience in this field.

(D) Monitoring the treated wastewater quality

In order to reduce any negative impacts resulting from the reuse of treated wastewater, the necessary analysis should be done such as:

• Chemical and biological analysis: - the national legislation should be considered as it specifies the necessary biological and chemical analysis to make ensure the safe reuse of treated wastewater, also it specifies the measures to be taken for sampling and methods of analysis, here we advise the necessity of the cooperation between the relevant water authorities, universities, and research centers that could provide a good help having equipped laboratories, trained individuals in order to develop a scheme for monitoring the activities related to wastewater reuse.
5.11 **Positive Impacts of the project**

Parallel to the identification of the negative impacts of the project, it should be noted that the nature of water supply and sanitation projects is highly appreciated for providing safe drinking water and sanitation measures that enhances public health and protecting the surrounding environment which is a major positive impact. Thus the identification of negative impacts does not decrease from the importance of the current project as a main achievement in protecting the environment and providing positive impacts for the served communities as:

- Provisions of safe water will improve human health
- Proper collection and treatment of wastewater will reduce the risk of parasitic infection.
- Proper wastewater handling will reduce the chance of groundwater contamination
  Improvement in the existing sewerage system will decrease the nuisance occurring in streets from overflows and surcharge of wastewater
- Improvement in the existing water supply and sewerage conditions will boost tourism activity and shall positively impact the economy of the area through diversifying population activities and income.

5.12 **Summary of Impact Assessment:**

Based on the previous discussions, the impact of the construction and operation of the different components of the Water Supply and Sanitation Project for Al-Mukalla can be summarized in Table (5.3) is shown hereafter.
### Table (5.3): Summary of Project Impacts

<table>
<thead>
<tr>
<th>Phase / Issue</th>
<th>Impact</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre Construction</td>
<td>Access to lands for topographic and subsoil surveys</td>
<td>Negligible</td>
</tr>
<tr>
<td></td>
<td>Subsoil investigation pits</td>
<td>Minor</td>
</tr>
<tr>
<td></td>
<td>Potential injury and death</td>
<td>Major</td>
</tr>
<tr>
<td>Construction Works</td>
<td>Nuisance value that may in extreme cases affect health</td>
<td>Major nuisance value</td>
</tr>
<tr>
<td>Public safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise and construction disturbance</td>
<td>Nuisance value that may in extreme cases affect health of general population. Vulnerable groups could have much higher health threat.</td>
<td></td>
</tr>
<tr>
<td>Disturbance</td>
<td>Traffic on Local dirt roads</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Removal and disposal of non usable soil material</td>
<td>Minor</td>
</tr>
<tr>
<td>Air Quality ( excl. dust</td>
<td>Dust emission from construction activities</td>
<td>Minor</td>
</tr>
<tr>
<td>Waste Soil Material</td>
<td>Dumping of excessive material not used in backfilling</td>
<td>Negligible</td>
</tr>
<tr>
<td>Fauna , Flora and Ecology</td>
<td>Impact on flora and fauna</td>
<td>Negligible</td>
</tr>
<tr>
<td>Archaeology / Cultural Heritage</td>
<td>Depends on extent of such sites in project area</td>
<td>Negligible</td>
</tr>
<tr>
<td>Off Site Works</td>
<td>Should be confined to areas owned by Client</td>
<td>Negligible</td>
</tr>
<tr>
<td>Project offices</td>
<td>Access roads and facilities</td>
<td>Minor</td>
</tr>
<tr>
<td>Traffic disruption</td>
<td>Temporary, partial and full closure of sections of road network.</td>
<td>Minor</td>
</tr>
<tr>
<td>Local access</td>
<td>Interference with property access, neighborhood access and access to special sites, (schools, mosques and such like) or other public buildings.</td>
<td>Major (on a site by site basis) but very short-lived.</td>
</tr>
<tr>
<td>Social impacts</td>
<td>Migration and social organization: negligible</td>
<td>Considered positive</td>
</tr>
<tr>
<td>Materials Stockpiles</td>
<td>Income and Employment</td>
<td>Considered positive</td>
</tr>
<tr>
<td></td>
<td>Resource use, Access, Storage</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
Table (5.3): Summary of Project Impacts (Cont’d)

<table>
<thead>
<tr>
<th>Phase / Issue</th>
<th>Impact</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre – Fabrication Yard</td>
<td>Storage and use of chemicals, industrial waste disposal (specialty oils)</td>
<td>Minor</td>
</tr>
<tr>
<td>Equipment maintenance and cleaning</td>
<td>Possible use of numerous sites, access requirements</td>
<td>Minor</td>
</tr>
<tr>
<td>Access and Traffic</td>
<td>Mix of heavy construction traffic and existing traffic will be a potential source of accidents</td>
<td>Moderate</td>
</tr>
<tr>
<td>Resource Use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>Effect on existing resource users</td>
<td>Major</td>
</tr>
<tr>
<td>Borrow Material</td>
<td>Reduction in quantum of resources available</td>
<td>Negligible</td>
</tr>
<tr>
<td>Permanent Impacts</td>
<td>Water resources depletion, additional farm land</td>
<td>Variable (-ve &amp; +ve)</td>
</tr>
<tr>
<td>Land acquisition</td>
<td>Limited areas</td>
<td>Minor</td>
</tr>
<tr>
<td>Property take</td>
<td>Limited for effluent reuse</td>
<td>Considered positive</td>
</tr>
<tr>
<td>Population relocation and settlement</td>
<td>None</td>
<td>Nil</td>
</tr>
<tr>
<td>Productive land loss</td>
<td>Adding new productive lands</td>
<td>Considered positive</td>
</tr>
<tr>
<td>Property acquisition</td>
<td>Land proprietary mostly by government</td>
<td>Minor</td>
</tr>
<tr>
<td>Employment loss</td>
<td>New job created</td>
<td>Considered positive</td>
</tr>
<tr>
<td>Phase / Issue</td>
<td>Impact</td>
<td>Significance</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td><strong>Water Supply Works</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrogeology</td>
<td>Potential impact of over pumping of water from groundwater source</td>
<td>Major</td>
</tr>
<tr>
<td>Rehabilitation of existing wellfields, increasing depth of existing wells and drilling new wells</td>
<td>Major potential impacts due to changes of water quality, and wells dryness</td>
<td>Major</td>
</tr>
<tr>
<td>Transportation of drilling equipments may need to construct roads to the new proposed wells civil work, storing building materials, equipments and machines</td>
<td>Wastes of drilling like mud may cause some negative impacts</td>
<td>Moderate</td>
</tr>
<tr>
<td>Reduction of water loss from leakages of the distribution networks</td>
<td>Waste material requires final disposal</td>
<td>Moderate</td>
</tr>
<tr>
<td>Flushing and Disinfection during construction phase</td>
<td>positive impacts of reducing water loss the reduction of the unaccounted water</td>
<td>Considered positive</td>
</tr>
<tr>
<td>Operation of facilities</td>
<td>Maintenance of supplies during construction, isolation of new systems from old, insure connection of all consumers, prevention of return of illegal connections.</td>
<td>Moderate</td>
</tr>
<tr>
<td>Flushing existing lines</td>
<td>Handling and disposal of flushing chemicals.</td>
<td>Major</td>
</tr>
<tr>
<td>Wastewater generation</td>
<td>Increase in wastewater generation will urge the implementation of sanitation facilities</td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Sanitation Works</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation of sewer lines</td>
<td>Capability of service areas to accommodate the installation of new sewers</td>
<td>Negligible</td>
</tr>
<tr>
<td>Treatment plants</td>
<td>Land acquisition, use of chemicals for disinfection</td>
<td>Moderate</td>
</tr>
<tr>
<td>Hydrogeology</td>
<td>Application of sanitation system will help protecting groundwater resources</td>
<td>Considered positive</td>
</tr>
<tr>
<td>Housing and urban development</td>
<td>Promote new housing and urban development</td>
<td>Considered positive</td>
</tr>
</tbody>
</table>
Table (5.3): Summary of Project Impacts (Cont’d)

<table>
<thead>
<tr>
<th>Phase / Issue</th>
<th>Impact</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sanitation Works (Cont’d)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cesspit removal</td>
<td>Threat to public health from the opening of the pit, including odor nuisance, access to 20m deep holes, traffic, etc.</td>
<td>Moderate, primarily to vulnerable groups, children, asthmatics, etc.</td>
</tr>
<tr>
<td></td>
<td>Removal and disposal of the waste materials from the pits</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Scale of input of fill and source of fill</td>
<td>Moderate</td>
</tr>
<tr>
<td>Potentially great number to be removed from all projects</td>
<td>Collection, handling and disposal of waste generated by households disconnected from their disposal system.</td>
<td>Moderate</td>
</tr>
<tr>
<td>Wastewater disposal</td>
<td>Fly dumping of cesspit wastes.</td>
<td>Moderate</td>
</tr>
<tr>
<td>Use of sludge and treated water at WWTP</td>
<td>Project is unlikely to alter the composition of wastes used by farmers at the WWTP</td>
<td>Negligible</td>
</tr>
<tr>
<td>Soil Contamination</td>
<td>Potentially extensive workforce contact with contaminated materials and casual public access (esp. children)</td>
<td>Minor (depends on results of sample testing program)</td>
</tr>
<tr>
<td>Flood hazards</td>
<td>High need of protection WWTP from such hazard</td>
<td>Major</td>
</tr>
<tr>
<td>Operational problems</td>
<td>Possible interruption of some project elements work</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
CHAPTER (6)

ENVIRONMENTAL MANAGEMENT PLAN
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ENVIRONMENTAL MANAGEMENT PLAN

6.1 Objectives of the Environmental Management System

The Environmental Management System (EMS) brings together and integrates the continuing mitigation measures recommended in the EIA. The objectives of the EMS are:

• To bring in one place the recommended mitigation measures concerned with the continuing management of the site, works and all the activities of the present project.
• To provide a framework for activity managing the environment within and around the area of the project.
• To provide a quality of environment within the coastal zone which is attractive to businesses, visitors and workers.
• To minimize environmental conflicts between businesses within the zone.
• To minimize adverse effects on the environment both within and around the area.
• To maximize the positive effects on the environment including the socio-economic benefits.
• To identify responsibilities for monitoring, liaison and enforcement of environmental regulations.
• To identify responsibilities for implementation and maintenance of physical works.

6.2 Philosophy of the Environmental Management Plan

The overall philosophy of the EMS is to manage the water supply and sanitation project and related activities so that environmental negative impacts could be avoided in different phases of the project.

This is much easier than correcting environmental problems after they have developed. The EMS cannot take into account every possibility or set out in detail all of the actions which need to be taken. It will need to be updated from time to time to meet changing situations. The details of how actions should be implemented will need to be worked out by all of the stakeholders involved including LCWSSHG-CA, businesses and the local community.

6.3 Structure of the Environmental Management Plan

The Environmental Management Plan comprises the following parts; it has been structured in this way to help with implementation and in particular to identify responsibilities:

D:\Documents\Scheduling\Scheduling\Local\Scheduling\Temporary Incomes\File Centre E6\PQ\FIRE\\\Matched.doc
• Physical Planning for the wastewater plant including zoning for land uses, design measures, landscape measures and protection of archaeological and building sites around the plant.

• Social and Economic Measures including education, training for workers and other community services; such as raising environmental and cultural heritage awareness and health services.

• Waste Management Plan including collection, treatment and disposal.

• Traffic and Transport Measures in the surrounding area including improvement of accesses and traffic management during implementation.

### 6.4 Physical Plan

The Physical Plan for the project works should comprise:

- A land use zoning plan which sets out facilities, utilities and other uses proposed for particular areas in the plant.

- A landscape plan which will include planting and maintenance of the green areas around and inside the plant.

The zoning plans should be prepared considering the following main objectives:

- To avoid activities which are incompatible with environment.

- To select activities which require a clean environment, do not emit gaseous, particulate or other matter, do not carry out any process or store any substance which poses a risk, are quiet, and tidy in appearance.

Such activities can coexist with housing and all but the most sensitive land uses without any problem.

Other activities which:

- Do not require a completely clean environment, and/or

- May emit some gaseous, particulate or other matter but within normal discharge limits, and/or

- May carry out processes or store substances which pose some risk, and/or

- Can result in some noise outside their buildings, and/or

- May involve some visual impact on their surroundings.

Will be provided with controlling and abatement facilities.

### 6.5 Plan for Protection of Archaeological Sites

The following mitigation measures are recommended to protect and enhance the archaeological sites in the area surrounding:

1. Maintain an undeveloped buffer green zone around the plant.

2. Avoid heavy traffic to avoid vibration, air emissions and noise.
Social and Economic Planning

- A training strategy to improve the local skill base in conjunction with works and activities.
- An education strategy working with local schools, and with particular focus on women.
- An economic strategy to ensure that the project benefits people in the area through (for example a small business development programme to enable local people to take advantage of economic opportunities).

The overall objective of social and economic planning is to increase the participation of local people in the economic activities of the project while minimizing any adverse social impacts on local communities.

Training and Education Strategies

The strategies will need to respond to the needs of existing and potential activities within the Zone and to make best use of the training facilities and technical schools available locally. The following features need to be incorporated:

- Designation of a person to act as a training and education coordinator to liaise between existing activities, training institutions, and schools.
- Maximizing the use of existing training facilities and encouraging them.
- Focusing training on meeting actual work needs.

Training should be planned, implemented and monitored with this in mind. Some activities need technical training; others need to focus training on management and marketing. Basic knowledge of public relations and interpersonal relationships are important. A combination of on-the-job and college-based training can be very effective in developing skills which focus on actual work needs.

- Consider the need to establish a fully equipped training unit within the LCWSSHG-CA in the future. The training unit can provide training in environmental management, e.g. handling of hazardous materials, as well as the normal skills such as machinery operation.

The unit will keep an assessment and training record for workers.

This will lead to more effective and more realistic training and consequently to higher quality and higher productivity both skilled and unskilled workers.

Economic Strategy

This could include a range of measures to encourage local participation. The construction of such project should encourage the national policy to fulfill the needs of the local labor markets and local contractors, but it needs to be accompanied by other initiatives if it is to be successful.
The following features could be developed:

- Encourage such larger scale projects can provide a market for smaller works by local community of Al Mukalla City.
- Encourage touristic enterprises which use local natural and environmental aspects.
- Providing managerial and technical advice necessary for managing such new investments.
- Suggesting changes which will increase the chance of success.
- Assisting in making feasibility studies for such project.
- Providing foreign investors with information about quality of infrastructure projects of the area.
- Giving advice on purchase, operation and maintenance of machinery and equipment for the sustainability of the project.

Continuing Support for Investments after Implementation.

6.9 Construction Code of Practice

Construction code of practice are generally short and clear and provide advice on avoiding the environmental impacts of construction which can readily be understood by those working on site. The construction activities within the project result in:

- Construction traffic to and from residential areas during implementation.
- Disposal of surplus material either within the site or off-site.
- Building and civil engineering operations within the sites including in particular machinery operations.

The construction code of practice should cover the following matters:

1. The routes to be taken by construction traffic to and from the sites.
2. Loading of goods vehicles: Goods vehicles of all kinds including those carrying waste construction materials shall not be overloaded; all goods and materials shall be properly loaded and secured to avoid spillage.

Disposal of surplus material: All surplus material should be deposited, whether on-site or off-site, in agreed locations. Note that such material can be very useful in covering biodegradable wastes in approved landfill sites.

Storage and handling of fuel, lubricants, hydraulic fluid and other hazardous or toxic liquids. The objective is to minimize the risk of spillage to the ground. An area should be set aside within the contractor's compound for the storage of fuel, lubricants and hydraulic fluid. The area should be properly fenced. All storage should be in storage containers which should be above the ground, e.g. on pallets. When not in use containers must be properly closed. The area should be inspected for leakage on a daily basis.
Where leakage is detected the contents of the leaking container shall be immediately transferred to sound containers which must be kept on the site for this purpose. Where containers are of more than 10 liters capacity, hand pumps shall be kept available at all times to effect transfer from a leaking container. Smaller containers may be transferred by pouring using a funnel.

5. Use and handling of building materials: Some building materials are of a hazardous nature and need special care in cutting and handling; for example asbestos cement pipes have been used in the water supply network.

Although asbestos cement is no cost hazardous form of asbestos any waste from cutting pipes should be kept separate and buried in a location where it is no longer likely to come into contact with people.

6. Noise: Development of individual lots and completion of infrastructure works after occupation of some units may cause noise problems.

These can be dealt with by providing control measures.

7. Safety: Building and civil engineering operations often mean that hazards are present on the construction site. These hazards include, for example, trenches left open, exposed reinforcing bars, unprotected buildings, working excavators, etc., risk can be reduced by cordonning off the working area, e.g. with posts and mark tape, and posting warning signs. Where people, particularly children, wander onto the site they should be asked to leave.

Note that health and safety rules, e.g. the use of hard hats and safety footwear should be applied where risks are present.

8. Fixed machinery: This may include concrete mixing machinery and cutting machinery. It should be located within a site compound which is not accessible to the general public.

Other matters can be added as needed. For example at present there are no trees in the area. If in later stages of construction trees have developed these will require protection with fencing to prevent damage to roots and the trunk. This fencing should be around the tree and just outside the spread of the branches.

6.10 Toxic Substances Management Plan

What Substances are included? Toxic substances may be present as materials use in works and processing including fuel, solvents, lubricants and waste.

They include:

- Almost all petroleum derived products including petrol, diesel, oil and lubricants.
- All inflammable liquids including organic solvents.
- All explosive substances.
- All corrosive substances including acids and alkalis.
• All other poisonous or toxic substances including those liable to give off poisonous fumes such as chlorine, carcinogens (cancer causing substances) such as asbestos, heavy metals such as lead and mercury, and chemicals such as PCBs found in oil used in electric transformers.

• Wastes, solids or liquids contaminated with any of the above.

Some activities will use at least some goods or materials which are toxic to some extent. Some very common substances are hazardous or toxic diesel fuel, although much less flammable than petrol can cause serious contamination when spilled on the ground.

Environmental impacts will occur where toxic and hazardous substances escaping to the atmosphere, are deposited on the ground or become a risk to groundwater or surface water. The risk will depend on the quantities stored, the manner of storage, the way in which the goods or materials are used and handled and the characteristics of the material. Risks can be reduced or avoided by comparatively simple measures at low cost. Where contamination occurs remediation (putting right the wrong, e.g. by removing the contamination) can be very expensive. The risks of contamination or pollution include loss of water resources, injury to life and limb, health problems and damage to property. Environmental management may cost money to implement now but pays very good returns in the longer term.

Note that the best way of dealing with toxic and hazardous substances is to avoid their use; always consider whether:

• An alternative process is available which does not use toxic or hazardous substances.

• An alternative non-hazardous substance is available, e.g. cleaning with a biodegradable product may be better than using a solvent.

• A less toxic or less hazardous alternative is available, e.g. white spirit is less toxic than carbon tetrachloride, both can be used as solvents.

• Storage and use or less product (one ton of a substance is likely to pose a smaller risk than 10 tons).

• The substance can be recycled, e.g. by filtering it, to reduce the quantities needed and minimize disposal costs.

• A toxic and hazardous substance is cost effective taking into account the risks to the investment and to the workers, it may be better to use a more expensive substance which is less risky.

The focus of these measures is on cleaner production and resource recovery which can:

• Conserve energy and reduce materials consumption.

• Reduce or eliminate toxic and hazardous substance use, and

• Reduce waste generation and thus the problem of waste disposal.
The EMS should:

1. Set up an Inventory of all hazardous substances kept within the different sites of the project. The inventory can be simple but must include:
   - A description of the substance stored including its chemical name and its characteristics, e.g. corrosive or inflammable.
   - The location where the substance is stored.
   - The maximum quantity stored.
   - How the material is stored, e.g. fixed enclosed tank, or drums.
   - How the material is handled.
   - Emergency measures in place to deal with escape, spillage or fire, e.g. availability of hand pumps and empty containers to transfer liquid from leaking containers.

2. Provide guidance on the safe storage and handling of toxic and hazardous substances which should include the following preventive measures as a minimum.
   - All workers coming into contact with any toxic or hazardous substances should know what the dangers they pose and how to deal with any problems.
   - Hazardous or toxic substances of any kind should never be stored or handled outside the lot.
   - Vehicles should never be overloaded with toxic or hazardous substances and such loads should always be secured properly so that there is no danger of losing any part of the load;
   - Hazardous or toxic substances should always be stored in proper containers which can be closed up properly, which are robust and which do not leak.
   - In general hazardous or toxic substances shall be stored above the ground in a separate walled compound with a concrete or similar hard floor to enable leaks to be readily identified and to prevent leakage to the ground.
   - Where materials are incompatible, e.g. mixing one with the other is likely to result in a chemical reaction, they should be kept in separate places.
   - Any stored toxic or hazardous substances shall be inspected regularly, at least once per day, to ensure that there are no leaks.
   - Appropriate equipment must be available to deal with fire risks, e.g. foam fire extinguishers.
   - Materials and equipment must be available to deal with any spillage, for example sand to soak up toxic liquids and a container to transfer these to a proper disposal point.
6.11 Air Quality and Atmospheric Management Plan

Criteria should be developed for application to businesses within the zone to
Cover:

• Noise
• Odor
• Dust and Smoke Emissions

These should be used to ensure that the works and activities do not cause a
nuisance to other occupiers of the area or to people or environmental resources
outside it.

6.12 Criteria for Noise

Noise from works may be:

• Within the site where it poses a risk to those working there.
• Heard outside where it may affect people in the street or in neighboring land uses.

Very high noise levels pose a health risk in that they can result in loss of hearing.
This is a particular problem for workers with machines. Noise levels can be
reduced:

• By the use of quieter machinery.
• By the use of protective equipment such as ear plugs or ear covers.
• By noise barriers such as sound proof walls and sound isolators.
• Businesses should avoid creating noise levels such that normal conversation in the
  street outside is not possible.
• Within the working areas higher noise levels are acceptable but workers should be
  provided with appropriate ear protection.
• Within the boundary of the plant any noise levels at night shall be sufficiently low
to avoid disturbance.
• Any noise levels shall be sufficiently low to avoid disturbance to land uses.

6.13 Criteria for Odor

Odor generally results from either liquid or solid matter which emits odor as a
result of evaporation of small particles or from discharges during processing
particularly those processes in which the products of combustion are vented via a
chimney. Some odors may be unpleasant and in extreme cases be an indication of
the release of gases such as chlorine or ammonia which can be harmful to health.
The most important source of bad odor within the present project are from the
seepage pits where sludge removing takes place.

The aim should be that all emissions are free from offensive odor outside the site
boundary.

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Settings\Temporary Internet
Files\C:en\626265YR8L\net\186 (1) DOC
6.14 Criteria for Dust and Smoke Emissions

The aim should be that all emissions to air, other than steam or water vapor, should be colorless, free from persistent mist of fume, and free from droplets.

Emissions from combustion processes should in normal operations be free from visible smoke.

A major concern is with the content of emission; full list of pollutants may be emitted and the proposed measures should aim to minimize such emissions.

A useful approach to reducing emissions is to:

- Check the input to see how clean it is.
- Check the process to see how effective it is in reducing harmful emission, higher temperatures generally result in a cleaner burn, and
- Ensure that measures such as air filters are in place to minimize any emissions and are properly maintained.

6.15 Solid Waste Management Plan

Avoidance of Waste: Solid waste collected by the Collection Service shall exclude:

- Any materials capable of being recycled; and
- Any toxic or hazardous materials.

This will limit waste to biodegradable and inert materials.

The key to waste management is to avoid creating waste in the first place. Waste can be avoided by:

- Waste minimization: careful use of materials can reduce waste.
- Reuse: products from one process can be reused in another.
- Recovery: waste can be reprocessed to recover products.

Filtering out impurities to recover product; can be an effective way of doing this. Clean paper and cardboard can be recycled.

6.16 Traffic and Transport Measures

A traffic and Transport Plan should be developed to include: Traffic management of heavy traffic in the area.

6.17 Environmental Management Plan for WWTPs

Negative impacts that would result in from the construction of the wastewater treatment plant can be minimized through the consideration of several mitigation measures and selection of adequate means of reducing such impacts or conflicts taking into consideration a general environmental management plan as follows:
6.17.1 Construction Phase

With regard to construction activities, all precautions taken to safeguard public safety, public health, and employee health and safety for the different components of the water and sanitation project applies to the construction of wastewater treatment plant.

The main features to be considered can be viewed as follows:

- Acquiring necessary actions for final allocation of land for treatment works and effluent disposal (e.g. land acquisition, end users agreement).
- Effective site management of earthworks.
- Providing adequate signing and protection for temporary access roads or tracks
- Providing adequate means for water supply and sanitation for the workers at the site of the treatment plant.
- Establishing or nominating the nearest health care facility for emergency cases.
- Abatement of noise and air pollution.

According to design reports, all works will be carried out within the existing public properties, this shall allow the construction of works with no interference from the land acquisition point of view. The land requirement either for the construction of the waste stabilization ponds or for effluent reuse are considerably large thus the importance of the availability of such areas for construction and operation works.

The design works addressed the selection of arbitrary leveling plans as to optimize excavation and filling works thus the construction cost of the stabilization ponds. This will help minimizing the use of borrow materials form outside the site and the consequent increase in hauling trips of heavy vehicles. However, this should be confirmed based on detailed geotechnical investigation at the site in order to assure the suitability of the excavated material for reuse, and the economic benefit of carrying out such excavation works according to soil type and characteristics.

6.17.2 Operation Phase

The negative impacts emanating from the operation of the treatment plant as previously identified can be dealt with through the followings:

- Odor Emissions

In case of odors emission, it is common practice to have the effluent pipe from the anaerobic ponds submerged (collecting effluent from sub-surface relative to top water levels). This allows the permanent accumulation of a layer of oil and grease that acts as a natural barrier to offensive odors emission to the atmosphere in addition to maintaining good anaerobic conditions in the lagoons for proper operation and high removal efficiency of the received organic loads.
Another potential area for odor emissions is the sludge disposal facility where the current design did not specify the means of ponds desludging, sludge drying and disposal. Since this is an important issue to be addressed it is herein addressed that more elaboration on this issue should be considered from the Engineering Consultant.

- **Effluent Reuse and Disposal**

  Significant benefits are offered by the sanitation project through providing the possibility of effluent reuse specially considering the scarcity of water, a problem that faces many countries in the region. Reuse of treated effluent should be coped or even preceded by several actions encouraging a strategy for effluent reuse comprising an assessment of the options available for the use of treated waters including direct reuse within a framework of a specific agricultural project, or through individual uses in addition to the creation of an effective framework for the safe use of treated effluent.

  Considerations for effluent reuse should appoint the followings:

  - Production, storage and handling of reuse water
  - Definition of areas where treated effluent may be utilized
  - Effluent disposal scheme
  - Adequate monitoring program for reusing treated effluent

  Previous efforts conducted in the field of wastewater reuse in Yemen have evaluated the opportunities and guidelines for wastewater re-use. Findings revealed that more stringent guidelines are recommended as some uncontrolled practice lead occasionally to incidences of health problems. The local authorities can manage such practice while planning programs related to wastewater reuse (out of scope of the current project) as: (i) educational programs in rural communities on the potential availability and use of wastewater, (ii) establishment of monitoring program for effluent reuse activities as well as for products, and (iii) health monitoring for direct reused water users.

- **Effluent Reuse**

  Data on agriculture water consumption will help identifying the required areas of lands to be potential used for agriculture activities using treated effluent as irrigation water. The consumption of irrigation water would depend on climatic conditions and the types of crops to be cultivated. As an example a rate of 100 m³/ha/d would result in that approx. 140 ha would be required for use through the newly developed agriculture activity on reused effluent. The local authority would take this into consideration in planning land uses and identifying potential beneficiaries from such activity.

  Recommendations for Yemeni Standards for wastewater addresses the issue of wastewater reuse by suggesting some criteria to be reached for treated wastewater...
prior to reuse of treated effluent into different reuse activities as shown in Table (6.1).

Table (6.1): Microbial Characteristics of Wastewater for Agriculture Uses

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Unit</th>
<th>Acceptable Limit</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intestinal Nematodes</td>
<td>Eggs</td>
<td>(0 - 1) / liter</td>
<td>In case of irrigating edible crops consumed raw (without cooking), mean concentration of faecal coliform shall not exceed 1000 / 100 ml during irrigation period.</td>
</tr>
<tr>
<td>Intestinal Nematodes</td>
<td>Eggs</td>
<td>(0 - 1) / liter</td>
<td>In case of irrigating play fields and national park where direct contact with people is possible, mean faecal coliform bacteria shall not exceed 200 / 100 ml during irrigation period.</td>
</tr>
<tr>
<td>Intestinal Nematodes</td>
<td>Eggs</td>
<td>(0 - 1) / liter</td>
<td>In case of irrigating cereals, industrial crops, and animal fodders crops.</td>
</tr>
<tr>
<td>Intestinal Nematodes</td>
<td>Eggs</td>
<td>(0 - 1) / liter</td>
<td>In case of irrigating fruit trees, irrigation should be stopped two weeks before harvesting and no fruit should be collected from ground, irrigation using sprinklers is not allowed.</td>
</tr>
</tbody>
</table>

* Reference shall be made to the complete Arabic version of these standards.

The new trend is to eliminate the existence of nematode in the treated effluent. The Standards include also limits for other contaminants as heavy metals. However, the presence of such heavy metals would be expected to be low as the origin of wastewater is from the domestic water uses mainly. In addition, there are limitations that govern the discharge of wastewater to public sewers, therefore, any existing industry in the project area has to pre-treat its effluent to meet with the acceptable discharge limits into the public networks. This will also minimize accumulation of such metals into the discharged wastewater and thus in reused treated effluent.

The target faecal coliform number suggested for the treated effluent provides the opportunity for effluent reuse for several activities while taking into considerations the precautions enclosed in the Standards. The selection of crops
should take into considerations the characteristics of treated effluent. Field crops suggested were:

- Trees such as Palm, Papaya, Banana, and Mangos
- Fodder Crops (alfalfa, elephant grass)
- Salt tolerant fruit trees (date palms, olive trees)
- Cereals (wheat, rice)

**Excess Effluent Disposal**

The current engineering design proposed the construction of an emergency outfall pipe to convey the excess treated effluent to the Sea. The outfall pipe shall discharge the effluent via a thoroughly studied and designed outfall to allow gravity discharge of effluent under the available gradients taking into considerations different aspects as marine current and tidal flow in addition to the expected solids concentrations in the effluent and the dilution effect of the designed outfall.

**Sludge Disposal**

The wastewater treatment process will result in the accumulation of solids in the form of sludge mainly in the anaerobic ponds. At a rate of 74 t/c/d sewage production and a total treatment capacity of 14,000 m³/day, the sludge generation of the equivalent (served) population can be expected referring to acknowledge sludge production rates for such treatment process, e.g. 4 liters/capita/year is a typical value previously used for such facility.

Produced sludge will required further drying or dewatering for decreasing its moisture content while returning the separated flow to the inlet works of the treatment. This issue needs to be further addressed in the engineering design of the treatment plant. The collected sludge will need further management to ensure sludge safe disposal or reuse profiting from the nutrient incorporated in the sludge material mainly nitrogen and phosphorus.

Several processes can be applied for sludge management as digestion, stabilization, composting, etc. Sludge can be composted to a degree that is suitable for land application offering the advantage of being a low cost fertilizer, soil conditioner through reducing the density of soil and improving moisture retention that all help in agricultural practice. Land application of dried sludge is a well established and successful process worldwide offering an easily applied fertilizer having reduced nitrate leaching characteristics.

Concerns related to sludge reuse through land application involves: pathogen destruction, heavy metals content, toxicity of extractable material, vector attraction, and general nuisance associated with management practices.

Pathogen destruction and vector attraction are generally effectively controlled by adequate sludge stabilization. The mean of sludge stabilization shall be clarified in the current engineering design of the project. Commonly, anaerobic digestion of
the sludge offers a good mean of reducing pathogens, however, means for sludge withdrawal, collection and handling should be highlighted.

Heavy metals content and toxicity generally emanate from the proportion of industrial wastewater discharged into the sewerage system. The project area is characterized by a residential occupation pattern where the industrial wastewater discharge is minimal. In addition, several regulations for controlling raw industrial wastewater discharge is expected to be implemented thus eliminating the discharge of toxic materials or heavy metals (oil discharge is also regulated). Therefore, it is expected upon implementation of industrial wastewater pre-treatment works, and continuous monitoring of such discharge that minimal accumulation of metals or toxic matter in the sludge shall occur.

**Increased Activities Due to Daily Operation Practice:**

Daily operation of the wastewater treatment plant results in the generation of new activities not previously encountered at the site. Most of these activities will have low frequency of occurrence as for example a monthly truck loading of chlorine for the site. The normal inspection of the daily operation is expected to be conducted by low number of workers who may need to inspect the inlet and outlet works, electric panels, filters indicators, etc. In addition, permanent safeguarding expected due to the use of chemicals as chlorine that need closer surveillance. This can be done through one guard residing at a guard room at the entrance of the treatment plant. Plant daily operators are expected to work mainly in the daily shift and can reside in the nearby residential areas.

6.18 **Monitoring Plan For Wastewater Treatment Plant Construction and Operation Activities.**

In order to ensure the proper operation of the implemented project and attain its targets that shall positively enhance the environmental conditions at the project area.

6.18.1 **Construction Phase**

The process of monitoring the impact of the construction of wastewater treatment plant will take into considerations the activities conducted during the construction of this component of the project.

In general, all general precautions considered for the construction of other components shall apply to this section as those concerning safety issues during construction, minimizing dust emission to air, etc.

In particular, some issues are of importance for close monitoring during the construction of the wastewater treatment plant as follows:

- Monitor particulate concentrations in the ambient air before and during construction activities.
- Monitor increased traffic loads on existing roads while conveying required construction materials, and make sure that intersections, routes, and gradients for
existing and temporary access works can easily accommodate heavy trucks motion.

6.18.2 Operation Phase

After the operation of wastewater treatment plant, several monitoring activities have to be undertaken in order to ensure proper operation of the facility as follows:

- The effluent quality should be monitored for main contaminants removal as to ensure compliance of effluent quality with final disposal requirements. Minimum parameters to be monitored are BOD5, Suspended Solids, pH, and Nematodes.
- The effluent quality should be monitored monthly through approved laboratory.
- The Sodium Adsorption Ratio shall be monitored periodically to assess the suitability of reused water for agricultural practice.
- The effluent has to be strictly used in reuse purposes as originally proposed during the project design, while eliminating as possible the use of the emergency outfall to the sea.
- Records of frequency of treated effluent discharge to the sea and flow measurement shall be undertaken by the responsible authority with possible involvement of other authorities as the research institutes, in order to undertake necessary actions if frequent discharge to the sea occurs.
- Monitor increased traffic loads on existing roads while conveying required materials for operation as chlorine used for disinfection, and make sure that intersections, routes, and gradients for existing and temporary access works can easily accommodate heavy trucks motion.
- Provide adequate measures for controlling any accidental leakage that may occur in the chlorination facility inside the wastewater treatment plant.
- With the collaboration of the research institutes available in the project area, investigate the quality of the produced sludge and the measures to be undertaken in order to promote the safe and extended use of the sludge as a gained by-product of the operation of the treatment plant.

6.19 How the EMS will work

The Contractor has the responsibility of undertaking and completing the construction works. This responsibility extends to the activities of all subcontractors. The purpose of the EMS is to provide the Contractor with the means to manage day to day environmental implication of site activities during the construction phase.

The EMS will provide guidance on how to avoid predicted impacts. It will also facilitate on-going prediction and management of any other environmental impacts, through the duration of the project by requiring the contractor(s) to make an assessment of potential impacts when finalizing Method Statements. These
should cover measures and controls in response to those aspects identified as having a significant environmental impact.

The EMS has two functions; to provide guidance to contractors on how to prevent and/or mitigate environmental impacts occurring; and secondly, to provide means to measure and verify project environmental performance. This shall be achieved as discussed hereafter.

The Contractor (and subcontractors), when developing the Method Statements, will consider the predicted environmental impacts and mitigation measures and incorporate these as appropriate into their Method Statements. If additional mitigation measures are required the contractor must specify them in their Method Statements. When the Project Manager reviews Method Statements he will be looking to see that all environmental impacts associated with that item of work are mitigated. The project will be audited on site to ensure that mitigation measures are being implemented. Potential environmental impacts (including those identified during the EIA process) have been evaluated during the EMS development, with Environmental Performance Targets being assigned to the range of environmental impacts. Performance against these targets will be monitored on site and checked by the Environmental Officer.

6.20 Elements of the EMS

A set of management procedures to ensure that the EMS is operated and maintained in accordance with the principles of ISO 14001 including:

- Environmental risks register
- Environmental legislation and other requirements
- Environmental performance targets
- Document control
- Records – Communications - Training
- Performance monitoring
- EMS audits and non-conformances
- Emergency response
- Environmental briefing documents
- Lessons learnt
- Environment policy
- Management and operational control procedures
- Environmental Consents, Permits, Licenses etc
- Environmental Work Instructions and Method Statements
- The Project EMS and the Requirements of ISO14001
6.21 Project Environmental Policy

A site specific environmental policy has been developed to guide the Environmental Management of the project. This EMS provides the mechanism by which the policy commitments will be delivered.

Site environmental policy statement includes commitments to continual environmental improvement and sustainable development. It recognizes environmental issues to be of concern to its customers, employees and the community as a whole, and it acknowledges the importance of working in partnership with them to reduce harmful; environmental impacts and achieve continual environmental improvement. In addition, it makes a commitment to liaison and co-operation with the appropriate authorities in achievement of these aims.

The policy confirms that an Environmental Management Systems (EMS) will be developed to manage the operational aspects of the project. The EMS will be based on the principles set out in the International Standard ISO14001, Environmental Management Systems. The environmental policy will be displayed prominently on notice boards at the site office.

6.22 Project EMS Roles and Responsibilities

Representatives from the above parties have responsibilities to ensure that the EMS is adhered to and implemented at all times during the construction phase as outlined in the following:

Site Roles and Responsibilities

Project Manager

The Project Manager is responsible for authorizing and reviewing the EMS. The Project Manager also will ensure that relevant staff are authorized to take appropriate measures to implement and maintain the EMS and to manage environmental performance.

Site Manager

The Site Manager is responsible for the environmental performance of construction and related activities and for ensuring that the Project EMS is implemented and maintained by other relevant site staff. He also has responsibility for ensuring environmental sections of agreed methods of working (e.g. method statements) are developed.

He will ensure that all contractors and subcontractor staff adhere to the requirements of the EMS. The Site Manager will liaise with the Employer's Chief Resident Engineer.

Environmental Group

Group of environmental specialists from relevant Yemeni Local Authorities and consultants to co-ordinate the commissioning of the Contractor. It is also
responsible for mitigating the social and environmental impacts associated with the development of the project.

The Employer

The Project representatives of the Yemen LCWSSHG- CA will be responsible for ensuring that the Contractor fulfills its obligations under the contract.

Sub-Contractors as employed by the Contractor

There may be several specialist Contractors involved with the project throughout the construction period. These will have to comply with the relevant sections of the EMS implemented by the Contractor.

Environmental and Safety Officer (ESO)

The Environmental and Safety Officer (ESO) will act as the Officer representative of the Project Manager with regard to managing environmental performance and implementing and maintaining the EMS. The ESO will be responsible for revising the EMS as appropriate to ensure that it continuously fulfill the Project Environmental Policy, commitments and satisfies operation requirements.

The ESO will develop appropriate statements, procedures and work instructions for inclusion in Method Statements as required, and will be responsible for ensuring that these are approved by the Project Manager and, if necessary, the Employer's Chief Resident Engineer.

The Environmental & Safety Officer will also undertake internal audits of the EMS, undertake the initial training of site supervisors and provide on-going training support as required by the contractors.

The ESO will provide day-to-day advice with regard to environmental matters on site, such as weekly site inspections, supporting contractor staff training, and supporting external communication as required by the Project Manager, such as liaison with local residents. The ESO will also undertake monitoring of various environmental aspects.

At the beginning, the ESO of the project will be an environmental specialist seconded to the Contractor from a recognized environmental consultancy. The role of the temporary ESO will include the training of a permanent ESO from the Contractor's staff.

External Environmental Auditor

The External Environmental Auditor will undertake independent environmental audits of the EMS at specified intervals.

The project is committed to ensuring adequate resources are made available to the project to implement the EMS and recognizes the need for people on site to understand their environmental responsibilities and authorities within the overall organizational structure. This will be communicated to staff through environmental briefings.
Table (6.2) provides a summary of the mitigation measures, responsibilities and cost of sampling at the pre-construction phase.

Table (6.2) Summary of Mitigation Measures, responsibilities, and costs

<table>
<thead>
<tr>
<th>Item</th>
<th>Potential Negative Impact</th>
<th>Mitigation Measure</th>
<th>Implementation Responsibility</th>
<th>Monitoring Responsibility</th>
<th>Total Phase I Cost (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sewage from destroyed cesspits and households</td>
<td>Contamination resulting from improper disposal of sewage.</td>
<td>Controlled transport to WWTP. Temporary designed and waste dilution if necessary. Cesspit Sampling</td>
<td>Contractor</td>
<td>LCWSHSG-CA</td>
<td>1800</td>
</tr>
<tr>
<td>Improved living conditions for Anopheles</td>
<td>Increase in incidence of malaria</td>
<td>A Malaria Abatement Program will be designed and implemented under the Project</td>
<td>Local malaria and health officials</td>
<td>LCWSHSG-CA</td>
<td>0</td>
</tr>
<tr>
<td>Dried wastewater sludge</td>
<td>storage space.</td>
<td>Sludge re-use policy study to be performed and financed under the Project</td>
<td>LCWSHSG-CA</td>
<td>LCWSHSG-CA, with assistance</td>
<td>0</td>
</tr>
<tr>
<td>Effluent and influent monitoring at WWTP</td>
<td>Low quality wastewater.</td>
<td>Regular sampling will be included in the mitigation measure s.</td>
<td>Independent sampling contractor</td>
<td>LCWSHSG-CA</td>
<td>2800</td>
</tr>
<tr>
<td>Soil &amp; Groundwater.</td>
<td>Contaminated soil and groundwater in construction areas and downstream of WWTP.</td>
<td>Proper clothing and worker education. Proper disposal if warranted soil and groundwater downstream of the WWTP and in the project area will be monitored to determine if contamination has occurred</td>
<td>Contractor, independent sampling contractor (lab tests)</td>
<td>LCWSHSG-CA</td>
<td>6200</td>
</tr>
<tr>
<td>Noise</td>
<td>Disturbances during construction.</td>
<td>Use of heavy equipment restricted from 7 p.m. to 6 a.m proper noise muffling devises, traffic routing and monitoring</td>
<td>Contractor, independent sampling contractor (lab tests)</td>
<td>LCWSHSG-CA</td>
<td>500</td>
</tr>
<tr>
<td>Item</td>
<td>Potential Negative Impact</td>
<td>Mitigation Measure</td>
<td>Implementation Responsibility</td>
<td>Monitoring Responsibility</td>
<td>Total Phase 1 Cost (US$)</td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------------------------------------------</td>
<td>------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------</td>
<td>--------------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td>Dust</td>
<td>Disturbances during construction</td>
<td>Use of suppression measures such as wetting, dust covers and speed restrictions. Monitoring will be carried out.</td>
<td>Contractor, independent sampling contractor (Lab tests)</td>
<td>LCWSSHG-CA</td>
<td>400</td>
</tr>
<tr>
<td>Water Use: On and Off Site</td>
<td>Water contamination. Reduced public water levels</td>
<td>Contractors will be required to bring all water on site in tankers and only be allowed to fill their tankers at approved sites. Water storage provisions must be made.</td>
<td>Contractor, LCWSSHG-CA</td>
<td>LCWSSHG-CA</td>
<td>0</td>
</tr>
<tr>
<td>Hazardous Chemicals</td>
<td>Improper disposal of chemicals used to flush water lines.</td>
<td>Supply of proper training and safety gear, spill contingency plans.</td>
<td>Contractor</td>
<td>LCWSSHG-CA</td>
<td>0</td>
</tr>
<tr>
<td>Medical Clinic</td>
<td>Construction site related injuries.</td>
<td>A temporary clinic will be established in project areas that do not have easy access to local facilities.</td>
<td>LCWSSHG-CA</td>
<td>Contractor, LCWSSHG-CA</td>
<td>8 600</td>
</tr>
<tr>
<td>Public Consultation</td>
<td>Unnecessary disruption affected communities.</td>
<td>An extensive public consultation program will continue to be undertaken, including the use of radio, TV, town meetings, and household surveys.</td>
<td>LCWSSHG-CA</td>
<td>LCWSSHG-CA</td>
<td>2 600</td>
</tr>
<tr>
<td>ESO &amp; information Campaign</td>
<td>Non-compliance with Management Plan.</td>
<td>An Environmental Safety Officer (ESO) will be hired to monitor mitigation measure and disseminate relevant information to public.</td>
<td>LCWSSHG-CA</td>
<td>LCWSSHG-CA</td>
<td>3 00</td>
</tr>
<tr>
<td>Environmental Review</td>
<td>Non-compliance with mitigation Plan.</td>
<td>Semi-annual reviews performed to examine compliance with mitigation plan, regulatory requirements, and to identify potential environmental problems.</td>
<td>LCWSSHG-CA</td>
<td>LCWSSHG-CA</td>
<td>300</td>
</tr>
<tr>
<td>Total Cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>12690</td>
</tr>
</tbody>
</table>
CHAPTER (7)

PUBLIC CONSULTATION MEETINGS
CHAPTER (7)
PUBLIC CONSULTATION MEETINGS

7.1 Introduction
The present project falls under the Category 'B' of environmental screening (The World Bank Operational Policies, OP4.01, Jan 1999) as discussed in EIA Section. However, it is important to maintain effective public involvement throughout project implementation to ensure that local concerns are adequately addressed. Local residents will often be in the best position to observe and report environmental and social impacts. Public involvement is crucial to a sound decision making process.

7.2 Consultation Process
Public Consultation process helps in eliminating any apprehensions regarding the project and gives insights to the problems faced by the lay public and also provides cost-effective solutions by participation of the affected populace in the implementation stage. During consultation, the following key planning tasks are taken care of:

1. Identifying all stakeholder groups
2. Directly affected stakeholders i.e. residents from local areas
3. Al-Mukalla City
4. Fowah City
5. Harshiyat
6. Joul Masha
7. Roukob
8. Buwaysh
9. Al-Eiss
10. Ghail Bawazir City
11. Al-Naga’a
12. Al-Rayyan, occupants of nearby houses, public buildings, farmers
13. Indirectly affected stakeholders including small enterprises around the urban site that provided services to the industries; customers who would lose their customer base. Social assessment can help to determine what interests each stakeholder group has in the project, and which groups have the best influence or control
14. Other Stake holders consulted covered the followings:
   - Fishermen
- Farmers
- Local community of areas receives wastewater, connections
- Agriculture land owners
- Local community of the wastewater plant area
- NGOs and civil community in Al-Mukalla city
- NGOs and civil community in Ghalb - Bawazir
- Religious men in the former areas

Undertaking of the key issues in the areas around which consultation were done for scoping are:

a) Environmental and social issues
b) Key organizations and interested parties involved
c) Local authorities and the agencies involved
d) Size of the issue or importance of the decision
e) Urgency and time frame

Consultations with concerned stakeholders included the following issues:

- Effluent quality and reuse
- Treatment plant capacity, site ability to accommodated future expansion and appropriate technology
- Disruption of services
- Project effects on marine environment
- Odor generation and vector breeding
- Coordination with Environmental Agencies
- Siting impacts on land use
- Proper control and disposal of construction materials and wastes
- Soil and groundwater contamination
- Surface water contamination
- Impacts on antiquities
- Maintenance and operation
- Construction impact on villagers
- Emergency evacuation plan in the event of a chlorine leak

To understand the decision making process, i.e. how environmental decisions are made; that is to identify which parties (such as government, sponsors or financing institutions) make which decisions, public consultation and meaningful
consultations typically take place at three different levels: a) conveying information to the public, b) listening to public opinion, and c) involving the public in decision making.

7.3 Public Consultation Meetings

Four Public Consultation Meetings have been planned in the light of the objectives of the proposed study and to ensure that Stakeholders and affected members of the society have an overall understanding of the present water supply and sanitation conditions:

- To determine satisfactory service levels and standards commensurate with affordability and environmental concerns
- There is satisfactory environmental management plan encompassing mitigation, monitoring and institutional measures to be taken during project implementation and operation to eliminate, offset or reduce potentially adverse environmental impacts to acceptable levels.

The first Public Consultation Meeting was held on 14 and 15 April 2002 in Al-Mukalla city at the Conference Room of Ghail-Bawazir Cultural Center. Nineteen participants belonging to different groups of stakeholders participated in the Consultation Meeting. The objective of the public meeting is to obtain comments and other feedback from the public and interested stakeholders on:

a) The broad outlines of the proposed project,

b) The proposed scope of the Environmental Assessment and Environmental Management and Monitoring Plan.

Accordingly, a hand out containing brief Project Outline, in Arabic, was circulated to all the participants for their information and comments. All the participants showed keen interest and freely expressed their views.

Further, the second and third Public Consultation Meeting was held in Al-Mukalla City and in Ghail-Bawazir on 24 and 25 December 2002 with different groups of stakeholders to elicit their expectation on environmental impacts (i.e. Construction / Operation phase impacts, Social impacts); various mitigation measures and monitoring.
CHAPTER (8)
IMPLEMENTATION OF THE ENVIRONMENTAL MONITORING AND MITIGATION PLAN
CHAPTER (8)
IMPLEMENTATION OF THE ENVIRONMENTAL MONITORING AND MITIGATION PLAN

8.1 General

The implementation of the environmental monitoring and mitigation plan for the Project will occur in three distinct phases, according to the program schedule in table (8.1). It is suggested that the Client initiate the formation of an environmental division within its facilities at the local authority for water and sanitation in Al-Mukalla. An Environmental and Safety Officer (ESO) would be responsible for monitoring and coordinating works to ensure adequate monitoring for the environmental impacts and the mitigation measures. Local experts from the research institutes and universities and governmental authorities shall be involved in the follow-up of monitoring and mitigation measures implementation in the project area.

Table (8.1) Implementation Schedule

<table>
<thead>
<tr>
<th>Event</th>
<th>Implementation Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Pre - Construction Phase</td>
<td></td>
</tr>
<tr>
<td>Establish ESO</td>
<td>-6</td>
</tr>
<tr>
<td>Initiate Baseline Studies(pre-construction testing), and Monitoring program</td>
<td>-5</td>
</tr>
<tr>
<td>Public Meetings to discuss commencement of Construction Activities</td>
<td>-4</td>
</tr>
<tr>
<td>Design and Implementation of Malaria Abatement Program</td>
<td>-3</td>
</tr>
<tr>
<td>Commencement of Sludge and Wastewater Re-use Study</td>
<td>-2</td>
</tr>
<tr>
<td>II) Construction Phase</td>
<td></td>
</tr>
<tr>
<td>Initiate construction Monitoring and Supervision Inspections, Audits and Random Sampling</td>
<td>0</td>
</tr>
<tr>
<td>Public Meetings, and Environmental Audit</td>
<td>0</td>
</tr>
<tr>
<td>Submission of semi-annual Environmental Report</td>
<td>1</td>
</tr>
<tr>
<td>Public Meeting, and Environmental Audit</td>
<td>2</td>
</tr>
<tr>
<td>Submission of semi-annual Environmental Report</td>
<td>7</td>
</tr>
<tr>
<td>Public Meeting, and Environmental Audit</td>
<td>8</td>
</tr>
<tr>
<td>Submission of semi-annual Environmental Report</td>
<td>13</td>
</tr>
<tr>
<td>Public Meeting, and Environmental Audit</td>
<td>14</td>
</tr>
<tr>
<td>Submission of semi-annual Environmental Report</td>
<td>19</td>
</tr>
<tr>
<td>Public Meeting, and Environmental Audit</td>
<td>20</td>
</tr>
<tr>
<td>Submission of semi-annual Environmental Report</td>
<td>25</td>
</tr>
<tr>
<td>Public Meetings, and Environmental Audit</td>
<td>26</td>
</tr>
<tr>
<td>Submission of semi-annual Environmental Report</td>
<td>31</td>
</tr>
<tr>
<td>Public Meetings, and Environmental Audit</td>
<td>32</td>
</tr>
</tbody>
</table>
8.2 Activities to be Implemented

Several tasks and activities should be implemented along the execution of the project as briefed hereafter.

**Environmental Monitoring Program**

It is essential to monitor the physical environment of the construction sites prior and after construction activities. This will require quantitative assessments derived from these sites in order to achieve the followings:

- monitor alterations in the existing physical, chemical and biological characteristics of the environment
- determine whether any detected changes in the environmental components are caused by the project or natural occurrences.
- determine the impacts of non compliance with EIA and EMP requirements by the Contractor, in particular to monitor emissions and discharges to ensure compliance with local, national and international standards.
- determine the effectiveness of the ameliorating and mitigating measures.
- highlight areas of concern unforeseen in the EIA and a basis for recommending further mitigation measures.

For the Monitoring Program to be effective it will be during the course of construction and operation, for authorized agents from key agencies and the ESO to occasionally conduct inspections for the purpose of determining compliance with the EMP and all applicable regulations and standards. Access to all sites related to the project must therefore be guaranteed. Accordingly, the contract documents and operating agreements shall incorporate a phrase with similar intent to that outlined below:

"Authorized Officers may:

- Examine and inspect equipment, control equipment, monitoring equipment or plant:
- Take samples of any pollutants that are emitted, discharged or deposited or are likely to be or are of a class or kind that are usually emitted, discharged or deposited from such pre-survey of this type may also help in identifying potentially larger unseen threats to the surrounding environment, such as unseen groundwater contamination"
**Contamination of Groundwater**

A program for the monitoring of pollution of selected groundwater sources will be established. Initially it is proposed to identify three or four wells within the study area for monitoring purposes. The ESO, in consultation with the Contractor, will specify the sites to be covered.

The wells should be the subject of a quarterly monitoring program, preferably starting at least three months before construction activities occur, and located in the immediate areas of influence. This will allow pro-project baseline conditions to be established. Possible changes in yield and quality of these groundwater extraction points should be observed during the period of excavation works.

The monitoring program will address the water extracted from nearby wellfields, which might potentially be contaminated by construction activities. Testing performed at the wellfields should be done in close collaboration with LCWSSHG-CA, in order to ensure that past and current testing are included in the results.

Water quality measurements should comprise the wastewater contaminants from housing and industry (where appropriate), including persistent organic compounds, nitrogen compounds, mineral oil compounds and chloride. The analysis should refer to Yemeni standards and WHO standards.

**Soil Conditions**

As a supplement to the above, prior to construction, a number of test samples should be carried out to determine basic nature and severity of the contamination of soil. The soils should be tested for microbiological contamination (mainly pathogens) and soil acidity and chemical contamination. Five sites should be tested per quarter during the construction phase, with all sites also sampled prior to the mobilization of construction works.

**Loading of Treatment Facilities**

A program for the monitoring of the interim treatment facility will also be established. Sampling will take place every two months, with three random sampling events taking place per annum. Sludge disposal attributable to the project will also be monitored on a quarterly basis, in order to ensure that this sludge is being disposed of properly. Analysis should be a part of the monitoring program. In this context, there is a need within the project framework to ensure that the wastes discharged and re-utilized meet the national standards.

**Malaria Abatement Program**

Malaria Abatement Program shall be implemented under the Project and should be outlined prior to commencement of construction works, such that it influences design and construction decisions. The ESO will be responsible for the
implementation of this program, in coordination with local and national malaria and health officials. The ESO will also be responsible for the hiring and supervision of any specialized personnel required for the implementation of this program.

**Sludge and Wastewater Re-use Study**

A sludge and wastewater re-use study shall be contracted out by the ESO. The study shall be completed prior to the completion of Phase 1 works.

**Site Inspections**

Regular and frequent site inspections will be required to permit the ESO to monitor the performance of the contractor, and at a later date, the system operators with regard to compliance with the stipulations contained in EMP. Site inspection should be carried out on a regular basis but not necessarily to a structured pattern.

To facilitate inspections, a checklist of items to be considered. The checklist should be distributed to all parties concerned with construction, which should also receive a briefing by the ESO prior to initiation of construction works.

**Principal Activities during Construction and Operation**

Several activities would be conducted and would involve mainly the following and the suggested frequency of inspection are highlighted as below:

<table>
<thead>
<tr>
<th>Table (8.2) Frequency of Site Inspections during Construction Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principle Activity</td>
</tr>
<tr>
<td>Site opening</td>
</tr>
<tr>
<td>Trenches / pipe laying</td>
</tr>
<tr>
<td>General activity</td>
</tr>
<tr>
<td>Camp / maintenance facility / pre-fabrication yard</td>
</tr>
<tr>
<td>Borrow sites</td>
</tr>
<tr>
<td>WWTP</td>
</tr>
<tr>
<td>Pre-existing facilities</td>
</tr>
</tbody>
</table>

Therefore, visits and inspections should be conducted in such sites in order to assess physical, chemical and biological conditions of different elements of the surrounding environment (soil, water, air).

**Periodical Environmental Review**

The environmental review process provides an assessment of the project environmental management activities and the effectiveness of the system in fulfilling GOY environmental policy. In implementing the review schemes, project areas perceived as having the highest environmental risk are stressed. The review program has the responsibility to:
• examine compliance with regulatory requirements
• examine line management systems, plant operations, monitoring practices etc.
• identify current and potential environmental problems especially during the operational phase of the project
• check the predictions in the EIA and assure the implementations and application recommended practices and procedures.
• make recommendations for the improvement of the management system of the operation.

It is suggested that the reviews should be performed by an individual authority to be contracted by the Client (can be assisted by the ESO) and conduct its assignment every six months with reports to document the real progress occurring in the field of environmental protection.

**Public Consultation**

The public consultation and awareness program comprises three components: (i) public meetings; (ii) newspaper and television articles and programs; and (iii) household surveys.

Meetings are suggested to be organized by the ESO and held semi-annually before and during the construction period whenever possible. Feedback elicited during these meetings will be used by the ESO in the semi-annual Environmental Reports, in this way, any necessary changes to the mitigation plan will be incorporated.

**NGOs Involvement**

It is also important that, wherever possible, the project helps develop the capacity of NGOs. At this stage, as with all projects, it is difficult to define NGOs that could be directly supported in the program. It will be the responsibility of the PIU and the ESO to identify and encourage NGO involvement.

**Health Clinic**

As part of the project it may be necessary to establish a health clinic (within an existing facility) dealing with populations from affected areas. Clinics should be established in cases where project construction is taking place in areas that are not readily served by local health facilities. Determination of this need will be the responsibility of the coordination with local health officials.

**Mitigation and Monitoring during Operation**

After identifying unavoidable environmental impacts of the project, compensation measures (e.g. replanting of trees, etc.) must be developed. These compensation measures may begin during the construction phase, but should be completed by the beginning of the operations phase. The results of the implementation of the compensation measures should be monitored by the ESO and local environmental
protection authorities, in order to ensure that the original goals of these measures have been met, and to correct false developments.
APPENDICES
PHOTOS
APPENDIX (A)
First Public Consultation Meeting
Republic of Yemen
Ministry of Electricity and Water
Local Corporation for Water Supply & Sanitation
In Hadramout Governorate – Coastal Areas
( LCWSSHG – CA )

Consultancy Services for Preparation of
Environmental Assessment and Environmental
Management and Monitoring Plan
For AL-Mukalla Water & Sanitation System

First Public Meeting
Summary Report

Dr. AHMED ABDEL WARITH
Consulting Engineers

April 2002
Contents

1. General
2. Project Objectives
3. Purpose of this report
4. Project Area
5. Public Consultation
Consultancy Services for Preparation of Environmental Assessment and Environmental Management and Monitoring Plan For AL-Mukalla Water & Sanitation System

First Public Meeting – April 2002

1. General

Al-Mukalla is an active seaport located on the southern shores of the Republic of Yemen. The City is located in a pleasant environment and has several activities varying from tourism to industrialization. Within the efforts to continuously promote and enhance the standards of living and the environmental and public health in the City and surrounding areas, several projects were implemented in the domain of water supply and sanitation.

Regarding the extreme importance of providing potable water to the inhabitants, these projects were leading and more spread compared with sanitation projects. The majority of inhabitants are connected to the water supply system, however, little water is available and pressures are unsatisfactory. Less than 50% or the population are connected to a barely functioning sewerage system. Foul sewers frequently discharge directly to the sea or overflow into Wadis causing pollution and posing health hazards.

As Al-Mukalla has the potential to attract investors, and to become a major commercial, touristic and industrial center, an integrated project for water supply and sanitation for the area is currently in its design phase.
2. Project Objectives

For long term planning of what is identified as Greater Al-Mukalla, a Development Program (DP) for water supply and wastewater collection and disposal is under preparing by Engineering Consultant.

The area to be covered under the succeeding Feasibility Study will be decided under the DP, and the area to be covered by Detailed Engineering Design for a first stage extension will be concluded under the Feasibility Study.

The study area, however will be composed of both Land and Marine areas.

Under a separate contract the Environmental Assessment and the Environmental Management and Monitoring Plan will be prepared. It will be implemented at roughly the same time as preparation of Feasibility Report by the Engineering Consultant.

However as this assignment is coordinated with the Engineering Studies, especially the Feasibility Stage, the actual commencement of work for the preparation of the Environmental Assessment and the Environmental Management and Monitoring Plan will be governed by the availability of the Feasibility Reports.

The Environmental Consultant will ensure that the following objectives are achieved under the project:

a) Stakeholders and affected members of society have an overall understanding of present water supply and sanitation conditions and of future requirements.

b) That services levels and standards are commensurate with Environmental Concerns.

c) There is a satisfactory Environmental Assessment and Environmental Management Plan for first stage investments proposed by the Engineering Consultant.
d) That proposed investments are least cost solution, financially and environmentally sustainable, and appropriate to the circumstances.

3. Purpose of this Report

In the context of implementing a development program for water supply and sanitation for Al-Mukalla (through Others herein termed as the Engineering Consultant), LCWSSHG - CA contracted, Dr. Ahmed Abdel Warith-Consulting Engineers- AAW, as the Environmental Consultant to conduct the Consultancy Services for the Environmental Impact Assessment (EIA), Environmental Management Plan (EMP), and the Environmental Monitoring Plan for the project developed by the Engineering Consultant.

The Engineering Consultant is currently conducting engineering design works of the Project that includes several phases as Inception Phase, Draft / Final Development Program, Draft / Final Feasibility Study.

Currently the Engineering Consultant submitted the Draft Development Program to the Client and one copy was delivered to AAW (The

4. Project Area

The Project area includes Cities and villages in Al-Mukalla and Ghail Bawazir directorates in Hadramout Governorate. The cities (including districts) and villages concerned in the current Project are as follows:

4.1. Al-Mukalla Directorate:

Al-Mukalla City (Old Al-Mukalla, Al-Ommal, October)

Fowah City (Old Fowah, New Fowah, Fowah Ibn Sina)

Roukob Village

Joul Masha Village

Harshiyyat Village

Buwaysh Village
Al-Eiss Village

4.2. Ghail Bawazir Directorate:
Ghail Bawazir City
Al-Naga’a Village
Al-Rayyan Village

5. Public Consultation

The Environmental Consultant will assist in coordinating the EA with government agencies, in obtaining the view of local NGOs and affected groups and in keeping records of meetings and other activities, communications and comments and their disposition.

Four public meetings will be held and inputs from all affected will be solicited.

The first public consultation will take place between award and comments on the draft Feasibility Study prepared by the Engineering Consultant. The objective of this public meeting is to obtain comments and other feedback from the public and interested stakeholders on the proposed scope of the Environmental Assessment and Environmental Management and Monitoring Plan and the broad outlines of the proposed project. Results of this public consultation will be reflected in the draft EA.
Summary

In the context of providing and ameliorating water supply and sanitation services in Al-Mukalla, the Local Corporation for Water Supply & Sanitation in Hadramout Governorate – Coastal Areas (LCWSSHG – CA) launched:

"Al-Mukalla Water Supply and Sanitation Project"

This project comes as a master plan for the area including Al-Mukalla and Ghail Bawazir taking into consideration the existing facilities and the recent projects implemented in the area.

LCWSSHG – CA selected, tendering process and evaluation, two Engineering Consultants Firms namely the Engineering Consultant (Dar Al-Handasah) and the Environmental Consultant (Dr. Ahmen Abdel Warith – Consulting Engineers-AAW) in Association with Misr Consulting Engineers - to conduct an integrated design work for the current project taking into account both engineering and environmental aspects.

The role of the Engineering Consultant is to provide all services required for the sizing of the different elements of the project with all necessary studies including (as an example) population estimation, current and future water consumption, proposing the sizing of new networks and making use of existing ones, proposing locations for pumping stations and wastewater treatment plants besides estimating costs for the above mentioned works and proposing construction phases to suit the prevailing conditions at the project area.

On the other hand, the Environmental Consultant (Dr. Ahmen Abdel Warith – Consulting Engineers-AAW) in Association with Misr Consulting Engineers is concerned with the environmental aspects of the project to highlight its impacts, either positive or negative, on the environment.
Republic of Yemen
Ministry of Electricity and Water
Local Corporation for Water Supply & Sanitation
In Hadramout Governorate – Coastal Areas
( LCWSSHG – CA )

Consultancy Services for Preparation of Environmental Assessment and Environmental Management and Monitoring Plan
For AL-Mukalla Water & Sanitation System

First Public Meeting
Questionnaire-Arabic

Dr. AHMED ABDEL WARITH
Consulting Engineers
In Association with
Misr Consulting Engineers

April 2002
الجمهورية اليمنية
وزارة الكهرباء و المياه
المؤسسة المحلية للمياه و الصرف الصحي بمحافظة حضرموت (مناطق الساحل)
مشروع دراسة الأثر البيئي لإمداد المياه و الصرف الصحي للمكلا و غيل باوزير

إستبيان المشاركة الشعبية في
تقييم الآثار البيئية للمشروع

يهدف هذا الإستبيان إلى استطلاع رأي الجهات والأفراد المعنيين بالمشروع من أجل مشاركتهم في عملية اختيار العوامل البيئية المحتمل تأثرها من المشروع أثناء مراحل التنفيذ و حتى دخوله الخدمة. توصل فريق العمل القائم على دراسة تقييم الآثار البيئية إلى مجموعة من العوامل البيئية لوردها هنا في الاستبيان و دأبل من المادة المشاركين إدراك رأيهم فيها و اقتراح أية عوامل أخرى لها علاقة بالمشروع.

بيانات عن المشارك:

الإسم:

الوظيفة:

الهاتف:

الجهة التابعة لها المشارك:
| (1) | विवेक राय | (2) | (क) |
| (2) | विवेक राय | (3) | (क) |
| (3) | विवेक राय | (4) | (क) |
| (4) | विवेक राय | (5) | (क) |
| (5) | विवेक राय | (6) | (क) |
| (6) | विवेक राय | (7) | (क) |
| (7) | विवेक राय | (8) | (क) |
| (8) | विवेक राय | (9) | (क) |
| (9) | विवेक राय | (10) | (क) |

1. कौन से प्रश्न के जवाब को इस प्रकार प्रदान करने की आवश्यकता है?

2. कौन से प्रश्न के जवाब को इस प्रकार प्रदान करने की आवश्यकता है?

3. कौन से प्रश्न के जवाब को इस प्रकार प्रदान करने की आवश्यकता है?
ثالثاً البيئة الاقتصادية والاجتماعية

1- ما هي أهم العوامل الواجب تناولها في الدراسة

(نعم) (لا)

1) العوامل الديموغرافية

(نعم) (لا)

2) حركة وديناميكية السكان

(نعم) (لا)

3) معدلات الزيادة السكانية

(نعم) (لا)

4) انشطة السكان السائدة

(نعم) (لا)

5) مصادر ومستويات الدخل

(نعم) (لا)

6) سوق العمل والفرص المستقبلية

(نعم) (لا)

7) فرص الاستثمارات الحالية والمستقبلية

(نعم) (لا)

8) مؤشرات الصحة العامة للمجتمع المحلي

(نعم) (لا)

9) الهيكل الاجتماعي للمنطقة

(نعم) (لا)

10) العادات والتقاليد

(نعم) (لا)

11) خصائص الاقتصاد المحلي

(نعم) (لا)

12) استخدامات الاستهلاك السائدة

(نعم) (لا)

13) استخدامات استهلاك المياه

(نعم) (لا)

(لا) أخرى تذكر
رابعًا: البيئة الثقافية والتاريخية

1- ماهي العوامل الثقافية والتاريخية الوافج تناولها بالدراسة

(أ) مستويات التعليم
(ب) المستوى الثقافي
(ج) نسبة الأمية
(د) مقومات الثقافة العامة بالمنطقة
(ه) مقومات الترفيه بالمنطقة
(و) الآثار ذات القيمة التاريخية
(ج) لخرى تذكر
Republic of Yemen
Ministry of Electricity and Water
Local Corporation for Water Supply & Sanitation
In Hadramout Governorate – Coastal Areas
( LCWSSHG – CA )

Consultancy Services for Preparation of
Environmental Assessment and Environmental
Management and Monitoring Plan
For AL-Mukalla Water & Sanitation System

First Public Meeting
Questionnaire – English

Dr. AHMED ABDEL WARITH
Consulting Engineers
In Association with
Misr Consulting Engineers
April 2002
Questionnaire for Public Participation
Environmental Impact Assessment and Environmental Management and Monitoring Plan for AL-Mukalla Water Supply and Sanitation System

This questionnaire intends to consult the authorities and people concerned with the current project (Al-Mukalla Water Supply and Sanitation Project) in order to provide for public participation in choosing the environmental factors that may be liable to impacts upon the implementation of the current project either during construction or operation.

The Project Team working on the study of the Environmental Impact Assessment identified several environmental factors that are listed in this questionnaire hoping that the Participants will provide their point of view or suggestions related to the Project.

Participant Information:

Name:
Position:
Telephone:
Affiliation:

I – Natural Environment

A) In your opinion what are the main natural factors that may probably be affected:
   1. Air quality (Yes) (No)
   2. Groundwater resources (Yes) (No)
   3. Surface water resources (Yes) (No)
   4. Marine environment (Yes) (No)
   5. Topography of the area (Yes) (No)
   6. Fauna (Yes) (No)
   7. Flora (Yes) (No)
   8. Geology of the area (Yes) (No)
   9. Climate (Yes) (No)
   10. Mineral resources (Yes) (No)
   11. Geotechnical properties (Yes) (No)
   12. Erosion and corrosion (Yes) (No)
   13. Forestry (Yes) (No)
   14. Other factors the Participant would like to add

B) What is the most sensitive environment at the Project area?
   1. Marine Environment
   2. Terrestrial Environment
   3. Others (pls. mention):
II – Constructed Environment

A) In your opinion what are the factors and areas to be addressed?
1. Residential areas (Yes) (No)
2. Industrial areas (Yes) (No)
3. Light industrial areas (Yes) (No)
4. Service areas (like markets) (Yes) (No)
5. Solid waste collection sites (Yes) (No)
6. Waste final disposal sites (Yes) (No)
7. Existing water supply networks (Yes) (No)
8. Existing sewerage networks (Yes) (No)
9. Telecommunication service (Yes) (No)
10. Health care sector (Yes) (No)
11. Fishery (Yes) (No)
12. Marine exchange facilities (Harbours,…) (Yes) (No)
13. Tourism areas (Yes) (No)
14. Agriculture activities (Yes) (No)
15. Others (pls. mention):

III – Socio-Economic Environment

A) In your opinion, what are the areas to be addressed?
1. Demography (Yes) (No)
2. Population dynamic (Yes) (No)
3. Rate of population increase (Yes) (No)
4. Prevailing population activity (Yes) (No)
5. Sources and level of income (Yes) (No)
6. Job market and future chances (Yes) (No)
7. Investment chances (current & future) (Yes) (No)
8. Public health indicators (Yes) (No)
9. Social aspects of the area (Yes) (No)
10. Traditions (Yes) (No)
11. Local economy characteristics (Yes) (No)
12. Prevailing consumption pattern (Yes) (No)
13. Water consumption pattern (Yes) (No)
14. Others (pls. mention):

B) In your opinion, what are the activities to be addressed?
1. Agriculture
2. Fishery
3. Commerce
4. Tourism
5. All previously mentioned activities
### IV—Historical and Cultural Environment

A) In your opinion, what are the factors to be addressed?

1. Level of education  
   (Yes) (No)
2. Level of culture  
   (Yes) (No)
3. Illiteracy level  
   (Yes) (No)
4. Potential for general culture in the area  
   (Yes) (No)
5. Potential recreational activity in the area  
   (Yes) (No)
6. Archeological sites  
   (Yes) (No)
7. Potential for visual recreation  
   (Yes) (No)
8. Others (pls. mention):
المؤسسة المحلية للمياه والصرف الصحي بمحافظة حضرموت - مناطق الساحل
مشروع مياه ومحاري المكلا - المرحلة الثانية

كشف بأسماء الشخصيات الاجتماعية وムدراء عموم المراقبة والمؤسسات المدعون لحضور الاجتماع الأول لتقديم الأنس اليابسي لمشروع مياه ومحاري مدينة المكلا المنعقد في قاعة اجتماعات الفرعية التجارية بالمكلا يوم الأربعاء 14/2/2003، ضمن برنامج التشاور حول تقييم الأنس اليابسي للمشروع الذي يقوم به مكتب الدكتور أحمد عبد الوهاب الاستشاري، بالاشتراك مع مكتب المهندسين الاستشاريين المصريون.

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المؤسسة المحلية للمياه والصرف الصحي بمحافظة حضرموت - مناطق الساحل
مشروع مياه ومحاربي المكلا - المرحلة الثانية

كشف بأسماء الشخصيات الاجتماعية ومدرباء في المواقع والمؤسسات المدعون لحضور
الاجتماع الأول لتمكين الأساتز البيئية لمشروع مياه ومحاربي المكلا في مدينة المكلا المنعقد في قاعة
اجتماعات الغرفة التجارية بالمكلا يوم الاثنين 15/4/2002م. ضمن برنامج التشاور حول
تمكين الأساتز البيئية للمشروع الذي يقوم به مكتب الدكتور أحمد عبد الوهاب.
بالاشتراك مع مكتب المهندسين الاستشاريين المصريون.

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ملاحظة: تُستُشهد النتائج في كل عمليّة حسب ترتيب الادارة.
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- المسجل: 4338
- الخدمة: 1977
- الدرجة: 2347
- الملاحظات: 
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Dr. Ahmed Abdel-Warith
Consulting Engineers

Environmental Impact Assessment
for Al Mukalla

EXECUTIVE SUMMARY

This report represents a Draft Environmental Impact Assessment Report for the Water Supply and Sanitation Project developed for the Greater Mukalla Region in the Republic of Yemen. The report is issued in parallel to the draft feasibility study submission by the Engineering Consultant for the Project (AAW & MCE being the Environmental Consultant). The report is issued at this stage as to consider its output during the final design of the project components according to World Bank procedure.

In order to assess the environmental impacts of the project, several steps were undertaken through this project for illustrating the legal aspects controlling the implementation of such project, a description of the project components, an assessment of the possible impacts of the project on the environment, and a plan for mitigation actions and operation monitoring.

The local Policy, Legal Framework and Administration Framework related to the Project were investigated including the organization of Governmental Authority, the National Water and Sanitation Authority (NWSA), and the Local Corporation for Water Supply and Sanitation In Hadramout Governorate - Coastal Areas (LCWSSHG-CA) that is the executing authority of the current project. Relevant Organizations and other relevant authorities as the Environmental Protection Agency as well as the relevant Environmental Legislation have also been highlighted.

The report highlights the current project objectives illustrating the real need for its prompt implementation. The project covers the need of the increased population along the project time horizon, while requires several sites for hosting the different project components.

A baseline study was included showing the present state of the Environment as a background prior to project implementation. This addressed both natural and man made environment including: climate, geology, groundwater hydrology, aquifers, topography, land resources and land uses, water resources, water supply works, distribution network, sanitation system and a summary of the diagnostics of the current systems.

An assessment of potential Environmental Impacts was herein conducted through evaluation of the activities to be conducted during construction and operation of the different project components. The expected potential impact of the different components of the project on the different physical and biotic elements of the environment were identified in order to assess their impacts relative to the background status of the environment; considerations for mitigation measures have also been proposed. The general approach in environmental impact assessment was the prediction of impacts compared with the baseline, consider who or what is
affected by positive or negative impacts, evaluate the significance, and develop specific mitigation measures.

Socio-economic impact assessment revealed that benefits are likely to be obtained from the implementation of the current project through enhancement of public health and reduction in household repairs and protective works against sewage inflow. The wider range of goods and services available will benefit many businesses and make it easier for them to operate and to focus on their core business, e.g. fisheries, tourism and commerce.

The current project in implemented in land plots that are either governmental properties (for pipelines routing) or abandoned sites, some of them are deserted land of no current activities or uses. It was concluded that little or no people will be affected by its intended use through the current project. The construction of works may have positive impacts on economics and landscape value of the land. The water supply and sanitation project in the area will not result in the loss of any archaeological or cultural features.

Construction activities impacts from traffic accessing the construction sites shall result in noise, possible spillage of fuel, lubricants and hydraulic fluid. This impact is temporary except where permanent damage occurs to land or resources. In the absence of adequate measures to manage construction activities it is to be an impact of moderate significance. During site preparation and construction, noise will be generated from a number of sources including; jack hammers, loaders, generators, etc. and in many instances these will be operating in immediate proximity to residential areas. Unmanaged air pollution, especially of particulate and gaseous emission from construction machinery, and some of the unpaved access roads may create nuisance and in extreme cases direct adverse health impacts or damage property. However, these impacts are not severe.

Groundwater at the project area may be affected by contamination from minor spillage at contractor camps or construction materials on site, increased chances of seepages of faecal material and other contaminants due to disturbances in soil physical properties, or increased potential mixing of contaminated surface flows with those of the shallow aquifer water table. With appropriate and effective mitigation in place the negative impacts may have a very short-adverse impact on local groundwater quality, but no adverse consequences are anticipated.

Assessment of the wastewater treatment plants impact initiated with the examination of the proposed layouts and design criteria and the possible modifications to be considered from the environmental point of view. Possible impacts were identified and the issues related to safe disposal of treated wastewater and produced sludge were addressed. The implementation of the current project especially the sanitation components are expected to improve the present state of the marine life within the project area.

With appropriate and effective mitigation in place, the different impacts of the project can be adequately managed. Air quality and noise levels can thus be reduced to low significance, the
negative visual impacts shall also be reduced to low significance. In addition, the impact of solid wastes should also be low, however, failure of mitigation will carry a high risk of much greater impacts.

The philosophy of the Environmental Management Plan addressed in this report includes the physical plan, land use zoning, protection of archaeological sites, social and economic planning, training and education strategies, economic strategy, and construction code of practice. Monitoring of essential parameters were suggested in order to ensure a sustained and environmentally sound operation of the facilities especially the wastewater treatment facility.

Finally, the participation of the public and stakeholders represents a milestone as the Consultants and Authority should consider the public points of concerns relative to the implementation of the current project. The different Public Consultation Meetings held along the project were listed illustrating the consultation process and the output obtained from these meetings.

Impact of WWTP

General

Assessment of the impact of the wastewater treatment plants to be implemented during the current project is of prime importance regarding the main role of wastewater purification prior to disposal to conserve the surrounding environment. Currently the project area is not served by any wastewater treatment plant as the current procedure for wastewater collection and disposal is through septic and holding tanks. Few areas are served with limited wastewater collection system where several local networks were executed through public contributions.

The project includes the construction of several wastewater treatment plants as follows:

- Construction of two modules (7000 m³/d) of the sewage treatment plant (STP) at Wadi Fowah, to serve Al-Mukalla, Old-Fowah, and the transmission line from Mukalla to Wadi Fowah STP.

- Construction of Al-Naga’a village sewage network and installation of a package treatment plant of capacity 150 m³/d (2 x 75 m³/d).

The proposed oxidation ponds for treating the collected sewage at Wadi Fowah treatment plant comprise anaerobic ponds, facultative ponds, and maturation ponds. The Engineering Consultant conducted a survey on actual rates for water consumption and selected water consumption rates to be used in the design of works (74 l/c/d). No sampling or testing have been conducted to determine the characteristics of raw sewage and criteria were proposed as: BOD₅ (500 mg/l), TSS (750 mg/l), NH₃ (100 mg/l), etc. The Engineering Consultant provided a brief on design criteria used to size the wastewater treatment plant highlighting the maximum permissible limits and the chosen criteria for the design as shown in Table (1).
Table (1) Design Criteria for Proposed Treatment Plant at Wadi Fowah

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<th>Purpose</th>
<th>Max. Design Criteria</th>
<th>Chosen Criteria</th>
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<td>Anaerobic ponds</td>
<td>- Receive and remove high organic loadings</td>
<td>- Volumetric Loading: 117 g BOD$_3$/m$^3$/d</td>
<td>- Volumetric Loading: 400 g BOD$_3$/m$^3$/d</td>
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<td>- D.T.: 5 days</td>
<td>- D.T.: 5.0 m</td>
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<td>- η BOD$_3$ removal: 60%</td>
<td>- η BOD$_3$ removal: 60%</td>
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<tr>
<td>Facultative ponds</td>
<td>- Further reduction of organic loading through aerobic and anaerobic actions</td>
<td>- Surface loading: 39 g BOD$_3$/m$^2$/d</td>
<td>- Surface loading: 40 g BOD$_3$/m$^2$/d</td>
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<td>- D.T.: 10 days</td>
<td>- D.T.: 10 days</td>
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<td>- η BOD$_3$ removal: 70%</td>
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<td>- Depth: 1.50 m</td>
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</tr>
<tr>
<td>Aerobic ponds</td>
<td>- Reduction of pathogens</td>
<td>-</td>
<td>Depth: 1.50 m</td>
</tr>
<tr>
<td>Sand Filters</td>
<td>- Removal of S.S.</td>
<td>4 filtration units: each with surface area 121 m$^2$ (11.0 m x 11.0 m)</td>
<td></td>
</tr>
</tbody>
</table>

Comments on Design Approach

- Define the need of preventing sewage infiltration to groundwater.
- Provide full calculation sheet indicating the efficiency of each stage in the removal of the different contaminants.
- Provide layout alternatives and the required storm water collection channels and the possibility of avoiding large flood areas.
- Adjust the expected influent organic loads to normal rates of per capita BOD production and proposed water consumption rates.
- Expected higher concentrations of bacterial cells in influent, and recommendation of using higher number of ponds in series for higher efficiency in pathogens removal.
- Disinfection of the treated effluent with high solids content will be questionable, tertiary treatment works needs to be applied.
- Current design does not provide facilities for sludge drying and disposal.
Wastewater Treatment Plant at Ghail Bawazir

Measures should be taken for the compact treatment unit to reduce or eliminate odor emissions from process and sludge drying and disposal facilities. In addition to the proper sizing based on estimated biological and solids loadings as described for Wadi Fowah WWTP.

Environmental Assessment

The current practice for removal and disposal of liquid waste is considered as a health hazard. It is thus important to start implementing the water supply and sanitation project. Various biological treatment processes will offer high ability to biodegrade the municipal wastewater, each has numerous aspects as construction cost, operation cost, land requirement, efficiency of contaminants removal, operators skills requirement, etc. The proposed treatment process requires the minimum operational capabilities and the lower operating cost, while requiring larger land areas and producing a reasonable effluent quality (less than treatment using mechanical equipment).

Construction Phase

The major impacts due to construction activities related to the construction of the treatment plant site would be related to the followings:

- Construction of access roads
- Optimization of earthworks
- Need for lining material to protect groundwater
- Identifying land requirement and location for effluent reuse activity
- Options for power supply to the site
- Minimizing interference with existing infrastructures and flood streams
- Routing, design, and construction of infrastructure facilities, e.g. access roads, electric power supply facilities, corridors for raw influent and emergency effluent pipelines, etc.
- Installation of temporary facilities for contractors working on site

It is expected that the following would occur during the construction of the wastewater treatment plants:

- Increased traffic due to conveyance of construction materials
- Generation of waste materials, either liquid or solid, from temporary workers camps
- Dust generation during excavation works
- Waste generation from machinery used at site (as spent oil, gasoline, etc.)
Environment Impact Assessment for Al Mukalla

Operation Phase

The preliminary impacts for the construction of the treatment plants can be viewed mainly in the followings:

- Odor emissions may be encountered at the inlet works and the anaerobic ponds of the wastewater treatment plant.
- From actual land uses in the project area, no current activity can be distinguished around the proposed site of wastewater treatment plant at Wadi Fowah thus low impact on the land uses.
- Monitored use of treated effluent to maintain good hygienic conditions.
- Treated effluent characteristics as expected through the engineering design are as follows: BOD$_3$ (30 mg/l), S.S. (30 mg/l), Faecal coliform (<200 / 100ml)
- Treated effluent offers the advantage of being available year round.
- Proposed emergency outfall location is nearby future planned tourism areas.
- Sludge disposal should be addressed to ensure an environmentally sound process of disposal or reuse.
- Increased activities due to daily operation practice.

Environmental Management Plan

All works will be carried out within the existing public properties (effluent reuse properties still to be investigated). Negative impacts that would result in from the construction of the wastewater treatment plant can be minimized through the consideration of several mitigation measures and selection of adequate means of reducing such impacts or conflicts taking into consideration a general environmental management plan as follows:

Construction Phase

The main issues to be considered can be viewed as follows:

- Taking necessary actions for final allocation of land for treatment works and effluent disposal (e.g. land acquisition, end users agreement).
- Effective site management of earthworks.
- Providing adequate signing and protection for temporary access roads or tracks.
- Providing adequate means for water supply and sanitation for the workers at the site of the treatment plant.
- Establishing or nominating the nearest health care facility for emergency cases.
- Abatement of noise and air pollution.
Environmental Impact Assessment for Al Mukalla

- Optimizing earthworks following site geotechnical conditions
- Safety issues during construction, minimizing dust emission to air, etc.

Operation Phase

The negative impacts emanating from the operation of the treatment plant as previously identified can be dealt with through the followings:

Odor Emissions

- Common practice to have the effluent pipe from the anaerobic ponds submerged (collecting effluent from sub-surface relative to top water levels) allows permanent accumulation of oil and grease layer acting as a natural barrier to offensive odors emission and maintaining anaerobic conditions in the lagoons.
- More elaboration on the issue of sludge drying and disposal should be considered in the design work

Effluent Reuse and Disposal

Reuse of treated effluent should be preceded by encouraging a strategy for effluent reuse comprising an assessment of the options available for the use of treated waters including direct reuse within a framework of a specific agricultural project, or through individual uses in addition to the creation of an effective framework for the safe use of treated effluent.

Considerations for effluent reuse should appoint the followings:

- Production, storage and handling of reuse water
- Definition of areas where treated effluent may be utilized
- Effluent disposal scheme
- Adequate monitoring program for reusing treated effluent

Effluent Reuse

- Data on agriculture water consumption will help identifying the required areas of lands to be potential used for agriculture activities using treated effluent as irrigation water, (e.g. 100 m³/ha/d would result in that approx. 140 ha) in addition to identifying potential beneficiaries from effluent reuse
- Recommendations for Yemeni Standards for wastewater reuse should be followed.
- Selection of crops should take into considerations the characteristics of treated effluent
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for Al Mukalla

- Limitations governing discharge of wastewater to public sewers should be followed by connected industrial facilities to minimize accumulation of contaminants as heavy metals into discharged effluent and sludge

- Excess Effluent Disposal
  - The issue of minimizing (or eliminating) the amount of water reaching the marine outfall needs further investigations through the estimates of the areas of land to be used for agricultural activities, the amount of water estimated to be consumed in cultivated areas and the expected amount of excess flow (if any) - at emergency cases - to be discharged to the sea.
  - Considerations of all different aspects in the design of marine outfall: as marine current and tidal flow in addition to the expected solids concentrations in the effluent and the dilution effect of the designed outfall

Sludge Disposal
- The wastewater treatment process will result in the accumulation of solids in the form of sludge mainly in the anaerobic ponds (additional volumes should be considered in these ponds to allow for periodical sludge withdrawal).
- Produced sludge will required further drying or dewatering for decreasing its moisture content while returning the separated flow to the inlet works of the treatment
- Sludge will need further management to ensure sludge safe disposal or reuse profiting from the nutrient incorporated in the sludge material mainly nitrogen and phosphorus

Increased Activities Due to Daily Operation Practice
Increased activities during operation will have low frequency of occurrence as for trucks loading disinfectant to the site, normal inspection of daily operation of the plant, permanent safeguarding of site, and plant daily operators (expected to be a low number of workers).

Monitoring Plan
In order to ensure the proper operation of the implemented project and attain its targets that shall positively enhance the environmental conditions at the project area.

Construction Phase
- Monitor particulate concentrations in ambient air before and during construction
- Monitor increased traffic loads on existing roads
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Operation Phase

After the operation of wastewater treatment plant, several monitoring activities have to be undertaken in order to ensure proper operation of the facility as follows:

- Periodical monitoring of effluent quality reference to final disposal requirements (e.g. BODs, Suspended Solids, pH, Nematodes).
- SAR should be monitored for agricultural practice purposes
- Effluent reuse should be maximized while eliminating as possible the use of the emergency outfall to the sea.
- Recording the frequency and amount of treated effluent discharge to the sea to undertake necessary actions if frequent discharge to the sea occurs
- Monitor increased traffic loads on existing roads
- Provide adequate measures for controlling any accidental leakage of chemicals
- Investigate the quality of the produced sludge and the measures taken to promote safe and sustainable use of sludge with the collaboration of Research Institutes.
ملخص
لدراسة تقييم الآثار البيئية لمشروع إمدادات المياه والصرف الصحي
لمنطقة المكلا - محافظة حضرموت - الجمهورية اليمنية

مقدمة
في إطار المجهودات الرامية إلى تحسين وزيادة الخدمات للمجتمعات السكنية في مجال الماء والصرف الصحي، قامت مؤسسة المياه والصرف الصحي بمحافظة حضرموت - المنطقة الساحلية بطرح:

مشروع إمداد بالمياه والصرف الصحي بالمكلا

والمشروع بمستويات مخطط عام للمنطقة شاملًا مناطق "المكلا" و"خليج بابوزير" أخذاً في الاعتبار الخدمات الموجودة حالياً والمشروعات المطروحة حديثاً.

وقد وقع لخبير المؤسسة، بعد عملية طرح وتقييم، على مكتبين استشاريين هما "دار الهندسة بحات الاستشاري"، ومكتب الدكتور أحمد عبد الوالد - مهندس استشاريون، بالإشراك مع شركة "المهندسين المصريون الاستشاريون" بقيادة الاستشاري البيني، وذلك لقيام بأعمال تصميم متكاملة لهذا المشروع أخذاً في الاعتبار العلاقة الهندسية والبيئية.

يقوم الاستشاري البيني بعمل الدراسات والتصميمات الخاصة بمنطقة مكوّنات المشروع وعلى سبيل المثال الدراسات المكانية، الاستهلاك الحالي والمستقبلي للماء، تقرير الشبكات المستقبلية وأطوارها بالإضافة إلى الاستفادة من الشبكات الحالية، تقرير أماكن محطات صرف المياه ومحطات معالجة مياه الصرف الصحي، بالإضافة إلى تقييم التكاليف لمشروع المشروع المختلفة.

وإثر ذلك، يختار مراحل التنفيذ بما يتناسب مع الظروف المادية للمنطقة للمشروع.

ومن ناحية أخرى فإن الاستشاري البيني (أحمد عبد الوالد - مهندس استشاريون) يدرس الآثار البيئية للمشروع سواء الآثار الإيجابية أو السلبية.

ويحتوي المشروع على إنشاء عناصر جديدة للإمداد بالعديد مثل أبار المياه، خطوط نقل المياه، خزانات تجميع المياه، وشبكات توزيع المياه (أدخلاً في الاعتبار شبكات المياه الموجودة حالياً بالمدينة أو التي تحت الإشارة). ويحتوي الجزء الخاص بالصرف الصحي على عناصر مثل شبكات تجميع مياه الصرف، محطات صرف فاقي (الرفع)، محطات معالجة مياه الصرف الصحي، وأعمال النخلة النهائي من المياه المعالجة.

وقد أخذ التصميم في الاعتبار معدلات نمو سكاني وسط بين المعدل السائد على مستوى الجمهورية والمعدل السائد في منطقة المشروع، واستخدم معدلات استهلاك المياه من واقع البيانات الفعلية.
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Consulting Engineers

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والشروط المستقبلية المناسبة. وقد تم دراسة ثلاث حالات لمعدلات استهلاك المياه (75 ل/ساعة، ل/ساعة، و100 ل/ساعة) قبل الوصول إلى التوصيات المطلوبة لتقدير التكاليف الناتجة عن كل حالة. وقد اختار الاستشاري الهندسي الحل الأكثر مناسبة لظروف المشروع من ناحية الاحتمالات وكاليف الإضاءة.

يتم خلال المشروع اختبار أمكانية إزالة المياه، ومحميات الرف، ومحطات معالجة مياه الصرف الصحي، وكيفية التغلب على مشكلة التلوث. وتهدف الدراسة إلى الوصول إلى التوصيات المناسبة من أجل تخفيف هذه الآثار واقتراح ما هو مناسب في مرحلة التصميم الأخاذ في الاعتبار.

مكونات التقرير

يكون تقرير الاستشاري البيئي لهذه الدراسة من عدة أجزاء تبدأ بالجزء الأول وهو ملخص تنفيذي للدراسة يضم الضوء على الدراسة ومكوناتها وبيانات الجزء الشرفية حيث يشملро الفرق بين المشروع والإطار الإداري والقانونية والتشريعات، وليCTR+ أن تتقدم بها أثناء مرحلتي التخطيط ودخول المشروع الخدية بكامل طاقته مع تحديد الآثار السلبية والبيئية للمشروع، وأن تتمثل هذه الدراسة تقييم الآثار السلبية وتشريع الإستعداد من الآثار الإيجابية للمشروع، ثم تؤثر الإجراء البيئية للمشروع، والتي تشكل محاولة على عناصر البيئة المحيطة والصحة العامة ومن خلال التوافق مع الشروط البيئية.

يتناول الجزء الثاني من الدراسة إعطاء الضوء على السياسات والأطر الإدارية، ويتناول فيه قياس معايير الدراسة بتحديد النظام الإداري في منطقة المشروع، طبقًا لنظام الإداري للجمهورية اليمنية والجهات المعنية، بدءًا من المؤسسات المحلية، والشرف الصحي بمحافظة صنعاء - المنطقة المستقلة، والتي تتضمن وزارة المياه والكهرباء، وموروثاً بالجهات الحكومية ذات الصلة والمشروع، وهي مشروعات الري، التي تكون معولمة في مجال البيئة والبيئية، والبرامج، والعلاقات، وبينية حماية البيئة، وغيرها من خلال فروعها ومكاتبها في منطقة المكلا - إضافة إلى حماية المكلا والجهات المعنية التابعة لها كما شملت الجهات المعنية أصباب المصانع وممتلكي السكان المحليين، حيث تم مقابلات شخصية واجتماعات مع معتمد تلك المؤسسات لاستطلاع رأيهم في المشروع.

E.P.A

شمل هذا الجزء تقديم الدراسات البيئية في اليمن من خلال استعراض الممارسات المحتملة، وربطها بيئة حماية البيئة اليمنية، وإشراك القوانين ذات الصلة بالدراسة، والجهة الثالثة من الدراسة الراهنة، وتناول وصف المشروع وأهميته، وردت حاجة المنطقة إلى ذلك مراحل تنفيذه، وقد يتناول هذا
شمالت الدراسة في هذا الجزء أيضاً تحليل التأثير على البيئة البحرية ووضعها الراهن إعتماداً على السياقات البيئية التي قام بها الخبراء وتصويف الآثار السلبية لوصول مياه الصرف إلى البحر.
وتآثر ذلك على الكائنات البحرية وأعمال الصيد والثروة السمكية.

تتناول الجزء الخامس من الدراسة التقييم البيئي الفعلي لعناصر البيئة السابقة دراستها وتوصيف وضعها الراهن ووضعت الدراسة نظام التقييم إعتماداً على مقارنة التغيرات المتوقعة حدوثها (في مراحل تنفيذ المشروع) على الوضع الراهن لكل عنصر من عناصر البيئة وكمية هذا الجزء للطريقة العلمية المستخدمة في عملية التقييم وإختيار أفضل البدائل بعد توصيف وسائل التخفيف لتظهر معظم الآثار المتوقعة في صورتها الإيجابية وكانت نتائج التقييم من خلال هذا الجزء كما يلي:

أثر إيجابية على البيئة الاقتصادية والاجتماعية تتمثل في:

- فتح فرص العمل في مراحل تنفيذ المشروع حيث يتم الإستثمار في العديد من الأعمال بسوق العمل المحلي للمنطقة.

- تنفيذ الخبرات في مجال الأعمال المتعلقة بإعدادات المياه والصرف من خلال الاتصال بالخبراء العاملين بالمشروع.

- زيادة فرص التدريب في المجالات الأخرى المتعلقة بترميم جودة مياه الشرب وجودة مياه الصرف الصحي.

- تحصين ورفع مستوى المعيشة في المجتمع المحلي لمنطقة الدراسة.

- خفض معدلات الإصابة بالأمراض ذات العلاقة بخدمات المياه والصرف بمنطقة المشروع.

- تحصين الصحة العامة للمجتمع المحلي بصفة عامة.

- التعرض للأثر الإيجابي المتوقع على حالة البيئة الاقتصادية وزيادة فرص الاستثمار وإستغلال المنطقة.

- تحسين السياحة البيئية إزاء التحديات المستمرة من الأراضي المستعمرة.

- تحسين جودة الهواء كنقطة إيجابية في تحسين الظروف البيئية.

- من المتوقع زيادة القيمة الاقتصادية للأراضي بمنطقة المشروع كنتيجة لتحسين الظروف البيئية.
Dr. Ahmed Abdel-Warith
Consulting Engineers

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- إتاحة الفرصة للإستغلال الأمثل للأراضي.
- بعد الإنتهاء من المشروع حيث التوقع إعادة توزيع السكان وشل المناطق التي لاتصلها خدمات المياه والصرف مما يحسن الصورة الراهنة لإستخدامات الأراضي.
- الآثار المتوقعة على العمران والآثار ذات القيمة التاريخية:
  خلصت نتائج المشروع إلى تحسن البيئة المحيطة بالمناطق العمرانية وقضاء على تسربات المياه والصرف ومظهر الطفح من الخطوط القديمة مما يمكن على تقليل فرص التأثيرات السلبية على العمران المنطقة وكما أكدت الزوارات الميدانية عدم وجود آثار سلبية على الآثار ذات القيمة التاريخية.

- الآثار المتوقعة على جودة الهواء بمنطقة المشروع:
  1- توجد بعض الآثار السلبية الناتجة من أعمال الحفر وتطير الجسيمات بالهواء وهي آثار مؤقتة تنتهي بإنهاء تلك الأعمال وقد تم وضع التوصيات للتخفيف منها.
  2- توجد آثار سلبية من الإبعادات الهوائية الناتجة من حرق الوقود من المعدات المستخدمة.
  3- توجد ضوضاء من المعدات والأعمال المتعلقة بتوفيد المشروع.
  4- من المستند حسوب إختيارات مرورية في بعض الشوارع بالمناطق السكنية التي تشملها أعمال خطوط المياه والصرف.
  5- هناك احتفال لإنبعاث بعض الروائح الغير مرغوب فيها بمنطقة محطة المعملية.
- شملت الدراسة المقتراحات الفنية ووسائل التخفيف الواجب إتباعها لتقليل الآثار السلبية السابق ذكرها.

- الآثار المتوقعة من الفضلات والمخلفات الصناعية الناتجة عن أعمال المشروع:
  1- أعمال الحفر والبناء ينتج عنها مخلفات صناعية لها بعض الآثار السلبية على المناطق المحيطة.
  2- المخلفات الصناعية البلدية للسكان والعمالين بمنطقة المشروع تناولتها الدراسة أيضاً كمخازن من العناصر السلبية المتمثل تواقيها.
  3- الفضلات والمخلفات الناتجة من محطات المعالجة وتشكل عصدراً مهماً ينتج عن الآثار السلبية على المجتمع المحلي والسكان المجاورين وهي مصدر للروائح الكريهة وتوالى تلاقات الأمراض.
- تناولت الدراسة أفضل السبل لتخفيف الآثار السابقة ووضعت خطة لإدارة المخلفات.
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ويمكن تلخيص ما توصلت إليه الدراسة فيما يخص محطة معالجة مياه الصرف الصحي فيما يلي:

الحاجة لدراسة طريقة التخلص من الهاوات الناتجة من عملية معالجة مياه الصرف الصحي.

تحديد الأراضي المستخدمة في إعادة استخدام المياه المعالجة وتحديد الفئات المتقدمة من هذه المياه.

تصميم المصسب البحري (المستخد من حالات الطوارئ فقط) أخذًا في الاعتبار نواحي التصميم المختلفة من تيار بحرية، وعمق المصب وخلاة.

عمل استنادًا إلى مجموعة المياء المعالجة الناتجة من محطة المعالجة في ألغاز الري بعد اختيار النباتات المناسبة لهذا الغرض.

أن يراعي التصميم الوصول إلى المواصفات المسموح بها لإعادة استخدام المياه في ألغاز الري.

يراعي نسب استناد الكثر في حالات استخدام أو عدم استخدام معالجة متقدمة (ثلاثية) باستخدام المرشحات الرملية، وتأثر ذلك على المياه المعالجة المنتجة.

الآثار البيئية لعملية معالجة مياه الصرف الصحي

مرحلة الإقلاع

يتوقع مع إنشاء محطة معالجة مياه الصرف الصحي أن تنتج بعض المتطلبات للإقلاع وما لها من بعض الأثر السلبي الذي يجب التعامل معه لتفادي حدة تلك الآثار. ومن هذه الاحتياجات ما يلي:

- إنشاء طرق مؤقتة لتنفيذ الأعمال

- وجود منطقة إعداد للعاملين وما يتطلب من إعداد مؤقت بالمياه والتخلص من مخلفات الصرف الصحي والمخلفات الصلبة.

- أعمال الحفر والردم بالموقع وما يتطلب من تعظيم الاستعداد من ناتج الحفر ما لم يكن في أعمال الردم - تلبية لدراسات التربة مع تنفيذ المشروع - مع العمل على تقليل الحميات الأثرية في الهواء.

- التحكم في الثقوب الناتجة عن معدات الإقلاع (مثل الزوبوت).

مرحلة التشغيل

مرحلة التشغيل لمحطات معالجة مياه الصرف الصحي ينتج عنها العديد من الآثار البيئية منها ما يلي:

- تولد الرؤوس خصوصا عند منطقة مدخل المحطة

- التأثير على استخدامات الأراضي سواء المحيطة بموقع المحطة أو القربية من المصاب البحري.
زيادة الحركة على الطرق المحيئة بسبب نقل المواد الكيميائية المستخدمة في تطهير المياه المتعادة.
- الاحتياج المستمر لاستخدام المياه المعالجة والحياة الناتجة في أعمال رئي ذا يناسب مع طămية المياه والحياة الناتجة، واحتياجات النباتات بعد اختيار اسمها للزراعة.
- احتمال تسرب مياه الصرف الصحي الخام من قاع البحيرات.

الإجراءات الوقائية وخطة المراقبة البيئية

مرحلة الإنشاء

يمكن اتخاذ العديد من الإجراءات الوقائية لتفقد الآثار السلبية والمراقبة البيئية في مرحلة إنشاء محلة معالجة مياه الصرف الصحي (كما هو الحال لباقي عنصر المشروع) نذكر منها ما يلي:
- توفير الخدمات الموكلة لتوفير مياه الشرب والتخلص من مياه الصرف الصحي والمخلفات للعملية.
- اتخاذ الإجراءات الوقائية لمنع أو تقليل الاثنان الضرر في أعمال الحفر.
- إحالة المراقبة على محفزات المعدات المستخدمة في أعمال الإنشاء وتجميع المخلفات الناتجة للتحصين السليم منها.
- رصد نوعية الهواء قبل وأثناء مرحلة الإنشاء.

مرحلة التشغيل

كما يمكن اتخاذ إجراءات وقائية لتفقد الآثار السلبية والمراقبة البيئية في مرحلة تشغيل هذه الممتلكات (كما هو الحال لباقي عنصر المشروع) ومنها ما يلي:
- الرصد المستمر ل نوعية المياه الناتجة من عملية المعالجة.
- الدراسة المستمرة ل نوعية النباتات المزروعة وتواقفها مع نوعية المياه المعالجة.
- رصد عدد مرات استخدام المصب البحري والعمل على تقليل المياه المنصرفة منه وذلك باستهلاك المياه المتيد في أعمال التربة.
- استخدام المواد البلاستيكية المبسطة لقطع وجوائب البحيرات لمنع تسرب مياه الصرف الصحي الخام إلى التربة خاصًا من أمراض المعالجة اللاهوائية.
- دراسة نوع الحماية الناتجة والطريقة الأكثر مناسبة لاستخدامه.
مكونات المشروع

أ - مصادر المياه
ب - شبكات توزيع المياه
ج - خزانات المياه
د - شبكة تجميع مياه الصرف الصحي
هـ - محطات تجميع وضخ مياه الصرف الصحي
و - محطات معالجة مياه الصرف الصحي
ز - أعمال إعادة استخدام المياه المعالجة والتخلص النهائي من المياه والحماة
الغرض من الاجتماع التشاوري

أ - عرض ما توصل إليه الاستشاريون لمكونات المشروع
ب - عرض مرجيات الاستشارات البيئية للتناول الفني للمشروع.
ج - التوصيات المبدئية التي تم التوصية بها للحفاظ على البيئة في منطقة المشروع.
د - مشاركة الرأى العام بالملاحظات والأضافات لهذا المشروع بصفتهم
آثار إيجابية على البيئة الاقتصادية والاجتماعية

أ - خلق فرص العمل في مراحل تنفيذ المشروع
ب - تكوين الخبرات في مجال الأعمال المتعلقة بإمدادات المياه والصرف الصحي

ك - زيادة فرص التدريب في المجالات الأخرى المتعلقة ومراقبة جودة مياه الشرب وجودة مياه الصرف المعالجة

د - تحسين ورفع مستوى المعيشة في المجتمع المحلي

ه - خفض معدلات الإصابة بالأمراض ذات العلاقة بخدمات المياه والصرف

و - تحسين الصحة العامة للمجتمع المحلي بصفة عامة

ز - انعكاس الآثار الإيجابية السابقة على الحالة الاقتصادية وزيادة فرص الاستثمار وإستغلال المنطقة سياحياً بما تضمه من عناصر ومقومات السياحة البيئية النادرة

الاجتماع التشاوري للسادة ممثلى المجتمع المحلي
لمدينة غيل بباوزير والمناطق المحيطة
الأثر المتوقع على الأراضي وإستخداماتها الراهنة بمنطقة المشروع

أ - المساحات المستقطبة من الأراضي لإستخدامات المشروع وإمداداته لتشكل إعتداءًا على إستخدامات الأراضي الراهنة بمنطقة المشروع ولاتؤثر على المساحات الخضراء.

ب - معالجة مياه الصرف وإتاحة إستخدامها في أعمال الري للمحاصل التي لا تؤكل يعتبر من الآثار الإيجابية ويتيج الفرصة لزيادة الرقعة الزراعية.

ج - تحسين جودة الهواء كإبعاس لزيادة المساحات الخضراء.

د - من المتوقع زيادة القيمة الاقتصادية للأراضي بمنطقة المشروع كنتيجة لتحسين الظروف البيئية.

ه - إتاحة الفرصة للاستغلال الأمثل للأراضي.

بعد الإنتهاء من المشروع حيث المتوقع إعادة توزيع السكان وشغل المناطق التي لاتصلها خدمات المياه والصرف مما يحسن الصورة الراهنة لإستخدامات الأراضي.
الآثار المتوقعة على العمران والآثار ذات القيمة التاريخية

خلصت نتائج المشروع إلى تحسين البيئة المحيطة بالمناطق العمرانية والقضاء على تسربات المياه والصرف ومظاهر الطفح من الخطوط القديمة مما يعكس على تقليل فرص التأثيرات السلبية على العمران بالمنطقة وكما أكدت الزيارات الميدانية عدم وجود آثار سلبية على الآثار ذات القيمة التاريخية.

الاجتماع التشاوري للسادة ممثلو المجتمع المحلي لمدينة غيل باوزير والمناطق المحيطة
الآثار المتوقعة على جودة الهواء بمنطقة المشروع

أ - توجد بعض الآثار السلبية الناتجة من أعمال الحفر وتطهير الجسيمات بالجو. وهي آثار مؤقتة تنتهي بانتهاء تلك الأعمال وقد تم وضع التوصيات للتخفيض منها.

ب - توجد آثار سلبية من الإنبعاثات الهوائية الناتجة من حرق الوقود من المعدات المستخدمة.

ج - توجد ضوضاء من المعدات والأعمال المتعلقة بتنفيذ المشروع.

د - من المتوقع حدوث إختلافات مرورية في بعض الشوارع والمناطق السكنية التي تشملها أعمال خطوط المياه والصرف.

ه - هناك إحتمال لإنبعاث بعض الروائح الغير مرغوب فيها من منطقة محطة المعالجة.

شملت الدراسة المقترحات الفنية ووسائل التخفيف الواجب إتباعها لتقليل الآثار السلبية السابقة ذكرها.
الأثر المتوقعة من الفضلات والمخلفات الصلبة

أ - أعمال الحفر والبناء ينتج عنها مخلفات صلبة لها بعض الآثار السلبية على المناطق المحيطة.

ب - المخلفات الصلبة البلدية للفضاء والعاملين بمنطقة المشروع تناولتها الدراسة أيضاً كعنصر من العناصر السلبية المحتمل توقعها.

ج - الفضلات والمخلفات الناتجة من محطات المعالجة وتشكل عناصر مهماً ينتج عنه الآثار السلبية على المجتمع المحلي والسكان المجاورين وهي مصدراً للروائح الكريهة وتوالد ناقلات الأمراض.

تناولت الدراسة أفضل السبل لتخفيف الآثار السابقة ووضعت خطة لإدارة المخلفات.
آثار متوقعة أثناء عمليات البناء والحفر وإمدادات خطوط المياه والصرف

أ - تسرب الزيوت والوقود للتربة.
ب - تراكم المخلفات بالشوارع وإعاقة حركة المشاه.
ج - تكدس المعدات بالمناطق السكنية.
الأثر المتوقع من جراء التلوث للأعمال والمعدات المستخدمة

احتمالات تلوث المياه الجوفية في مناطق الأعمال من التسربات وأعمال الحفر.
احتمالات تغير مواصفات المياه أثناء فترة تنفيذ المشروع.
احتمالات تلوث المياه الجوفية من مياه الصرف المعالجة.
الآثار المتوقعة على البيئة البحرية

خلصت الدراسة إلى أن الآثار المتوقعة توجه إلى تحسين البيئة البحرية ووقف أعمال صرف المياه القادمة الغير معالجة وتحسين أعمال الصيد وزيادة فرص استغلال شواطئ المنطقة.
الآثار البيئية لعملية معالجة مياه الصرف الصحي
مرحلة الإنشاء

- إنشاء طرق مؤقتة لتنفيذ الأعمال
- وجود منطقة إعاشة للعاملين وما تتطلبه من إمداد مؤقت بالمياه والتخلص من مخلفات الصرف الصحي والمخلفات الصلبة.
- أعمال الحفر والردم بالموقع وما يتطلب ذلك من تعظيم الاستفادة من ناتج الحفر ما أمكن في أعمال الردم - تبعا لدراسات التربة مع تنفيذ المشروع مع العمل على تقليل انبعاثات الأثرية في الهواء.
الآثار البيئية لمرحلة التشغيل لمحطات معالجة مياه الصرف الصحي

تولد الروائح خصوصاً عند منطقة مدخل المحطة وتأثير أشعة الأراضي سواء المحيطة بموقع المحطة أو القريبة من المصبا البحر.
زيادة الحركة على الطرق المحيطة بسبب نقل المواد الكيماوية المستخدمة في تطهير المياه المعالجة.
الاحتياج المستمر لاستخدام المياه المعالجة والحماة الناتجة في أعمال ري بما يتناسب مع طبيعة المياه والحماة الناتجة، واحتياجات النباتات بعد اختيار أنسبها للزراعة.
احتمال تسرب مياه الصرف الصحي الخام من قاع البحيرات.
إجراءات الوقائية وخططة المراقبة البيئية
مرحلة الإنشاء

- توفير الخدمات المؤقتة لـ توفير مياه الشرب والتخلص المناسب من مياه الصرف الصحي والمخالفات السلبية
- اتخاذ الإجراءات الوقائية لمنع أو تقليل انبعاث الأتربة في أعمال الحفر
- إحكام الرقابة على مخالفات المعدات المستخدمة في أعمال الإنشاء وتجميع المخالفات الناتجة للتخلص السليم منها
- رصد نوعية الهواء قبل وأثناء مرحلة الإنشاء.
إجراءات الوقائية وخطوة المراقبة البيئية
مرحلة التشغيل

الرصد المستمر لنوعية المياه الناتجة من عملية المعالجة.

دراسة المستمرة لنوعية النباتات المزروعة وتوافقها مع نوعية المياه المعالجة.

رصد عدد مرات استخدام المصب البحري والعمل على تقليل المياه المنصرفة منه وذلك باستهلاك المياه المتبقي في أعمال الرى.

استخدام المواد البلاستيكية المبطنة لقاع وجوانب البحيرات لمنع تسرب مياه الصرف الصحي الخام إلى التربة خاصة من أحواض المعالجة اللاهوائية.

دراسة نوع الحمأة الناتجة والطريقة الأكثر مناسبة لاستخدامه.

الاجتماع التشاورى للسادة ممثلى المجتمع المحلي
لمدينة غيل باوزير والمناطق المحيطة

14
بسم الله الرحمن الرحيم

الموضوع: "البيئة والتنمية" مقالة محاضرة

Meshoud، مهندس مدن الصناعية

مهنة: مهندس المكا - المرحلة الثانية

أعمال الفساد على الإشاعات الأولى لتمذج الأثر البيئي لمبحث ماء

مهندس المكا - المرحلة الثانية

محاضرات الفساد التجارية بالمكا بمختلف الجوانب، 1984

صورة: ينير السماح بخصوص تشييد هذا المشروع حول تقييم الأثر البيئي، والذي تتم تشرب

وعدد الوارد الإستثارة: 

والمهندسين الإستثرا بهم المسرعون:

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<tr>
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الملاحظات:
- يجب استكمال بعض الوثائق المطلوبة.
- يجب عدم الاعتماد على الوارد الإستثارة.
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تم تصحيح بعض الأخطاء الصوتية من الكتابة.
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*Note: The contents of the table are not legible due to the handwriting style.*
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(التوقيعات والرسائل手上ية)