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**PRE-FEASIBILITY STUDY REPORT**  
**TO FUND**  
**A BASELINE ENVIRONMENTAL ASSESSMENT**  
**FOR**  
**ADEN, YEMEN**

**YEMEN FREE ZONES PUBLIC AUTHORITY**

**UNITED ENGINEERS INTERNATIONAL**

**FEBRUARY 1993**

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## **PRE-FEASIBILITY PROJECT SUMMARY**

**Sponsor:** Yemen Free Zones Public Authority  
(YFZPA)

**City and Country:** Aden, Yemen

**Region:** Middle East

**Sector:** Environment

**Project Title:** Aden Free Zone Master Plan

**Project Description:** A master plan for the the Yemen Free Zones Public Authority is nearly complete for the development of the Aden Free Zone in Aden, Yemen. The master plan looked at various criteria for successfully developing an international free zone in Aden by capitalizing on its strategic location relative to international water and air routes. The plan assumes that any development in the free zone should be built to be compatible with the environment. To determine a project's effects on the environment, there must be some standard for comparison. A baseline environmental assessment is considered to be a necessary benchmark to control the amount and extent of environmental damage caused by new development. The level of existing damage to the environment can also be quantified through such a study.

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## **ACKNOWLEDGMENTS**

United Engineers International would like to acknowledge the following U.S. organizations who made significant contributions to the Aden Free Zone Master Plan:

- **URS Consultants**  
Denver and Colorado Springs, Colorado  
Portland, Oregon
- **Louis Berger International, Ltd.**  
Washington, D.C.

## EXECUTIVE SUMMARY

This pre-feasibility study report has been prepared to convey to the reader the intent of the Yemen Free Zones Public Authority (YFZPA) to prepare a baseline environmental assessment for Aden Governorate to limit the amount and extent of damage to the environment caused by new development in the Aden Free Zone and to determine the level of existing damage. Since the Aden Free Zone presents significant business development opportunities for American investors and business interests, the expenditure of funds from the U.S. Agency for International Development (USAID) to conduct such a study would appear to be justified.

The successful development of the free zone is strongly dependent on improvements in Aden consisting of expanded infrastructure and new construction of primarily commercial facilities. One possible side effect of improving facilities in the free zone is damage to the environment. Also, the extent of damage to the environment currently is not known. To answer these two questions a baseline environmental assessment needs to be done in Aden. This information will help reduce the potential for future environmental disasters by having a benchmark to measure possible sources of pollution. Mitigation and cleanup can be performed before new sources of pollution become a problem. Good environmental control will make investing in the free zone more attractive to investors, especially American, and will help reduce the possibility of having to fund a large and costly environmental clean up later.

Aden has a rich history of serving the world's trade as a major international port. During the 1960s, as a British protectorate, Aden was the fourth busiest port in the world. Yemen became a divided country in the 1970s with South Yemen, including Aden, becoming aligned with socialist powers. The reunification of North and South Yemen in 1990 brought with it the country's return to a market-based economy. The development of the Aden Free Zone is seen as a major economic stimulus for the region.

If the feasibility study can be viewed as the root of development, then funding for the feasibility study can be viewed as the seed. The Yemen Free Zones Public Authority is asking the U.S. Agency for International Development to provide funds to conduct a baseline environmental assessment for Aden. The estimated total cost of such a plan is approximately US \$1.75 million. This investment will benefit American firms and contribute to greater understanding and cooperation between the U.S. and this strategic city in the Middle East.

## 1 INTRODUCTION

In April of 1991 a preliminary master plan was completed by United Engineers International (UEI), a Raytheon company, to identify the impacts of Kuwait's reconstruction and replenishment on the logistics infrastructure of the Arabian Gulf region. The study team included companies with extensive experience in international engineering and construction, international cargo transportation, and Gulf economic development. The results of this preliminary study indicated that significant opportunities exist within the region related to the transportation, handling and delivery of heavy and specialized cargoes. Although these opportunities were driven in the short term by the logistical requirements of Kuwait's reconstruction and replenishment, in the long term the requirements were driven by the need for additional specialized facilities within the Arabian Peninsula for the worldwide transport of cargo into, out of, and through the Gulf region. Upon further study UEI determined that the port city of Aden, Yemen, had significant potential to serve as a regional cargo transportation center by virtue of its strategic position on major sea and air routes, and projected growth within the region.

In November 1991, a regional master plan was initiated to establish the data base required to facilitate the commercial development of the Aden Free Zone. United Engineers International was enlisted to accomplish this regional master plan study. The initial study work was done at cost by UEI, with funding provided through the Yemeni government. As a result of this study, including extensive site visits to Aden, it has been shown that a significant potential exists to upgrade and expand the existing facilities in Aden to support a viable free zone offering many opportunities to foreign and domestic investors.

Businesses in the free zone will support many commercial activities in Yemen including the oil and gas industries, light manufacturing, intermodal cargo transfer, and tourism. The *Land Use Plan* prepared by UEI gives a broad perspective of development in the free zone in terms of proposed land uses that would be compatible with the environment and surrounding communities. Such development would impact energy, minerals, transportation, residential and industrial sectors in this developing region resulting in potential damage to the environment.

Because the development of the Aden Free Zone is viewed as critical to the commercial, industrial and economic development and political stabilization of the region, the Yemen Free Zones Public Authority (YFZPA) is formally requesting that USAID funds be set aside for the co-funding of a detailed baseline environmental assessment for the city of Aden, Yemen. The residents of Aden, as well as foreign investors, would benefit from this assessment.

The baseline environmental assessment would be accomplished by United Engineers International and will build upon the data acquired and work already accomplished to date on the Aden Free Zone Master Plan. UEI can combine its extensive experience in environmental engineering and its experience working directly with the Yemeni government on the Aden Free Zone Master Plan. It is expected that the USAID funding would match other funding provided through the government of Yemen for this work effort.

This request is being made jointly by the YFZPA and UEI.

## **2 LOCATION AND BACKGROUND INFORMATION**

### **2.1 Location and Geography**

The newly reunited Republic of Yemen is located along the southern coast of the Arabian Peninsula. The Kingdom of Saudi Arabia is immediately north of Yemen, and the Sultanate of Oman is directly east. The coast of Yemen borders on two major bodies of water, the Red Sea and the Gulf of Aden. The Gulf of Aden opens to the Arabian Sea located to the east (see Figure 1). The country's land area is 500,000 sq. km., and the mostly Muslim population numbers approximately 15 million. Arabic is the dominant language of Yemen, but English is considered a commercial language.

### **2.2 History**

Yemen's rich trading history dates back to the Minaean kingdom of 1200 B.C. It was known as Arabia Felix, the fortunate Arabia, due to its pleasant winter climate, sandy beaches, varied topography, and wealth created by the trade of frankincense. Later coffee became a major source of wealth.

Large lava mountains rise from the shoreline at Aden and create a natural protected harbor for ships. Aden served as a major port for the ancient kingdom of Aswan starting in the 5th century B.C. and continuing until 1497 A.D. when an alternative route was discovered around the tip of Africa. The British established a major settlement and trading center in Aden in 1837. The importance of Aden as a major world trading port peaked in the 1960s under British rule and, at a time, was the fourth busiest port in the world. After the Suez Canal closed in 1967 due to the Arab-Israeli War and the British withdrawal from Aden, activity at the port declined dramatically. Even after the Suez Canal was reopened, traffic through the port of Aden failed to recover.

With the division of Yemen, the economies of the two countries suffered. South Yemen, which included Aden, became economically aligned with socialist countries such as Eastern Bloc European nations, the Soviet Union, North Korea, and the People's Republic of China. The centralized government did not encourage private investment or market-based production.

### **2.3 Current Developments**

On May 22, 1990, the Yemen Arab Republic and the People's Democratic Republic of Yemen, North Yemen and South Yemen, respectively, reunited to become the Republic of Yemen. Since then the government of Yemen has aggressively pursued foreign investment. One major development was the establishment of the Yemen Free Zones Public Authority, which is charged with the responsibility of attracting foreign investment in free zones and thereby encouraging domestic economic growth and social stability. Aden has been chosen as the flagship free zone in Yemen due to its unique and strategic location on the major trade routes of the world (see Figure 2).

Recently significant recoverable oil reserves were discovered in Yemen, which could signal the beginning of a new era in oil production. Transporting oil, or any other commodity for that matter, requires a good transportation and trade industry. These industries form the basis of commercial development that the Yemeni government would like to attract and improve. All of these developments can have an impact on the environment.

Having become a free country, the Republic of Yemen needs western expertise and capital to develop its new market-based economic structure. The transition to a new economy can be difficult, as has been the case in other parts of the world recently. The Arab states can contribute somewhat to help the Yemeni economy develop, but the United States and other western

industrialized nations have the bulk of the available resources necessary to transform Yemen into a regional economic partner. As with many partnerships, each side contributes its resources to benefit both.

United Engineers International (UEI), located in Denver, Colorado, is currently developing the master plan for the Aden Free Zone under a contract with Al Dar Engineering Consultants and Technical Services Company Ltd. of Yemen. UEI, along with its subconsultants, has performed much work in this effort, and the following work items have been completed or are in progress:

- Recommended Free Zone Reserved Area Report
- Resolved Goals for the Aden Free Zone
- Existing Conditions Report
- Case Studies
- Free Zone Hub Administration Report
- Land Use Plan
- Codes, Standards and Regulatory Criteria Recommendations Report
- Phased Development Plan
- Brochure
- Marketing Video
- Satellite Imagery and Geographic Information System
- Cargo Hub Study
- Executive Summary Report

On September 23, 1992, Mr. Hussien Al-Gunied, the general secretary of the Environmental Protection Council of the Republic of Yemen, asked UEI to submit a proposal to conduct a baseline environmental assessment for Aden in anticipation of significant development in the Aden Free Zone. The YFZPA is responsible for assuring that activity within the free zone does not negatively impact the environment; consequently, the YFZPA is the sponsoring authority of this baseline assessment.

### 3 MARKET ANALYSIS

Before getting into detail about the proposed environmental assessment, a discussion of the potential market in Aden would be helpful especially in light of the fact that this report has been prepared with the intent of requesting U.S. funds to accomplish this project. It would be more difficult to justify funding this project if there were no opportunities for American interests. Aden is the financial and business capital of Yemen, which makes the free zone's potential market significant on its own merit. The potential markets for the seaport and the airport are significant by themselves and are analyzed separately.

Little development is possible without a solid commitment from the governing authorities of Yemen and Aden. Fortunately, the new government has taken an active stand to revive a market economy and promote the nation's commercial development despite economic and social adversity. Two major events in 1991 show the nation's determination to resolve its troubles and become partners in international trade: 1) the formation of the Yemen Free Zones Public Authority and 2) the designation of Aden to become a free zone. Recognizing that economic development and social and political stability are mutually supportive, the YFZPA began its mission preparing Aden to become a successful free zone.

#### 3.1 Potential Market for the Aden Free Zone

The economic resources available within Aden will determine which industries can be promoted. One of Aden's major economic attractions is its port (see Figure 3). With Yemen's limited natural resources, low-cost labor pool, and natural harbor, manufacturing would be one suitable industry that should be pursued. Raw materials can be imported from other countries and assembled by Yemeni workers in Aden. Oil production and tourism are other major markets that can be exploited in the Aden Free Zone.

##### 3.1.1 Manufacturing

The growth of manufacturing in Aden will be closely tied to the development of the Aden Free Zone. Raw natural resources, such as textiles, could be imported at the Port of Aden and manufactured into clothing. The completed garments could then be shipped, via sea or air, to other markets around the world. Other potential manufactured products that would be suitable for Aden are footwear, simple electronic components, toys, car parts, and jewelry. Each of these products require high labor times, low labor costs, simple manufacturing, and low weight-to-volume relative to value.

##### 3.1.2 Oil Production and Shipment

The discovery of new oil reserves raises Yemen's prospects of becoming a more substantial producer of oil in the region. Current estimates put Yemen's recoverable oil reserves at 4 billion barrels. Gas reserves are estimated at 15 trillion cubic feet. In 1991 the Yemen Hunt Oil Company produced nearly 195,000 barrels of oil per day. Oil exports amounted to annual sales of nearly a half billion dollars. In 1992 the level of oil production was expected to increase by 10,000 to 20,000 barrels per day.

One oil refinery currently operates in Aden. The Aden Refinery in Little Aden is currently processing 120,000 barrels of oil per day. Prior to 1988 crude oil had to be imported to Yemen for processing because there was no domestic oil production.

In 1991 18 oil companies purchased rights to explore for additional crude. Oil production is expected to be 365,000 barrels per day in 1992 increasing to one million barrels per day by 2000.

This new industry could attract new commercial interest in the area, which could in turn generate more business developments in the free zone.

### *3.1.3 Tourism*

The diversity of its landscape, cultural heritage, and climate make Yemen a fascinating and adventurous tourist attraction. Ecotourists and adventure travelers can use Aden as a departure point for trips to various destinations in Yemen and eastern Africa. For tourists interested in leisure and relaxation the beauty of the sea and beaches draws people to Aden's resorts.

### *3.1.4 Storage and Distribution*

With the local economy based on manufacturing, oil production and transportation, storage and distribution facilities will be necessary in the free zone. Goods must be stored in secure places as they progress from the manufacturing sites to ships and aircraft. Alternatively, imported raw materials may need to be stored before being used in a manufacturing facility in the free zone.

## **3.2 Potential Market for the Seaport**

Because of its strategic location and naturally protected harbor, Aden would appear to be a natural choice for transshipment operations. After all, it is located at the mouth of the Red Sea where several major trade routes converge. In 1990 nearly 18,000 ships went through the Suez Canal of which 7,500 were container or general cargo ships.

Aden is on the long-distance trade route between Europe, India, Southeast Asia and Australia. It is also on the shorter trade route between Europe, the Middle East and India and between the east and Gulf coasts of North America, the Middle East and India. Aden is also nearby for ships traveling between the east coast of Africa, the Middle East, India and Southeast Asia. Most long-distance steamship lines do not stop at any intermediate ports regardless of proximity.

There are other important criteria for transshipment ports. Aden's inadequate port facilities and lack of locally generated cargo make it somewhat undesirable for transshipment operations. The depth of the berths, lack of gantry cranes and roll-on roll-off ramps, insufficient storage area, and lack of computerized control systems makes Aden a less desirable place to transship cargo. Other competitors in the region, like Dubai and Jeddah, have adequate physical facilities, but their locations are not as favorable as is Aden's. Fortunately, these shortcomings at the Port of Aden can be fixed given sufficient resources.

It is fair to say that the Yemen Free Zones Public Authority has the resolve to invest in improvements to the port. Without these improvements, the success of the free zone itself may be in jeopardy. Preliminary estimates of cargo traffic through the Port of Aden show that 150,000 tons of cargo may be processed through Aden in the near future while nearly 1 million tons of cargo could be processed through the port in the long term. Given that improvements to the port facility are made in an orderly and timely manner, Aden could eventually attract up to 20 percent of the total transshipment market in the Middle East. Considering the level of competition in the region, this is a high market share.

## **3.2 Market Analysis for Aden International Airport**

The world's economy has become more globalized due to the speed at which people and commodities can be transported in jet aircraft. Distances now are measured more in terms of units of time. Businesses must respond quickly to the demands of customers and clients or face the prospect of losing business. The Aden Free Zone, in order to compete successfully in the global economy, needs ready access to the air transportation system. The markets that can be served from

Aden are impressive. Europe, Africa, the Middle East and Asia are all almost equidistant from Aden (see Figure 4). This makes the potential market for Aden International Airport and the free zone one of the major justifications for capital improvements. Aden International Airport is the major airport in what was South Yemen that is served by international air carriers. By serving the needs of the city and the free zone, the airport must be planned to accommodate current and future traffic from air cargo shipments and passenger traffic.

### *3.2.1 Air Cargo Market*

The Aden Free Zone will be the major source of air cargo at the airport. Two key elements of the free zone will be the development of industrial parks and capital improvements at the seaport. The airport is located adjacent to the proposed industrial parks and the seaport thereby making access to the air transportation system extremely convenient.

Industrial parks located near airports attract businesses that have some time-sensitive characteristics. For example, distributors of mechanical parts need to stock their products and get them to clients quickly. Manufacturers of pharmaceuticals or perishable goods similarly need to get their products to market as rapidly as possible. Even garments and sporting goods need to be delivered in a timely fashion to meet the market demand based on seasonal variations. In Nepal, which has a similar export potential as Yemen, an estimated 5,000 tons of apparel and 3,000 tons of hides, skins and carpets will be exported in 1994 to 1995 out of a total expected 8,400 tons of exported goods. Leather goods, like handbags and shoes, are also good prospects for light industrial development in the free zone with a need for access to air transportation. These industries already exist in Yemen and can easily be expanded, thus creating an even greater demand at the airport.

The free zone can certainly stimulate the local economy and promote growth in other local industries. Industrial growth outside of the free zone will also create demand for air cargo operations. In the last several decades there has been strong interaction between industrial growth and airport demand. This has come about due to market pressures to reduce travel times of goods and services.

### *3.2.2 Sea-Air Hub Potential*

Delivering products and services by air is certainly fast, but it may not be the most efficient in terms of cost. Increased competition forces businesses to look at ways to reduce costs and increase diminishing profits. This type of business pressure forces producers to find cheaper methods to get their products to market. Transporting goods by air is significantly more costly than by ship and is much faster. A compromise to resolve this dilemma is to create sea-air hubs, which is now the fastest growing segment of the air cargo industry. Under the sea-air hub system ships transport large quantities of goods between major ports. Aircraft are used to deliver the goods from manufacturers and to final markets (see Figure 5). This concept is similar to the hub-and-spoke system developed by the airlines after deregulation to reduce their costs of transporting passengers to many destinations.

Aden's strategic location is ideal for the development of a sea-air hub. One major criteria for the location of a successful sea-air hub is its proximity to major intercontinental sea and air routes. Aden is conveniently located on the major sea route between Europe and Asia. Access to Asian markets is important because recent studies show that within the decade more than half of the world's air cargo will be carried on Asian routes. The rate of growth of air cargo into and out of Asia is expected to be much greater than the growth rate of the air cargo industry in general worldwide.

Improved airport and seaport facilities by themselves do not contribute to the success of a sea-air hub. The link between the seaport and airport is equally critical. Seattle, Washington, is the most successful sea-air hub in the world. The airport is 20 to 25 kilometers from the two seaports at this hub. Aden's airport, on the other hand, is 7 to 10 kilometers from the seaport. A causeway on the west side of the airport goes directly to the port facilities in Aden Harbor. Other factors such as a unified management structure and a computerized cargo tracking system are also important in the success of a sea-air hub.

Unlike Seattle, Dubai's sea-air hub is in a free trade zone. Dubai's sea-air hub supports trade from the U.S. and Europe to Iran, Africa and the Indian subcontinent. The seaport and airport facilities are large enough to have processed more than 17,000 tons of sea-air cargo in 1989. Major air cargo carriers have established bases in Dubai, and 250 companies have established offices there because of the benefits of being in a free trade zone.

A recent market study revealed that a sea-air hub in Aden would process between 3,000 and 5,000 tons of cargo per year by the year 2000. With further improvements these numbers could increase to 10,000 tons per year by 2005. For the sake of comparison, Seattle processed 20,000 tons in 1990. Naturally these estimates for a sea-air hub in Aden are based on the assumption that all capital improvements are made to the seaport and the airport to support this market.

### *3.2.3 Passenger Market*

Tourists form a major source of potential passengers at Aden International Airport. Most international tourists in Yemen are from Germany, France, Great Britain, Arab nations and the Middle East. Most tourists tended to stay in North Yemen according to reports that end in 1990, the year of reunification. That year the percentage of tourists going to South Yemen increased dramatically from the levels of previous years. Nearly 80 percent of all arriving tourists came by air during the period 1988 to 1990 (the years for which data are available).

Passenger counts show that in 1990 nearly a quarter million passengers passed through Aden's airport. In 1988 and 1989 the number of international passengers outnumbered domestic passenger by nearly a two to one margin. In 1990, however, the split was almost even. It is also interesting to note that the aircraft operations jumped nearly 20 percent from 1989 to 1990. There appears to be some correlation between reunification and airport activity although it is too soon to be certain. It is fair to say that reunification and the return to a market economy should foster increased air travel.

Development of the free zone will have a pronounced effect on airport traffic as well. Increased business travel should result directly due to development of the free zone and indirectly due to improved economic conditions overall in Aden as a result of the free zone.

## 4 EXISTING ENVIRONMENTAL CONDITIONS

Environmental concerns fall under three major classifications, namely physical, biotic and cultural. Physical features form the inanimate components of the environment. Biotic communities are the biological living members of our environment. Cultural factors influence the quality of life for humans and must be considered in a complete environmental analysis. Some basic environmental information has been gathered by UEI for the Aden Free Zone Master Plan. This information, however, is typically incomplete or basal.

### 4.1 Physical Characteristics

The physical environment is composed of geological and hydrological features, the climate, and air and water quality. Aden's physical characteristics are reminiscent of a desert environment. The terrain is flat and featureless with nearly barren sand dunes and hills. Little surface water and a hot climate are also typical for desert regions.

#### 4.1.1 Geology

Aden is primarily situated on a coastal plain physiographic zone, which is characterized by flat terrain sloping gently toward the sea. The plain is approximately 50 km wide and consists of alluvial material deposited in layers on a marine bench of sediment and crystalline rock. Several wadis carry the alluvial material from the mountains of the hinterland toward the sea. The wind blows the finer sand and silts to form dunes and silt pans.

In the western parts of the governorate, the sloped plateaus are composed of Cretaceous to Eocene trap sheets. In the eastern regions, the crystalline materials are composed of the Kawr al'Awadhil and Kawr al'Alaliq. Crater has significant geographic relief caused by a volcano cone. Volcanic activity from the Miocene, Pliocene and Recent ages have caused the formation of upland areas in various locations throughout Aden.

Marine geology is also an important facet of the total geological picture of Aden. Recent marine deposits include sands and shells. These deposits lay on top of Upper Medium Quaternary formations. Most of these formations are sandy loams and hard, plastic formations. Under the sandy loams is a heavy layer of loams which are hard to plastic. Powdered and fine sand deposits are located under the heavy layer of loams. In a few areas, sands varying from medium to gravelly can be found.

#### 4.1.2 Hydrology

Surface drainage is the result of the interaction of precipitation, topography, soil mechanics and vegetation. Because of the shortage of rainfall, surface runoff is minimal. Wadi Al Kabir, just west of Greater Aden, runs perpendicular to the shoreline. Drainage flow from the wadi passes over the highway to Little Aden, and there are no visible significant signs of significant damage caused by flooding.

A sedimentary aquifer associated with Wadi Al Kabir is a primary source of water for the people of Aden. Depleting the aquifer rapidly led to the construction of a desalinization plant. Since 1985 the aquifer has shown signs that it is being recharged.

#### 4.1.3 Climate

Aden's climate is "dry tropical." High surface temperatures and little precipitation are characteristic of this type of climate. The mean daily temperature is 28.7°C. The hottest month of the year is

June when the mean daily high temperature is 36.6°C, and the mean daily low during the month is 28.9°C. January is the coldest month of the year with a mean daily high temperature of 28.1°C and a low of 22.4°C. Relative humidity varies between 50 and 80 percent with higher humidity levels in the morning. The mean relative humidity is fairly constant throughout the year.

The average annual rainfall is 46.7 mm. The wettest month is January with an average rainfall of 5.8 mm. The driest month is June with nearly no rainfall. Humidity levels vary from 13% to 99% with a yearly average of 70%.

Predominant winds in Aden are easterly with mean wind speeds around 10 knots. According to wind data from the 1980 airport master plan prepared by Netherlands Airport Consultants, B.V, 63 percent of the time the wind at the airport is less than 10 knots. Average wind speeds are highest in January and lowest in June.

Wind speeds greater than 15 knots can cause dust storms in Aden. Dust can restrict visibility to nearly zero at times but is usually greater than 200 m (54 percent of the time). The wind can lift the sand to heights of 500 m or more. The dust contains high concentrations of sea salt, which can adhere to structures and cause rapid corrosion of unprotected steel surfaces. Fortunately on the average only four to six sand storms occur per year with most storms lasting less than two hours.

#### 4.1.4 Air Quality

Air quality is affected by not only sand storms but by pollutants discharged into the atmosphere by the population. Sand storms place high levels of particulates into the atmosphere which is nearly impossible to filter. Particulates cause breathing difficulties, eye irritation and other adverse impacts.

The current level of air pollution in Aden is not known. The flow of vehicle traffic in the city is slow, which can cause elevated levels of pollution. The level of vehicle traffic has increased significantly (estimated to be by a factor of four) in the past two years. The sea breezes tend to blow the pollution away from the city and into the Red Sea.

#### 4.1.5 Water Quality

Water quality can be affected by both natural and man made factors. The saline nature of the sea water has an aggressive sulfate reaction with concrete. The salinity of the water ranges from 35% to 43% with an average of 41.5%. In the port, substantial amounts of biomass are present. In an area of 1 m<sup>2</sup> 200 grams per day of organisms can be collected from underwater surfaces. These organisms mainly consist of *Balanus Amphitrite*, Polyhets of Hydroids family, amphipods, two-fold mollusks (*Bivalvia*), and colonial ascidius.

Sewage is collected for the vast majority of buildings in Aden. However, the majority of the sewage produced in Aden is not treated before being dumped into the sea. According to the Japan International Cooperation Agency (JICA), the per capita sewage flow for Aden is 118 liters per capita per day (lcd). The biological oxygen demand (BOD) concentration is 324 mg/l; the per capita BOD loading is 38.2 grams per capita per day (gcd).

## 4.2 Biotic Communities

Biotic communities consist of flora and fauna, or plant and animal life. Human development should be compatible with the natural environment to the maximum extent possible. The development of the free zone presents many challenges to planners. The physical size of the free

zone is only one aspect that can alter biotic communities in the area. Another major consideration that needs to be analyzed carefully is the intended uses of land and water in and near the free zone. Increased population and traffic will also have some bearing on the biotic communities that exist in Aden.

#### 4.2.1 Wildlife

The arid climate and sparse vegetation of Aden can only support small forms of wildlife. Generally speaking wildlife is limited to reptiles, small mammals and birds. Species of lizard (*Gecko Pristurus slavipunctatus*) and snake (*Psammophis schokari*) have been observed in Aden along with various small mammals like mice.

Several varieties of birds are evident around Aden especially along coastal areas. Such species as pelicans, egrets, herons, flamingos, spoonbills, ducks, gulls, terns, sandpipers and plovers are found along the shorelines and other wetland areas. The following birds are found further inland in the desert areas: sand partridge, cream colored courser, lichtenstein's sound grouse, black-crowned finch lark, desert lark, hoopoe lark, scrub warbler, desert warbler, red sea warbler, arabian babbler, brown necked raven, and house bunting. Predatory birds include the black kite and dark chanting goshawk.

#### 4.2.2 Vegetation

As with wildlife, the hot and dry climate of Aden does not support much plant life. Long-thorned acacia trees are common in the region especially in the inner coastal plain. These trees have deep root systems to tap ground water. Duom palms (*Hyphaene thebaica*) and Suaeda can be found in Aden and Khormaksar. Large mignonettes (*Reseda amblycarpa*), bushy green capers (*Capparis galenata*), acacias (*Acacia Edgeworthii*), and herbaceous spiderworts (*Cleome brachycarpa*) are also common in Aden.

In hollows and silty areas between sand dunes tussock grass (*Panicum turgidum*) and *Cassius hirstus* are common. Coconut palms are found near the shoreline. Duom palms (*Hyphaene thebaica*) and *Suaeda* grow on the sand dunes between Sheikh Othman and Aden and in Khormaksar.

In the more rugged regions, euphorbia (*Euphorbia schimperi*) shrubs can be found. These shrubs have intricate naked branches and fragrant flowers. The wadis of the region support the acacia and ariata (*Conocarpus erectus*) in coastal areas and the nebq (*Zizyphus spina-christi*) and date palm in drier areas.

### 4.3 Cultural Factors

Development of the free zone not only affects the physical and biotic environments but also the civilization of local human inhabitants. Various cultural concerns need to be addressed during the planning process. Local residents have concerns over the impacts that improvements will have on historic or archaeological sites, recreational areas, socioeconomic considerations, and land use.

#### 4.3.1 Historic and Archaeological Sites

Few historical and archaeological sites exist in Aden. It is, therefore, important to preserve those historical sites that are present. These places are reminders of the heritage of the people of Aden and should be maintained for future generations to enjoy.

One of the oldest sites in Aden is known as the Cisterns of Tawila or the Tanks of Aden. These 18 tanks were built high on the slopes of Jabal Shamsan in Crater in the first century A.D. by the

Himyarites. A network of canals and basins conveyed rainfall to the tanks, which could store up to 45 million liters of water. The tanks were renovated in the mid 1800s by the British.

Two religious monuments in Aden are historically significant. The al-Aidruss Mosque was first built in the 14th century. It was destroyed in 1859 and later rebuilt. It is one of the few buildings in Aden built before 1900. The Aden Minaret was built in the eighth century, but its accompanying mosque is long gone.

An impressive fort built during the 18th century at Jabel Hadid, between Khormaksar and Crater, is currently being used by the military. The fort is protected by massive walls, and mountain tunnels connect sections of the fort to Crater. The steps carved into the rocks of the mountain are also spectacular.

Two old lighthouses at Elephant Bank and Ras Marshaq and windmills in the salt pans south of Mansura are other notable historical sites in Aden.

#### *4.3.2 Recreational Areas*

Being located adjacent to the Red Sea and the Gulf of Aden, it would seem natural that the major recreational amenity for the citizens of Aden is related to the beaches. Abian Beach is just to the east of Khormaksar and offers residents a place to enjoy sports and water activities. Other beaches are located south of Tawahi and south of Little Aden.

The only large stadium in Aden can hold 10,000 spectators. It is located in Crater in a heavily residential area where noise and traffic cause some discomfort for nearby residents.

Local playgrounds and sports fields also contribute to the enjoyment of Aden's residents. Kindergarten schools have playgrounds for the most part, but densely populated areas of Crater, Ma'alla, Tawahi, Sheikh Othman and Dar Saad have insufficient space for playgrounds, which forces children to play between houses or in the streets. Each city district has one or two small sports fields, and schools usually have their own facilities.

There are very few parks in Aden. Sheikh Othman city park and Crater's park surrounding the cisterns are the two major parks in the governorate. Small gardens exist in Tawahi, Ma'alla and Mansura. Khormaksar, Dar Saad, Al-Shaab and Little Aden, however, do not have any public green areas.

#### *4.3.3 Socioeconomic Considerations*

A large part of the human environment is closer to the heart of the people than culture, history and recreation. Some essential factors, like employment, economics, education, demographics, and health affect all people differently. The socioeconomic conditions in Aden are reminiscent of an impoverished nation. With an estimated gross domestic product (GDP) of \$580 per capita, Yemen is one of the poorest Arab countries. The socioeconomic factors affecting Yemen have been caused by limited natural resources, an arid climate, lack of incentives from the previous socialist government, recent reunification, and repercussions of the Gulf War.

Recently there has been a shift from agricultural work and fishing to service industries in cities. Some major industries in which Yemenis work are personal and social services, transportation and storage, hotel and restaurant, and manufacturing. One industry that seems to be expanding rapidly is small shops. This sector has grown from 4% to 22%. Skilled and government employment have remained fairly stable.

The agricultural industry produces fruits, vegetables, qat, coffee, cotton, dairy products, poultry, eggs, meat, fish, livestock and honey. Fishing is becoming more privatized with the advent of fishing villages and the decline of state-run fishing fleets.

One of Yemen's major sources of income is its petroleum industry. In 1991 Yemen exported nearly a half billion dollars worth of oil. Recent explorations have revealed that there may be four billion barrels of oil to be extracted from Yemen along with 15 trillion cubic feet of natural gas. Current oil production is nearly 200,000 barrels per day.

Larger manufacturers produce cement, salt, and flour. Smaller plants typically produce consumer goods, food and building materials for domestic consumption. This segment of the economy employs a small portion of the work force and contributes only 12% to the GDP.

One impediment to Yemen's economic progress has been a high illiteracy rate among the adult population estimated at 45%. This makes it more difficult to fill positions in the service and industrial sectors. Education is compulsory for children seven to 14 years old. After ninth grade, many students drop out of school to pursue work. Aden had 85 schools with 1,933 classrooms, 73,589 students, and 3,176 teachers in 1990.

Higher education is available in Aden through technical schools and the Aden University. The university offers programs in engineering, agriculture, economics, law, medicine and education. Nearly half of the 1,000 degrees awarded in 1990 were in education.

Aden is a cosmopolitan city with a diverse population consisting of Arabs, Bedouins, Somalis and other Africans, and a few Chinese. Aden's population in 1990 was 326,636 not including the 12,712 expatriates working in neighboring countries. The population distribution shows that nearly half of the population is less than 20 years old. The average life expectancy for Yemenis is 45 to 47 years; more than 10% of Aden's population is older than 50. The infant mortality rate for children under 5 years of age is 142 to 210 deaths per 1,000 births, depending on the source. The population growth rate in 1989 was 2.3%.

The life expectancy of the population is directly related to the level of health care that can be provided to the residents. In 1990 Aden had six hospitals with 1,466 beds, two health centers with 34 beds, 11 primary health units, and one mother-and-child center. Medical care was provided by nearly 600 doctors, 27 dentists, 34 pharmacists, 30 laboratory technicians, nearly 1,300 nurses, and more than 200 other health care technicians. Of the various infectious diseases that are common in Yemen, enteritis, influenza, pneumonia, other diarrheal infections, and malaria accounted for most of the cases of infectious diseases in Aden.

#### *4.3.4 Land Use*

The efficient and intelligent use of limited land is an important example of environmental resource management. Proper control of land uses can improve the quality of life in an area. Adjacent land uses should be compatible and as aesthetically pleasing as possible. Good visibility, as a combination of aesthetics and function, is one way to improve a city's image in the eyes of inhabitants and visitors. Efficient land use practice involves the proper placement of residences, businesses, industries and the supporting infrastructure within the limits of an urban environment in a way that produces a quality environment.

Aden's land-use system is best described as mixed use. Residential areas are interspersed with shopping and other business centers. In most areas, apartments are located above businesses in single buildings. Small retail shops and manufacturers are often found in predominantly residential areas of the city. Residential neighborhoods from the British occupation are still primarily single-use areas. Heavy industrial operations are typically segregated from population centers.

The layout and character of Aden is typical of most large cities in the Middle East. Traditional Islamic architecture is very common, but more modern styles are also present. Open air markets and mosques can be found in most areas of Aden.

One land use that probably has the most potential for polluting the environment is solid waste disposal sites. The city's dump is north of Sheikh Othman in Lahej. Another dump in Little Aden is used only for disposing waste generated in the local community. Burning solid waste is still common in Aden, and the subsequent smoke contributes to the level of air pollution in the area.

Land is also used as linkages between city centers or other inhabited sites. These linkages consist of roads, water lines, sewer lines, and electrical and telephone utilities. Water and waste water treatment plants also fall under this category. Aden has a very congested road system perhaps caused by lack of traffic control and traffic flow patterns that are inefficient for the current level of traffic. Most people get around by car or public transportation or on foot; bicycles and motor scooters are nearly nonexistent in Aden.

The city's water distribution system provides municipal water to nearly 79% of the city's residences. Water conservation is encouraged through the use of meters to measure the amount of consumption by each customer. Desalinated water is mixed with groundwater and then pumped to reservoirs or storage tanks. Water is then distributed via a network of water lines throughout the city. Water quality is checked for contamination throughout the distribution system.

The vast majority of buildings in Aden are connected to some sewerage system. The system conveys waste water to the treatment plant near Al-Shaab or directly to the sea.

Three power plants provide electricity for the people of Aden. All of the plants are fueled by heavy oil or diesel from the refinery. There are numerous problems with the power plants. The Hiswa plant has one turbine out of service due to a damaged rotor, which has been sent to Russia for repairs. The other four turbines are operational, but there are many problems with the instrumentation and control system. The hydrogen cooling system is leaking; this condition has been described as very dangerous. The Mansura plant had two turbines out of service due to vibration problems. The smallest plant, in Khormaksar, has been working relatively well.

Eight substations are located around Aden. Electrical power is then distributed through 33kV overhead power lines and underground cables. A 132kV overhead transmission line connects the Hiswa plant to the Abian area.

The city's telephone system is being upgraded to state-of-the-art technology. These upgrades will not be complete for several more years.

## 5 JUSTIFICATIONS FOR A BASELINE ENVIRONMENTAL ASSESSMENT

Before any work can be done related to environmental concerns, it is important to know the status of existing conditions in the area. The previous section of this report described briefly what is known about Aden's environment. By having a good understanding of current environmental conditions, planners will have a better idea of how much damage has already been done to the environment and how to correct those problems.

Another benefit of a baseline environmental assessment is it can help establish a basis from which to measure the effects of industrial and urban development along with the value of better environmental controls. For example, the flow of traffic in Aden is not efficient and could be a source of air pollution. By analyzing the change in the level of air pollution, planners will be able to judge if new traffic control devices have had any impact on the flow of traffic in Aden. A host of other similar studies would be possible with such an assessment. Conversely, planners would be unable to make intelligent comparisons without first having done a baseline assessment.

Any environmental work would be nearly useless if it did not provide some information that could be used to plan for the future. A baseline assessment is the foundation of a useful methodology to prevent or correct damage to the environment caused by neglect or willful destruction. Proper environmental planning saves money in the long term because environmental clean-ups are significantly more costly than environmental safeguards. Naturally environmental safeguards must be planned in advance to prevent future environmental damage.

Conducting a baseline environmental assessment is a good indication that the governing authorities consider environmental protection a priority. The new Yemeni government created the Environmental Protection Council to oversee Yemen's efforts to safeguard their environment. The council recently proposed the draft law for environmental protection. The new government has made a significant and long-term commitment to protecting the environment.

With such a commitment to environmental protection, the Yemeni government hopes to leave a sound legacy for future generations. Conducting a baseline environmental assessment is an early step to ensuring that an important natural resource is well protected. Such initial steps could potentially save significant amounts of money by increasing the level of environmental awareness among officials in the government and thereby reducing or eliminating the possibility of having to take part in expensive environmental remediation later.

## 6 PROPOSED SCOPE OF WORK

The proposed baseline environmental assessment in Aden would be the first phase of what is anticipated to be a three-phased environmental program. In the second phase, information gathered from the first phase would be used to develop an environmental plan for the area. Facilities for hazardous materials, waste treatment and solid waste disposal would be designed to meet Aden's current and future needs. The third phase would involve actually building, operating and maintaining facilities to protect the environment. Although UEI is fully qualified to provide all of these services, the scope of this baseline assessment will be to fulfill only the first phase of this program.

### 6.1 Data for the Study

To conduct a baseline environmental assessment, existing sources of information would be analyzed to learn about the human and natural environment of the area. Studies and data collected from the field will supplement the information acquired earlier. The baseline environmental assessment will be the starting point for more detailed studies and analyses which focus on a specific environmental problem, the impact of a specific project, or the improvement or deterioration of environmental conditions over time.

Data for the baseline environmental assessment will be collected utilizing the techniques of environmental scoping, environmental impact analyses, and socioeconomic studies to evaluate Aden's environment. During this essential phase the existing conditions of the air, soil and water will be determined through data accumulated from the following sources:

- Existing studies, reports, maps and other published documents
- Sampling and testing
- Monitoring and field observations

Most of the work would be done by United Engineers International although it is anticipated that UEI will retain the services of a regional expert to achieve an effective and sensitive cultural focus. UEI also anticipates employing local students from the University of Aden with training in appropriate disciplines to gather data more effectively. This baseline environmental assessment would provide opportunities for training of Yemeni workers and students

### 6.2 Components of the Study

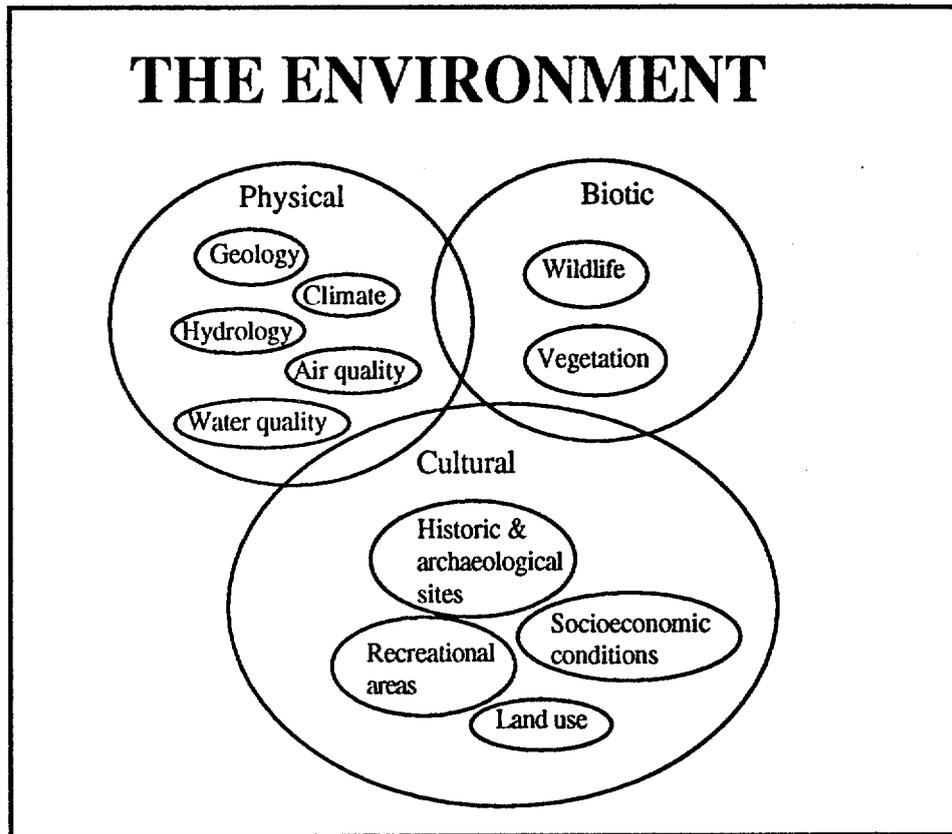
The baseline environmental assessment study will be divided into several groups to present the findings of the study clearly, coherently and intelligently. Within the major components, physical, biotic and cultural features, will be several interrelated subjects all of which, when taken in aggregate, will present a complete picture of the major components of the environment (see Fig. 6.1).

#### 6.2.1 *Physical*

The physical environment consists of those elements that are basic to the existence of the planet. In other words, the physical environment would exist regardless of inhabitants. This category consists of geological formations and topography, hydrology, climate, air quality and water quality. Field and literature investigations will be conducted to characterize the physical environment of the Greater Aden area.

In addition to a review of existing documents, this assessment will include a geological field investigation to identify and characterize the terrestrial structure of the area. Site studies based on

direct field observations will be conducted to provide information to map the surface geology, identify geological hazards, and disclose other relevant information.



**Figure 6.1**  
**Major components of the environment**

The soils in the area also will be studied to identify and characterize the soil units that exist within the area of interest. As with the geological investigation, existing sources of information will be researched first, such as soil maps and scientific literature. A major objective of the soils evaluation study will be to develop appropriate soils maps. Existing soil units will be described in terms of physical and chemical characteristics, suitability for various uses, water transmissibility, and susceptibility to erosion. Only major categories of soils will be identified in the study.

At times there may not be sufficient data to piece together information gathered from existing documents and field investigations. After identifying the information that is still required, additional investigations may be scheduled in conjunction with other development work. For example, core samples taken from new wells being drilled or from geotechnical investigations for building foundations can be used to provide more information about the geological nature of the area.

Hydrological studies are expected to be very limited due to the scarcity of surface water in Aden. Historical records will be researched to determine the amount of precipitation throughout the year in various locations in Aden. The types of soils in the area influence the amount and extent of surface runoff. Topography and ground cover also play significant roles in hydrology. These factors will be examined carefully during this portion of the assessment. Data on ocean waves and currents would also be included in the study. Assuming that there is some surface flow in Wadi Al

Kabir during the wet season, flow measurements will be taken to determine the amount of runoff in the wadi. Flood flows, if any, will be studied to determine the extent of possible flooding in Aden.

Groundwater levels should also be monitored as part of the hydrological assessment. Since groundwater is a source of water in Aden, the depletion of water in the aquifer should be monitored carefully. Monitoring the level of water in the aquifer should be done year round since periodic fluctuations in supply and demand could alter the groundwater level.

To assess the climate and meteorological conditions in Aden, UEI would refer to its collection of climatological records in its library and access records worldwide. Historical data will be gathered from records at the Aden International Airport, World Climate Atlases, satellite records, and other sources to characterize the seasonal frequency and distribution of cyclones and anticyclones, monsoonal flows, temperatures, wind, and other relevant characteristics.

It will be necessary to gather meteorological data on site. This will require that proper instrumentation be installed to measure and record meteorological information. The equipment should be of adequate quality to make it useful in future dispersion modeling studies. Therefore, one year of data should be collected with at least a 95% data recovery rate. These are minimum USEPA (United States Environmental Protection Agency) requirements, which should be appropriate for Aden as well.

As an option, UEI could procure and install the required meteorological monitoring equipment consisting of a tower, sensors, instrumentation, and a shelter for the equipment. UEI could also operate and maintain the facility and perform quarterly instrument calibrations. The meteorological data would consist of continuously measured wind speed and direction, temperature, humidity and precipitation. Data would be recorded automatically and stored electronically. A strip-chart/paper-tape backup would be part the system. This method would recover at least 95% of the accumulated data. PC-based computer programs would be used to reduce and analyze the data for various time distributions, for example, hourly, daily or weekly. The data then can be analyzed, interpreted and presented in a format suitable for the baseline assessment.

Air quality should be monitored and analyzed to determine the level of atmospheric pollutants. Air quality can be monitored either at the meteorological station or at a separate sites. One to three air quality (AQ) stations should produce the desired coverage. The AQ stations will continuously monitor levels of sulfur dioxide (SO<sub>2</sub>), oxides of nitrogen (NO<sub>x</sub>), and particulate matter. Other pollutants, such as carbon monoxide (CO), ozone (O<sub>3</sub>), and hydrocarbons, can be monitored if desired but are not included as a part of this proposal. In addition, metals can be analyzed from particulate samples if desired.

The AQ data will be stored electronically with strip charts used as backups to ensure that at least 85% of the data is recovered. As with the meteorological monitoring program, PC-based computer programs will be used to reduce and tabulate the levels of pollutant concentrations. These concentrations will be compared to the ambient air quality standards used by the USEPA, and the results will be presented in a format suitable for the baseline assessment.

Water quality can be sampled at various sites to determine the level of pollutants in the coastal areas and in the groundwater. Water samples should be taken at several points along the coast. For example, it would be useful to gage the level of pollutants near the desalinization facility and at the sanitary sewer outfalls. Additionally, water in the vicinity of the port facilities and the airport should be monitored for pollutants caused by those operations. The quality of groundwater should also be tested through monitoring wells.

### 6.2.2 *Biotic Communities*

The living non-human elements of the environment should be included as part of the baseline environmental assessment. Wildlife and vegetation should be characterized and mapped by types, communities, and species within the Aden area. The extent of wildlife populations and migration habits should be monitored and their associations with the flora should be analyzed.

The purpose of this effort will be to map vegetation types, identify important plant communities, and construct an inventory of species present. One intent will be to isolate those species that may be threatened or endangered. Maps of vegetation will be developed from satellite data and color imagery. These initial maps will be verified and refined based on field visits and observations. During the field visits, important plant communities within the initial vegetation mapping areas will be identified.

Studies of the local biotic communities will consist of field surveys and literature reviews. Existing relevant studies, reports, maps and other published documents should be reviewed carefully to prepare for field visits. These documents will give investigators a good basis for their field work.

During the seasonal field investigations, qualitative and limited quantitative sampling will be conducted. The qualitative work will consist of verifying information on maps, identifying communities of flora, and compiling an inventory of Aden's flora species. Specific efforts will be committed to identify significant plant communities and species. Significant plant communities or species are those that are unique, rare or endangered (if such recognition is possible) and species that are significant to the economy or to area wildlife.

Some plant communities that have been identified as significant will be sampled to determine their density, frequency, cover and dominance. This information will be used to identify the plant communities and their significance in terms of wildlife habitat, ecological uniqueness, economic importance or other criteria.

The wildlife of Aden will be studied concurrently with the vegetation studies. These studies will serve to characterize the ecological setting, determine the existing wildlife populations, and, to the extent possible, describe plant and animal associations.

Qualitative wildlife studies will be executed during seasonal surveys. During the field surveys data will be collected to provide information on mammals, birds and reptiles; fish populations will not be surveyed. To prepare for site-specific field survey work, existing maps, reports, surveys and other published documents will be researched to find pertinent information on Aden's wildlife.

The field investigation will consist of observing mammals, birds and reptiles (possibly amphibians) to determine the presence and significance of animal groups. Small mammals, such as rodents, and other diurnal species should be trapped alive for positive identification. Care should also be taken to differentiate between migrant and resident bird populations during the field study.

The results of the field investigation will be the basis of a description of the wildlife of Aden. Species that are significant in some way, for example economically valuable; unique, rare threatened or endangered; or having unusual habitat requirements, will be identified to the extent possible considering the limitations of the data. After the data have been analyzed and interpreted, all the findings will be assembled, tabulated and presented in the baseline assessment.

### 6.2.3 Cultural Factors

The human element of the environment also needs to be considered with the same level of analysis that is afforded the physical environment and biotic communities. The characteristics of the culture should be preserved and promoted to benefit future generations of inhabitants. Aden's historic and archaeological sites and recreational areas, and its socioeconomic characteristics and land uses should be investigated to determine the effects that human habitation has already had on the area.

Aden's historic and archaeological sites should be investigated and documented to preserve and protect them from exploitation and damage. This investigation will be done by reviewing existing documents that describe such sites and by interviewing knowledgeable sources, such as city officials, museum curators and educators. Each site that has been identified as a historic or archaeological site should be documented carefully to monitor the effects of development on the sites.

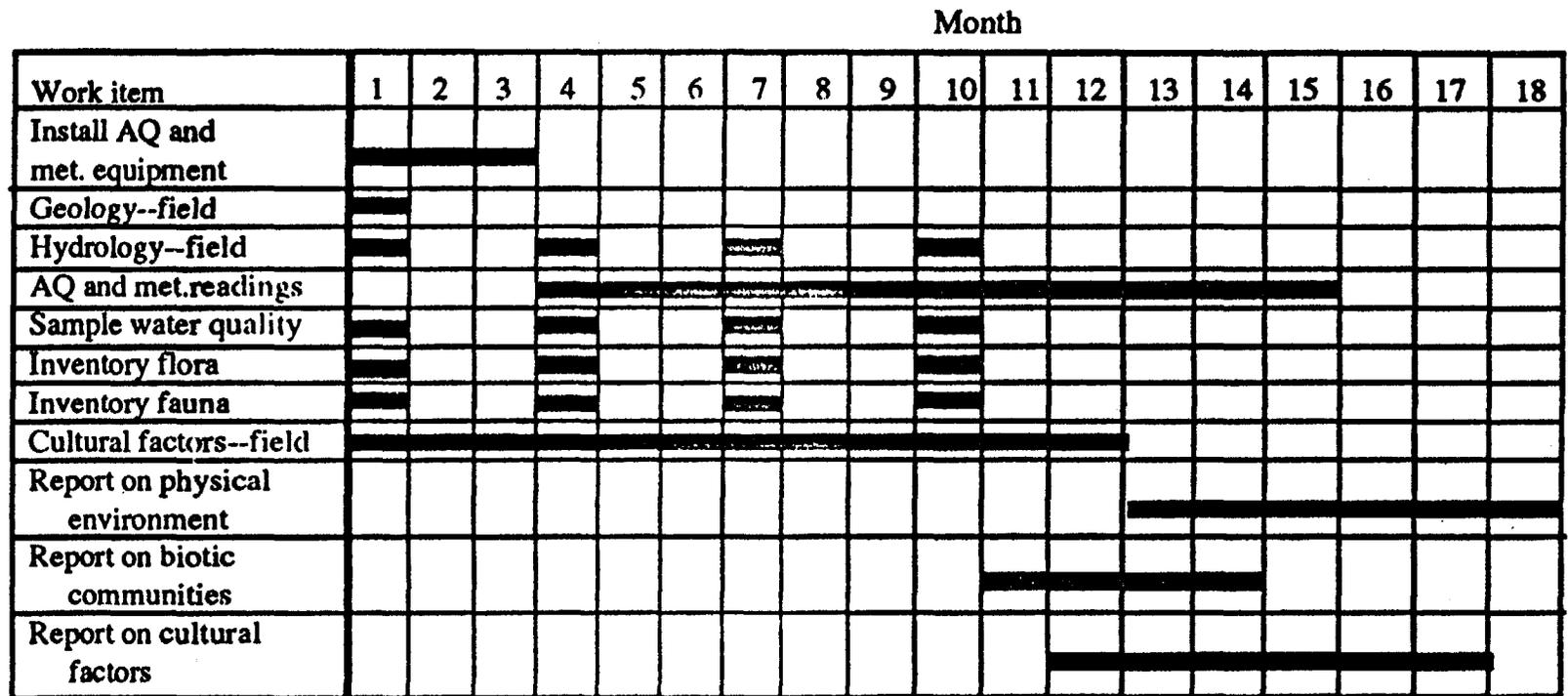
Recreational areas contribute to the quality of life of residents and visitors. Aden's recreational areas should also be inventoried to preserve existing recreational areas and help determine the need for new ones due to future increases in population or differing distributions of Aden's population. This study should be conducted similarly as other aspects of the baseline assessment. Existing documents should be reviewed to get preliminary information followed by actual site visits to the various recreational areas in Aden to determine current conditions. The data should show the types of recreational areas present, and their conditions, locations and sizes.

A land-use plan has been prepared for the YFZPA as part of the master plan for the Aden Free Zone. The plan contains recommendations for certain intended uses of land within the free zone based on several criteria, one of which is compatibility with adjacent districts. The baseline environmental assessment study team will identify the predominant land uses throughout Aden, which will be used to help guide proper development of the free zone. This study will consist of identifying existing land uses, visual aesthetics, and other environmental factors that may affect the public's full use and enjoyment of the land.

Infrastructure facilities and linkages constitute important land uses and will also be identified in this portion of the study. In particular, access routes; utilities, including treatment plants; solid waste landfills; and hazardous waste disposal areas will be examined. If the amounts or types of wastes are excessively damaging to the environment, recommendations will be presented to control wastes more effectively.

### 6.3 Project Schedule

The baseline environmental assessment will take approximately 18 months to complete. The bulk of this time will be spent collecting data. To collect air quality and meteorological data alone is expected to take place over the course of one year. Figure 6.2 shows a proposed schedule to complete the assessment.



**Figure 6.2**  
**Proposed schedule**

## **7 UEI EXPERIENCE AND QUALIFICATIONS**

United Engineers International (UEI), a Raytheon company, is uniquely qualified to perform the work presented in this report. There are many firms that offer environmental services, but only UEI can offer extensive environmental experience in combination with existing knowledge of the Aden Free Zone and working experience with the Yemen Free Zones Public Authority, the Yemeni Environmental Protection Council, and the government of the Republic of Yemen. This section introduces some of UEI's major environmental capabilities.

### **7.1 UEI's Environmental Systems and Services Department**

The Environmental Systems and Services Department (ESSD) of United Engineers International is staffed with personnel trained in the engineering disciplines and sciences necessary to provide a full-service capability related to environmental matters. ESSD is composed of the following three principal groups

- Environmental Licensing and Sciences
- Geotechnical Engineering and Geosciences
- Environmental Systems Engineering.

Together, the staff of environmental engineers and scientists represents a truly integrated resource for the assessment and resolution of environmental problems.

ESSD offers its clients the following environmental services:

- Site selection
- Site planning
- Project licensing
- Environmental impact assessment
- Environmental/compliance audits
- Hazardous materials management
- Wastewater treatment
- Air pollution control
- Incineration systems
- Solid waste treatment and disposal
- Hazardous waste management
- Site environmental assessments
- Hazardous waste site remediation
- Underground storage tank (UST) assessment and remediation
- Laboratory analytical services
- Field testing
- Process simulation and treatment studies
- Start up and operations assistance

UEI's comprehensive worldwide environmental services are integrated with engineering and architectural resources to provide turnkey solutions that can meet all present and future project goals. With more than 5,000 architects and engineers worldwide and more than 100 environmental engineers and scientists on staff, some of whom are currently working on the Aden Free Zone Master Plan, UEI can meet the challenge presented by the Environmental Protection Council of the Republic of Yemen. Through UEI's turnkey capabilities this project can be accomplished in a timely and cost effective manner. UEI is committed to maintaining their reputation by providing their clients with a professionally engineered project on schedule and under budget.

## **7.2 Air Quality**

United Engineers International has the capabilities to procure and install an air quality (AQ) monitoring station, operate and maintain the AQ sensors and instruments, and calibrate the equipment as required. UEI engineers and construction managers can design and procure the necessary tower, instrument building, and instrumentation as well as supervise the installation of the facilities and equipment by others. UEI can provide the option to subcontract with local sources to provide a full time, qualified technician to operate the monitoring system. If the technician needs to be trained, UEI can provide the necessary technical training as well. UEI's environmental engineers would periodically visit the station for routine inspections, maintenance and calibrations. Special visits may be necessary to assure the equipment is fully operational.

## **7.3 Liquid Waste Disposal Experience**

UEI has significant capabilities and experience solving water and wastewater pollution control problems for urban environments, commercial zones, general manufacturing, and petroleum industries. In addition to services in engineering, procurement, and construction, UEI is capable of conducting field development work, process design, plant start-up, operational assistance, and operator training programs. The company can also prepare operation and maintenance manuals for its clients as needed.

UEI has a broad background in physical, chemical and biological waste treatment processes with over 25 years of experience, including more than 60 wastewater treatment plants completed since 1980. The company has undertaken many wastewater treatment projects from grass-roots installations to expansions at existing facilities and upgrades of existing systems. UEI's water pollution control expertise, combined with years of experience serving most industrial categories, provides the company with the ability to develop practical, cost effective solutions to water pollution control problems integrating source abatement with wastewater treatment.

Through a multitude of projects, UEI's staff has gained working knowledge of a wide range of wastewater treatment unit operations including:

- Equalization
- Oil/water separation
- pH control
- Chemical oxidation
- Ozonation
- Chemical reduction
- Chemical precipitation
- Flocculations/coagulation
- Clarification
- Evaporation
- Ion exchange
- Reverse osmosis
- Solvent extraction
- Distillation
- Biological treatment
  - aerobic suspended - growth
  - aerobic attached - growth
- Aerobic sludge digestion
- Polishing filtration
- Sludge thickening
- Mechanical dewatering
- Disinfection

## **7.4 Solid Waste Disposal Experience**

UEI has provided expert services in all facets of solid waste disposal from materials collection and transportation through processing and final disposition. The company's experience includes a broad geographic, technical and economic database encompassing modifications and upgrades of existing facilities as well as designs of new facilities.

### **7.4.1 Waste Incineration**

UEI has demonstrated its expertise in the application and implementation of incineration technology, whether to control air pollution, destroy materials, or reduce the volume of solids. The company has experience with incinerators dedicated to vapors, liquids or solids in addition to multipurpose units handling a variety of wastes. Over the years UEI has gained experience with the use of many types of incinerators, including rotary kilns, fluid bed, moving grate, liquid/vapor, horizontal and downfired with submerged combustion, and multiple-chambered. Many of these employed combustion modifications for NO<sub>x</sub> control using low-NO<sub>x</sub> burners or staged combustion techniques. Most incorporated some form of air pollution control to remove particulates and/or acid gases. Recent designs also incorporated techniques to recover waste heat to produce a more energy efficient operation.

### **7.4.2 Waste Management**

UEI has developed extensive capabilities to solve both hazardous and non-hazardous waste management problems. From the experience of more than 100 assignments directly and indirectly involving various aspects of storage, handling, treatment, disposal and decontamination, the company offers a full range of services from initial site assessments and waste characterizations through detailed design, licensing and site supervision. Staff geologists, geotechnical engineers, and environmental scientists and engineers are fully versed in the proper design of waste containment systems and the evaluation and remediation of contaminated sites.

### **7.4.3 Site Selection**

UEI has been conducting site selection studies since the early 1970s and, to date, has conducted over 30 studies. The company's experience in this field ranges from single-stage siting efforts, which qualitatively evaluate each site's environmental and engineering characteristics, to complex multistage site selection projects, which include quantitative rankings of sites, utilization of the weighting summation model, and nominal group techniques. In addition, the scopes of work for site selection studies have ranged from site investigations for relatively small geographical areas, such as a single county, to multistage efforts.

### **7.4.4 Licenses and Permits**

UEI also has been involved in licensing major utility and industrial facilities since the early 1970s having obtained construction and operating permits for power plants, steel mills, chemical plants, and associated facilities in over 22 states under all major federal regulatory programs. In the past five years, the company has played a major role in the licensing of over a dozen facilities involving generating stations, industrial plants, transmission lines and rail corridors.

## **7.5 UEI Experience in Yemen**

United Engineers International is currently under contract with Al Dar Engineering Consultants and Technical Services Co. Ltd. to develop a master plan for the Aden Free Zone, Republic of Yemen. As a part of this master plan UEI issued an *Existing Conditions Report.*, which documents the

current status of facilities, activities and the natural environment in the Aden Governorate. The information outlined in the report was obtained through field investigations, local and international research sources, and comprehensive literature searches during the first half of 1992.

The report is organized as shown below:

•Description of facilities, utilities and transportation:

- Airport
- Harbor
- Refinery
- Business and industry
- Housing
- Utilities
- Ground transportation

•Description of the current social and economic conditions:

- Industrial production
- Demographics
- Governmental structure
- Regulatory framework
- Archaeological, historical and cultural features
- Cultural issues

•Description of the natural environment:

- Geology
- Hydrology
- Oceanography
- Climate
- Vegetation
- Wildlife

UEI has accumulated a substantial amount of information about Aden, which will benefit the development of a baseline environmental study. This information exists in UEI databases and should help save much time preparing a baseline environmental assessment for the Aden area.

## 8 ESTIMATED COSTS FOR A BASELINE ASSESSMENT

The preparation of a baseline environmental assessment for Aden is expected to take one and a half years. During that time teams of scientists, engineers and technicians will gather data from Aden that will be used to develop sufficient information of existing conditions to provide a basis for the assessment.

UEI proposes to approach this project in three phases as described below. However, only Phase 1 is being proposed at this time; the cost estimate below is only for Phase 1.

### 8.1 Phase 1

This phase consists of environmental scoping studies and an environmental assessment. During this essential phase the air, soil and groundwater will be tested and monitored, and the current socioeconomic conditions will be analyzed.

### 8.2 Phase 2

The results from the phase one will be analyzed in the second phase to develop a plan for Aden's current and future needs. The developed plan could evolve into the design and engineering of facilities for the treatment of hazardous materials, waste treatment, and solid waste disposal. The cost estimate to complete the work in Phase 2 will be developed during Phase 1.

### 8.3 Phase 3

Work during this phase involves the operation and maintenance of the sites and facilities for continued efficiency and productivity. The implementation of an environmental program can be technologically and environmentally complex as well as time consuming.

### 8.4 Cost Estimate for Phase 1

#### *Baseline environmental assessment*

<u>Description</u>	<u>Quantity and Units</u>	<u>Unit Cost</u>	<u>Total Cost</u>
Production Engineering	11,060 man-hours	\$32.12/man-hour	\$355,204
Engineering Support	3,518 man-hours	28.56/man-hour	100,476
Overhead	1 lump sum		555,930
Expenses	1 lump sum		<u>224,548</u>
<b>SUBTOTAL</b>			<b>\$1,236,158</b>
Escalation			31,755
Contingencies	20% of subtotal		247,232
Fee	15% of subtotal		<u>227,272</u>
<b>TOTAL FOR BASELINE ENVIRONMENTAL ASSESSMENT</b>			<b>\$1,742,417</b>

## 9 CONCLUSION AND RECOMMENDATION

The port of Aden in the new Republic of Yemen has been a focal point of commerce in the Middle East for many centuries. Its strategic location on sea and air routes between Europe and the Far East and between Africa and Asia puts Aden at the crossroads of international trade. Under the Soviet-supported socialist regime that lasted several decades, the level of ship traffic through Aden plummeted. Now that Yemen has reunited, the country's economy is based on capitalistic ideals, and Aden is in need of western capital to regain its stature as a world-class port city. Yemen has created a free zones authority to encourage foreign investment in this impoverished nation. A free zone has been established in Aden because of the commercial potential of the port.

United Engineers International, a Raytheon company, is presently under contract with Al Dar Engineering Consultants and Technical Services Co. Ltd., a Yemeni firm, to prepare a master plan for the Aden Free Zone. One of the goals stated in the master plan was that the environment should be protected while developing the free zone. This theme is evident throughout the many components of the master plan, and it is apparent that much work has already gone into assessing Aden's environment.

Any changes, good or bad, to the environment would be nearly impossible to detect, especially when those changes are subtle, without the knowledge of existing environmental conditions. This is precisely why the Environmental Protection Council of Yemen has embraced the idea of conducting a baseline environmental assessment in Aden. There is now a larger potential to affect the environment in Aden because of the development of the free zone.

The Yemen Free Zones Public Authority is committed to preserving the local environment for the benefit of local residents, foreign investors and tourists, and future generations. It will become even more important now to monitor the environment to detect beneficial and harmful trends. Equally important, the baseline assessment will help the Yemenis become aware of existing damage to the environment that will need to be resolved.

The assessment will benefit free zone investors as well as the citizens of Aden. By taking inventory of the existing environment, any damage to the environment will be noted before many new businesses begin work in the free zone. This knowledge will help eliminate indiscriminate accusations of pollution and should help authorities focus their enforcement efforts on likely violators. Foreign investors will also reap the benefits of having their businesses located in a free zone that will attract other complementary businesses.

Based on the information contained in this report, it is recommended that the U.S. Agency for International Development provide funds to the Environmental Protection Council of the Republic of Yemen to conduct an environmental baseline assessment for Aden. The actual baseline environmental assessment report will then be prepared at a cost of \$1,743,000. This cost will vary depending on the quantity and quality of the information acquired during the scoping study. If automated meteorological monitoring equipment needs to be installed, that cost would be approximately \$400,000. A more definitive estimate can be developed if the tower is to be included in the scope of this project.

The formerly divided country is standing ready to welcome foreign investors and tourists. The former South Yemen is once again embracing the ideals of a free market economy and is actively taking steps to reestablish Aden as one of the premiere ports of the world. Environmental awareness and protection is becoming a key goal of the new government with the same level of determination as economic and political reform. The resolve of the Yemeni government to protect the environment in their country is additional testimony to their progressive nature. With the help of friendly governments, such as the U.S., Aden can once again realize its potential as a hub of commerce in the Middle East.