REPUBLIC OF YEMEN

YEMEN: SANA'A BASIN WATER MANAGEMENT PROGRAM

PHASE I PROJECT - ENVIRONMENTAL IMPACT ASSESSMENT REPORT

VOLUME 2: ANNEXES

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ANNEXES

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Annex 1. Field Study Regarding Biodiversity and Cultural Heritage

Introduction

Taking into consideration certain criteria, which include hydrological features, supply structures, irrigation demand and groundwater abstraction and socioeconomic aspects, four areas were initially selected as possible potential sites for dam construction. These areas are

1 Western area (Hamdan and Bani Matar) This area covers sub-basins 14 and 15
2 Southeast area (Sanhan and Bani Bahloul) This area covers the sub-basin 19
3. Eastern area (Bani Hushaish and Bani Al-Harith). This area covers sub-basin 11, 12, 17 and north-east part of 9
4 Northeast area (Nihm and Arhab) This area covers sub-basins 5, 6 and part of 3

Eight possible sites were selected to construct new dams These sites are located in the western, eastern, and north-eastern areas However, only three of these sites will be given priority during stage 1 of the project The eight sites are

5 Shi^{c}b Al-Ma^{c}ādī, Nihm – project site
6 Banī ^{c}Abdillah, Nihm – dropped from project
7 Al-Malāḥ/ near Al-Ḥinamī, Banī Ḥushaysh – project site
8 As-Sin/ near Abū ^{c}Alī, Banī Ḥushaysh – project site
9 Al-^{c}Awrā/ near Ḍarwān, Hamdān – dropped from project
10 Sā'ilat Al-^{c}Uqlah, Arḥab – dropped from project
11 Bahmān/ near Al-Jabbaylah, Nihm – project site
12 Wādī Hijrah, Banī Ḥushaysh – dropped from project

These areas were visited during July 2001. An additional site – Bait Shaiban – was added to the project works during the course of the EIA and was visited later by the EIA team, findings on this site are reported on page 10 The findings of the environmental team on the eight original sites are set out below

Other sites for later consideration are

1 Wādī Mukhtān, Banī Ḥushaysh
2 Al-Qarātil, Bayt N^{c}am, Hamdān

Findings Regarding Biodiversity (by Dr. Abdel Karim Nasher, Biodiversity Specialist)

Eastern Area
This area was visited twice on 12 and 13 July 2001 The first one was made to an existing dam in Bani Hushaish, namely Wadi Mukhtan Dam, which is located at N 15° 22' 49", E 44° 19' 43", alt 2400 masl There was plenty of water in the reservoir However, a good number of plants was growing on the hillsides and were not affected by the large amount of water No mosquitoes were seen breeding in the water. The common plants were *Kanahia lanifolia, Fagonia sp., Argemone mexicana* ,and *Aerva javanica* A few plants of *Citrullus colocynthis*, which is used locally for the treatment of skin itch and dermatitis, were seen near the dam site. Also, *Lavandula pubescens*, used as an infusion for heartburn, was also seen growing in this area Despite the fact that these plants are used "occasionally" by people, they are not of importance from the conservation point of view, and are not endangered species

Since vertebrate animals are generally shy and hide away in the presence of humans, the only one seen was *Agama yemenensis*, a common agamid lizard all over the country A small

stream was seen in the village, a few hundred meters from the dam It was full of *Bufo* tadpoles, leeches and larvae and pupae of *Simulium ruficorne* All of these are not harmful, and apparently were present in the area before the dam was constructed. There are a lot of agricultural fields in this area, and most people grow *qat* and grape vines

The second visit was to the site of Al-Milah, near Al-Hinami village The suggested site for the dam is suitable. It is a mountainous area, and the *wadi* contains small rocks and pebbles No plants of conservation value were seen There were a few weeds which included *Centaurea sp., Aerva javanica, Lavandula pueiscens*, and *Chenopodium sp* No vertebrate animals were seen in this area However the people claim that there are many carnivores which attack their livestock and chicken at night These are possibly wolves, jennets and foxes People in and around this village are engaged in agriculture The most common crop is *qat*, and grapes come in the second place. Construction of a dam in this site does not seem to have a negative impact, as there are no rare and endangered plants growing in the *wadi*

On 26 July 2001, Bahman area was visited The suggested site for dam construction is a narrow gorge located at N 15° 31' 53" E 44° 27' 47" (alt 2459 meters above sea level) This wadi receives a large amount of water during the rainy season Most of the plants growing in and around the *wadi* are weeds of no conservation value. A few trees of wild fig *Ficus sp* were seen growing on the sides of the wadi. The most common herbaceous plants are *Dipcadi veride, Echinops sp , Solanum incanum, Fagonia sp , Boerhavia sp , Pulicaria sp , Fagonia sp* and a few grass species A single plant of the succulent *Kleinia pendula* was seen growing on the *wadi* side A few *Aloe sp* Plants were also seen. No animals were seen at the time of the visit However, the inhabitants of the area claim that foxes are common in the area, and they appear at night

On 31 July 2001, a visit was made to Al Hijra village. The suggested site for the dam is located at N 15° 31' 46" E 44° 34' 55", altitude 2410 meters above sea level The most important plants growing in the area include *Caralluma petraea,* succulent *Euphorbia sp* , and *Dipcadi veride* Common weeds of no conservation value were various grass species, *Fagoni sp , Sonchus sp , Tagetes minuta,* and *Pulicaria sp* There were several fields of *qat* in the bottom of the *wadi* These will definitely be affected and will be flooded if a dam is to be constructed there Therefore, it is very important to bear in mind the problem of compensating the farmers in this area[1].

Northeast Area·
On 19 July 2001, the team visited Nihm on the north eastern part of the basin Two sites proposed for construction of new dams were visited The first is located near Shib-al-Maadi village (N 15° 43' 24" E44° 27' 51", alt. 2047 masl). The site proposed for the dam construction is near a rocky plateau, mainly limestone rocks Two plant species, *Acacia sp* and *Ziziphus spina-christi* can be seen growing in the bottom of the wadi The wood of the first plant is used as fuel and the leaves are consumed by camels The wood of Ziziphus is used by the locals in house construction and the fruits are edible These trees, which make a small population in the *wadi*, will be destroyed when the dam is constructed The most important plants from conservation point of view are *Euphorbia balsimefera, Euphorbia sp , Caralluma spp* and *Aloe sp*

Very few lizards of *Agama sp.* were seen in the area The people who responded to the questionnaire said that wolves, foxes and hyenas are also found People in the area are engaged in agriculture where they grow *qat*, grapes There are also a few orchards where some fruit trees are grown

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[1] This is now a moot point, since this site has been dropped from the project

The Acacia and Ziziphus plants growing in the *wadi* constitute a small population of these two species compared to the populations growing elsewhere in the village, which will not be affected by the dam Other plants growing in the area are weeds of no conservation importance These are *Aerva javanica, Calatropis procera, Solanum incanum, Lavandula dentate* and some grasses which have no conservation valuc

The second site is located near the mountainous village of Bani Abdullah The main activity of the people is growing *qat*. Very few vine fields were seen The suggested site for the dam (N 15° 31' 55" E 44° 26" 02", alt 2364 masl) lies in a relatively narrow wadi with sparse vegetation. The few plant species growing there were weeds of no conservation value Only *Agama* lizards were seen in the wadi. However, people claim that snakes and monitor lizards are also found in the area

On 31 July 2001, Az-Zubairy village in Arhab was visited The proposed site for the dam (Sailat al Oqla) is located at N 15o 35' 13" E 44o 20' 51", altitude 2184 meters above sea level. It is a narrow wadi with sandy/rocky bed It has a high potential for absorbing water efficiently There are several Acacia trees growing at the sides of the wadi, which are likely to be affected if the dam is constructed. The most important plants from conservation point of view are *Dipcadi veride* and *Caralluma spp* No animals were seen during the time of the visit, but the inhabitants claim that hyenas, wolves, and foxes are frequently seen in the area

Field Visit Findings Regarding Cultural Heritage (by Mr. Saba Taher Al Suleihi, Cultural Property Specialist)

DAM SITE 1 (Shiᶜb Al-Maᶜādī):

- N15°43'24"E44°27'51" alt 2,047 masl
- Shicb Al-Macādī, Nihm
- The dam site is located in a *wadi* bed in a limestone rock formation
- No habitation or dwellings of any sort are found. No irrigation structures or agricultural terraces are found
- No visible sign of potential cultural importance of the site.
- The site is not part of any known folk tradition or practice

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DAM SITE 2 (Banī ᶜAbdillah):

- N15°31'55"E44°26'02" alt. 2,364 masl
- Banī ᶜAbdillah, Nihm
- A deep and narrow *wadi* between two sandstone rock mountains of steep inclination
- No habitation or dwelling found
- Many small water diversion structures
- Many abandoned agricultural terraces on the side of the steep *wadi* sides, as well as newly constructed terraces at the wadi bed of newly reclaimed agricultural land
- No visible sign of potential cultural importance of the site
- The site is not part of any known folk tradition or practice
- Not far away from the site downstream, there exist simple single-room structures constructed side by side in an overhanging hollow rock formation on the *wadi* side These rooms are used now by the farmers to store fine clay used to dust plants (a traditional way for plant protection against certain diseases) This place is curiously named Jurūf as-Salāṭīn literally meaning Caves of the Sultans, which may suggest special importance of the site[2]

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[2] Also a moot point, as this site is no longer in the project

DAM SITE 3 (Al-Malāḥ):

- N15° E44°
- Near Bayt Al-Hinamī, Banī Hushaysh
- The site is located in a pocket at a wadi top between mountains of igneous rock and soil
- Major earthmoving works have evidently been taking place at the site either for the intended dam as reported by local informants, or as part of a new agricultural reclamation process
- No habitation or dwellings of any sort are found No irrigation structures or agricultural terraces are found.
- No visible sign of potential cultural importance of the site
- The site is not part of any known folk tradition or practice

DAM SITE 4 (As-Sin):

- N15° E44°
- Near Abū cAlī, Banī Hushaysh
- The site is located in the middle of a flat *wadi* bed covered with soil and sand
- Earthmoving works have evidently been taking place there, probably for the intended dam project
- There are many villages and clusters of houses in the vicinity on both sides of the *wadi*, as well as agricultural land.
- No visible sign of potential cultural importance of the site.
- The site is not part of any known folk tradition or practice

DAM SITE 5 (Al-ʿAwrā):

- N15°32'48"E44°04'22" alt 2,450 masl
- Near Darwān, Hamdān
- A deep, relatively wide *wadi* in a saddle of an igneous rock mountain
- No habitation or dwellings found
- A natural seasonal water stream runs in the *wadi*
- According to local informants, this was a military post of the Egyptian army during the Civil War (1961-1969) A litter of rusted food cans covering a spot at the adjacent mountainside is the only visible sign confirming this report More investigation is needed to determine the importance of the site[3]
- The site is not part of any known folk tradition or practice

DAM SITE 6 (Al-ʿUqlah):

- N15°35'13"E44°20'51" alt 2,184 masl
- Sā'ilat Al-cUqlah, Arhab
- The site is located in a deep *wadi* winding in a huge sandstone formation
- No habitations or dwellings were found
- No significant structures were found.
- There are not any special features to the site apart from the impressive natural setting
- No evidence of potential cultural importance
- Not part of any known folk tradition or practice

[3] Another dropped site

DAM SITE 7 (Bahmān):

- N15°31'53"E44°27'47" alt. 2,459 masl
- Near Al-Jabbaylah, Nihm.
- Located at the top of a *wadi* bed between two mountains of sandstone of an almost vertical inclination.
- No habitation or dwellings
- According to a local informant, the location is the site of an ancient "mājil" water cistern called "Mājil Al-Azharī " No visible trace of such a structure was seen by the EIA team . However, further site investigations should be carried out during final design and appropriate actions taken, as provided in the EMP
- No sign of cultural importance
- Not part of any folk tradition or practice.

DAM SITE 8 (Hijrah):

- N15°31'46"E44°24'55" alt 2,410 masl.
- Wādī Hijrah, Banī Hushaysh
- A deep narrow *wadi* between two high mountain sides
- There exist few dwellings, watch posts built of stone, agricultural terraces cultivated with *qat* trees
- Many water diversion structures
- No evidence of potential cultural importance
- Not part of any folk tradition or practice

DAM SITE 9 (Mukhtān):

- N15°22'49"E44°19'43" alt 2,400 masl
- Wādī Mukhtān, Banī Hushaysh
- At the top of a *wadi*, in an enclave surrounded from three sides by a mountain
- The site contains an existing dam with a water lake already formed behind it
- No dwellings found
- No significant structure apart from the dam itself
- No special features found
- No cultural importance
- Not part of any folk tradition or practice

DAM SITE 10 (Al-Qarātil):

- N15°26'14"E44°04'17"
- Bayt Ncam, Hamdān
- The site is located in an opening at a mouth of a *wadi* formed between mountains of igneous rock
- On one side of the wadi, there are few terraces of agricultural land as well as inhabited dwellings. The main Sana'a-Thula Road passes under the location of the proposed dam Farther below, there are many agricultural terraces and cultivated land
- No special features recorded
- No evidence of potential cultural importance
- Not part of any known folk tradition or practice

Findings on the Bait Shaiban Site (biodiversity and cultural heritage)

The Bait Shaiban site (also known as Thajer) is located in the Nihm district The nearest upstream village is Hawrah and down stream the village of Bait Shaiban Approximately one-third of the cultivable land in the areas surrounding the villages is farmed, mainly *qat* and some fruit trees and grape irrigated from open wells The proposed dam site lies in a remote, shallow, fairly narrow and gently sloping *wadi*, with sparse vegetation, mainly grasses, weeds and scrub No flora species of conservation interest were noted No animals, other than a few lizards, were seen during the time of the visit but local inhabitants report that foxes are frequently seen in the area No sites of architectural or cultural importance were seen The dam would not affect any buildings or cultivation

Annex 2. List of Endangered Species in Yemen

Flora

Endangered species (or rare) are:
Aloe squarrosa - Socotra
Bignonia socotrana - Socotra
Dendrosicyos socotranus - Socotra
Dirachma socotranus - Socotra
Dorstenia gigas - Socotra
Euphorbia abdelkuri - Socotra
Punica protopunica - Socotra
Taverniera sericophylla – Socotra (was considered as extinct)
Wissmannia carinensis -Southern part of Yemen

Endangered or rare species at national level are also:
Aloe sp
Acacia laeta
Adnasonia digitata
Alkanna orientalis
Adenia sp
Caralluma sp
Cerepegia sp
Commiphora opobalsamum
C mukal
C parciflora
C. socotranum
Crinumyemense
Delosperma harazanium
Dracaena sp
Duvalia sp
Eulophia sp
Euphorbia fruticosa
Juniperus procera
Huernia sp
Kniphofia sumerae
Oncoba spinosa
Ochna inermis
Plectranathus hadiensis
Rhytidicaulon sp
Taverniera sericophylla

Trees and shrubs considered rare are
Antiaris taxicaria
Barlaria bispinosa
Bauhinia tomentosa
Ceiba pentandra
Cussonia holstii
Dombeya schimperiana
Nuxia congesta
Nuxia oppositifolia
Ormocarpum yemenense
Pouzolzia mixta
Trema orientalis

Plants species recorded as extinct are
Ailanthus excelsa
Celtis integrifolia
Entandrophragma angolens
Podocarpus gracilis
Pygeum africanum

Fauna

Endangered Mammals are
Arabian Mountain Gazelle
Goitered Gazelle
Dorcas Gazelle
Ibex
Arabian Wolf
Jackal
Arabian Leopard

Extinct Mammals are
Queen of Sheba's Gazelle
Arabian Oryx
Cheetah

Annex 3. List of Pesticides Approved for Use in Yemen

Insecticides	
Common Name	**Common Name**
Acetomıprıd	Ethıon
Alpha-Cypermethrın	Esfenvalerate
Benfucarb	Fenvalerate
Beta- Cypermethrın	Fenpropathrın
Bıffnthrın	Carbaryl
Buprofezın	Fepronıl
Cabaryl	Fenvalerate
Carposulfan	Imıdacoprıd
Chlorpyrıfos	Lambda- Cyhalothrın
Chlorpyrıfos & Cypermethrın	Lufenuron
Chlorpyrıfos & Dımethoat	Malathıon
Chlorpyrıfos & Methomyl	Malathıon
Cyfluthrın	Methıdathıon
Cypermethrın	Methıdathıon & Ethıon
Cypermethrın & Quinalphos	Permethrın
Cyromazın	Pırımıcarp
Deltamethrın	Prımiphos methyle
Dıafentıuron	Propoxur
Dıazinon	Profenophos
Dımethoate	Profenophos & Cypermethrın
Dımethoate & Alpha-Cypermethrın	Pymetrozıne
Dımethoate & Cypermethrın	Thıamethoxam
Dımethoate & Deltamethrin	Thıamethoxam Hydrogen Oxalat
Dımethoate & Fenvalerate	Trıchlorfon
	Zeta- Cyermethrın
Acrıcıdes	
Azocyclotin	Dınocap
Abamectın	Dıcafol & Tetradıfon
Amıtraz	Flufenızın
Bromopropylate	Hexaythıazox
Dıcafol	Propargıte

Fungicides	
Common Names	**Common Names**
Azxıstrobin	Mancozeb & Copperoxychloride
Benomyl	Mancozeb & Copper & Iron
Bupirimate	Metalaxyl
Buthiobate	Metalaxyl & Mancozeb
Carbendzim	Metalaxyl & Copperoxychloride
Captan	Metiram
Carboxin & Captan	Myclobutinal
Carboxin & Thirma	Ofurace & Mancozeb
Copperoxychloride	Penconazol
Copperoxychloride & Metalaaxyl	Phosphonic Acid
Copperoxychloride & Maneb & Zineb	Propinep
Cymoxainl & Mancozeb	Propmaocarb HCL
Fenarimol	Pyranzophos
Flusilazol	Pyriphenox
Fluidoxonil	Sulfur
Frosty Aluminium	Terbuconazole
Hexaconazol	Thiophanate methyl
Iprodine	Triadmefon
Mancozeb	Triadmorph
Maneb	Triforin
	Triadimenol
	Trifloxystrobin
Nematicides	
Cadusafos	Methomyl
Oxamyl	Ethoprorophos
Herbicides	
Fluziphop putyl	Glyphosate

ANNEX 4. Summary of the Proceedings of an Environmental Assessment Workshop

Scoping Workshop
May 6, 2001 - Hadda Hotel Sana'a

Background and Objectives of the Workshop

A one-day workshop was held with the following objectives

i) To launch a process of consultation and public disclosure regarding the projects concept and design,
ii) To verify the key stake holders;
iii) To make a preliminary assessment of the key environmental issues to be addressed in the project, and
iv) Agreement on the draft Terms of Reference (TOR) for the Environmental Assessment.

Some forty-five participants and officials attended the workshop, together with press and television observers A list of participants is attached.

Expected Outputs

The expected outputs from the workshop were

i) Agreement on the consultation and public disclosure process;
ii) Issues identified that should be addressed in the EIA, and
iii) Substantial inputs to the finalization of the TORs for the EIA

Summary of Workshop Proceedings

Presentations of introduction and welcome were made by the Minister of Electricity and Water, representatives of the World Bank and the Royal Netherlands Embassy

The Scope and Objectives of the Project were presented by Peter Koenig, Task Manager, World Bank The origins of the project were set out, together with the present status and future steps to be taken, this was followed by a brief discussion in which a number of issues were clarified

Preliminary Findings of the Stage 1 Preparation Studies: the Social Survey and Basin Characteristics were presented by Dr Tariq and Dr Al Mooji, Water and Environment Centre (WEC), University of Sana'a Dr. Al Mooji set out in some detail the complex hydrogeology of the basin and its recharge and depletion mechanisms Dr Tariq explained the rapid rural appraisal that had taken place and the stakeholder consultations that had been held (these are documented elsewhere) This was followed by a brief discussion in which the pilot sub-basin selection process was clarified

The EIA Process, time frame, consultation methodology and documentation was presented by Dr R A Boydell, Consultant This was followed by a brief discussion on the inputs that will be required from various parties.

World Bank Safeguard Policies and Guidelines were presented by K Shankar, World Bank The WB policies on Environmental Assessment, Natural Habitats, Pest

Management, and Dam Safety were highlighted, together with the WB's social and legal policies and guidelines.

Environmental Impact Assessment Policy and Application in Yemen was presented by Dr Hussien Al Gunied, Environment Protection Council This was followed by a brief discussion in which Dr Al Gunied explained the functions of the EPC and made a firm commitment to support the project

Discussion of Issues and Benefits of the Project and Formation of Working Groups Presentations were made on the following topics in order to highlight potential issues and benefits, and stimulate working group discussions Working groups were formed by the participants, who deliberated the issues during the afternoon and presented their findings in a plenary session at the end of the working day.

* Domestic Water, Irrigation & Waste Water Reuse, facilitator Mr A Tabet
* Public Health, facilitator Khaled Al Dubai
* Cultural Heritage, facilitator Sabah Al Suleihi
* Biodiversity, facilitator Dr Karim Nasher

Terms of Reference for the Working Groups

Group 1: Public Health, Domestic Water, Irrigation and Wastewater Reuse

1 What public health benefits and issues are likely to arise from the project? As a starting point, you may want to consider the following areas

* water quality
* increased water availability
* pollution
* sanitation
* wastewater and sludge reuse
* pests and pesticides
* solid wastes

2 What water-related benefits and issues are likely to arise from the project? As a starting point, you may want to consider the following areas

* surface versus groundwater
* water quality
* increased water availability
* conjunctive water use
* wastewater reuse
* modern irrigation techniques, etc

Group 2: Cultural Heritage and Biodiversity

1 What cultural heritage and biodiversity benefits and issues are likely to arise from the project? As a starting point, you may want to consider the following areas

* possible endangering of buildings, structures and sites of historic and cultural value,
* possible endangering of the natural habits of flora and fauna through the construction of dams and canals etc

Group 3: Dams and Dam Safety

1 What dams and dam safety benefits and issues are likely to arise from the project? As a starting point, you may want to consider the following areas

* the state and safety of existing dams
* new dam construction
* land acquisition
* flooding and resettlements
* operations and maintenance
* dam rehabilitation
* underground check dams, etc

General Questions to be Answered by All Groups:

2 What are the best social and institutional arrangements to ensure that the benefits of the project are realized by the community and that potential issues are addressed?
3 Have all the key stakeholders been identified, or who has been omitted?
4 What are your recommendations for future consultations and public disclosure regarding the project?
5 What are the key issues to be addressed in the environmental assessment and do the terms of reference reflect these issues?

Brief Summary of Working Groups' Findings and Recommendations

A. Responses and recommendations arising from specific questions:

Group 1. Public Health, Domestic Water, Irrigation and Wastewater Reuse

Water Quality Benefits Water mining and evaporation will be decreased
Water Quality Concerns Salinity / high evaporation may be increased

Water Availability Benefits Deep aquifers will be preserved and promotion of wastewater reuse will ease increase water availability

Pollution Benefits Wastewater treatment will be improved thereby reducing pollution
Pollution Concerns. Run off from untreated wastes may form sources of pollution

Sanitation Benefits Promotion of household sanitation will improve environment and public health

Wastewater and Sludge Reuse Benefits: Improvements to Sana'a wastewater treatment plant's effluent, which is used for irrigation, will improve environment and public health

Pests and Pesticides Benefits. Adoption of integrated pest management plan, improvement of environment and public health

Solid Wastes Management Benefits Public awareness campaign will reduce dumping and improve the environment

Conjunctive Water Use benefits Increased water availability for household and personal use will improve public health

Group 2. Dams and Sam Safety

Benefits Groundwater recharge and water availability for irrigation Reduction of dam failure risk and secured benefits

Issues Poor dam maintenance / repair and lack of safety inspection Possible need for resettlement and land acquisition which will impact on traditional systems Voluntary contribution may be required Weak institutional capacity in GDI and other organization such as NWRA Groundwater recharge benefits may be offset by evaporation

Group 3. Biodiversity & Cultural Heritage

Concerns re Flora. Some succulents are very rare (i e *Carulluma*) and should be transplanted to new sites

Concerns re Fauna Reptiles and rodents should not pose a problem in small dam sites, however, some snail vectors breed in dams and eggs survive dry periods, biological control should be investigated

Benefits re Biodiversity Creating water bodies can have positive impact on birds and other species and flora

Benefits· Preservation of historic sites and buildings, and restoration and rehabilitation of neglected cisterns and irrigation systems

Concerns Loss of structures, cisterns, terraces, and watch towers etc , and damage to religious buildings, rural grounds and other social and culturally important sites (spaces), although this was thought to be minimal

B. Responses and Recommendations Arising from General Questions:

2 What are the best social and institutional arrangements to ensure that the benefits of the project are realized by the community and that potential issues are addressed?

"At the community level· Local Councils, Water Users Associations should be involved and awareness campaigns mounted in schools and clinics etc
At the higher level. capacity building in EPC and GDI for monitoring is required, plus a registration and licensing system for water pumping should be introduced"

3. Have all the key stakeholders been identified, or who has been omitted?

"Stakeholders to be involved are NGOs, farmers associations, big farmers, share croppers, women, local leaders/local councils, social support groups, private sector, Government (EPC, GDI, MOH, NWRA). Dam safety should be one of the focal points for Government involvement"

4 What are your recommendations for future consultations and public disclosure regarding the project?

"Increase consultation in the field, use media to promote project, use focus groups and one to one interviews, use women as entry points, promote inter-community field visits Public awareness campaign and mechanism for grievances".

5 What are the Main Issues to be addressed in the EIA and are these covered in the EIA TOR?

Consensus on issues to be addressed:

Dam safety
Public Health (including household water supply, sanitation and the Sana'a WWTP)
Biodiversity
Cultural Heritage
Pesticides
Monitoring water quantity and quality
Promotion and involvement of women

It was agreed that the EIA TOR generally covered the above issues, but that they should be refined to ensure their comprehensiveness.

List of Participants

Name	Authority
Mr Muhssen Al-Hamdany	Environmental Protection Council
Mr Fuad Al-kadasi	EPC
Mr Jamal M Abdo	National Water Resource Authority (NWRA)
Mr John Skoda	NWRA
Mr Roel Mulder	NWRA
Mr Farid Mujawar	Min Agriculture and Irrigation (MAI)
Mr Mutahar Zaid	MAI General Directorate of Irrigation (GDI)
Mr Kataria	MAI GDI
Mr Abdullelah Hatrum	MAI
Dr Yossif Al-Mooji	Water & Environment Center (WEC)
Dr Tareq Al-Aghbay	WEC
Mr Ali Jabr Alawy	WEC
Mr Tim Kennedy	CARE NGO
Mr Ali Al-Soraimy	Farmers Union NGO
Mr. Anwer Sahooli	Min Energy & Water /GTZ
Mr Isam Makky	Min Energy & Water
Mr Abdullah Al-Mutawakil	LCSW
Mr Mohamed Al-Yadomy	LCSW- SD
Mr Mamoud Aludami	GHAITH Private Sector Consultant
Mr Khalid Al-Dubai	EIA Consultant Public Health
Dr Abdulkarim Nasher	EIA Consultant Biodiversity
Mr Saba Al-Sulaihi	EIA Consultant Cultural Heritage
Dr Robert Boydell	EIA Consultant Team Leader
Ms Firuza Hamed Mohamed	Min of Health
Mr Abdullatif Tabet	Food & Agriculture Org Res Representative
Mr Saeed Shami	FAO
Mr Mohamed Houmymid	FAO
Mr Abdulaziz Tabet	FAO/IC Coordinator
Ms Naima A Hassan	FAO
Mr Bob Angier	FAO Consultant
Mr Peter Koenig	World Bank (WB) Project Task Manager
Mr Gianni Brizzi	World Bank Res. Representative
Mr Jean-Frncois Barres	WB
Mr Naji Abu Hatim	WB
Mr Vahid Alavian	WB
Mr Kanthan Shanker	WB
Mr Mohamed Harmal	WB Project Preparation Team Leader
Mr Satoru Ueda	WB
Mr Mohamed Al-Arossy	Netherlands Embassy
Mr Hans Van De Heuvel	Netherlands Embassy
Mr Martin De La Bey	Netherlands Embassy
Mr Najib Maqtary	UNDP

Annex 5. Summary of the Stakeholders Meetings

Main Issues for Stakeholders Meetings

A realistic evaluation of the situation and identification of specific problems that may be particular to any basin requires a direct involvement of all concerned stakeholders / users Information collected through meetings with such parties is usually the 'safeguard' for the success of any action plan for water resources management. Important issues relevant to the situation in the Sana'a Basin were identified, as described in Annex 4 Specific issues to be discussed during the stakeholders meetings and a provisional question list for this purpose is given in Table 5 3

Main Outcome of the Meetings

Main Issues:
Main issues that appeared to be of most concern to all stakeholder groups are summarized as follows

1 **Groundwater depletion scarcity:** This was raised by all groups as the most serious problem affecting all districts Several evidences were cited including

- In Wadi Rijam – Sa'awan shallow hand-dug wells (~ 15m deep) were most common in the past Farmers began to deepen these wells to ~ 30m in 1972 using local metal tools known as "Suppayr", until modern drilling techniques were introduced in the late 1970s From early 1980 onwards, a significant drop in water level was observed such that the average well depth ranged between 200-250 meters Now most boreholes are ≥ 400m deep and the "water reservoir" is still getting deeper and deeper
- In Hamdan, there are large number of wells which are being over-pumped in a manner that, according to one farmer, is likely to be disastrous unless quick and effective measures are taken.
- Arhab district is practically a mountainous zone devoid of groundwater resources except for 4 or 5 areas, as a result of which many locals migrate to Sana'a City because of lack of fresh water for drinking
- In Bani Al-Harith, many farmers started rehabilitating catchment areas for agriculture purposes by using surface flow/flood water that used to either recharge the shallow aquifer or benefit downstream users As a result, more and more users are drilling boreholes that tap the deeper aquifer system
- In Sanhan-Bani Bahloul, there is a drastic change in groundwater use where practically very few shallow dug wells (known locally as Yousufi wells) existed in the near past whereas deep boreholes are now spreading across the district in a frightening manner In the Bani Bahloul, part of this district, the inhabitants of Bait Uqb village had to abandon their wells as the depth of finding groundwater has reached 500-800 meters

2. **Inadequate infrastructure:** A good number of water harvesting structures (small dams, reservoirs, ponds, etc) have been constructed through public/private cooperative efforts and funds However, many of them have totally collapsed Those that still exist are in poor shape due mainly to lack of financial resources and/or proper maintenance Specific examples given by the participants include.

- In Sanahan-Bani Bahloul, construction of the Hamal Dam, constructed by the locals as a good means of aquifer recharge, is now abandoned

- In Hamdan, a reservoir dam was built in Tawthan area long time ago for collecting rainwater but the locals are not benefiting from it apparently because "the water infiltrates deep through the rocks"
- In Bani Al-Harith, there is an ideal location for a dam in Al-Ushsha east of Bayt-Doudah in Al-Baahili that the locals would like to be considered as a potential site within this study.
- In Sanhan-Bani Bahloul, there are a number of suitable sites for dams such as Al-Qushaybah area, which is known to have good catchment characteristics
- In Nihm, there is substantial quantities of surface water that flows out towards Wadi Al-Jawf and that could be utilized by the locals for irrigation if proper dams and/or other water-retaining structures
- In Arhab, there are a number of reservoirs for water harvesting in different areas, some in good shape while others need rehabilitation
- In Nihm, there are two dams (Shayban and Hatha) that could not be completed due to lack of resources
- Two other sites that are considered important for the population in both Arhab and Nihm are
    - Musayreka plain in the foothills of Jabal Sama', and
    - Al-Kharid spring area, which could also be used for supplying the urban population in Sana'a with fresh water.

3 **Dishonesty of the Government:** All parties, without exception, expressed a great anxiety and mistrust in the Government with regards to seriousness in alleviating the water-related problems that exist in their districts. It appeared that most of those present did not deal with NWRA, or even hear about it Rather, the negative feeling expressed was mainly engraved in them over many years of contacts with NWRA and the MAI, particularly the irrigation bodies attached to the latter mainly the Directorate of Irrigation and the ACU Specific issues/incidents that were raised in relation to this institutional aspect include

- Representatives from Bani Al-Harith expressed their anger mainly through the performance of NWSA, which they regard as a complete lack of concern for the local population in this district They summarized their grief in the following points, all related to environmental aspects
    - Continuous discharge of sewerage into their cultivated lands and nearby wadi channel for 15 years
    - Construction of treatment plant recently without any consideration for building a separate plant for the solid waste
    - Inefficient operation of the new plant in a continuous manner as a result of which huge quantities of accumulated waste gets suddenly released to inundate the cultivated crop and human health degradation.
    - Lack of proper canal system to discharge the wastewater such that the local can make use of it while at the same time not being subjected to its harmful effects
    - Total absence of any activities to fight disease-carrying insects that appeared as a result of the wastewater discharge.
    - Lack of Government response to the local populations' need for municipal water despite the fact that several boreholes have been drilled for this purpose, which only require the installation of distribution system
- Representatives from the other districts expressed mainly their frustrations with Government officials (urban inhabitants) who "always promise but

never do anything for the rural areas". The following expressions were often thrown from different persons

- Farmers simply do not feel that anything positive will come out of the current meetings as nothing have materialized from similar meetings in the past.
- Government officials, particularly those involved in projects implementations, "should first respect their words and we are ready to fully cooperate with them "
- We should not think only about how to get new water supply sources for the city, but also about the rural population, such that an action, such as building dams, could benefit both population groups
- There are certain powerful social groups/individuals with strong links to the Government (e g the Irrigation Cooperative, Sheikhs, etc) who monopolize the water-related issues, hence the implementation of any activity within the context of this project should be through direct contact with the main beneficiaries

Perceived Solutions

There was a strong consensus that dams construction/rehabilitation, adoption of modern irrigation systems and implementation of an intensive public awareness program in the rural area are the main solutions (in this order) Specific details relevant to these proposed actions included.

- Construction of surface reservoirs and other water-retaining structures in the ideal solution for alleviating some of the pressure from the aquifer system
- Recharge dams have proven effectiveness in several areas (e g Mukhtan in Bani Hushaysh) and the experience learned should be taken into
- Let us start first with the rehabilitation of the numerous different structures scattered in the various districts, using local material (known as Al-Qudad) that has proven effectiveness and endurity We can then evaluate the feasibility of resuming construction of incomplete works while at the same time planning for new ones
- Planning for any new dams/structures should be in accordance with actual needs in each region rather than satisfying or pleasing certain tribe or social groups
- Selection of sites should be based on careful and scientific analysis and approach
- All farmers are willing to adopt using modern irrigation methods but first let the Government convince us that it actually works as an effective water-saving mechanism without affecting crop yield

Specific Issues:

A number of issues raised during the meeting were either zone-specific problems, or expressed interesting opinions that reflected on the farmers perceptions stemming from their own point of views on the future of the region. Among the first category were the following

- Environmental and Water Quality Monitoring in Bani Al-Harith
  It is clear from the information given above that pollution issues related to the current practice of wastewater disposal is spreading in Bani Al-Harith Participants from this district put forward some interesting suggestions for handling the situation

- Continuous monitoring on the wastewater treatment plant operations to ensure that water discharged from the plant is clean and suitable for irrigation use
- Discharge of hydrocarbon–based pollutants into wadi channel, particularly oil and other lubricants discharged from gas station and car-wash workshops, should be closely monitored and controlled by forcing these places to put all such materials in special tanks/barrels to be collected later on regular basis and stored in properly-sealed reservoirs.
- Any such monitoring programs are likely to be ineffective if local inhabitants from the district are not involved directly.

- Heavy Reliance Rainfed Irrigation in Sanhan - Bani Bahloul About 60% of the farmers in these two districts, officially combined into one still live on rain-fed cultivation along major wadis. Among the most common problems affecting crop yields (and hence water-use efficiency) are soil/land erosion and infectious diseases due to heavy attack by plant insects Effective rehabilitation measurers are therefore urgently needed
- Concentration of Dams Construction in Nihm and Bani Hushaysh - Khawlan A good number of dams have been constructed in Nihm as well as Bani Hushaysh – Khawlan districts, mostly through cooperative efforts with public and/or private money. In Nihm, the main aim behind constructing these dams was surface water retention while those in Bani-Hushaysh-Khawlan were both for retention as well as recharge purposes. Of particular importance with respect to the situation in the latter region is the heavy role that the Agricultural Cooperative Union (ACU) has played through the Cooperative Society for Irrigation and Hydraulic Structures This society has been involved in the construction of three recharge dams (two in Mukhtan, one existing and another under construction plus a proposed one (in As Sarf area)) and three reservoirs (one each in Wadi Sa'awan, As sir, and Ash Sharya area)
- The Need of Galvanized Pipes in Hamdan Most areas in this district are mountainous such that many farmlands are cultivated on almost barren rocks with very limited soil cover Experience has shown that the construction of modern irrigation systems using polyethylene pipes is not suitable for this terrain Hence, any future development in the area should consider galvanized (metal) pipes.
- High Rock Permeability in Bani Al-Harith During a heavy flood, it has been observed that flood water directed in an open dug well has quickly disappeared from the well The same water (as judged from its quality) was later found in a borehole 500 m away that the locals were pumping from
- Horizontal Expansion of the City into Agricultural Land Farmers from this district complain that their agricultural land is shrinking due to the expansion of urban area, as well as asphalt roads (highways) connecting the city to secondary towns in the Arhab and Nihm regions

Interesting ideas that were brought up during the meetings and are related to future expansion in pump-irrigated areas include:

- Responsibility for regulating and monitoring any future expansion, as well as controlling, must be vested in a specific body/institution that, preferably, should also be in charge of the expansion of urban areas into agricultural lands.
- The implementation of any development works or management plans is bound to fail without involving the immediate beneficiaries in an effective manner, particularly with respect to operation and maintenance

- Controlling the expansion means "sacrificing and compromising with the future of our sons and grandchildren so what are we (farmers) getting from the Government in terms of compensations"

Table 1: A list of Main Issues to be Addressed in the Discussion Groups

Main Issue	Questions to be addressed
Identification of the water problem perception by the government agency responsible for the management of the Basin (NWRA)	What are the objectives / plan of NWRA for the Basin? What are its views on water resources management? How does NWRA perceive itself (including institutional problems)? What does NWRA consider as possible measures for water resources management (i e possible solutions)? What are the means that NWRA has, or hopes to have, to implement these measures?
Description of the existing situation in water resources management	What is the existing socio-economical system? What is the existing natural resources system? What is the existing administrative and institutional system? How does NWRA perceive the current situation in the Basin? What are the problems that NWRA considers relevant? What are the possible solutions for these problems, from NWRA's point of view?
Identification of stakeholders / users in relation to water resources management	Which stakeholders / users are involved and how are they organized? What are the objectives of stakeholders? How do they perceive the current situation? What possible solutions do they consider? What are the points of view of stakeholders towards NWRA and its future activities? What are the bases for these points of view? What measures are feasible for stakeholders? What measures are acceptable to stakeholders? What measures are they willing to negotiate? What are the means of the stakeholders to contribute to the implementation of possible solutions? What are the means of the stakeholders to frustrate the implementation of possible solutions?
Relations between stakeholders / users.	How do stakeholders perceive each other? What are the similarities and the differences between the individual problem perceptions? What kind of communication structures is there? What kind of mechanisms is there for coordination? Are there stakeholders who cooperate and, if yes, in what way? What kind of interaction between stakeholders and NWRA is there at this moment, if any? To what extent can the structures between stakeholders be incorporated in NWRA's policy structures and to what extent are these structures contradictory with NWRA's objectives? Which sub-groups can be identified within each stakeholder group?
Possible improvements of the relations between stakeholders	Between which stakeholders would additional interaction be useful? What kind of alternatives is there for this additional interaction? What are the criteria to assess these different alternatives? Which alternatives seem promising, and how?
Possibilities to implement the promising alternatives	How do stakeholders feel about the promising alternatives? What are their means to support or frustrate successful implementation of these alternatives? What are the means of NWRA to implement the alternatives? Which first steps could NWRA take to implement the alternatives?

Annex 6. Dams Constructed Under Supervision of Northern Development Authority in the Sana'a Basin

Dam Name & Location	Capacity Cu.m.	Cost Riyals Millions
Bait Naam Dam, Hamdan	500,000	96 44
Sayyan Dam, Sanhan	350,000	85 80
Saiba Dam, Khawlan	1,210,000	86 43
Bait Jarm Dam, Khawlan	180,000	29 35
Alwakar Dam, Nehm	250,000	7 17
Khal Dam, Khawlan	700,000	62 73
Khalaga Dam, Nehm	264,000	66 69
Al Merbaha Dam, Hamdan	433,000	123 52
Rithim Dam, Arhab	837,000	113 13
Sheb Al jooz Dam, Bani Matar		98 42
Sanaf Dam, Bani Hushaish		
Eial Musa Dam, Arhab		
Al Dhaiykain Dam, Khawlan		16 63
Bait Al Dhalaah Dam, Bani Matar	25,000	20.29
Teeshan Dam, Sanhan	63,500	41 50
Al Rakab Dam, Hamdam	50,000	17 14
Wadi Baihan Dam, Al Haima	45,000	12 46
Ash Shariah Dam, Bani Hushaish	150,000	38 55
Al Shuaibi Res Al Haima	4,200	9 83
Nabi Shuaib Res Bani Matar	15,000	53 81

Annex 7. Pesticides Use and Pest Management Plan

Situation in Yemen - Use of Pesticides

Agriculture plays an important role in the Sana'a Basin Its total areas are estimated to be 3200 km2, of which 110,000 ha arable with 24,000 ha are irrigated Unfortunately in recent years, farmers have began to shift from traditional substance crops such as wheat, barley, corn and sorghum to *qat*, which occupies about 45% of the irrigated area, followed by grapes of 30%, and the rest of land is balanced among vegetables, cereals and tree crops

Agricultural crops are the targets of several pests including insects and diseases whose active presence can cause a reduction in crop quality and quantity Farmers in the Sana'a Basin increasingly rely on pesticides to control crop pests and also on non-organic fertilizers to increase the crop yielded Even though use of these chemicals may give farmers good profits in the short term, it can create serious problems for human health and the environment Unfortunately, little information is available concerning the type of pesticides and fertilizers being used and their application.

The use of synthetic fertilizers and pesticides has grown enormously in the past decade particularly to maximize cash crops such as qat and grape Moreover, traditional practices, such as dusting of grape to reduce fungal infections, hand weeding, and crop rotation, are declining in use Although control regulations do exist they are not enforced which leads to a serious public health hazards and damage to crops The Yemen Observer (July 28, 2001) reported a number of cases in which farmers became seriously ill through chewing qat that had been treated with "unidentified killer pesticides" Recent scientific studies have indicated insecticide residue in vegetables and fruits In another study, organochlorine insecticide traces was detected in human milk

The scarcity of water may force farmers to use less water for irrigation, but availability of water may encourage farmers to excessively use water to irrigate their crops This excessive use of water, together with misuse of pesticides and fertilizers and other chemicals, may increase irrigation runoff which will have an impact on the water quality of the aquifer in the basin Therefore, to avoid and mitigate such runoff the design options for irrigation channels should be as such to reduce such runoff.

Practice and Extent of Pesticide and Fertilizer Use in Yemen

A field survey was carried out in July 2001 Eight locations were selected for sampling representing the four pilot sub-basins of the Sana'a Basin Bani Husias, Hamdan, Arhab, and Nahem The survey indicated that the main pests in the Sana'a Basin attacking qat and grape, the main crops in the area, are, powder mildew, downy mildew, mealybug, scale insects, jassid green worm and spiders Farmers claim that, in the past, pest problems did not exist and only in recent years, after the introduction of synthetic pesticides, had the pest problems appeared and that it was getting worse year after year. The study results also indicated that lack of knowledge and carelessness are common among farmers who deal directly or indirectly with toxic chemicals which cause health and environmental hazards The interview revealed that farmers in the Sana'a Basin utilize several pesticides, however, dimethoate and penconazole were found to be widely used and highly preferred by farmers in all the sub-basins Most farmers had little idea of recommended dosages to protect their crops, farmers used their own judgment based on experience The qat growers, for example, stated that they can manage to increase qat production and harvest three to four times a year through the application of more pesticides, fertilizers and irrigation All of farmers interviewed stated that they do not wear any protective clothing whilst applying pesticides, nor take showers on

completion Most farmers stated that pesticides containers are stored in their houses or farm building and not kept secure from children Empty pesticide containers are dumped indiscriminately and, in a couple of instances, half-liter pesticide bottles were used as drinking water containers A study by the Yemeni/German Plant Protection Project (Salman,1993) undertook blood tests for Cholinesterase (an enzyme) Inhibition which is an indicator of organophosphorus pesticides poisoning A sample of some 288 farmers and sprayers, pesticides shopkeepers, habitual qat chewers and a control group were tested The study found that there was a high level of exposure to poisoning particularly within the farmers' sprayers and qat chewing group, shop keepers were at less risk More than 60% of habitual qat chewers displayed enzyme inhibition but were not interested in trying to find untreated qat, or qat that had not been sprayed for more than two weeks and washed Similar levels of enzyme inhibition were seen in the spraying group The major symptoms being suffered were headaches and tiredness

General Principles of Integrated Pest Management

In order to control or minimize pests which damage crops whilst protecting the environment, a holistic approach or strategy has developed over recent years known as Integrated Pest Management (IPM) IPM strives to be ecologically sound yet pragmatic such that communities can be involved in its implementation. IPM brings together the best strategies of all control measures that can be applied to a given problem created by pests There are four basic elements of IPM natural control, insect biology, ecology and adoption of sound Economic Threshold Levels (ETL) as a basis for applying control measures such as pesticides Natural Control relates to the fullest utilization of naturally occurring suppressive factors, including any practices by man that make the ecosystem less favorable for the growth of a pest population A sound knowledge of insect biology and ecology is essential to both natural control measures and the use of ETL and CAT, particularly an understanding of the dynamic relationship between the pest and the crop during the growth cycle Adequate pest sampling data is essential in determining the timing, frequency and dosage of interventions

IPM is not unknown in Yemen and research and pilot activities on citrus crops, potatoes, etc have taken place but have not been widely adopted Present government pest control practice in Yemen take three forms The most common are one-off campaigns that are aimed at specific problems such as the eradication of locust or army worms during infestations The second is limited biological control through the introduction natural predators on crop pests, such as the ladybird beetle, which is presently being cultured in mass in Sana'a for release against the mealybug which is a serious grape pest Third, farmers can approach GDPP to request spraying or allocation of chemicals However, the funds and resources are limited, as are the research and information and databases.

Pesticides Management Planning

In order to mitigate the negative impact of the use of pesticides and fertilizers, the following approach must be implemented.

- Encourage and promote farmers to retain their traditional practices in plant protection
- Educate and train farmers and pesticide and fertilizer dealers on safe way of handling and applying the toxic chemicals and the necessary precautions that must be taken
- Use more appropriate tools like TV, radio and personal communications to raise public awareness
- Train medical personnel in the Sana'a Basin on handling pesticide poisoning and provide them with necessary materials
- Utilize more efficient and appropriate measures to enforce the pesticide laws, rules and regulations

- Introduce any additional legislation to better regulate the pesticide and fertilizer use and handling including prohibiting the importation and sale of any chemical products without an official permission from the governmental authority
- Ensure that the protective clothing is available at local market and at a reasonable price
- Design and implement IPM programs as described below

These activities will not be effective and successful without participation and sharing responsibility with all parties in the basin, including local authorities, NGO, farmers, chemical dealers and governmental institutions

IPM Action Plan for Grape Cultivation[4]

The starting point in launching an IPM program is to gather information on indigenous farmer traditional practices as well as on the agro-ecological system in each sub-basin However, it must be noted that the agro-ecological system of each basin and each crop has its own pest problem, therefore, an IPM plan must be designed specifically for a particular crop

Despite its benefits, farmers may not readily accept integrated pest management techniques because of the complexity of the IPM techniques Lack of incentive to change their traditional pest management practices, inadequate information of economic threshold levels for various pests, inadequate supply of suitable trained to help farmers understand and apply IPM techniques

Main Objective:
To design a demonstration or pilot Integrated Pest Management (IPM) plan for grapevine cultivation in the Sana'a Basin Project pilot areas and communicate the recommendations to the farmers by way of consultations, farmer field schools and "field days" Grapevine cultivation uses much less water than qat However, for grapevine farmers, qat is an attractive alternative crop because of its higher profitability. By helping the grapevine farmers to achieve a better level of production from their crop, the shift from growing grapes to growing qat can be slowed down to some extent

The MAI Department for Plant Protection has identified a second important issue which is that the majority of the pesticides dealers are concentrated in the Sha'ub area in the center of Sana'a City. These consist of rows of open fronted shops in which the pesticides are stored indiscriminately on the floors or in cellars, which is felt to constitute a public health risk

Expected outputs

(i) Grape farmer would use environment-friendly methods to control pests and diseases
(ii) Grape farmers become more aware of natural methods of control of pests and plant diseases and of the negative effects of pesticide use on the natural environment and health.
(iii) Recommendations for dealers to improve control and storage of pesticides

Field Operational Plan:
The following operational plan is envisaged

(a) Initially, a Participatory Rural Appraisal (PRA) would be undertaken among grapevine farmers in the Bani Husheish area to gather information about the crop pests, plant diseases and present knowledge and practices regarding their control. Other social, physical, ecological, economic and environments data would also be gathered The results will be discussed with the farmers and a joint action plan formulated

[4] A similar program will shortly be developed for *qat* – see Main Text, para 114

(b) The second step would be the development of an IPM plan, through consultation between the farmers and outside facilitators The plan would consist of a package of recommendations for the farmers, including plant protection measures, better agronomic practices including pesticides use and management as one component of a series of measures, plus improved marketing strategies

(c) Training and communicating the IPM plan and its recommendations to the grapevine farmers, through field days and farmers' field schools would follow this

(d) A post-campaign evaluation would be undertaken after one year

Supporting activities:

A number of supporting activities would be undertaken including

(a) Production of information brochures and posters outlining the IPM plan Plus simplified versions of the pesticide and plant quarantine laws and their regulations that could be easily understandable by the general public These would be disseminated through various media including radio and TV

Expected outputs.

(i) All dealers of pesticides and agricultural products are familiar with the regulations concerning pesticides

(ii) Farmers and "importers" are familiar with the dangers of importing plants and plant products and with the quarantine regulations

(b) Training of targeted groups (extension agents, farmers, farmers' wives, cooperatives, pesticide importers and dealers) about the dangers of pesticides and the safe use of pesticides, including the training of farmers in adequate application techniques and safety precautions

Expected outputs:

(i) The targeted groups would be aware of the dangers of pesticides and know how to handle them safely

(ii) The hazards of the release of excessive amounts of pesticides into the environment will have been reduced

c) Establishing a mobile information unit, managed by the MAI General Department of Plant Protection

Expected outputs.

(i) Farmers and extension agents would have better and easier access to information about pest control and plant disease identification and control

(ii) Computerized information and data on plant protection is readily available

(iii) Documentaries about plant protection to be used for further training would be available in the field on videotape

(d) To undertake a study about the feasibility and costs of relocating the pesticide stores and shops concentrated in the Sha'ub area to a safer location outside of the center of Sana'a

Expected output

(i) A report on the feasibility of moving the pesticide stores and shops from Sha'ub to a safer location outside of the center of Sana'a would be made available

Implementation Arrangements and Costs

The activities will be executed by the staff of the General Department of Plant Protection, in collaboration with extension staff of other institutions, such as the Agricultural Research and Extension Authority, and the Northern Regional Development Authority, plus the Sana'a Basin project management staff

Total estimated cost (2 years) US$ 95,000

Support to the New Pesticide Residue Laboratory

A new pesticides residue laboratory has been constructed in the General Department of Plant Protection headquarters in Sana'a City, with support from German bilateral aid However, the laboratory lacks staff and equipment and additional support is requested for the purchase of some equipment and training of some members This would enable the laboratory to be operational at an earlier date and thus to be able to monitor agricultural crops produced in the area for pesticide residues, thus protecting consumers and improving pest management practices A list of requirements has been prepared by the Department Total estimated cost: $20,000

Annex 8. Dam Safety Expert's Report No. 1 (February 2002)

Executive Summary

1 The Project includes feasibility studies for three new dams and rehabilitation of ten existing dams and will be carried out by Hydrosult Consulting The studies for one new dam and two existing dams rehabilitation is carried out by TAGDI. The dam safety expert (DSE) will review the studies carried out by the consulting firm and TAGDI and to provide comments and recommendations

2 The Dam Safety Expert for the Sana'a Basin Water Management Project (SBWMP) was convened to perform his services starting Nov 2002 to review the TAGDI reports about one new dam and other two existing dam's rehabilitation within the above mentioned project (Shaiban Dam and Thoma and Tozan Dams)

3 The technical issues, which the PPT requested the DSE to consider, include the following major aspects of planning, investigation, designing, construction supervision, and procurement/bid tendering, O&M, and safety inspection

4 Review of the TAGDI Preliminary Reports, concerning Thoma, Tozan Dams and Shaiban site, was carried out in Jordan in Dec 2001, discussed with their expert Mr Hubbosh while he was in Jordan for about four days The comments were sent directly on Dec , 7th and 27th to TAGDI, WB and PPT (see Attachments 1 and 2)

5 The visit to Yemen was made on Jan 30 /31st and ended on Feb 11th, 2002 Two site visits were made to the existing dams, on Feb. 5th to Tozan dam and on Feb 9th to Thoma Dam and U S Shaiban proposed dam site with TAGDI technical staff and their Yemen counterparts Several meetings were held with TAGDI team to discuss the findings of the sites' conditions Two meetings were held with Hydrosult Consulting Firm on Feb 1st and 8th in their office, attended by TAGDI, PPT and W B consultants, to discuss several subjects on Criteria for Ranking rehabilitation of existing dams and evaluation matrix of potential dam sites. No reports have been handled from Hydrosult during my first mission to Yemen.

6 The Thoma Dam is in a serious condition and is badly needed for rehabilitation, especially the spillway, left and right abutment and D S area Although I haven't received, during my mission, the investigation reports done by the MOMR

7 Tozan Dam needs some investigation works, but from the reconnaissance investigation the right abutment should be grouted to cut off the water privilege pass, between the reservoir and D S area, which interconnect the dyke and the joints within the sandstone formation. The Concrete face would be easier to be rehabilitated if it was not damaged by man-made, as existed now

8 The U S Shaiban site should be investigated by about three borcholes (B Hs) to check the foundation, right and left condition Also, the Borrow area at the left bank should be investigated, quality and quantity-wise From the information provided by the TAGDI Team and the site visit on Feb , 9th, it appears that the U S site is more favorable than the D S site but needs to be confirmed by further investigation

9 Thoma Dam was taken over recently in March 2000 and maintenance certificate has not been issued yet while Tozan Dam was constructed before about 15 years Both present conditions are not satisfactory, the first because it was not constructed and supervised properly while the second it was not treated properly during the post construction period, i e no remedial work such as cracks and open joints in the U S concrete face should be filled with asphalt or epoxy resin instead of removing wide area from the concrete Also, no grouting works in the abutments were carried out

during the construction stage That is why items 2 &3 from the W B operational policies in relation to Safety of Dams should be strictly applied concerning the design, construction, supervision and O&M

1-Introduction

The Terms of Reference (TOR) for the Dam Safety Expert (DSE) established by the PPT under the Ministry of Panning and Development for the SBWMP is as follows
To undertake a comprehensive review and evaluation of the feasibility studies of the four new dams, including planning, investigation design, construction supervision/quality control and O&M to ensure their safety aspects Also to review the assessment of the ten existing dams in the inception report and finalize the dams to be rehabilitated in the project to ensure their safety and proper function, in consultation with PPT, FAO/IC, GDI and W B

The report No. 1 presents the review made by the DSE between Dec 2001 and Feb 11th 2002 on the studies made for the two existing dams and one new dam carried out by TAGDI Also, the review depends on the site visits made to the three sites with TAGDI team and subsequent discussions

The DSE wish to acknowledge the helpful assistance provided during this assignment by the TAGDI team who provided useful dialogue and wide ranging discussions on the two existing dams (Thoma and Tozan) and the new Shaiban proposed dam. I would like to thank Mr Harmal who made my tasks much easier by providing the site entry security permission and the transportation means I would like to acknowledge the helpful correspondences with Mr Satoru, which was directed by email

2-Technical Issues and Evaluation

2/1-Thoma Dam
The principal issues considered by the DSE are as follows

- The present condition of the dam body and foundation
- Spillway condition
- Right and left abutments
- Seepage traces esp., sand boil
- Construction problem
- Quality control
- New investigation works
- Proposed rehabilitation works

The TAGDI Report was sent by email on Nov 27 and 29, reviewed, discussed and responded by email to TAGDI on Dec 2001(see Attachments 1 and 2)

My comments are

The dam was designed by GDI local engineer and no previous investigation was carried out to investigate either the foundation or the Borrow areas. The construction supervision was inefficient due to the limited capacity and funds of GDI, beside incomplete conditions of contract and instructions

2/1/1 The upstream and downstream slopes were carried out without any berms as in the submitted drawings No traces for any slopes failure appear on the D S or U S.
The GDI supervision staff for the construction informed me that the dam work was suspended by about one year at about mid-height of the dam, and then continued later on to the crest level This might be resulted in developing a tension cracks in the clay core at that level due to dryness and

hasn't been treated properly before filling the next layers This might resulted in seepage potential zones within the dam

Much sediment (resulted from the ponds created by the backwater from the spillway discharge) and waste material is available at the vicinity of the downstream toe of the dam Therefore, piping of concentrated leaks may progress unobserved and lead to failure The D S leaks should be located and the area should be cleaned from all deposit

No treatment was carried out to the foundation except the excavation of cut off trench under the dam, which was filled by cohesive clayey material, but it seems that the contact between the dam and abutments is weak and inefficient

2/1/2 The spillway condition is very serious The chute foundation, beyond the concrete lining, has been washed out as well as the foundation under the left guide wall which resulted in a long water opening which direct the flood towards downstream toe

The spillway capacity has been checked by TAGDI and found that 100-year frequency flood is used as inflow design which is sufficient for this structure The outlet facilities could be used to enhance the spillway capacity by passing part of the inflow design flood

2/1/3 I was informed by the TAGDI team that big cavity is available at the contact between the dam and the left abutment and the driller noticed this during the investigation work

2/1/4. Traces of leaks at D S area could be noticed, sand boiling might happen there

2/1/5 The quality of the construction work seems to be unsatisfactory Only four density tests were carried out for the core, two for trial tests and the other two for the embankment (degree of compaction ranges between 84% to 98%). The results do not represent the situation and undependable.

2/1/6 Recent investigation works were carried out by the MOMR (some B Hs, permeability tests, etc) but no documents have been submitted to evaluate the condition The taking over certificate was issued in March 2000 but the maintenance certificate has not been issued due to the present condition of the dam and spillway

2/1 /7 Although the result of the investigation works has not been submitted but the rehabilitation work might be consisted from the following.

Grouting the left and right abutments to minimize the water seepage there If the carried out investigation shows high permeable zone under the dam some grouting work will be done accordingly

Concreting the chute foundation in addition to constructing the reinforced concrete foundation under the left guide wall of the spillway connected to chute slab This will direct the floods water far away from the D S slope of the dam. The stilling basin area should be filled with big boulders

Cleaning of all the sediment and waste excavated material located at the D S area adjacent to the toe of the dam

Construct relief wells and drain ditch at the D S area to control the pressure of seeping water under the foundation (Design criteria were handled to TAGDI) Any uncontrolled seepage appears in the form of springs in the ground D S from the dam is potentially dangerous Until the construction of relief wells, the area D S must be observed and controlled with filter, especially if sand boil existed, a sandbag protection around the boil should be placed

Treatment of the upstream face depends on the result of the grouting works in the left right abutment If the seepage through the dam body will continue, the asphaltic concrete could be used to treat the U S face

The contractor for the rehabilitation works should be professional in this field and carefully chosen and supervised properly

2/2 Tozan Dam

The principal issues considered by the DSE are as follows

- The present condition of the dam body, concrete face and foundation
- Right and left abutments
- Sediment and topography of the present reservoir
- Bottom outlet
- Spillway condition
- Seepage traces
- New investigation works
- Proposed rehabilitation works

The TAGDI Report was sent by email on Nov 27 and 29, reviewed, discussed and responded by email to TAGDI on Dec 2001(see Attachments 1 and 2).

My comments are

2/2/1 The last part (about 1 km) of the access road to the dam site should be rehabilitated, as it can't be used at present by any vehicle

2/2/2 No serious traces for any settlement or slope failure at the dam crest, downstream slope and upstream slope have been observed Only some cracks and narrow joints opening in the concrete slab were noticed, besides a man-made breaking in the concrete face at left hand side, where a previous trial was made to remedy the concrete Unfortunately, this made the problem worse. The main reason for this main crack is the differential settlement between the foundations under the right portion of the dam, which is compressible while the steep rock abutment is incompressible The problem could be easier solved if the Concrete Face (C.F) was not broken and removed by jackhammer Foundation has not been investigated yet for better evaluation

2/2/3 The right abutment consisted from sandstone formation It is observed that this formation is intersected by mineral dike and interconnected to the rock joints, therefore, a potential privilege pass to water is available between the reservoir and the D, S right area.

The GDI surveyor carried out the topographic surveying for the reservoir and the free board, and he will prepare the rating curves for the reservoir accordingly

2/2/4 The bottom outlet (B O) is used by the farmers there to evacuate the reservoir upon arrival of big flood exceeding the opening elevation in the (C F). Some small sink holes are available near the entrance of the (B O)

2/2/5 The spillway condition is O K but it needs some protection work (about 500 m3 of big boulders to prevent the stilling basin area from being scoured The spillway capacity was checked by TAGDI and found that the 100-year frequency flood is used as inflow design, which is suitable for this structure

2/2/6 Seepage traces are seen in the reservoir near the (B O) and near the right D S area around outlet of the (B.O)

2/2/7· TAGDI has prepared the TOR for the required investigation works (2 B.Hs) at the right abutment and D S right area to investigate the permeability of the two locations and the foundation shearing strength MOMR will carry out the work, which depend on the condition of the access road

2/2/8. During the last visit to the site on Feb 5th, the rehabilitation work, which include grouting, C F remedial works and placement of well graded gravel beneath the damaged slab, applying cracks filling with asphalt and providing boulders to protect the far end of the spillway, have been estimated and TAGDI has prepared the draft B/Q schedule It will be checked and the cost will be roughly estimated, and will be confirmed later depending on the investigation results

As the dam has not been filled with its full reservoir capacity, it was controlled only up to the level where the concrete face was damaged, therefore, the dam stability should be checked depending on the investigation results.

3-Bayt Shaiban- (New Dam)

The evaluation matrix of the potential dam sites within Sana'a Basin, which was agreed upon with Hydrosult, shows that Shaiban site comes in the second ranking priority within the nine potential dam sites (See Annex 3 for comparison between the U S and D S sites which shows the preferability of the U S Site)

TAGDI has completed the field topographic survey and the hydrology studies, and the related information is under preparation by TAGDI

The TOR for the investigation work has been prepared by TAGDI and will be corrected because of the visit on Feb 9th, 2002, where Borrow areas at the left abutment shall be investigated to confirm the quality and quantity of the existing material, i e clay, filter and rock The dam type might be Concrete face rock fill dam if the impervious and pervious soil are not available in enough quantity or the dam will be a zoned type dam depending on the result of the geological and geotechnical investigation Therefore, it is badly needed to construct the access road on the left abutment of the site to have the MOMR equipment to carry out the investigation I recommend that the study for this site should be carried out in details.

4-Conclusions and Recommendations

4/1 Thoma Dam is badly needed for rehabilitation MOMR investigation report should be issued to have the appropriate comments for the rehabilitated works.
The dam should be monitored properly, preferable as per text issued by the Bureau of Reclamation for the Safety Evaluation for Existing Dams previously sent to TAGDI by email

4/2 Tozan Dam, the investigation works is preferable to be carried out to confirm and evaluate the required grouting works The C F should be rehabilitated to increase the efficiency of this dam and to make it safer

4/3 Shiban Dam Project, the study should be confirmed by the investigation works so as to choose the best dam type suitable for this site.

4/4 Usually, most of the small dams' foundation, where required, is treated by consolidation grouting to strengthen the foundation and minimize the water seepage, but it has been noticed that this instruction has not been followed for the existing dams

4/5 The construction supervision plays a major role for controlling the required rehabilitation works for the dams In future, efficient and complete contract conditions and specifications are required

Attachment 1 (December 07 2001)

Dear Wajih (TAGDI),

Greetings from Jordan, attached herewith please find my comments which are related to the summary report and to the five drawings of the two existing dams Upon your arrival in Jordan, we will carry out further discussion related to these dams

Furthermore, it is preferable, where applicable, to use the SEED Manual attached as a guideline for checklist examination of dams The attached checklist is taken from the SEED manual prepared by the U S Department of the Interior Water and Power Resources Services

Tozan Dam

1) It is not clear what exactly the upstream face is made of Is it an asphalt concrete as in the drawing or reinforced concrete as was mentioned in the summary report?

2) There is a difference in the slope mentioned in the drawing and in the summary report as the U/S slope in the report is 2H 1V while in the drawing it is 1 8H 1V Which is correct?

3) Give sketch to the U/S face and cracks location

4) Show the volumes, areas, elevation curves and the elevation of the water in the reservoir, also show where the farmers control the water level, which is not to be higher than the crack location in the upstream face and indicate the reservoir water volume at that level

5) Give a sketch where the water leaks in the D/S slope of the dam or foundation and show clearly the area and elevation of the water leak in the sketches It is not confirmed yet whether the seepage is coming through the foundation or from the dam body

6) Nothing has been mentioned about the crest, upstream face and downstream face settlement Give comparison between the elevation as built and the present situation

7) The underneath transition zone (1) between the face and zone (2) should be checked and proved to be well graded and well densified Accordingly, the face will be rehabilitated or upstream geotextile membrane should be considered and installed

8) Nothing has been said about sediment in the reservoir and how much the reservoir volume being affected in the last 14 years (from 1987 till 2001) and does the area around the draw off works needs to be cleaned or not

9) Stability of the dam should be checked Similarly, check if cracking of the U/S face was due to settlement or slope failure Additionally, the dam stability should be checked under earthquake loading

10) Nothing has been said about Spillway. Is it designed properly to discharge the anticipated flood in the area?

11) Water measurement scales are required to be installed at the upstream face Bench mark should be fixed at right or left abutment to monitor dam body movement

12) Condition of the bottom outlet should be described if it needs rehabilitations

13) One or two boreholes with approximate depth of about 25 m at the right abutment could be investigated and water permeability test shall be carried out. If permeability is excessive more than 3 to 5 Leagons grouting might be needed

Thoma Dam

1) Extreme seepage was observed from abutment, foundation and through the embankments etc Also as it was mentioned that some sand particles were seen in the seeping water. This is called piping phenomenon, this should be checked and treated accordingly
2) Two-dimensional seepage study should be carried to quantify the allowable seepage through the dam and foundation and compare it to the actual condition and evaluate the risk associated with that
3) Check the stability of the dam considering the actual condition Besides, the dam should be checked considering all possible loading conditions such as rapid draw down, normal condition, steady flow, earthquake loading, i e OBE and MCE condition
4) All components of the Spillway design should be checked and modified if they were not adequate and rehabilitation should be carried out accordingly.
5) Referring to item 8 from page 6 It has been noticed that thick sediment is being deposited at the downstream toe of the dam This is resulted from the backwater curve at the far end of the spillway (stilling basin) where this water is in touch with the toe of downstream slope This should be prevented and sediment must be cleaned for future visual inspection
6) Nothing is being mentioned about the treatment of the foundation by grouting during the construction phase except a cutoff trench filled by impervious zone
7) I am in agreement with the investigation program proposed by the TAGDI team, however, soil samples or in-situ tests should be carried out to determine the shear strength of the soil to be able to carry out stability analysis for all the components of the dam
8) Rating curve for the reservoir volume, area, elevation should be added to the report and water level scale should be installed
9) Refer to the proposed treatment for the upstream riprap by mortar grouting This is not practical solution since it highly possible to crack again Also, I agree with the proposed installation of the relief wells
10) Water publing phenomenon in the reservoir should be investigated Is it due to existing occluded cavities or holes by burrowing animals? A treatment should be carried out, i e by impervious blanket.
11) Nothing has been said about the draw off works.

New Dam on Wadi Bayt Shayban

1) I have not got the topographic map for the area, so I can't locate any other potential dam site
2) Check the annual water yield for both sites, i e at the lower and upper dam site
3) Make sure that full geotechnical and geological investigation should be carried out to make sure that foundation is adequate, stability is performed using the correct shear strength parameters, seepage calculation is carried out correctly, etc

Attachment 2 (December 27 2001)- additional comments in relation to Thoma, Tozan and Shayban dams

Tozan Dam

One borehole should be carried out in the dam body, the borehole should extend up to 3/4 of the dam height in the foundation Samples should be collected otherwise SPT should be conducted in the dam body and foundation Also, water permeability tests in the foundation should be carried out As a village is located 1 km downstream of the dam with about 4000 population, the stability of the dam should be checked

Steel net is recommended to be installed at the banks of the dam to prevent rock falling on the upstream face of the dam

Thoma Dam

Two boreholes should be carried out through the dam body, one at the crest and extends to about 3/4 of the height of the dam in the foundation, and the other at upstream berm and extends only to the foundation level From these two boreholes, disturbed and undisturbed samples should be collected These samples should be tested to determine the drained and undrained direct shear tests, Atterberg limits, Density, Gradation, etc Core samples should be collected where is possible, otherwise SPT should be conducted Water permeability tests should be used to estimate permeability in the dam body and foundation Full stability analysis should be carried out to insure the dam is stable under static and dynamic loading(earthquake) In checking the stability of the dam under earthquake loading, the existing village downstream should be considered Upstream Geomembrane (impervious Membrane) could be recommended to prevent seepage CD-R showing the installation of this membrane on some other dams will be provided to you, upon getting it from the source

Shayban Dam

A decision, preliminary sensitivity, analysis has to be carried out for the two sites location, showing the reservoirs volume, Reservoir filling potentiality, suitability of dam's foundation, Banks condition, availability of construction material, spillway excavation ,dam type and preliminary cost The higher site weighted rating, from the sensitivity analysis, will be considered

However from TAGDI preliminary report, it seems that the Upstream site is more preferable

The following should be checked

Check suitability of the dam foundation, permeability, quality of rock, modulous of elasticity and strength, etc.

Evaluation of local materials, haulage distance and it availability with reference to the dam type

Stability analysis, static and dynamic, should be carried out for the dam Accordingly, samples should be collected to determine strength Drained and undrained direct shear tests is recommended Soil indexes should be determined like Atterberge limits, gradation, density, etc

If the upstream site is chosen the inter-catchment flow between the upstream and downstream sites could be collected by other water harvesting method depending on the topography of the area

Attachment 3. Prioritization of Potential Dams within Sana'a Basin

No	Dam	Hydro-logy	Recharge	Command Area	Geology	Topo-graphy	Geotech-nical/ Construc-tion Material	Social Support	Impact Down-stream	Environ-ment Aspect	Spillway Availabi-lity	Accessibi-lity	Total
		11	8	5	9	10	6	7	2	3	4	1	264
1	Bayt Shaiban Upper	4	4	3	3	4	3	4	2	4	4	3	
2	Bayt Shaiban Lower	3	4	3	2	2	3	2	2	3	3	3	
Total	Bayt Shaiban Upper	44	32	15	27	40	18	28	4	12	16	3	239
Total	Bayt Shaiban Lower	33	32	15	18	20	18	14	4	9	12	3	178

Point scores (subjective evaluation by the dam safety specialist) 4 Excellent, 3 Good, 2 Average, 1 Poor

Annex 9. Sana'a Waste Water Treatment Plant- Rapid Assessment

Background

1 The waste water treatment plant (WWTP) was originally designed by Howard Humphreys consulting engineers in 1995 Later in 1997, NWSA awarded a tender for construction to a partnership of Dumez-Degremont based on the original design MISR consulting engineers were awarded a supervision contract, which also required that the original design be reviewed. It seems that the original design was not reviewed in depth and construction took place on the basis of the 1995 design The WWTP was completed in mid-2000 and was operated by Dumez-Degremont under a one-year commissioning phase, which ended in May 2001

WWTP Equipment and Processes

2. *The inlet works consists of* 2 no (number) mechanically racked screens for normal use and 1 no manually racked screen in the bypass channel Penstocks to divert incoming flows to a 1 5 m dia bypass pipeline discharging into the adjacent wadi 4 no screw pumps (3 duty, 1 standby) rated at 800 l/s lift the influent to allow gravity flow through the works 2 no 8 0 m dia mechanical detritors are provided for grit removal, each with a grit washing machine

Biological treatment consists of Activated sludge treatment in 8 no aeration lanes, 105 m x 21 m x 5 5 m deep, each with an inlet mixer and 4 no aerators Settled "activated" sludge is taken from the sludge settling tanks and returned to the inlet works

Sedimentation consists of 8 no 30 m dia mechanically scraped "secondary" settling tanks

A Form of Tertiary treatment consists of Chlorination in a contact tank with 20 minutes retention (a separate chlorine store is provided on site). Plus an effluent polishing lagoon with a volume of 4 45 days flow at average design flow

Sludge treatment consists of. 4 no 8 0 m dia sludge thickening tanks each with mechanical stirrers, floor scrapers and a pump discharging to the sludge drying beds. Polymers are added to accelerate dewatering 20 no sludge drying beds are provided each 55m x 27 5m with sand and gravel under drainage and designed for manual desludging These are being upgraded

Flow Measurement consists of A weir at the outlet of the chlorination tank measuring flow through the plant A weir at the outlet of the aeration channels measuring flow to the sludge thickening tanks A flume in the pipeline measuring returned activated sludge

Electrical energy. is drawn from the mains but is backed up by 2 no 2000 kVA diesel generators The plant manager reports an operating cost for electricity of
$ 130,000/month The plant is also equipped with, an office, laboratory, workshop and store, canteen and kitchen, and showering facilities

Effluent Disposal effluent is discharged into an adjacent wadi from which some 600 farmers pump the effluent to irrigate approximately 280 ha of land

Design Criteria and the Actual Situation

3 The original design assumed that the incoming sewage would have a biochemical oxygen demand (BOD) loading of 500 mg/l and suspended solids (SS) loading of 750 mg/l and that the ultimate average design flow (ADF) would be 50,000 m3/day and a peak flow of 3x ADF The proposed quality standard for the treated effluent was set at a BOD of 30 mg/l and SS of 30 mg/l. Sludge production was estimated to be some 570 m3/day

4 In reality, the incoming sewage was found to be much stronger In February 2001, the incoming BOD ranges from 520 to 1,360 with an average of 940 mg/l, almost 100% higher than anticipated Similarly, the SS range from 554 to 1352, with an average of 1004 mg/l, some 140% higher than anticipated The incoming flow rate ranges from 10,650 to 52,000, with an average of 26,900 m3/day, some 53% of the anticipated ultimate design capacity The actual quality of the treated effluent is within BOD ranges from 6 6 to 62 4, with an average of 23 8 mg/l, and SS ranges from 3 6 to 132 with an average of 27 9 mg/l These are acceptable standards in terms of BOD and SS, if consistency can be achieved However, independent micro-biological tests have indicated that helminths and pathogenic bacteria are still viable in the effluent as indicated in the table below

5 However, the plant is occasionally bypassed by its operators who close the inlet penstocks, so that raw sewage is discharged into the adjacent *wadi*, under three circumstances. First, during electricity failure or during periods of low voltage, the standby generators have failed to "trip-in" Second, it was also assumed that the incoming trunk main would transport sewage only, however, the city's storm water drainage is finding its way into the sewer system, which means that, during the rainy season, storm water flushes out the sewerage system and these excess flows bypass the WWTP via an overflow weir at the inlet, polluting the *wadi* to the rear of the plant Third, plug flows of mineral oil and grease have been observed to be entering the plant During these occurrences, operators bypass the plant in order to protect its operations

6 A further problem is that the sludge production is more than twice than anticipated The effects of this are that the sludge drying beds are overloaded and too little sludge is being drawn off from the aeration channels, which inhibits the activated sludge process and overloads the secondary settling tanks Independent micro-biological tests have indicated that, although helminths and pathogenic bacteria are still viable in fresh sludge, these had died off after six months

Table 9-1: Original Design Assumptions and the Actual Situation

Original Design Assumptions		Actual situation (e g Feb 2001)
BOD	500 mg/l	BOD (520 – 1360) av 940 mg/l (187%)
SS	750 mg/l	SS (554 – 1352) av 1004 mg/l (134%)
Av Flow rate (peak 3 x afr)	50,000 m3/day	AFR (10,643 – 51,968) av 26,809 (53 6%)
Treatment standard		Effluent standard
BOD	30 mg/l	BOD (7 – 62) av 24 mg/l
SS	30 mg/l	SS (4 – 132) av. 28 mg/l

7. A recent micro-biological analysis of the effluent from the WWTP was carried out by WEC, University of Sana'a, a summary of which is shown in the table below As can readily be seen, the presence of pathogens contravenes the Yemeni Standards for irrigation water, which stipulates zero pathogens

Table 9-2: Microbiological Analysis of Influent and Effluent at Sana'a WWTP (WEC 2001)

Parameter	Influent	Effluent
Pathogenic Bacteria No. Col/100ml		
Salmonella	20	2
Shigella	15	1
E coli	15	1
Streptococci	16	3
Candida	6	3
Heminths No Ova/Cysts/ ml		
Amoeba	10	8
Giardia	5	4
Taenia saginata	5	4
Ascaris	7	5
Schistosoma	5	3
Ancylostoma duodenale	4	2

Identified Problems

8 Consulaqua, a German Consulting Company, was commissioned in 2000 to review the operations of the WWTP and to make recommendations for solutions to the problems that had arisen and to review the possibilities for wastewater and sludge reuse Six particular problems were identified

(i) Sludge drying and disposal.
(ii) Discharge of raw sewage into the wadi and inconsistent effluent quality
(iii) Foul odors emanating from the WWTP
(iv) Establishing optimum plant operations.
(v) Achieving the ultimate plant design capacity
(vi) Safe disposal of the effluent and sludge

The consultant recommended four packages of improvements Package 0 comprises a number of measures to improve plant operations, including constructing primary sedimentation tanks and additional sludge thickeners and improvements to the bypass channel Package 1 includes geological exploration and effluent reuse through aquifer recharge and improved irrigation Package 2 includes sludge treatment using mechanical dewatering, improving the drying beds and construction of a packaging station Package 3 includes Odor Control measures These measures are prioritized into primary and secondary interventions each having stages or steps. Many of the recommendations have merit but others appeared costly in terms of capital and operational costs The total cost of all the packages was some $47 m, of which up to $21 m would be for a facility to use the treated effluent to recharge the aquifer These modifications would add an operations and maintenance burden of approximately $8 m per year

9 The purpose of this assessment is not to comment on Consultaqua's recommendation, however, it is recommended that any further works should be the subject of a **detailed design study** that should emphasize appropriate and least cost technological solutions

Possible Solutions

10 Sludge Drying and Disposal The production of sludge is more than twice that anticipated and the sludge drying beds and sludge stock piling area is far too small This is exacerbated by NWSA who have not removed any sludge from the site, as they were expected to do each six months under the terms of the contract It is claimed that some 100,000 m3 of dried sludge are presently stockpiled at the plant The immediate solution would be to find as suitable landfill site nearby in which to dispose of the sludge In parallel, the area of drying beds and stockpiling area should be increased by obtaining land adjacent to the WWTP This may be linked to giving dried sludge to farmers for their own use or resale as a soil conditioner The local farmers cooperative have expressed interest in undertaking this enterprise. Sufficient drying time of six months or more should be allowed to ensure the die-off of pathogens, helminths and ova and regular micro-biological and chemical testing of the sludge should be carried out to safeguard health The sludge loading on the aeration tanks could be greatly reduced by providing primary sedimentation.

Discharge of raw sewage and inconsistent effluent quality An immediate action would be for NWSA to investigate where oil and storm water is entering the sewer and seek to stop the dumping. In parallel, a holding tank of 24-36 hours capacity should be constructed at the inlet to store excess storm water flows or flows polluted with oil and grease and equipment provided to skim off the oil and pump the stored influent back into the treatment stream when the flow has returned to normal.

Foul odors emanating from the WWTP Foul odor emanates mainly from the inlet area, the aeration channels and the sludge drying areas of the plant which is an embarrassment, as the plant is adjacent to the international airport Odors from the sludge drying area and aeration channels can be minimized by improving operations and, particularly, removing the dried sludge to land fill or other disposal Consulaqua recommends enclosing the inlet works and providing an exhaust fan, ducting and a bubble aerator in the aeration tanks This is a reasonable suggestion but other alternatives should be sought for comparison

Safe disposal of the effluent The wastewater (effluent) is a valuable resource in the water scarce Sana'a Basin It could be reused in two ways; for aquifer recharge or irrigation Irrigation could be made more efficient by providing a balancing lagoon after the outlet from the WWTP and providing a piped or channel gravity distribution system The feasibility of such a system has been investigated by the FAO Watershed Management and Wastewater Reuse Project that was active in the area Although the effluent is chlorinated before discharge, there is a risk in operating such a scheme - the WWTP must maintain a consistent flow of effluent free from pathogens, as the farmers may use the effluent for irrigation of tomatoes and other crops that need not be cooked before consumption This risk to public health could be controlled by strict monitoring of the effluent, education of the farmers and control of cropping patterns Aquifer recharge is more problematic due to the risk of polluting the aquifer or alternatively the high costs of purification (Consulaqua estimates $34m capital costs and $2.7m/year operational costs which seem unrealistic) A secondary issue is that farmers have assumed the right to use the effluent for irrigation and diverting the flow to aquifer recharge may cause social problems.

- ***Next Steps***

11 The design and operational problems of the Sana'a WWTP pose clear health risks to the population, both to farmers using the effluent for irrigation and to consumers of the crops they produce, especially vegetables eaten raw There are also risks to the environment, to the ecosystems along the *wadi* and to groundwater quality These problems are most severe when raw sewage is being bypassed around the plant However, even when the treatment process is working correctly and the effluent standard in terms of BOD and SS are within acceptable ranges, the reuse of the effluent calls for better monitoring and restrictions on the crops grown because of the pathogenic content in the effluent. The present inability to deal with the large volumes of sludge is also creating an increasingly severe health and environmental threat, as the partly stabilized wet sludge also contains high levels of pathogens until drying and degradation has taken place

12 Addressing these issues will require two types of actions First, short-term actions that could be implemented immediately. Second, the completion of a **detailed plant audit**, and the production of final designs for minimum plant modifications, i e increased area of sludge drying beds, construction of detention tanks to avoid bypassing the plant, primary settling tanks to reduce the sludge load and odor control. It is envisaged that the detailed design study will be funded by the Government The detailed designs could commence in February 2003 and be completed within four months. The civil works would be funded from the Arab Fund. The works themselves could be completed within 12 months, if a contractor with good resources could be hired It is estimated that the minimum improvement costs would be approximately $12 million.

13 The WWTP management may fall under a lease management contract being negotiated by the Sana'a Local Corporation It is essential that WWTP performance guarantees and penalties for non-performance be specified in the contract

14 The "short-term actions" that could be instituted in the immediate future should include the following actions, which are reflected in the EMP

- Removal of the accumulated dried sludge within the WWTP to a land fill site
- A "red flag" system to warn farmers if raw sewage is being discharged to the wadi
- Farmer education on the hazards of treated and untreated wastewater
- A ban on the use of effluent to irrigate vegetables eaten raw.
- A restriction of the types of crops being grown

15 In parallel, a feasibility study funded by CIDA has been launched to review the reuse of wastewater and sludge The recommendations of this study, which should be available in early 2003, will provide clear guidance as to future strategy for safe and economic waste water and sludge reuse

Annex 10. Yemeni National Guidelines of Water Quality for Irrigation 1993

Table 10-1: Yemeni Guidelines for Water Quality for Irrigation

Parameter	Symbol/unit	Guideline
Salinity		
Electrical Conductivity	ECw mmhos/em	0 7 – 3.0
Total Dissolved Solids	TDS mg/l	
Iron Toxicity		
Sodium	Na meq/l	3-9 (>3)*
Chloride	Cl meq/l	4-10 (>3)*
Boron	B mg/l	0 7 –3
Others		
Nitrogen	N mg/l	5-30
Bicarbonate	HCO3 mg/l	1 5-8 5
Acidity	PH	6 5-8 4

* for sprinkler irrigation

Table 10-2: Guidelines for Maximum Concentrations of Trace Elements in Irrigation Water

Element	Maximum mg/l
Al	5 00
As	0 10
Br	0 10
Cd	0.01
Cr	0 10
Co	0,05
Cu	0.20
F	1 00
Fe	5 00
Pb	5.00
Mn	2 50
Mo	0 20
Ni	0 01
Se	0 20
V	0 10
Zn	2 00

Annex 11. Chemical and Biological Testing of Effluent and Sludge from Sana'a WWTP

Part 1. Chemical and Physio-chemical Analyis for Wastewater and Sludge from Wastewater Treatment Plant in Sana'a

Sampling and Reservation and Methods of Analysis

A. Wastewater:

A1. Samples collection:

Samples were collected from influent of the wastewater treatment system for 24 hrs and after the retention pond Samples were collected in plastic bottles of 500 ml, with care to leave ample air space when closing the container. Two samples were of each were collected

A2. Samples reservation:

Samples were mixed with some drops of chloroform for preservation and kept in refrigerator at 4°C

A3. Methods of Water Analysis:

1 Suspended Solids (S.S). was determined using filtration technique followed by weighing according to the standard methods
2 pH· was determined by pH meter
3 EC was determined by electrical conductivity meter
4 Na+· was determined by atomic absorption spectrophotometer at characteristic wavelength Standard Solution was prepared
5 Ca^{++} and Mg^{++} were determined by titration with Fersinite
6. Residual chlorine was determined by Iodometric method
7 Determination of chloride (Cl-) was determined by titration of chloride with silver nitrate
8 Total Kjeldahl Nitrogen (TKN)· was determined by Kjeldahl method
9 Heavy metals as "B, Mn, Cu, Pb, Cd, Ni, Zn, Se, Cr, Al, and Co" were determined by atomic absorption spectrophotometer
10 Heavy metal as "Cn" was determined by spectrophotometer

B. Sludge:

B1. Samples collection:

Samples were collected from four places, thickener, drying beds, storage area after 3 months, six months and 12 months

B2. Samples preservation

Sampling was done by the use of an auger which has a wide diameter for collection of samples

Samples were placed in plastic bags, particularly plastic bags which are covered by cloth Data and all necessary information were written (date of collection, quantity and sampling position)

Samples were kept aerobic, dried after transporting to the laboratory Samples were collected before drying to determine the moisture content

C. Methods of Analysis:

1 Extract preparation extract was prepared proportionally (1 1) distilled water and sludge. This quantity should be sufficient for the following analysis

1-1 pH determination using pH meter
1-2 EC using Electrical Conductivity meter
1-3 Na, Ca, Mg, Cl was determined as mentioned for the wastewater

2 Heavy metals as B, Mn, Cu, Pb, Cd, Ni, Zn, Se, Cr, Al, and Co" were determined after digestion of samples, by atomic absorption spectrophotometer, while "Cn" was determined by spectrophotometer

3 Organic matter (O M) was determined by "Weakly & Blake" method This method is based on oxidation of organic matter

4 Total nitrogen was determined by digestion, distillation by Kjeldahl method followed by titration

Results and Discussions

Wastewater after retention pond:

Comparing the results of the analysis (Table 11-1) with the standard guidelines for irrigation, the following conclusions can be drawn

Chloride is in the range of 7-8 meq/l, which is less than the maximum allowable However, according to FAO, 4-10meq/l is considered as the range of negative effect Chloride at high concentrations might cause some problems to some fruits such as grapes

EC, which reflects the salinity of the wastewater, indicates that EC are high This concludes that wastewater is in the range of medium to high salinity A continuous application of this water will render the soil as saline SAR was calculated to be 14 7, which indicates the possible negative effect on irrigated soil, which will then have an impact on the growth of the plants

High pH of 8 1 indicates the wastewater has included high concentration of base as Ca CO_3, which will cause a decrease in the soil fertility, which will have a bad effect on the plant growth, especially in the Yemen soil which is generally base

Concentration of Boron was in the high limits, which might cause toxicity to some plants.

Heavy metals as Cobalt, Boron, Nickel, and Cadmium have exceeded the permissible levels for irrigation water This would cause accumulation of heavy metals in the soil and eventually will cause toxicity to plant

Copper and Chromium, although their concentrations are still close to the allowable levels, the continuous use will cause accumulation with time, which will pollute the soil and affect the plant growth

Moreover, as far as the health conditions of people and animals is concerned, some heavy metals might not affect the plant growth but could have a toxicity effect on the people and animals Accumulation of heavy metals in the plant will be transferred and accumulated in the bodies of the consumers However, this implies continuous measurements of the heavy metals

concentrations in the soil and plant irrigated by the wastewater after retention ponds, which are ultimately consumed by the people and animals

Influent Wastewater:

From Table 11-1, it is clear that only Cobalt was detected at higher concentrations of 0 08-0 09mg/l which is higher than the industrial wastewater guidelines, which should not be higher than 0.05mg/l This needs more investigations to check the source of this high concentration level

Sludge:

From Table11-2, it is shown that all values are within the values expected in the international typical sewage sludge

The sludge, as an organic matter, is generally used to improve the soil especially the base soils This is very useful for Yemen as the Yemen soil is generally base However, care should be taken when adding sludge to soil

Apart from wastewater application, sludge application to soil is more safe as it can easily be controlled by dosing the proper weight of sludge to soil according to the chemical concentrations needed in the final mixture

Awareness of the biological pollution should be done with the farmers in order to avoid the transfer of diseases from the sludge due to application and direct contact with the sludge and plants.

Table 11-1: Results of the Wastewater-Physico-Chemical and Heavy Metals Analysis

Parameter	Unit	Influent wastewater		Industrial WW guidelines	Retention pond		Standard for irrigation
		Sample 1	Sample 2		Sample 1	Sample 2	
1 Physical and Chemical parameters in wastewater							
4 a. pH	--	7 1	7.2		8 1	8 1	
4 b. EC	ds/m	2 3	2 5		1 8	1 8	<1
4 c TSS	mg/l	423	611		122	136	
4.d Na^{+}	meq/l	74 01	74 50		81 24	81 32	60
4.e. Cl^{-}	meq/l	9.00	8 74		7 87	7 89	10
4 f. Mg^{2+}	meq/l	2 72	2 69		3 06	3 06	
4 g. Ca^{2+}	meq/l	36 0	36 5		58 1	57 9	
4 h. TKN	mg/l	52 5	52 5		25 0	22 5	
4 i. Residual Chlorine	mg/l	--	--		3 06	2 75	
SAR (Sodium Absorption Ratio)	----	16 8	16 6		14 70	14 75	10

2 Heavy metals in wastewater							
5 a B^{-},	mg/l	0 62	0 66	5	0 54	0.59	<0 5
5 b Mn;	mg/l	0 02	0 03	10	0 02	0.02	0 2
5 c Cu,	mg/l	0 20	0 30	5	0 20	0 15	0 2
5.d Pb,	mg/l	0 24	0 25	0 6	0 22	0 23	5
5 e. Cd,	mg/l	0 07	0 06	1 0	0 13	0 11	0 01
5 f Nı,	mg/l	0 26	0 25	5	0 23	0 21	0 1
5 g Zn,	mg/l	0 05	0 04	15	0 02	0 01	2 0
5 h Se,	mg/l	<0 001	<0 001	0.1	<0 001	<0 001	0 5
5 ı Cr,	mg/l	0 04	0 05	5	0 05	0 05	0.05
5 j Al,	mg/l	<0 001	<0.001	5	<0 001	<0 001	1 0
5 k. Cn,	mg/l	0.025	0.025	5	0 020	0 020	--
5 l Co	mg/l	0.09	0.08	0 05	0.002	0.005	0 05

Table 11-2: Results of the Sludge Physico-Chemical and Heavy Metal Analysis

Parameter	Unit	Thickener		Storage								Typical sewage sludge
		S1	S2	Drying beds		Three months		Six months		12 months		
				S1	S2	S1	S2	S1	S2	S1	S2	
3 Physical and Chemical parameters for sludge:												
pH	--	6 96	6 89	7 17	6 91	7 10	6 95	6 20	6 74	6 69	6 82	
EC	ds/m	6 82	6 82	3 28	2 96	2 68	2 15	2 85	2 62	3 14	3 20	
SS	mg/l	--	--	--	--	--	--	--	--	--	--	
Na^+	meq/l	--	--	--	--	--	--	--	--	--	--	
Cl^-	meq/l	60.0	58 6	17 8	16 5	6 9	5 7	4 3	4.9	8 5	7 3	
Mg^{2+}	meq/l	5 5	4 8	8 2	6 6	2 3	3 8	1.5	1 9	6 0	5 5	
Ca^{2+}	meq/l	1 8	2 2	3 3	3 5	1 8	2 1	2 0	1 6	5 3	5 2	
N	%	4 6	4 6	6 3	6 0	12 0	12 3	13 0	13 0	18.5	21 1	
Organic Carbon	%	25.5	25 4	23 9	24 2	23 8	23 6	23 4	23.3	22 4	22 7	
C/N	--	4 6	4 6	6.3	6 0	12 0	12 3	12 9	12.9	18 5	21 0	
Organic matter	%	43 9	43 7	41 1	41.7	41 0	40 7	40 3	40 1	39 6	39 2	

Parameter	Unit	Thickener		Storage								Typical sewage sludge
		S1	S2	Drying beds		Three months		Six months		12 months		
				S1	S2	S1	S2	S1	S2	S1	S2	
4. Heavy metals in sludge												
5 a B,	mg/kg	12 0	11 8	13 0	12 3	1 6	1 6	6.0	6 0	13 2	14 1	100
5 b. Mn,	mg/kg	234	202	233	214	296	342	364	366	222	297	500
5 c Cu,	mg/kg	39	38	40	43	48	41	59	91	154	181	1000
5 d Pb,	mg/kg	105	112	139	128	47	63	170	140	123	103	1000
5 e Cd,	mg/kg	1 8	1 2	4 2	4 8	1 1	1 5	2 1	2 6	3 0	2 9	150
5 f Ni,	mg/kg	23	19	30	29	10	10	28	22	45	42	400
5 g Zn,	mg/kg	605	559	378	402	208	164	437	437	306	352	5000
5 h Se,	mg/kg	<0 01	<0 0	<0 0	<0 0	<0 0	<0 0	<0 0	<0 0	<0 0	<0 0	--
5 i. Cr,	mg/kg	0 03	1	1	1	1	1	1	1	1	1	--
5 j Al;	mg/kg		0 05	0 03	0 02	0 01	0 02	0.07	0 08	0 01	0 03	--
5 k Cn,	mg/kg	1 0	1 0	0 6	0 7	0 2	0 3	0 4	0 5	0 6	0 8	--
5 l Co	mg/kg	12.0	12 0	3.84	3 84	1 92	1.92	7 68	7 50	8 64	6 72	--
			14 4	15 6	14.1	73.5	58.8	54 6	43 2	37 2	18 4	
		12 6										

Part 2. Microbiological Analysis for Wastewater and Sludge from Wastewater Treatment Plant in Sana'a

Introduction

Pathogenic organisms in wastewater and sludges as fungi, bacteria and pathogenic protozoa cause many diseases for humans and animals Fungi pathogenic to humans such as *Candida albican,* can be recovered in varying numbers from wastewater treatment plant effluents, streams receiving such effluents, and recreational waters In humans, this fungus is usually a commensal organism, in healthy adults have detectable levels in their feces also a very large proportion of the female population has vaginal candidiasis in varying degrees of severity 984 species of fungi listed in water and wastewater (Cooke, 1986) *Trichophyton mentagrophytes*, the cause of tinea pedis or athlete's foot

Pathogenic bacteria that have been transmitted by water or wastewater are *Salmonella, Shigella , Escherchia coli, Vibrio cholera, Mycobacterium, Leptospira* and *Francisella* These organisms cause many diseases for humans and animals such as fever, vomiting, diarrhea, weakness and weight loss The distribution of *E coli* is worldwide in water sources (Wachsmith, 1984)

The parasitic protozoa and helminths of primary concern in drinking water and wastewater are *Entamoeba histolytica, Giardia lamblia, Naegleria, Taenia* worms, *Ascaris* worm, *Belharisia* worms and others as *Ancylestoma duodenale.* These organisms cause diarrhea or gastroenteritis of varying severity for humans and some animals

Between 1963 and 1984, 90 waterborne outbreaks and more than 23,000 cases of giardiasis were reported in America (Craun and Jaku Bowski, 1987) Micro-organisms examination of wastewater and sludge may indicate the effectiveness of wastewater treatment process

The aim of this project is to analysis the wastewater and sludge from wastewater treatment plant in Sana'a, in order to investigate the quality of wastewater and kind, and density of micro-organisms in wastewater and sludge

- **Materials and methods**

A. Sampling:

A1.Wastewater:
Samples were collected from influent of the wastewater treatment system for 24 hours and from retention pond Sterilized bottles 1l were used with care to leave ample air space in the bottle (at least 2 5cm) to facilitate mixing by shaking before examination Two samples each were taken

A2. Sludges:
Samples were collected from thickener, drying beds and from the storage at different places (three, six and twelve months age) Sterilized containers for 1 kg sludge were used Two samples each were taken

B. Preservation and storage:

Samples were transported to laboratory within 30 minutes and started microbiological examination promptly to avoid unpredictable changes.
Samples were stored in refrigerator at 5°C during examination The time elapsed between collection and examination did not exceed 24 hours.
Each plate with sample number, dilution, date, and any other necessary information before examination was marked

C. Methods of Analysis for water and sludge:

To examine fungi and bacteria, membrane filter technique was used as follows

Membrane filter technique

Procedure

Preparation and dilution:

To a sterile 250- ml erlenmeyer flask 135 ml sterile distilled water and 15 ml sample from both influent of the wastewater treatment system and retention pond were added individually to obtain a 1 10 sample dilution
Dilution was continued until 1 1000 sample dilution with shaking vigorously after each transfer A sterile measuring device was rinsed with sterile distilled water between samples

To examine sludge, 10 0g sludge from different sampling positions were dissolved in 100ml sterile distilled water and filtrated to remove debris Then 15 ml solution from each sample was added to 135 sterile distilled water to obtain a 1 10 sample dilution Dilution was continued till 1 1000 sample dilution

Media

1 For fungi, Streptomycin Tetramycin Malt Extract Agar (STMEA) is useful in analyzing sewage and polluted water (Quresh and Dutka, 1978) 30 0g malt extract, 5 0g pepton, and 15 0g agar were mixed in 800 ml distilled water and was sterilized 70 0 mg each of streptomycin and tetramycin in separate 100 ml portion distilled water Then the mixture was sterilized by filtration and were added to the cooled (45°C) agar base The pH was 5 4

2 For bacteria, Trypton glucose yeast agar was used for bacteria, 5 0g trypton, 2 0g yeast extract, 1.0g glucose, 15.0g agar and 1l distilled water The pH was 7.0 Then 20-ml portion fungi and bacteria media were poured into sterile petri dishes and let agar harden

- **Filtration**

100ml of well-shaken sample of the diluted1·1000 sample was filtered through membrane filter with pore size of o.8μm Filters were transferred onto surface of pre-dried agar plates.

- **Incubation**

All petri dishes for fungi were incubated at 15°C for 7-10 days, but bacteria incubated at 35°C for 24-48 hours

- **Counting and recording**

A binocular dissecting microscope was used at a magnification of 10x, all colonies were counted on each selected plate. Record results were as colony forming units (CFU) /100 ml

original sample Sludge samples were reported as "CFU/g wet weight Average number of colonies for four plates and for two samples were counted by the following equation

(Total) coliform colonies or other pathogens/100 ml

$$= \frac{\text{coliform colonies or other counted pathogens x 100}}{\text{ml sample filtered}}$$

To examine pathogenic protozoa, concentration technique was used as follows

100 ml samples from both influent to wastewater treatment plant, and retention pond were filtered by cheesecloth also 10 0g sludges from different sampling positions were mixed in 100ml sterile distilled water and filtrated to remove debris
50 ml from each sample was filtered through membrane filter Membrane filter was removed by a pair of forceps and placed to side wall of a 100-ml beaker and repeatedly flushed filter surface with several milliliters distilled water Scanned portions of each sample concentrate were poured into a 10- ml conical centrifuge tube and centrifuged at 1000 rpm for 5 minutes Without disturbing sediment, removed supernatant with a capillary pipette then a drop of the remainder was transferred to a microscope slide and a Sedwick-Rafter counting cell for examination and counting

Results and Discussions

Table 11-3 shows that there were differences among density of various bacteria in wastewater The density of bacteria in influent of the wastewater treatment system were more than retention pond and this is due to efficiency of chlorination process (80-94%) Chlorine dose used is about 6-10mg/L (Hamid Alkomisy, personal communication)

In Table 11-4, numbers of bacteria in thickener were more than that in drying bed This is due to the presence of organic material Bacteria decrease in the sludge from the storage of twelve months This is due to the exposition of sludge to sun, which killed the bacteria

Table 11-3 shows that there were differences among density of *Candida* in the wastewater The density of fungus in Retention pond was less than that in the influent of the wastewater treatment system by 50%

This means that efficiency of chlorination process was more useful on bacteria than fungi Fungi are more resistant to chlorination and disinfection than coliform bacteria. Rosenengweig et al (1983) reported that fungal cells, especially *Conidia*, can survive at much higher doses of chlorine than coliform bacteria, including 10 min exposure He found that Fungus in thickeners was more than that in drying bed this relevant into organic substances in thickeners and exposition of drying bed to sun

Table 11-3and 11-4 show that there were differences among density of various protozoa and other parasites in wastewater and sludge. The density of protozoa in retention pond were less than that in influent of wastewater treatment system by 10- 50%

This indicates that efficiency of chlorination process in the treatment plant is 10 – 50% for protozoa *Giardia* cysts and other protozoa are more resistant to disinfection than bacteria

Sludge monitoring also may indicate treatment processes efficiency The density of protozoa in thickener were more than that in drying bed relevant into organic materials and the effectiveness of sunshine and other factors

Table 11-3: Results of the Wastewater-Microbiological Analysis

Parameter	Unit	Influent wastewater		Retention pond	
		Sample 1	Sample 2	Sample 1	Sample 2
5 Pathogenic bacteria in wastewater					
1 a *Salmonella*	#Col/ 100ml	20	19	2	2
1.b *Shigella*	with dilution	15	15	1	1
1 c *Vibrio cholera*	factor of	nil	nil	nil	nil
1.d Enteropathogenic *E coli*	1000	15	14	1	1
1 e *Mycobacterium*		nil	nil	nil	nil
1 f *Leptospira*		nil	nil	nil	nil
1 g *Francisella* and		nil	nil	nil	nil
Streptococci		16	15	3	2
6. Fungi in wastewater (which would cause skin diseases)					
3 a *Candida albicans*	#Col/ 100ml	6	5	3	2
3 b Other kinds of *Trichophyton*		nil	nil	nil	nil
7 Helminth eggs in wastewater					
2 a parasitic Amoeba (*Entomoeba*	#Ova or	10	9	8	7
histolytica)	Cyst/ml	5	5	4	4
2 b parasitic *Giardia lamblia*		nil	nil	nil	nil
2 c parasitic *Naegleria*		5	4	4	3
2.d *Taenia saginta*		7	6	5	5
2 e *Ascaris lumbriciodes*		8	8	7	6
2 f Belharsia worms (*Schistosoma*		5	5	3	3
mansoni) (*Schistosoma*		4	3	2	1
haematobium)					
2 g Others as *Ancylostoma duodenale*					

Table 11-4: Results of the Sludge-Microbiological Analysis

Parameter	Unit	Thickener		storage							
		S1	S2	Drying beds		After 3 months		After 6 months		After 12 months	
				S1	S2	S1	S2	S1	S2	S1	S2
8. Pathogenic bacteria in sludge:											
1 a. *Salmonella*	#Col/ 10gm	24	23	10	9	5	4	2	2	nil	nil
1 b *Shigella*	with dilution	20	20	12	12	4	4	1	1	nil	nil
1 c. *Vibrio cholera*	factor of	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
1 d Enteropathogenic *E coli*	1000	20	19	8	7	3	2	nil	nil	nil	nil
1 e. *Mycobacterium*		nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
1 f *Leptospira*		nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
1.g. *Francisella* and		nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
Streptococci		20	20	10	10	3	3	1	1	nil	nil
9 Fungi in sludge (which would cause skin diseases)											
3 a. *Candida albicans*	#Col/ 10gm	10	10	4	4						
3 b Other kinds of *Trichophyton*		nil	nil	nil	nil						

Parameter	Unit	Thickener		storage							
		S1	S2	Drying beds		After 3 months		After 6 months		After 12 months	
				S1	S2	S1	S2	S1	S2	S1	S2
10 Helminth eggs in sludge											
2 a. parasitic Amoeba (*Entomoeba histolytica*)	#Ova or Csyt/ gm	10	9	6	6						
2.b.parasitic *Giardia lamblia*		6	5	2	2						
2.c parasitic *Naegleria*		nil	nil	nil	nil						
2.d *Taenia* worms		6	6	2	1						
2.e *Ascaris* worms		8	7	4	4						
2 f Belharsia worms (*Schistosoma mansoni*)		8	8	3	3						
(*Schistosoma haematobium*)		5	5	4	3						
2 g Others as *Ancylostoma duodenale*		3	3	1	1						

Annex 12. Regional Environmental Assessment Component

Terms of Reference

1. PROGRAM DESCRIPTION AND PHASE I PROJECT OBJECTIVES

The Sana'a Basin is located in central highlands of Yemen and includes the Capital City Sana'a The basin has an area of 3,200 km2 and an average elevation of 2,200 meters above mean sea level Current population of the basin is estimated at about 1 5 million, of which 300,000 live in the rural areas, and the population growth rate is projected to decline from the current 6% to about 4% by 2030 The basin includes some 110,000 hectares (ha) of arable land, of which about 20,000 ha are irrigated Groundwater is the major source of water in the basin Abstractions began to exceed recharge during the mid 1980s as a consequence of the rapid urban population growth and a sharp increase in water use by agriculture, encouraged by the introduction of tube-well technologies The basin is experiencing a serious depletion of groundwater resources with an associated alarming degradation in water quality. The situation is further complicated by the absence of an integrated water resources management plan for the basin including lack of data, absence of a regulatory framework to manage the groundwater extractions and inefficient irrigation practices Unless action is taken to improve the management of the basin's aquifers, current levels of water resources depletion will create a crisis in water availability and supply in the near future In addition a new Waste Water Treatment Plant (WWTP) has recently been commissioned to the north of Sana'a, its effluent could provide a valuable resource if public health issues can be avoided The Government of Yemen is well aware of the situation and is taking steps to address the water resources management issues in the basin

To address some of the development issues, the Government and the World Bank have agreed to prepare a Sana'a Basin Water Management Program The objectives of this proposed program are a) to increase both quantity and the usable life of the groundwater resources available for domestic and industrial use in the Basin, and so to postpone the date at which the new supplies have to be brought in from outside the Basin, and b) to simultaneously increase the efficiency of agriculture water use so as to allow time for a gradual shift to a less water-based rural economy in the Basin.

The Sana'a Basin Water Management Program will be implemented through an Adaptable Program Credit (APC) financed by the International Development Association (IDA) a part of the World Bank Group This would allow IDA and the Government of Yemen to agree on a long-term (15 years) program to be implemented in three consecutive phases of which the proposed project is the first phase Each phase would be built on the experience and progress of the preceding one and starting only after certain milestones have been met In this first phase (five years), technological solutions and institutional arrangements will be tested on a pilot basis in four representative sub-basins for later incorporation into a full-scale basin-wide program to be implemented during the subsequent two phases

The objectives of Phase I of this Program are 1) to test and develop demand and supply management methods for large-scale implementation throughout the Basin during the subsequent phases of the program; 2) to establish the regulatory, legal and institutional framework needed for more sustainable water resources management in the Basin, and 3) to carry out the preparation of the Phase II project of the Program

These TORs where modified in May 2001 to reflect the findings of World Bank mission to identify the pilot sub basins and the proceedings of an Environmental Assessment Scoping and Public Disclosure workshop..

2. ENVIRONMENTAL ASSESSMENT OBJECTIVES AND REQUIREMENTS

The Sana'a Basin Water Management Project has been designated as a Category A project requiring an environment assessment, in accordance with the Bank's Operational Policy (OP 4 01) Additional Bank environmental and social safeguard policies to be evaluated for possible application and compliance would include Natural Habitats (OP 4 04), Pest Management (OP 4 09), Involuntary Resettlement (which includes involuntary land acquisition (OD 4.30), Cultural Property (OP 4 11) and Safety of Dams (OD 4 37) which are available in Arabic and English In addition, the project should comply with the provisions of the Water Resources Management Policy The Environmental Assessment should also comply with Yemeni Environmental Protection Law No 26 of 1995 Given the spatial dimension and complexity of the water issues in the Sana'a Basin, a Regional Environmental Assessment (REA) would be conducted as part of the project preparation The objectives of this REA are to (1) examine the environment issues and impacts associated with the water resources, irrigation and agricultural strategies, policies, programs and projects in the basin; (2) evaluate and compare the impacts these against those of the alternatives, (3) assess legal and institutional aspects relevant to the issues and impacts, and (4) recommend broad measures to strengthen environmental management in the sector Particular attention will be given to potential cumulative impacts of multiple activities envisioned in the Project

A number of studies have been identified as necessary to the preparation of a Sana'a Basin Water Management Program. These studies are designed to fill the gap in the information and knowledge required to develop a project targeted at the real water issues in the basin and to provide extensive input in the preparation of the REA Phase I of the program will be implemented in the selected four sub-basins is expected to focus on enhancing supply management through groundwater recharge schemes (particularly small retention dams and underground recharge) as well as on improving demand management through the improvement of irrigation efficiency In parallel with demand and supply management, the project will also assist in setting up water monitoring system and addressing the social and institutional issues The project will take place within the context of the strategic water resources management plan for the basin currently being developed by the Yemen National Water Resources Authority (NWRA) with assistance from UNDP

2.1 Coordination with Other Project Preparation Studies

These terms of reference (TOR) are intended to integrate the environmental assessment (EA) requirements with the Phase I project preparation components into a single process The international and local specialists specified in this document will join the other specialists engaged in the project preparation to form a multidisciplinary team for the preparation of the project, including the environmental impact The international environmental assessment specialist will have the overall responsibility for the preparation of the draft environmental assessment report.

The international environmental assessment specialist (the Consultant) and his specialist team (biodiversity, public health and cultural heritage) will be members of the Project Preparation Team (PPT) and will liaise directly with study teams. The studies that will form the basis for designing the project components to be prepared by the PPT are listed in the table below These studies will also provide basic data for the EA. Each of the individual studies, other than Satellite Imagery have a specific environmental component The Consultants will also liaise with NWRA staff working on the Sana'a Basin Master Plan (with assistance from UNDP), to collect information which would be relevant to the EA

Project Preparation Component	Status
Satellite Imagery Study	To be completed by May 31 2001
Sana'a Basin Characterization and Selection of Pilot Sub-Basins	To be finalized by May 31 2001
Supply Management and Aquifer Recharge Component	Scheduled to commence in August 2001
Demand Management and Irrigation Improvement Component	Scheduled to commence in June 2001
Institutional and Social Design Assessment and Component	Scheduled to commence in June 2001
Safety Review of existing Dams and Proposed New Dam sites	Scheduled to commence in August 2001

3. POTENTIAL ENVIRONMENTAL ISSUES ARISING FROM THE PROGRAM AND PHASE 1 PROJECT

As expected in any program or project, the program and phase 1 project have the potential to create both negative and positive environmental impacts as a result of rehabilitation and construction and operation of groundwater recharge enhancement schemes, installation of irrigation improvement equipment, as well as institutional and social arrangements Some of the commonly known potential environmental impacts of water resources and irrigation improvement projects are categorized and described below.

3.1 Land and Soil Resources

- Increased crop yields due to improved irrigation may involve increased use of pesticides and fertilizers and their related impacts. Long-term accumulation of chemicals in the soil may permanently alter the types of crops that can be supported Different water use scenarios may have effects on production of cash and subsistent crops such as fruits, vegetables, qat[5], etc.

[5] *Qat* is a cash crop produced predominantly in the highlands of Yemen A large proportion of the population is dependent on *qat* production and sale for their livelihood Furthermore, *qat* plays an important role in Yemeni social life.

- In some locations, increased irrigation and drainage could lead to significant accumulation of salts and its related impacts on the soil fertility, crop yields, and natural plant communities
- Land may need to be taken for establishment of improved drainage on individual farms and for drainage areas This may require involuntary acquisition of small areas of land to construct these improvements

3.2 Water Resources/Water Quality

- Water logging and associated impacts resulting from the proposed small dams and wastewater recharge components of the project This includes the impacts on the water quality issues in recharging of the aquifer Similarly the impacts of irrigation runoff on the water quality of the aquifers in the basin Construction of the small dams may require involuntary land acquisition and will also require site specific archaeological surveys to assess potential adverse impacts to cultural property
- Impacts of tube well pumping on the water resources in the basin including potential problems of saline water intrusions into freshwater aquifers
- Increase in sedimentation and silting due to the construction of recharge basins and small dams
- Impacts on the water quality due to point and non-point sources For example non-point sewage pollution due to cesspits and solid wastes dumping

3.3 Natural Habitats and Cultural Heritage

- While the increase in irrigation and recharge basins could alter the hydrology of the area affecting the local natural and man-made habitats of importance to resident and migratory species. In addition, the proposed project could also create new aquatic habitats on a local basis These issues should be evaluated at the program and phase 1 project level on the basis of a project area review of natural habitats, which should be complemented by field based surveys of proposed sites for investment activities
- The region is rich in cultural heritage and hence potential impacts of the project should be evaluated including sites of archaeological, historical, architectural and/or sacred significance A desk based review of cultural heritage values should be made at the program level while site specific investigations will be carried out for all proposed site specific investments The investigation will also evaluate potential impacts to graveyards and/or burials Chance Find Procedures will be developed for use in the project to address management of unknown archeological finds that may be encountered during the course of construction activities
- Increased crop yields may require changes in field patterns and involve land leveling Given the ancient and/or historic nature of terraces in many places in Yemen, proposed actions should be reviewed for their potential archacological impact In addition, land leveling may damage or destroy archaeological sites and areas proposed for land leveling should be subject to site specific archaeological reviews

3.4 Public Health Issues

- Impacts due to the pollution being caused by urban wastewater and the potential impacts of the increase in habitats for pests and other disease vectors as result of the recharge basins and small dams. This issue is particularly important with the inadequate sewage treatment and potential for water resource contamination in the Basin
- Reuse of treated wastewater and sludge, particularly from the Sana'a Waste Water Treatment Plant, through direct application or recharge and pumping may adversely affect health of the farmers, as well as the consumers

- Potential public health impacts resulting from water borne diseases due to the presence of small dams, irrigation and drainage structures and stagnant water bodies
- Potential public health impact related to pest management activities

3.5 Pesticides and Pest Management

- Increased crop yields due to improved irrigation may involve increased use of pesticides and fertilizers Exposure of agricultural workers to pesticides and fertilizer
- Impacts to surface and groundwater quality from the use of pesticides and fertilizers

3.6 Dams And Dam Safety

- The Sana'a Basin contains more than 40 hydraulic structures of which 25 are dams of more than 15 meters in height Of these dams many are in need of repair and rehabilitation and may be a hazard to public safety
- The project will propose construction of a number of new dams or recharge structures that may entail the acquisition of land or possibly resettlement although this is unlikely.
- A Dam Safety Review activity will be carried out separately to examine the quality and safety aspects of the design of the new dams and the required rehabilitation work
-

4. CONSULTANT SCOPE OF WORK

Using the above mentioned preparation studies and other relevant assessments, the consultant will be responsible for the following tasks

4.1 Initial Scoping, Stakeholder and Public Disclosure Consultation

Generally the Consultant will collect and review existing information on the relevant physical, socio-cultural and biological environmental characteristics of the Sana'a Basin This will help to provide baseline conditions from which to establish benchmarks for project impact assessment and monitoring. However, more specific studies will be required in the pilot sub basins where, for example, potential dam sites or sites of cultural heritage may require inspection

- Review relevant reports, data, maps, charts, documents, study results prepared by the national and international consultants including but not limited to those prepared by Italconsult, Mosdgiprovodkoz, SAWAS Review the NWRA Regional Plan being assisted by UNDP, including Water Resources Management Action Plan for the Ta'iz Region and preparation documents for a Sana'a Water Resources Management Action Plan Review the working papers, PCN, PCD, and other documents prepared by the World Bank for the Sana'a Basin Water Management Project Review the results of the Social Assessment, the Satellite Imagery Assessment, the Isotope Application studies, and other studies

- On the basis of this review and in cooperation with the Environmental Protection Commission (EPC), carry out scoping and stakeholder consultations in coordination with the stakeholder meetings/hearings planned by the other preparation studies, particularly the Stage 1 study "Sana'a Basin Characterization and Selection of Pilot Sub-Basins " The purpose of these consultations will be to review the scope of the REA and to seek views and advice of the government representatives, local officials and dignitaries, potentially affected parties, and national/local nongovernmental

organizations Particular attention should be given to seeking the views of the women in an appropriate fashion The scoping workshop should also develop a strategy, mechanism and program for public disclosure (A scoping and public disclosure workshop was held on 5 6 01 the proceeding of which will be distributed separately and later incorporated into the final EA report)

4.2. Description of the Environment

Upon completion of Task 1, the consultant will assemble and present the baseline conditions and relevant characteristics of the study area The study will include but not limited to the following areas

4.2.1. The Physical Environment: Benefiting from the preparation studies, the consultant will identify the boundaries of the watershed and characterize the distribution of resources within the basin The geology and hydrogeology of the project area should be studied and areas of high and low permeability formations identified, in addition to the topography The consultant should also describe the climate and meteorology conditions, existing water pollution discharges to receiving waters, groundwater quality, groundwater infiltration, and hydrological pattern and water balance of the catchment area The Consultant should be aware of and make use of the database and information obtained from other planned studies It is important that the Consultant be directly involved in the studies related to the project preparation, as listed above

4.2.2. The Biological Environment: The Consultant should investigate the flora, fauna, rare or endangered species, sensitive habitats, species of commercial importance, and species with potential to become public health hazards The investigation will focus on the sub-basins selected for the Phase I Project and expand as subsequent phases are developed

4.2.3. The Socio-economic Environment: The social assessment for the Sana'a Basin Water Management Project was conducted in 1999-2000 as a preparatory step for the design of the project This assessment shows the social and economic conditions that exist and the possible risks afforded by the project The Consultant should use the social assessment as the point of departure to focus the investigation on the links between the beneficiary population and the specific physical and health problems that could arise On the basis of the combined findings provide the socially appropriate mitigation measures The Consultant should conduct analysis and evaluation of population figures and distribution, land use, planned development activities, identification of affected persons, community structure, and organization with respect to water use Furthermore, employment, distribution of income, goods and services, recreation, public health, cultural and religious properties, tribal peoples and customs, aspirations, attitudes and restraints to changes in water use behavior should be assessed The Consultant will also refer to planned rural assessments which will determine the extent of agricultural areas, cropping patterns and intensities, typical crop yields, farm incomes, irrigation water requirements and consumption patterns. The Consultant is expected to work closely with the PPT to benefit from the information being collected and to ensure that additional information needed to carry out this task are indeed gathered by the PPT and the study teams Particular emphasis should be placed on the role and impact on women

4.2.4. The Cultural Heritage Environment: The Consultant should assess, using qualified specialists, the potential impacts of the proposed program on archaeological, historical, architectural and/or sacred values The assessment will focus on the sub-basins selected for the Phase I Project and expand as subsequent phases are developed.

4.3. Institutional, Legislative and Regulatory Framework

The consultant will describe the present strategy, legislation and regulations governing the sector and specifically institutional issues related to environmental quality, health and safety, protection of sensitive areas, siting, land use control, safety of small dams, etc. The consultant will focus on but not be limited to the following areas

- Summarize the Government development strategy in the water resources management sector and in particular for the Sana'a basin Assess the potential conflicts with other sectors (competition for natural resources, water use, political and tribal priority, potential conflicts between large scale schemes and traditional users)
- Analyze the regulatory issue of the water and waste sector related to the laws, regulations and guidelines in this sector and their comparison with international good practice
- Outline institutional issues and capacity to manage the water and wastewater sector and to regulate and enforce the environment-related laws Special emphasis should be placed on assessing the institutional capacity for application and compliance with the environmental safeguards Measures should also be formulated to strengthen the training, monitoring and evaluation of mitigation tasks are properly implemented and enforced. In addressing these issues, the Consultant will make recommendations for linkages between the Environmental Protection Commission (EPC), Ministry of Agriculture, and NWRA
- Assess capacity for achieving, maintaining and monitoring wastewater treatment to WHO quality standards for wastewater reuse and for aquifer recharge ,as well as provide proposals to strengthen capacity. Other potential pollution sources must also be assessed.

4.4. Assessment of Environmental Impacts and Selection of Best Alternatives

The consultant shall assess the environmental impacts of the proposed project As an integral part of the PPT and the feasibility study teams, the Consultant shall participate in the selection of pilot sites and best options for each site in terms of appropriateness, stakeholder participation and sense of ownership, cost, efficiency, and minimal adverse environmental impact. The Consultant will also carry out an analysis of alternatives in consultation with the planned feasibility studies. In this context, alternatives refer to siting, design, technology selection, construction techniques, phasing and operations and maintenance procedures Alternatives should be compared based on potential environmental impacts The analysis should also include the "do nothing" option and the related environmental impacts associated to this option. Issues to be addressed will include, but are not limited to the following

4.4.1. Demand Management/Irrigation Improvement

- Address the sustainability of the water resources and determine if the increased use or water extraction is sustainable
- Address environmental impacts of surface and sub-surface construction works such as effects on the environment including public health and natural habitats of other species
- Review impacts of proposed planning and design options to convey and dispose of polluted drainage water (as a result of pesticides, fertilizer, other agricultural chemicals) including reuse to make sure these do not have adverse environmental impacts

- Assess the effects of different water saving scenarios on cropping patterns, public health
- Alternative sources of water and configurations and requirements for distribution and demand reduction through conservation, provision of agricultural extension services

4.4.2. Supply Management and Aquifer Recharge

- Review the experience and pattern in Yemen for construction of small dams and spate breaks and their related environmental impacts Develop siting environmental criteria for small dams and spate breaks construction and ensure that the site selection would minimize environment hazards and adverse impacts.
- Address environmental impacts during construction and operation such as impacts of channeling wastewater to recharge areas including the possible effects on public health due to potential increase in disease vectors, odor, etc
- Review conceptual design of the selected small dams and dams to be rehabilitated to ensure that they can be carried out with minimum environmental impact
- Review the applicability and suitability of each technology in different parts of the catchment should be addressed taking consideration of effects on settled populations An integrated approach should be taken for the analysis of alternatives rather than assessment of individual sub-components of the project.
- Coordinate activities with those of the dam safety review

4.4.3 Wastewater Management and Reuse

- Assess adequacy of existing sewerage system and related design and construction activities to be undertaken The Consultant will ensure that coverage is sufficient to avoid adverse impacts to soil, habitats, water sources, and humans
- Identify sources of wastewater and review strategies to implement, maintain, and monitor treated wastewater quality standards according to current WHO guidelines for use in agriculture
- Review plans for scheduling reception of wastewater from treatment plants and use to ensure that this does not result in environmental pollution
- Assess impacts of wastewater reuse on the types of crops that can be produced and how this will impact crop yields and patterns as well as livelihoods
- Review provisions for wastewater storage conditions to ensure that they do not lead to worsening of wastewater pollution The Consultant will review design of such holding facilities to ensure that low permeability basal liner are used to mitigate contaminant migration into the surrounding environment.
- Address protective measures and health implications for farm workers who will use or be exposed to wastewater effluent. The Consultant will review strategies for addressing user safety and protection and ensure that these are not unduly cumbersome
- Assess the impacts due to pests and odor

4.4.4 Dam Safety

- Review and summarize the findings of the parallel Dam Safety Review for inclusion in the REA report
- Assess the environmental impact of the findings and any proposed dam safety mitigation plans. Evaluate alternatives proposed for addressing dam safety issues, if any, assess the associated environmental risks and recommend a course of action to mitigate the environmental impacts
- Include the Dam Safety Review Report as an annex to the REA

4.5. Environmental Management Plan

As part of the EIA report, the Consultant will develop an Environmental Management Plan (EMP) to address the major environmental impacts of the best alternative and implement strategies for mitigation of those impacts The EMP will account for monitoring of environmental parameters and the influence of mitigation measures on environmental impacts The EMP should include the following components

4.5.1. Institutional and Social Component

- Assessment of institutional capacity for responsibility for environmental protection
- Institutional responsibilities for management of the irrigation and drainage sector and/or the agricultural sector
- Institutional responsibilities for health and socio-economic issues management
- Define the role of communities in environmental management, particularly the impact on and the role of women
- Develop guidelines to ensure that minimum contact of farm workers with wastewater is allowed by incorporation of adequate conveyance and reception facilities for wastewater reuse.
- Responsibilities for monitoring, reporting and enforcement for water quality, wastewater treatment standards, water balance, salt balance, and related issue management
- Identification of capacity building, training and equipment needs.
- An institutional responsibility for enforcing pumping limits

4.5.2. Environmental Mitigation Component

The Environmental Mitigation Plan should be comprehensive, covering the physical, biological, and socio-cultural environments The key aspects required of the mitigation plan should be provided under the headings given in the table below

Issue	Mitigating Measure	Responsibility	Time or Cost Requirements
Land and Soil Resources			
Water Resources/Water Quality			
Habitats			
Health			
Cultural Heritage			
Pest Management			
Dams and Dam Safety			

4.5.3. Environmental Monitoring Component

The Consultant will participate in the development of the basin-wide water monitoring strategy (Stage 1 Feasibility Study), as well as design of an appropriate monitoring plan for Phase I implementation Monitoring should address all potential key issues discussed in previous sections of this paper in addition to any other issues, which are considered relevant to the project and the location Results of monitoring and analysis including interpretation and recommendations should be reported to the Bank quarterly The Consultant will provide a list of surface and groundwater monitoring parameters and their suggested monitoring frequency that can be realistically and reliably monitored under Yemenis conditions

4.6. Interactive Review of the Draft REA by Stakeholders

Once the draft REA is prepared, the environmental consultant, in coordination with the Government, will consult with the stakeholders including the potentially affected public and the relevant Government offices including EPC, NWRA, NWSA, and MAI on the outcome of the environmental assessment and the Environmental Management Plan This task would ensure that the environmental issues raised at the initial scoping and stakeholder consultations (Task 1) have been adequately have been adequately addressed An interactive review process should be undertaken to facilitate a meaningful review of the draft documents A series of stakeholder meetings should be held in the selected pilot sub-basins at which the consultant will present the status of the REA document, major findings/recommendations, and the next steps towards project appraisal, financing, and eventual implementation The presentation should be followed by a discussion session to allow reaction and input from the stakeholders A record of the consultations, including the name of the participants, issues discussed, and comments made should be included as an annex in the REA document

5. REPORTING AND TIME SCHEDULE

Progress reports should be submitted to the Client and the Bank as set out below This report should present a brief overview of progress in completing the task, dates, difficulties in achieving the work as described in the contract, proposed alternate means to achieve project objectives, status of budget and major scheduled milestones, any proposed modifications to the contract mandate All reports shall be in English and use SI units of measurement The summary of the Final REA report will be translated to Arabic by the PMU The duration of the study will be approximately 6 months from the date of commencement The following reports should be submitted according to the timetable given below. Arabic translations will be arranged by the PMU

- **Interim Report** will contain a status report, summary of the findings of the consultants, plans to overcome major problems and issues encountered and draft outline for the environmental assessment It should also include a draft Executive Summary that would be suitable for use in public consultations
- **Draft REA Report** will be submitted prior to appraisal and shall include an executive summary, the final analyses, findings, conclusions, and recommendations of the Consultant In addition to addressing the regional environmental issues, the draft report must also include specific chapters on the environmental impact assessment of the selected pilot sub-basins related to the project
- **Draft Final REA Report** will reflect responses to the comments on the draft REA that provided by the Government, the FAO IC, the World Bank, and other parties
- **Final REA Report** shall be issued in Arabic and English taking into consideration the review/comments of the Government, FAO IC, and the Bank

6. ESTIMATED STAFF REQUIREMENTS

The environmental specialist will work closely with the PPT and the specialists on the feasibility study teams, which include experts from a wide range of disciplines The environmental specialist should have at least a MSc. degree and 10 years of practical experience in his/her field and have participated in the development of EAs Estimated time requirements are set out below In addition to the environmental expert, specialists in cultural heritage issues, public health, pest management and biodiversity will also be

required in order to complement the project preparation study teams Individual TORs for these specialists are attached as annexes

Expert	Months	Qualifications
Environmental Specialist (International)	3	• Specialized in managing the EA process, provide expertise on the environmental impact of surface and ground water development and management, and the preparation of the EA report
Cultural Heritage Specialist (National)	1	• Specialized in cultural heritage of Yemen, particularly in Sana'a Basin
Public Health Specialist (National)	1 5	• Specialized in water and health issues related to water supply and wastewater impacts and pest management
Biodiversity Specialist (National)	1	• Expertise in biodiversity issues especially as related to local species of flora and fauna
Pests and Pesticides Specialist (National)	1	• Expertise in pesticides and pest management

In addition to the REA specialists identified above, other specialists assigned to the other preparation studies will also work with the environmental impact assessment team and provide direct contribute to the preparation of the draft REA report These specialists do not appear in the above table, as they are retained through other contracts These specialists both national and international include Water Resources Management, Irrigation, Agronomist, Hydrogeologist, Watershed Management, Institution, Legal and Socio-Economic.

7 INPUTS TO BE PROVIDED BY THE GOVERNMENT

The PPT will provide all the available documents, reports, maps, maps, data, etc to enable the consultants carry out the assignment. The documents provided will include those prepared by Italconsult, Mosdgiprovodkoz, SAWAS, EPC, the NWRA Regional Plan being assisted by UNDP, as well as the working papers, PCM, PCD, and other project preparation documents prepared by the World Bank

The available results of the completed Social Assessment, the Satellite Imagery Assessment, and the dam inventory report will also be provided by the PPT

i) The PPT will act so as to facilitate temporary work permits and immigration procedures for all the foreign consultants.

ii) The PPT will act so as to cover any travel subsistence and accommodation costs for government and local participants to any stakeholder workshops or public participation

activities that may occur The Government will also make the necessary arrangements, including vehicles, clearances, permits, etc for field visits and meetings with various institutions and stakeholders

8. EXPECTED OUTPUT

All reports and documents indicated in Section 5 above, including the final Regional Environmental Assessment report, should be submitted to the PPT office according to the specified schedule At least 15 copies of the report should be prepared and distributed according to the instructions from the PPT leader The report, including the executive summary, must be prepared in English and will be translated into Arabic by the PMU At a minimum, the draft and final REA reports should include the following items (not necessarily in the order shown)

Executive summary. Concisely discusses significant findings and recommended actions
Policy, legal, and administrative framework. Discusses the policy, legal, and administrative framework within which the EA is carried out. Explains the environmental requirements of any cofinanciers Identifies relevant international environmental agreements to which the country is a party

Project description. Concisely describes the proposed project and its geographic, ecological, social, and temporal context, including any offsite investments that may be required (e g , dedicated pipelines, access roads, water supply, housing, and raw material and product storage facilities) Indicates the need for any resettlement plan or indigenous peoples development plan Includes a map showing the project site and the Project's area of influence

Baseline data. Assesses the dimensions of the study area and describes relevant physical, biological, and socioeconomic conditions, including any changes anticipated before the project commences Also takes into account current and proposed development activities within the project area but not directly connected to the project. Data should be relevant to decisions about project location, design, operation, or mitigatory measures The section indicates the accuracy, reliability, and sources of the data.

Environmental impacts. Predicts and assesses the project's likely positive and negative impacts, in quantitative terms to the extent possible Identifies mitigation measures and any residual negative impacts that cannot be mitigated Explores opportunities for environmental enhancement Identifies and estimates the extent and quality of available data, key data gaps, and uncertainties associated with predictions, and specifies topics that do not require further attention.

Analysis of alternatives. Compares feasible alternatives to the proposed project site, technology, design, and operation—including the "without project" situation. The comparison will be made in terms of their potential environmental impacts, the feasibility of mitigating these impacts, their capital and recurrent costs, their suitability under local conditions; and their institutional, training, and monitoring requirements For each of the alternatives at each pilot sub-basin, quantifies the environmental impacts to the extent possible.

Environmental management plan (EMP). Covers mitigation measures, monitoring, and institutional strengthening and public disclosure mechanisms

Pest management plan (PMP). Covers mitigation measures, monitoring, and institutional strengthening and public disclosure mechanisms specifically related to management of pest

Appendixes

(i) List and expertise of the REA report preparers—individuals and organizations
(ii) References—written materials both published and unpublished, used in study preparation
(iii) Record of interagency and consultation meetings, including consultations for obtaining the informed views of the affected people and local nongovernmental organizations (NGOs) The record specifies any means other than consultations (e g , surveys) that were used to obtain the views of affected groups and local NGOs
(iv) Tables presenting the relevant data referred to or summarized in the main text
(v) List of associated reports (e g., resettlement plan or indigenous peoples development plan)
(vi) Dam Safety Review Report (prepared under a separate activity)

Sana'a Basin Water Resources Management Project

Environmental Impact Assessment

Terms of Reference - Public Health Specialist

Background:

The GOY is preparing a Water Resources Management Project for the Sana'a Basin for World Bank funding A mandatory requirement of the World Bank for the processing of the project is that an Environmental Impact Assessment (EIA) be carried out The EIA will focus on a number of specific areas including, Land and Soil Resources, Water Resources and Water Quality, Public Health, Natural Habitats and Cultural Heritage Some indicative information for the EIA will be collected during a Stage 1 Basin Characterization Study surveys which will be complete by mid April 2001 and result in the selection of three or more pilot sub basins in which the project will concentrate However, primary data and information for the EIA will be gathered during three Stage 2 project preparation studies i.e Supply Management and Aquifer Recharge, Demand Management and Irrigation Improvement, and Institutional and Social Design which will be undertaken between May and August 2001. In parallel, an EIA team will be formed consisting of an International Environmental Expert/ team leader plus four national experts on Public Health, Biodiversity, Pest Management and Cultural Heritage who will undertake additional studies and analysis in order to prepare an EIA Report and Mitigation Plan. These terms of reference should be read in conjunction with the TOR for stage two studies in order that the consultant should be fully aware of the data that will be provide to him/her and that which will have to be collected from the field

Scope of Work:

It is anticipated that the consultant will make up to one month's part time inputs during the period between April and July 2001 consisting of the following tasks

Participate in an EIA "scoping workshop" and make a brief presentation on potential public health risks based on his/her experience

Review and analyze relevant documentation and data collected in the stage 2 project preparation studies with particular regard to public health issues These terms of reference should be read in conjunction with the TOR for stage two studies in order that the consultant should be fully aware of the data that will be provide to him/her and that which will have to be collected from the field.

Review the quality of water from various sources being consumed in the pilot sub basins for both agricultural and domestic use and identify any actual of potential environment or health issues.

Review the potential impact of increased water availability and use with regard to public health as this may increase the use of pesticides and fertilizers etc Similarly, review the potential impact of increased water availability and use as this may increase the population of insects, rodents and other pests, which in turn may provide or increase disease vectors

Review any proposed construction, of canals, small dams and recharge structures etc to ensure that they will not contribute to any public health risks

Assess the adequacy of existing excreta disposal/sewerage system (if any) and review any proposed investments including ponds and storage tanks to ensure there are no adverse impacts to water sources, and human health

Assess the potential for wastewater reuse on crops that can be produced locally and how this could impact crop yields and patterns as well as livelihoods (The extent of the potential for wastewater reuse in rural areas is unknown but is probably limited)

Identify any possible sources of commercial or industrial wastewater (if any) and review capacity and strategies to treat and monitor wastewater quality standards according to current WHO guidelines for use in agriculture

Review protective measures and health implications for farm and treatment plant workers who will use or be exposed to wastewater effluent and review strategies for addressing user safety and protection

Urban Wastewater reuse and Solid Wastes Disposal· Special regard should be given to the urban area of Sana'a and its surroundings because of the high rates of water abstraction from private wells for domestic consumption via local reticulation schemes and tanker deliveries Also because of the high levels of groundwater pollution from septic tanks and dry latrines Moreover, the proposals for reuse of effluent from the new waste water treatment plan for irrigation and aquifer recharge should be reviewed to ensure that this does not result in environmental pollution and endanger public health Similarly, the siting of the proposed solid wastes disposal facility to the north of Sana'a should be reviewed

Participate in the EIA "reporting workshop" in which the findings of the studies and proposed mitigation plan are presented and discussed

Reporting

Reporting to the International Environmental Expert and in close liaison with the PPT and the consultants undertaking stage 2 project preparation studies, the national expert will prepare a report on his/her findings, analysis and recommendations in a format to be agreed with the EIA team leader. The report should provide a general analysis of the public health issues in the selected pilot sub-basins and make specific references to any interventions proposed in the project The report should also make recommendations for the mitigation of any identified issues including a budget

Sana'a Basin Water Resources Management Project

Environmental Impact Assessment

Terms of Reference - Biodiversity Specialist

Background:

The GOY is preparing a Water Resources Management Project for the Sana'a Basin for World Bank funding A mandatory requirement of the World Bank for the processing of the project is that an Environmental Impact Assessment (EIA) be carried out The EIA will focus on a number of specific areas including, Land and Soil Resources, Water Resources and Water Quality, Public Health, Natural Habitats and Cultural Heritage Some indicative information for the EIA will be collected during a Stage 1 Basin Characterization Study surveys which will be complete by mid April 2001 and result in the selection of three or more pilot sub basins in which the project will concentrate. However, primary data and information for the EIA will be gathered during three Stage 2 project preparation studies i e Supply Management and Aquifer Recharge, Demand Management and Irrigation Improvement, and Institutional and Social Design Which will be undertaken between May and August 2001. In parallel an EIA team will be formed consisting of an International Environmental Expert/ team leader plus four national experts on Public Health, Biodiversity, Pest Management and Cultural Heritage who will undertake additional studies and analysis in order to prepare an EIA Report and Mitigation Plan

Scope of works:

It is anticipated that the consultant will make up to one month's part time inputs during the period between April and July 2001 consisting of the following tasks

Participate in an EIA "scoping workshop" and make a brief presentation on potential biodiversity risks based on his/her experience

Review and analyze relevant documentation and data collected in the stage 2 project preparation studies These terms of reference should be read in conjunction with the TOR for stage two studies in order that the consultant should be fully aware of the data that will be provide to him/her and that which will have to be collected from the field

Visit each sub basin and compile a report on the existing biodiversity making specific reference to any unique special or endangered flora or fauna of which the PPT and consultants should be aware

Visit the proposed site of any construction, excavation or leveling to ensure that no sites of particular ecological importance are placed in danger and to inform the EIA Team Leader and PPT of any possible risks

Review the environmental impacts of any physical construction or excavation on the natural and man made habitats of other species and flora

Review the potential environmental impact of increased water availability/use, waste water reuse and change of natural habitats with regards to the increase of insects rodents and other pests which may provide disease vectors

Participate in the EIA "reporting workshop" in which the findings of the studies and proposed mitigation plan are presented and discussed

Reporting

Reporting to the International Environmental Expert, and in close liaison with the PPT and the consultants undertaking stage 2 project preparation studies, the national expert will prepare a report on his/her findings, analysis and recommendations in a format to be agreed with the EIA team leader The report should provide a general analysis of the biodiversity issues in the selected pilot sub basins and make specific references to any interventions proposed in the project The report should also make recommendations for the mitigation of any identified environmental issues including a budget

Sana'a Basin Water Resources Management Project

Environmental Impact Assessment

Terms of Reference - Cultural Heritage Specialist

Background:

The GOY is preparing a Water Resources Management Project for the Sana'a Basin for World Bank funding A mandatory requirement of the World Bank for the processing of the project is that an Environmental Impact Assessment (EIA) be carried out The EIA will focus on a number of specific areas including, Land and Soil Resources, Water Resources and Water Quality, Public Health, Natural Habitats and Cultural Heritage Some indicative information for the EIA will be collected during a Stage 1 Basin Characterization Study surveys which will be complete by mid April 2001 and result in the selection of three or more pilot sub basins in which the project will concentrate However, primary data and information for the EIA will be gathered during three Stage 2 project preparation studies i e Supply Management and Aquifer Recharge, Demand Management and Irrigation Improvement, and Institutional and Social Design Which will be undertaken between May and August 2001 In parallel an EIA team will be formed consisting of an International Environmental Expert/ team leader plus four national experts on Public Health, Biodiversity, Pest Management and Cultural Heritage who will undertake additional studies and analysis in order to prepare an EIA Report and Mitigation Plan

The areas surrounding Sana'a are rich in sites and structures of cultural significance It may be possible that some of the physical components of the proposed project, small dams, recharge structures, wadi terraces, pipelines and canals etc , could have an impact on theses sites which may have archaeological, architectural or religious importance These sites which could include special habitations, forts, towers, cisterns, mosques and burial grounds etc which should be identified and evaluated at an early stage in the planning of any project investments or interventions.

Scope of works:

It is anticipated that the consultant will make up to one month's part time inputs during the period between April and July 2001 consisting of the following tasks

Participate in the EIA "scoping workshop" and make a brief presentation on potential cultural heritage risks based on his/her experience

Review and analyze relevant documentation and data collected in the stage 2 project preparation studies. These terms of reference should be read in conjunction with the TOR for stage two studies in order that the consultant should be fully aware of the data that will be provide to him/her and that which will have to be collected from the field.

Consult the Antiquities Register and other archives and documentation to identify any sites of historic or cultural importance in the Sana'a basin and pilot sub basins

Visit each sub basin and compile a annotated list of sites and structures of cultural or historic importance of which the PPT and consultants should be aware.

Visit the proposed site of all proposed construction, excavation or leveling to ensure that no sites or structures of cultural or historic importance are placed in any danger of damage of destruction and to inform the EIA Team Leader and PPT of any possible risks

Develop procedures for "chance find procedures" in case of the discovery of any previously unknown artifacts or archaeological materials

Participate in the EIA "reporting workshop" in which the findings of the studies and proposed mitigation plan are presented and discussed

Reporting

Reporting to the International Environmental Expert and in close liaison with the PPT and the consultants undertaking stage 2 project preparation studies, the national expert will prepare a report on his/her findings, analysis and recommendations in a format to be agreed with the EIA team leader The report should provide a general analysis of the cultural heritage issues in the selected pilot sub basins and make specific references to any interventions proposed in the project The report should also make recommendations for the mitigation of any identified environmental issues including a budget

Sana'a Basin Water Resources Management Project

Environmental Impact Assessment

Terms of Reference – Pest & Pesticides Specialist

Background:

The GOY is preparing a Water Resources Management Project for the Sana'a Basin for World Bank funding A mandatory requirement of the World Bank for the processing of the project is that an Environmental Impact Assessment (EIA) be carried out The EIA will focus on a number of specific areas including, Land and Soil Resources, Water Resources and Water Quality, Public Health, Natural Habitats and Cultural Heritage Some indicative information for the EIA will be collected during a Stage 1 Basin Characterization Study surveys which will be complete by mid April 2001 and result in the selection of three or more pilot sub basins in which the project will concentrate. However, primary data and information for the EIA will be gathered during three Stage 2 project preparation studies i e Supply Management and Aquifer Recharge, Demand Management and Irrigation Improvement, and Institutional and Social Design Which will be undertaken between May and August 2001 In parallel an EIA team will be formed consisting of an International Environmental Expert/ team leader plus four national experts on Public Health, Biodiversity, Pest Management and Cultural Heritage who will undertake additional studies and analysis in order to prepare an EIA Report and Mitigation Plan The areas surrounding Sana'a are heavily cultivated and the farmers make use of fertilizers and pesticides which may have environmental impact on ground water and surface water and be a hazard to public health

Scope of works:

It is anticipated that the consultant will make up to one month's part time inputs during the period between June and August 2001 consisting of the following tasks·

Review and analyze relevant documentation and data collected in the stage 2 project preparation studies These terms of reference should be read in conjunction with the TOR for stage two studies in order that the consultant should be fully aware of the data that will be provide to him/her and that which will have to be collected from the field

Based on field visits and any available data and studies estimate the types and extent of the use of pesticides and fertilizer in the Sana'a basin.

Evaluate the exposure of agricultural workers to pesticides and fertilizer and evaluate the risk to health and well being

Evaluate the impacts of pesticides and fertilizer on surface and groundwater quality

Propose mitigation measure to reduce any negative impacts of the use of pesticides and fertilizer and develop a Pest Management Plan.

Participate in the EIA "reporting workshop" in which the findings of the studies and proposed mitigation plan are presented and discussed.

Reporting

Reporting to the International Environmental Expert and in close liaison with the PPT and the consultants undertaking stage 2 project preparation studies, the national expert will prepare a report on his/her findings, analysis and recommendations in a format to be agreed with the EIA team leader The report should provide a general analysis of the cultural heritage issues in the selected pilot sub basins and make specific references to any interventions proposed in the project The report should also make recommendations for the mitigation of any identified environmental issues including a budget

Annex 13. List of Principal Informants

Abdo, Jamal, Director, National Water Resource Authority
Abu Ras, Sadiq Bin Amin, Minister of Local Administration
Al Muntaser, Rajeh Mohammed, Deputy Director of the Irrigation Dept NDA
Al-Hamdany, Muhssen, Environmental Protection Council
Al-Kadasi, Fuad, Information Officer, Environmental Protection Council
Al-Mooji, Yossif, Director Water & Environment Center, University of Sana'a
Al-Soraimy, Ali, Farmers Union
Al-Syani, Mohanned Ahmed, Director General of Antiquities, Sana'a
Gabbar, Mohammed Amin Abdul, General Director Of The GAAMM
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