PN-ADJ-343

FY1997-Z-WBG

USAID

Palestinian Water Authority

Program funded by the

U.S. Agency for International Development

assisted by

CDM/Morganti

Water Resources Program

Task 26
Environmental Assessment for the Hebron-Bethlehem Area Water Supply System

Final Environmental Assessment

18 May 1997

USAID Contract No. 294-C-00-96-90560-00
Contractor: Camp Dresser & McKee International Inc.
Deliverable 26.06

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Preface

The Water Resources Program, funded by the U.S. Agency for International Development (USAID), will contribute to implementation of water-related aspects of the Israeli-Palestine Liberation Organization Peace Accords of 1993.

USAID has entered into a three-year contract with Camp Dresser & McKee International Inc. (**CDM**) to provide comprehensive services under USAID's Municipal Services Project in the West Bank and Gaza. These services are being provided by CDM through a team of firms referred to as **CDM/Morganti**. Under the contract, **CDM/Morganti** will provide data collection, investigations, planning, design, training, institutional support, commodity procurement, and construction services.

All contract funds are being administered by **CDM/Morganti** which, working under the direction of USAID and in close collaboration with the Palestinian Water Authority (PWA) and the Joint Water Committee (Israeli-Palestinian), will coordinate the provision of U.S. Government assistance for the supply of water to Palestinian consumers. **CDM/Morganti** is implementing the Water Resources Program consistent with the USAID/West Bank and Gaza Mission's Strategy.

Of primary, though not exclusive, concern are the Trilateral Committee (U.S.-Israeli-Palestinian) activities. These activities focus on the development of water systems in the Eastern Aquifer basin of the West Bank consistent with the Water Agreement known as "Article 40" between the Government of Israel and the Palestine Liberation Organization. The Joint Water Committee has identified and presented to the Trilateral Committee activities for consideration. To date, the Joint Water Committee has identified: 1) a major water supply and transmission system to serve the Hebron-Bethlehem Area and 2) a water supply and transmission system to serve the Jenin Area as priority projects. **CDM/Morganti** will assist the PWA in packaging unfunded activities for presentation to other donor agencies.

Work under the contract began on 1 July 1996 and is expected to be completed by 30 June 1999. This report is the final of a series of environmental impact assessment reports for the Hebron-Bethlehem service area. The principal preparers of this assessment are Dr. Iyad Abumoghli and Mr. Lane Krahl.

Significant Differences Between the "Final" and "Draft" Environmental Assessment

The Draft Environmental Assessment (DEA) for the Hebron-Bethlehem area (Deliverable 26.05) was submitted on January 7, 1997. Since that time, the engineering teams have up-dated and refined the facility plans and designs. In addition, comments on the DEA were received from USAID. This environmental assessment responds to the changes made by the engineering teams as well as the comments received from USAID. Following is a guide to those changes.

1. CHANGES IN THE IMMEDIATE STAGE

Since publication of the DEA, the Final Engineering Design Report for the immediate stage facilities was produced. This report provides detail information on facility layouts for the proposed action. As a result, some changes have been necessary in the description of the proposed action and in the calculations of the area disturbed by the facilities. These changes have been reflected in the environmental assessment (EA), but they have not changed the environmental consequences of the immediate stage.

2. CHANGES IN THE FACILITY MASTER PLAN

The Final Report of the Water Supply Facility Master Plan for the Hebron-Bethlehem Service Area (Deliverable 25.02) made changes in the sources of additional water in year 2010, the number of facilities, and the timing of their construction. The new proposed action begins use of groundwater from the Western Aquifer in the year 2010, instead of in the year 2020, as in the preliminary plan. The other changes are summarized in the following table.

SUMMARY OF DIFFERENCES IN THE PROPOSED ACTION FOR THE FACILITY MASTER PLAN

Item	2000[a]		2010		2020	
	Old	New	Old	New	Old	New
Transmission Pipelines (km)	28	79	275	194	118	106
Regional Reservoirs	None	2	8	6	2	3
Local Reservoirs	None	None	143	96	101	65
Pump Stations	None	2	5	4	1	2

[a]In addition to existing, planned, and immediate stage facilities.

The changes in future sources of water, combined with the availability of new information on groundwater conditions (see response to USAID's comments on safe yield), required changes in the assessment of impacts on sustainable groundwater (section 4.2.2). The other changes caused differences in the timing of impacts, rather than their magnitude, and as a result, the new proposed action has essentially the same impacts as the proposed action in the DEA.

3. COMMENTS BY USAID

USAID transmitted official comments to CDM/Morganti on February 20 and 27, 1997 and March 20 and 31, 1997. The February comments covered safe yield, groundwater availability, design consumption levels, monitoring responsibilities, and some editorial corrections. The March comments addressed potential impacts from increased wastewater discharges. The editorial changes have been made in the EA. Following is a description of how CDM/Morganti responded to the other comments.

3.1 Safe Yield and Groundwater Availability

Comment by USAID

The safe yield values reported in the DEA (from Isaac et al. 1995) do not agree with the values in Article 40 of the Interim Agreement. The values reported in the DEA show that safe yield in the Eastern Aquifer will be reached in the year 2010, only 13 years from now. After that time, the plan calls for using water from the Western Aquifer, for which Article 40 identifies zero additional water available for development.

Response

All references to the Isaac et al. 1995 safe yield values have been removed from the EA. The values reported in section 3.1.3 and used to predict the environmental consequences in sections 4.1.2 and 4.2.2 reflect information from Article 40 and the Interim Report, Comprehensive Master Plan for Water Resources in the West Bank and Gaza Strip (Deliverable 4.02).

The EA now concludes that implementation of the facility master plan will result in overdraft unless a regional water exchange scheme is developed and implemented, allowing for economically efficient exchanges of desalinated seawater or imported freshwater for groundwater (see section 4.2.2).

3.2 Design Consumption Levels

Comment by USAID

The design consumption rates are considerably higher than the WHO minimum of 100 L/c/d. There is a discrepancy in the design consumption rates in the DEA with 227 L/c/d cited on page 45 (section 4.1.2) and 113 rising to 202 L/c/d cited on page 53 (section 4.2.2).

Response

The domestic consumption rates reported in sections 4.1.2 and 4.2.2 have been changed to reflect actual consumption, rather than total withdrawals. Text and a new table (Table 3.4) have been added to section 3.1.3 to explain how the demand projections were derived. As shown in the table, the domestic consumption component of the design demand is 75 L/c/d in 2000, 126 L/c/d in 2010, and 156 L/c/d in 2020. These rates are comparable to the WHO minimum of 100 L/c/d and average of 150 L/c/d, which are also consumption rates without allowances for other uses and system losses.

The remainder of the withdrawals are for public, livestock, and commercial/industrial uses as well as for system losses.

Even with these changes, there is still a discrepancy between the domestic consumption rates reported for the year 2000 in sections 4.1.2 (immediate stage) and 4.2.2 (facility master plan). This is because section 4.1.2 reflects a calculation of domestic consumption (using the planning allowances for other uses and losses) with a discreet increase in quantity to a known population and delivery system. The domestic consumption rates in section 4.2.2 are regional averages, which reflect the general future planning assumptions.

3.3 Monitoring Responsibilities

Comment by USAID
Most of the monitoring and mitigation measures for the master plan are the responsibility of the PWA and/or JWC. These responsibilities should be highlighted in the EA and it should be clearly stated that PWA and JWC need to establish systems to undertake the monitoring.

Response
The monitoring section of the report (section 5) describes the types of systems which are necessary and identifies responsibilities. The language regarding groundwater quantity and quality has been strengthened, including identification of the need to monitor groundwater conditions in the Western Aquifer, as well as the Eastern Aquifer.

3.4 Wastewater Issues

Comment by USAID
The EA needs to contain more specific language in regards to mitigation of potential shallow groundwater contamination.

Response
Language concerning mitigation of potential shallow groundwater contamination, called for by USAID and accepted by CDM/Morganti, has been added to sections 2.3.1, 4.1.2, and 4.2.2.

EXECUTIVE SUMMARY

1.1 Purpose and Objectives

The purpose of the Water Resources Program of the West Bank Municipal Services Project is to provide greater access to and more effective use of scarce water resources. The objectives of the program in the Hebron-Bethlehem area are:

- To locate, drill, and develop three new wells capable of producing 5 to 8 million cubic meters per year.
- To locate, design, and construct transmission mains and associated facilities to deliver the water from the wells to the cities of Hebron and Bethlehem.
- To locate, design, and construct storage reservoirs in Hebron and Bethlehem.
- To provide the necessary guidance to systematic improvement, renovation, and expansion of water supplies throughout the Hebron-Bethlehem service area for the year 2000 through the year 2020.

The activities in the Hebron-Bethlehem area will be implemented in two stages. The immediate stage includes design and construction of wells, transmission mains, and associated facilities to meet immediate needs for water supply in cities of Hebron and Bethlehem. The facility master plan includes development of a long-term water supply system plan for the years 2000, 2010 and 2020.

1.2 Significant Issues

The EA team, after conducting a scoping session, identified 12 significant issues and grouped them into three categories of impacts.

> Impacts on the Physical and Natural Environment: vegetative cover and soil erosion; and sustainable use of groundwater resources.
> Impacts on the Built Environment: improved hygiene; increased wastewater flows; destruction of cesspits during construction; noise; energy generation and transmission; and destruction of archaeological resources.
> Impacts on the Socio-Economic Environment: traffic disruption; induced development; increased cost of cesspit pumping; and land use and acquisition.

Three of these issues -- sustainable use of groundwater resources, induced economic development, and energy generation and transmission -- are significant only for the facility master plan stage.

2. PROPOSED ACTION AND ALTERNATIVES

2.1 Immediate Stage

Development of alternatives began with the selection of well sites. Twelve well sites were considered for providing supply in the immediate stage. These sites were evaluated by the CDM/Morganti team in consultation with PWA technical staff using technical, environmental, and cost criteria. The analysis identified three sites for development. These wells will produce a total of 6 Mcm/yr. Using these three wells, the CDM/Morganti team developed three action alternatives for supplying water to Hebron and Bethlehem. These alternatives are summarized in Table ES.1.

Table ES.1
SUMMARY OF THE IMMEDIATE STAGE ALTERNATIVES

Item	Proposed Action	Minimum Pipe Diameter Alternative	Separate Systems for Hebron & Bethlehem
Water Sources	Well nos. 12, 11 & 3	Same as the proposed action	Same as the proposed action
Length and Size of Pipelines	28.9 km total 8 km of 600 mm 20.9 km of 900 mm	28.9 km total 2 km of 300 mm 2 km of 400 mm 4.3 km of 500 mm 8.2 km of 600 mm 12.4 km of 700 mm	26.8 km total 6.1 km of 600 mm 22.6 km of 900 mm
Size and Location of Reservoirs	10,000 m^3 Bethlehem 25,000 m^3 Hebron	Same as the proposed action	Same as the proposed action
No., Size, and Location of Pump Stations	1 pump station northeast of Hebron 3 booster pumps, one at each wellhead	Same as the proposed action	Same as the proposed action
Roads	0.16 km		
Source: Deliverables 28.01 and 29.01			

2.2 Facility Master Plan

Facility master plan alternatives were developed to meet the objective of supplying adequate water to all of the residents in the larger Hebron-Bethlehem area, through the year 2020. The CDM/Morganti team developed a proposed action to meet this need with specific targets for the years 2000, 2010, and 2020. The target for the year 2000 includes the immediate stage facilities. The proposed action is summarized in Table ES.2.

The team developed two action alternatives, which differ from the proposed action primarily in the source of water beginning in the year 2010. The source of water for Alternative 2 is a proposed desalinization plant in Gaza, from which water would be transported to the area via an 80 kilometer pipeline. The source of water for Alternative 3 is a multi-national project involving conveying sea water to the Dead Sea from either the Mediterranean Sea or the Red Sea, desalinating the water, and pumping it to the West Bank as well as to Jordan and Israel.

Table ES.2
SUMMARY OF THE FACILITY MASTER PLAN PROPOSED ACTION

Item	2000[a]	2010	2020
Water Sources	Eastern Aquifer 12 wells at Al'Izariyya 15 Mcm/yr	Eastern Aquifer 4 wells at Bani Na'im 10 Mcm/yr 4 wells at As-Sammu 2 Mcm/yr Western Aquifer 5 wells at Ar-Ramadin 10 Mcm/yr 2 wells at Ithna 4 Mcm/yr 1 well at Surif 2 Mcm/yr	Western Aquifer 3 wells at Kharas 6 Mcm/yr 3 wells at Beit Ula 6 Mcm/yr 2 wells at Al-Majd 4 Mcm/yr 2 wells at Dayr Samit 4 Mcm/yr 1 wells at Ithna 2 Mcm/yr 1 well at Surif 2 Mcm/yr Reuse of Treated Wastewater, 9 Mcm/yr
Transmission Pipelines (km)	78.6	194.5	106.3
Regional Reservoirs	1, 10,000 m^3 1, 5,000 m^3	6, 5,000 m^3	3, 5,000 m^3
Local Reservoirs	None	96 5, 100 m^3 17, 200 m^3 11, 300 m^3 22, 500 m^3 13, 1,000 m^3 12, 2,000 m^3 11, 5,000 m^3 5, 10,000 m^3	65 2, 50 m^3 9, 100 m^3 6, 200 m^3 8, 300 m^3 11, 500 m^3 16, 1,000 m^3 5, 2,000 m^3 5, 5,000 m^3 3, 10,000 m^3
Pump Stations	2	4	2

[a]In addition to existing, planned, and immediate stage facilities.

Source: Deliverable 25.02

2.3 Mitigation Measures

Ten mitigation measures were developed, applicable to all alternatives.
Development of an Archaeological Resource Protection Program
Adoption of Design Standards to Minimize the Intrusive Character of Proposed Facilities
Adoption of Design Standards to Minimize Noise in Residential Areas
Development of Construction Control Program to Avoid Undue Disruption of Access and Services
Development of Construction Control Program to Avoid Undue Destruction of Cesspits
Adoption of Design Standards to Minimize Soil Erosion and Destruction of Vegetation
Avoid Groundwater Overdraft
Adoption of Design Standards to Prevent Releases of Chlorine Gas and Minimize Potential Impacts
Adoption of Design Standards to Prevent or Contain Fuel Releases at Well Sites and Pump

Stations
Shallow Groundwater Impact Assessment

3. EXISTING ENVIRONMENT

3.1 Physical and Natural Environment

The Hebron-Bethlehem area is located in the Central Highlands in the southern part of the West Bank. It has a Mediterranean climate characterized by long, hot, dry summers and short, cool, rainy winters, which are modified locally by altitude and latitude. Annual rainfall ranges from 700 millimeters in the mountains to 400 millimeters in the foothills.

The Bethlehem-Hebron area is underlain by the Western and Eastern Aquifer Basins. The Western Aquifer is currently at or near safe yield. The Eastern Aquifer has water available for development, although the exact amount is uncertain. Domestic wells in these aquifers supply 80 of the 151 communities in the area. In 1995, 13 Mcm was withdrawn for domestic use.

3.2 The Built Environment

The Hebron-Bethlehem area, with a total area of 1,283 km, includes within its boundaries 151 Palestinian towns and villages, and 47 Israeli settlements. Twenty-five percent of the total land area is cultivated, primarily with rain-fed orchards and vineyards.

Only Hebron and Bethlehem have sewers, which serve only about half of the residences. Neither sewer system has an operating treatment plant, so raw sewage is dumped into wadis. Homes without sewers are generally served by cesspits.

The Hebron-Bethlehem area is famous for its archaeological sites and historic places. An initial literature survey identified 230 known archaeological sites in the Hebron-Bethlehem Area.

3.3 Socio-Economic Environment

The total population in the Hebron-Bethlehem area is 434,041. The population is expected to grow to 774,850 by the year 2010 and to 991,870 by the year 2020. The main source of income in Bethlehem is tourism, and in Hebron is trade and marketing. The unemployment rate in the area is estimated at 40.5 percent. Approximately 91 percent of the employed work force have permanent employment, one percent has seasonal employment, and eight percent have part-time jobs. In some of the villages south of Bethlehem City most of the work force is concentrated in the stone industry and quarries. Major industrial activities in the Hebron District include stone and aggregate quarrying, stone and marble cutting, leather tanning, glass manufacturing, and shoemaking. People in rural areas depend primarily on agriculture for their income.

4. ENVIRONMENTAL CONSEQUENCES

Environmental consequences were assessed for the no action alternative and the action alternatives for both the immediate stage and facility master plan.

4.1 Immediate Stage

The project is designed to address the most significant impact of taking no action: continuation of inadequate water supply to the residents in the Hebron-Bethlehem area. All of the action alternatives address this issue, by providing adequate water. The most significant impacts of any of the action alternatives are increased flow of wastewater and associated increased costs

of cesspit pumping. Increasing water availability will increase wastewater flows. All of the other potential impacts of the project can and will be mitigated during implementation. The potential environmental and economic consequences of increasing wastewater flows, however, cannot be mitigated within the framework of this project. Mitigating these impacts will require investments in wastewater management, either in sewers and treatment facilities or in improved cesspit/septic tank designs. Such investments are beyond the scope of the current project.

4.2 Facility Master Plan

Assessing the environmental impacts of the facility master plan is not as straight forward as assessing the impacts of the immediate stage facilities. With the exception of the facilities proposed for construction in the year 2000, most of the proposed facilities will not be constructed for many years. The exact locations of these facilities are not known, making site specific determinations of impact impossible.

It is impossible to fully quantify the potential impacts of the facility master plan or to even adequately describe them qualitatively. However, if the mitigation measures presented in this EA are implemented at the time of design and construction, the facilities should pose no significant impacts on the environment.

As with the immediate stage facilities, some of the greatest potential impacts are associated with increasing wastewater flows. These impacts will need to be addressed in the future through wastewater management. The other potential impact of most concern is unsustainable use of the groundwater resource. This issue can only be addressed with development and implementation of a regional water exchange scheme involving all of the parties currently using the Eastern and Western aquifers. The regional scheme should include economically efficient exchanges of desalinated seawater for groundwater. A regional solution, in combination with implementation of the groundwater monitoring program proposed in the EA, should eliminate the potential for overdraft of the aquifer.

The facility master plan alternatives eliminate concern for sustainability of the groundwater resource by relying on other sources of water. They, however, raise significant issues concerning construction of desalinization plants and conveyance of large amounts of water over great distances. A full assessment of these impacts is beyond the scope of this EA.

5. MONITORING PLANS

To ensure that the implementation of the project has the desired environmental consequences, the EA provides for three monitoring programs:

- The development of a water resource monitoring plan, focused on the relationship of local demand for water and local sources of supply.
- The development of a domestic water quality monitoring program to ensure that the water systems are not contaminated by wastewater.
- The development of a monitoring program that ensures the implementation of the proposed mitigation measures.

During implementation of the immediate stage, most of the monitoring responsibilities will fall upon CDM/Morganti. For the facility master plan, monitoring will primarily be the responsibility of PWA.

FINAL ENVIRONMENTAL ASSESSMENT OF THE MASTER PLAN FOR THE HEBRON-BETHLEHEM SERVICE AREA

Abbreviations

ACE	- Associated Consulting Engineers, Palestine
CEP	- Center for Engineering and Planning
CDM	- Camp Dresser & McKee International Inc.
Chemonics	- Chemonics International, Inc.
DEA	- Draft Environmental Assessment
EA	- Environmental Assessment
GTZ	- Deutsche Gesellschaft fur Technische Zusammenarbeit (German Technical Office)
Harza	- Harza Environmental Services
JWC	- Joint Water Committee (Israeli - Palestinian)
km	- Kilometers
L/c/d	- Liters per capita per day
m	- Meters
m^2	- Square meters
m^3	- Cubic meters
Mcm/yr	- million cubic meters per year
M&I	- Municipal and Industrial
mm	- Millimeters
mmsl	- Meters above mean sea level
Morganti	- The Morganti Group, Inc.
NGO	- Non-Governmental Organization
PEA	- Partial Environmental Assessment
PWA	- Palestinian Water Authority
UNRWA	- United Nations Relief and Works Agency
USAID	- United States Agency for International Development
WBWD	- West Bank Water Department
WSSA	- Water Supply and Sewage Authority

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1. INTRODUCTION

The United States Agency for International Development (USAID) is funding the Water Resources Program of the West Bank Municipal Services Project. The program is being implemented by a team (CDM/Morganti) led by Camp Dresser & McKee International Inc. and including the Morganti Group, Associated Consulting Engineers-Palestine, Center for Engineering and Planning, Chemonics International Inc., and Harza Environmental Services. CDM/Morganti, working in close collaboration with the Palestinian Water Authority (PWA) and under the auspices of the Joint Water Committee (Israeli-Palestinian), will carry out the works from studies and field investigations through designs and modeling to actual implementation and construction. PWA, the implementing agency, has established a permanent office and staff to coordinate on a daily basis with the CDM/Morganti engineers. This arrangement ensures close coordination between the engineers implementing the project and the decision makers at PWA.

In the Hebron-Bethlehem area (Figure 1.1) the program will be implemented in two stages. The immediate stage includes design and construction of wells, transmission mains, and associated facilities to meet immediate needs for water supply in cities of Hebron and Bethlehem. The facility master plan includes development of a long-term water supply system plan for the greater Hebron-Bethlehem area for the years 2000, 2010, and 2020. These activities were identified by USAID/West Bank and Gaza as requiring an environmental assessment (EA).

This EA addresses significant environmental issues for both stages of the project. Because of the need for timely construction of wells and transmission mains to Hebron and Bethlehem, the EA was preceded by a Partial Environmental Assessment (PEA) which assessed potential environmental impacts of design alternatives and identified necessary mitigation measures for the immediate stage facilities. To facilitate decision making, development of the Partial Environmental Assessment proceeded in parallel with the engineering team activities in well and water supply system design. The Final PEA was submitted to USAID on October 22, 1996 (Deliverable 26.04). The results of the PEA are incorporated in this EA. In some cases, changes have been made in the proposed actions and the alternatives since publication of the PEA. These changes and their environmental consequences have been incorporated into this EA.

The EA also presents impact assessment and mitigation measures for the broader, long-term concerns and larger project area associated with the facility master plan for the years 2010 and 2020. The assessment of the environmental impacts of the facility master plan has been closely coordinated with the facility master planning team to ensure that environmental concerns were considered in the development and selection of planning alternatives.

This Environmental Assessment is organized as follows. Section 1 presents the purpose and objectives of the project, identifies the significant issues which are addressed in the EA, and describes the criteria which will be used to make the assessments. Section 2 presents a description of the proposed action and alternatives and the required mitigation measures. Section 3 describes the existing environment which will affect and/or be affected by the project. Section 4 presents the environmental consequences associated with the proposed action and each alternative. Section 5 contains the proposed monitoring plans, and Section 6 lists the preparers, persons contacted, and references consulted throughout the preparation of the assessment.

1.1 PURPOSE AND OBJECTIVES

The purpose of the Water Resources Program of the West Bank Municipal Services Project is to provide greater access to and more effective use of scarce water resources. The objectives of the program in the Hebron-Bethlehem area are:

- To locate, drill, and develop 3 to 6 new wells capable of producing 5 to 8 million cubic meters per year.
- To locate, design, and construct transmission mains and associated facilities to deliver the water from the wells to the towns of Hebron and Bethlehem.
- To locate, design, and construct storage reservoirs in Hebron and Bethlehem.
- To provide the necessary guidance to systematic improvement, renovation, and expansion of water supplies throughout the Hebron-Bethlehem service area for the year 2000 through the year 2020.

The first three objectives are directed at the immediate stage facilities. The immediate stage will serve nine communities in the Bethlehem area[1] and the city of Hebron. All of these communities have existing water distribution systems. In 1996 the population of the area to be served was 160,682, and it is projected to grow to 367,190 by the year 2020.

The fourth objective is for the facility master plan which covers the larger Hebron-Bethlehem area of 1,283 square kilometers, encompassing 151 communities (Figure 1.2). The current population of the Hebron-Bethlehem area is 434,041, and it is projected to grow to 991,870 by the year 2020. Hebron is the largest community in the region with a population of 94,758. Other large communities include Bethlehem, Beit Jala, Beit Sahour, Halhul, Ithna, Dura, Yatta, Ad-Dhahriyyeh, and Al-'Izariyya. Only 80 of the communities in the area have existing water systems. The other communities rely upon hauled water, springs, shallow wells, and cisterns for their water supply.

1.2 SIGNIFICANT ISSUES

A scoping session was held on 19 August 1996 in Bethlehem for the Hebron-Bethlehem area to identify the significant environmental issues[2]. The participants at the scoping session identified 24 potentially significant issues. The EA team grouped similar issues and developed a consolidated list of 17 potentially significant issues. Using criteria on the relevance, magnitude, extent, duration, and uncertainty of the potential impacts associated with each issue, the team identified 12 significant issues for the Hebron-Bethlehem area and grouped them into three categories of impacts (Table 1.1). All but three of the issues (sustainable use of groundwater resources, induced economic development, and energy generation and transmission) are significant for both the immediate and the facility master plan stages.

During the scoping session and subsequent analysis, potential impact on threatened and endangered species was not identified as a significant issue. This is due to the nature of the facilities to be constructed. Well sites, reservoirs, and pump stations will be small in size and

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[1]Bethlehem, Beit Jala, Beit Sahour, Ad-Dawha, Al-Walaja, Al-Khadr, Ayda Refugee Camp, Al-'Azza Refugee Camp, and Adhaysha Refugee Camp.

[2]The results of the scoping session are presented and discussed in the Scoping Report submitted to USAID on 30 August 1996 (Deliverable 26.01).

number. Each well site will occupy less than 0.4 hectares, each reservoir will require about 0.1 hectares for the reservoir and associated facilities, and a pump stations will occupy only about 15 square meters. Transmission mains and distribution will be located within already disturbed road rights-of-way. Most importantly, field investigations and personal contacts with residents indicate that wild plants in the area are abundant and have been sustainably used for medicinal purposes for hundreds of year, with none of them reported as being threatened or endangered.

Table 1.1
SIGNIFICANT ENVIRONMENTAL ISSUES

Category	Issue	Significant	
		Immediate	Master Plan
Impacts on the Physical and Natural Environment	Vegetative Cover and Soil Erosion	✓	✓
	Sustainable Use of Groundwater Resources		✓
Impacts on the Built Environment	Improved Hygiene	✓	✓
	Increased Wastewater Flows	✓	✓
	Destruction of Cesspits During Construction	✓	✓
	Noise	✓	✓
	Energy Generation and Transmission		✓
	Destruction of Archaeological Resources	✓	✓
Impacts on the Socio-Economic Environment	Traffic Disruption	✓	✓
	Induced Development		✓
	Increased Cost of Cesspit Pumping	✓	✓
	Land Use/Acquisition	✓	✓

1.3 ASSESSMENT CRITERIA

For each of the significant issues, the EA team developed assessment criteria for use in measuring impacts. To the extent possible, the team developed criteria which could be quantitatively measured. These criteria are described in this section.

1.3.1 Impacts on the Physical and Natural Environment

Vegetative Cover and Soil Erosion: The impacts on vegetative cover and soil erosion will be short-term and primarily associated with construction. They can be mitigated by adopting proper mitigation measures. The criterion for vegetative cover and soil erosion is area disturbed.

Sustainable Use of Groundwater Resources: Sustainability of groundwater resources was identified to be significant only for the long-term development of the aquifer and not for the immediate stage activities. The criteria for assessing the impacts of alternatives on sustainable

use of groundwater are projected withdrawals and estimates of safe yield of the groundwater resources.

1.3.2 Impacts on the Built Environment

Improved Hygiene: The project will increase water availability which will improve hygiene by providing more water for personal hygiene in households. The assessment criterion for this issue is per capita water consumption. Current and projected per capita consumption rates were evaluated using the WHO design recommendation for minimum per capita consumption for in-house piped systems.

Increased Wastewater Flows: Increased water availability will also increase wastewater flows, which has the potential to negatively impact both public health and groundwater quality. Analysis of the impacts of increased wastewater flows depends mainly on the projected quantity and quality of the wastewater produced. The criteria for assessing this issue are current and projected water supply and subsequent wastewater generation, wastewater collection and disposal methods, depth of groundwater resources, surface discharges and seepages, final disposal site of wastewater and pumpage from cesspits, and effluent quality.

Destruction of Wastewater Cesspits: The destruction of cesspits during construction of the project is a significant concern because many cesspits are located in the rights-of-way for roads, the same rights-of-way which will be used for water pipelines. Destruction of cesspits during construction will cause short-term nuisance problems, inconvenience to homeowners, and increased project costs (assuming that the project will have to replace any cesspits it destroys). This issue is a short-term impact that can be mitigated during construction by adopting proper mitigation measures. The EA does not attempt to provide an *a priori* assessment of impact, therefore, no assessment criteria were developed.

Noise: This issue covers short-term noise impacts during project construction as well as long-term impacts from project operation (e.g., noise from pump stations and generators). These impacts can be mitigated during construction by adopting proper mitigation measures. The EA does not attempt to provide an *a priori* assessment of impacts, therefore, no assessment criteria were developed.

Energy Generation and Transmission: The provision of additional electrical power for pumping may create indirect impacts of the project. The assessment criteria for this issue are energy requirements and current and projected energy sources and availability. The energy requirements were compared to energy availability to determine if there was an energy deficit. If a deficit existed, the potential impacts of required energy sources were assessed.

Destruction of Archaeological Resources: Construction of water supply facilities may destroy archaeological resources, resulting in irreversible impacts. To the extent possible, the project should be implemented in such a way as to avoid destruction of archaeological resources. The criterion for assessing impacts on archaeological resources is location of resources relative to proposed facilities. Archaeological resources were located through literature and walk-over surveys conducted in the early stages of the assessment.

1.3.3 Impacts on the Socio-Economic Environment

Traffic Disruption: Traffic disruption is a short-term impact associated with construction which can be mitigated by adopting proper mitigation measures. The EA does not attempt to provide an *a priori* assessment of short-term disruption of traffic, therefore, no assessment criteria were developed.

Induced Development: Impacts associated with induced development were assessed by analyzing economic growth with and without program implementation. The EA team used existing information on projected economic growth, rather than producing project specific economic growth models.

Increased Cost of Cesspit Pumping: Increased water availability will increase wastewater flows, which will increase the costs to some households of pumping cesspits. The criteria for this issue are size of the cesspits, unit pumping cost, and current and projected frequency of pumping.

Land Use/Acquisition: Facility construction will require land acquisition and cause irreversible changes in land use. These impacts can be mitigated by ensuring adequate compensation for any irreversible commitments. These impacts were assessed by determining land use and land ownership at proposed facility sites.

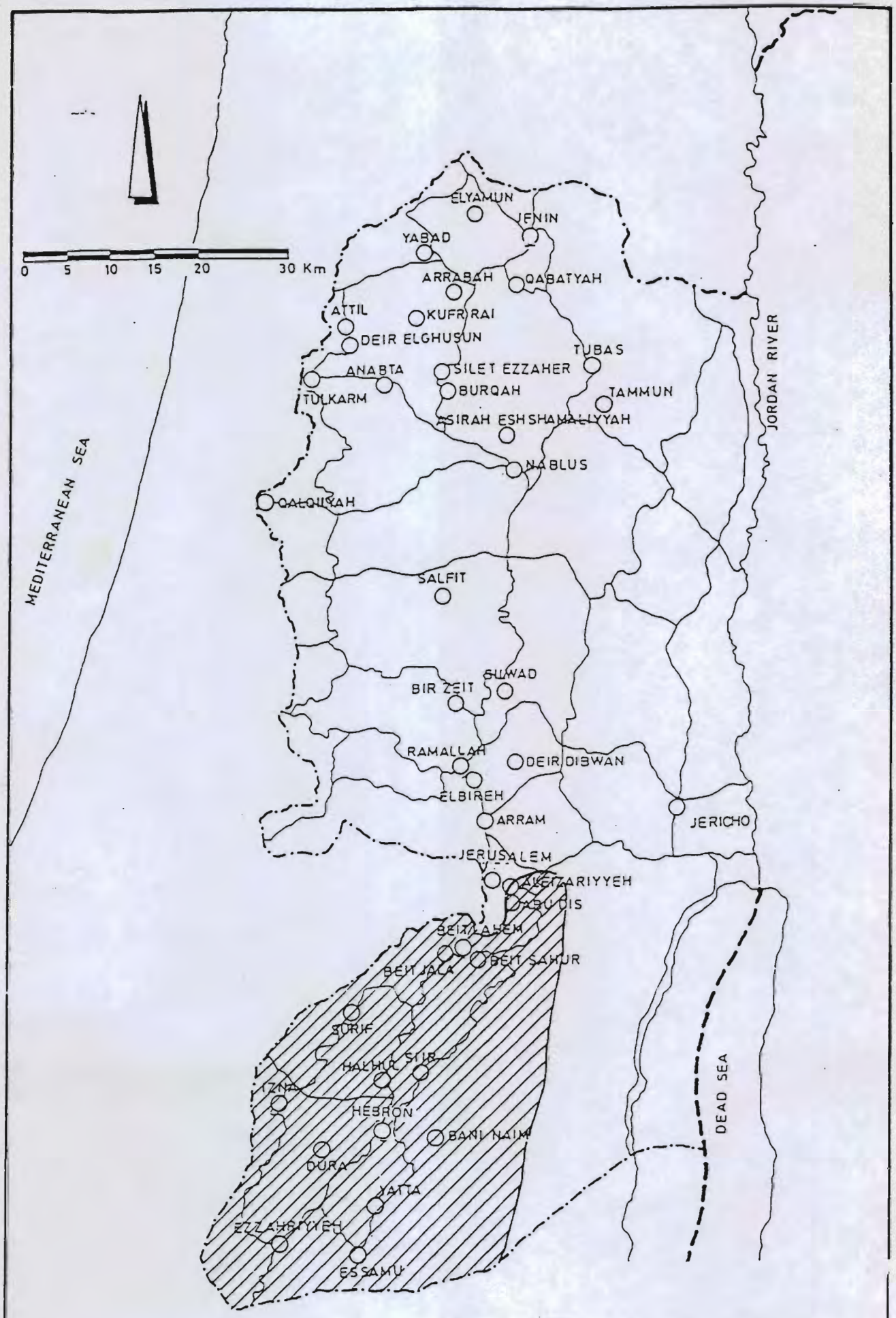

Figure 1-1
General Location Map

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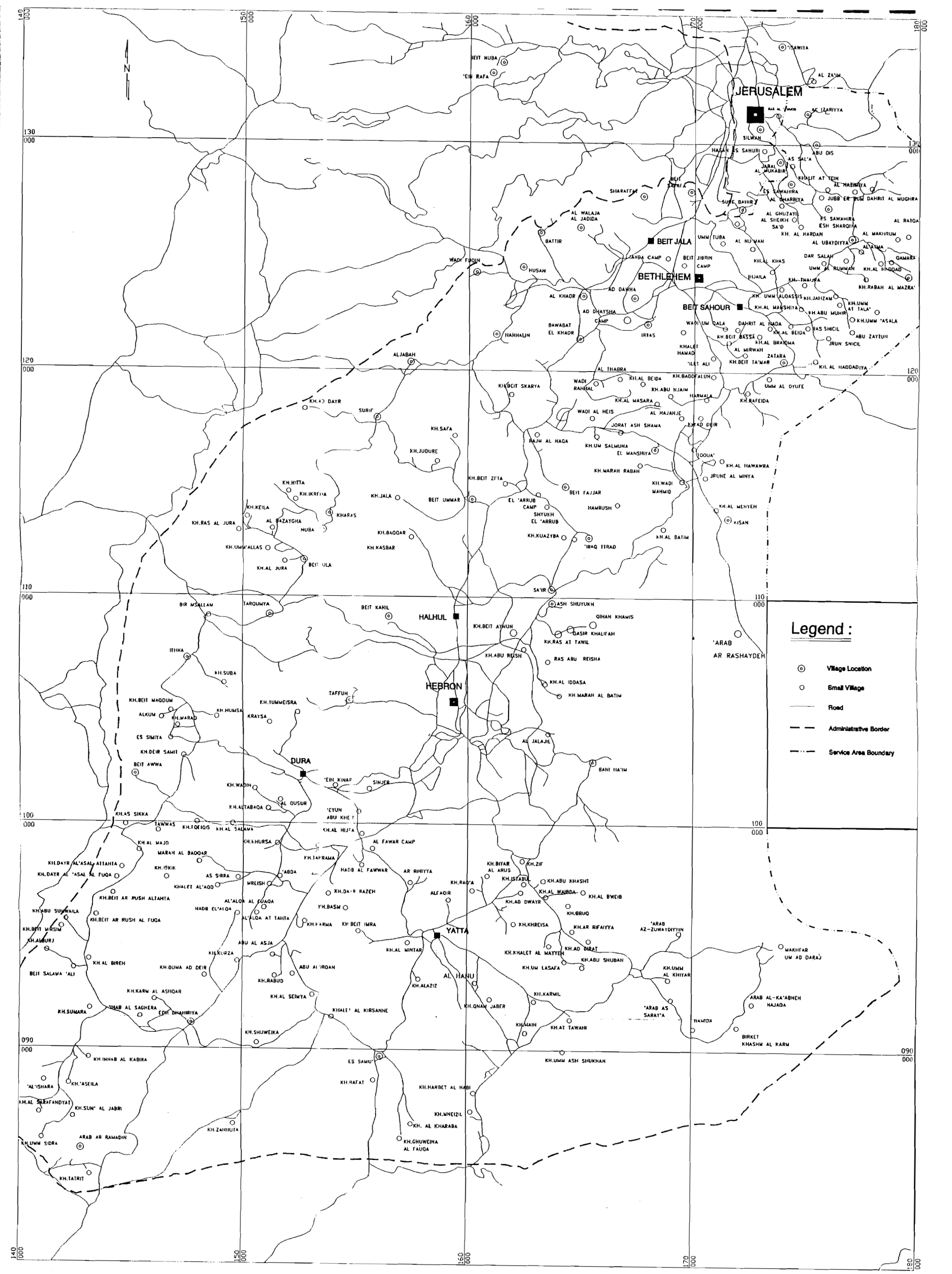

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CDM/Morganti

Figure 1-2
Service Area for the Facility Master plan

2. PROPOSED ACTION AND ALTERNATIVES

The project team reviewed several system component options and identified the proposed action and reasonable alternatives for both the immediate and facility master plan stages. In order to ensure efficient decision-making with full provision for environmental concerns, the options analysis was conducted with complete integration between the technical and environmental components. This chapter describes the process used for screening and evaluating component options, identifies the alternatives which have been eliminated from further consideration, presents the no action alternative, and presents the proposed action and reasonable alternatives. The chapter is divided into two sections. The first section describes the proposed action and alternatives for the immediate stage, and the second section describes the proposed action and alternatives for the facility master plan stage.

2.1 IMMEDIATE STAGE

2.1.1 Alternative Development Process

The proposed action and alternatives were developed by the design and environmental teams using differing combinations of sources of supply, transmission routes, and storage locations. Table 2.1 lists plan elements that were considered by the teams. All of the alternatives use the same three well sites (see the following section for a discussion on selection of the well sites), a booster pump station eight kilometers northeast of Hebron, 25,000 m^3 of new storage in the Hebron area and 10,000 m^3 of new storage in the Bethlehem area. All of the alternatives will also chlorinate the water at the wellheads using gas chlorination.

Alternatives which were considered but eliminated from further analysis were designs which meet only the demands for the year 2000 and drilling a single borehole at each well site which would tap both aquifers. The former was eliminated because it did not meet the objectives of the project and the later because of technical difficulties from the potential reduction in head and environmental problems associated with facilitating contamination of the lower aquifer by creating a hydraulic connection between the two aquifers.

Table 2.3, at the end of this section, summarizes the alternatives for the immediate stage. The Final Engineering Design Report (Deliverable 29.01) provides a detailed description of the proposed action. The Feasibility Study for the immediate stage activities (Deliverable 28.01) provides a detailed description of the two alternatives.

Table 2.1
COMPONENTS FOR IMMEDIATE STAGE ALTERNATIVES

Element	Components
Source Development	13 potential well sites Tandem (cluster) wells at each site tapping the upper and lower aquifers Single wells at each site tapping both the upper and lower aquifers
Transmission	Single pipeline and well field system serving both Hebron and Bethlehem Separate pipelines and well fields, one serving Hebron and the other Bethlehem
Storage	Alternative locations for a 10,000 m^3 reservoir in the Bethlehem area and a 25,000 m^3 reservoir in the Hebron area

2.1.2 Selection of Well Sites

Thirteen well sites were considered for providing supply in the immediate stage (Figure 2.1). Prior to initiation of the Water Resources Program, 11 potential well sites had been identified. CDM/Morganti identified two additional sites and eliminated one potential site, Site 10, because it was too distant from the project area. The remaining 12 sites were evaluated using multiple objective analysis. The analysis included technical (likelihood of success), environmental, and cost criteria. The criteria and weighting factors used in the analysis were developed jointly by the CDM/Morganti technical and environmental teams, PWA technical staff, and WBWD specialists. The CDM/Morganti technical team, in close consultation with PWA technical staff and the environmental team, scored each criteria. Figure 2.2 presents the evaluation criteria and scoring results for each well site.

The analysis identified four well sites for development: Site No. 12, Site No. 11, Site No. 3, and Site No. 1. The first three sites were subsequently selected for development with Site No. 1 being identified as an alternative site for future development if necessary[3]. Drilling at each well site will disturb a 3,600 m^2 area, although the completed well and associated facilities will occupy only 1,600 m^2. Each well site will include a guard house, diesel generator and above ground fuel tank, electrical equipment shed, chlorination building, pump, and a 1,600 m^3 balancing tank.

The final design for the wells calls for only tapping the lower aquifer. Table 2.2 presents some information on the proposed well sites. All of the alternatives use these three wells as their source of water.

[3]Deliverable 27.01

Table 2.2
PROPOSED WELL SITES FOR THE IMMEDIATE STAGE

Data	Site 11	Site 12	Site 3
Coordinates	16930/11635	17155/11875	17125/12025
Elevation (mmsl)	750	560	610
Expected Drilling Depth (m)	800	800	800
Expected Static Water Level (m)	380	300	320
Expected Pumping Rate (m^3/hr)	200	300	250
Source: Deliverable 25.01			

2.1.3 No Action

The no action alternative continues the use of the existing water supply and distribution system serving the Hebron-Bethlehem area with the addition of a new well, transmission main, and reservoir under construction to serve the city of Hebron. The addition is being funded by GTZ. The well is expected to produce 3 Mcm/yr, which will be delivered to a 5,000 m^3 reservoir through a 14 kilometer pipeline. With the new well, total water deliveries to Hebron will be 6.1 Mcm/yr. Water deliveries to the WSSA in Bethlehem will be 2.9 Mcm/yr. The existing water supply system is presented in Figure 2.3.

2.1.4 Proposed Action

The proposed action will provide transmission mains to Hebron and Bethlehem designed to carry the anticipated water demand for the year 2020. It provides the water from the three wells through a combined Hebron-Bethlehem transmission main. Figure 2.4 shows the general layout of the proposed action, and Figure 2.5 shows the schematic layout. The system consists of three wells with a total capacity of 6 Mcm/yr, chlorination at the wellheads, a transmission pipeline, a booster pump station, and two storage reservoirs.

The proposed action will build a 28.9 kilometers of large diameter transmission pipelines (600 and 900 mm diameter) running north and south along Route 356, connecting the proposed wells to new storage reservoirs in Bethlehem and Hebron. Proposed storage will consist of two rectangular storage reservoirs: a 10,000 m^3 reservoir southwest of Bethlehem and a 25,000 m^3 reservoir in Halhul, north of Hebron. Most of the proposed facilities will be accessible by existing roads, but 100 meters of road will need to be constructed to gain access to the Halhul reservoir and 60 meters of road will be needed at the site of well number 11. A pumping station will be built in Sa'ir, eight kilometers northeast of Hebron, to boost water up to the new Hebron reservoir. Two 1,600 m^3 balancing reservoirs will be constructed at the site of the booster station.

2.1.5 Minimum Pipe Diameter Alternative

The minimum pipe diameter alternative will provide water to Hebron and Bethlehem through transmission mains designed to carry only enough water to meet the anticipated demand for the

year 2000. It has the same layout and basic components as the proposed alternative, except that the transmission mains are smaller. The transmission mains will be sized from 300 to 700 mm rather than 600 and 900 mm as called for in the proposed action. Figure 2.6 presents a schematic for this alternative.

The major advantage of this alternative is that it reduces initial capital costs. However, it will be necessary to build a similar, parallel pipeline in the year 2005 to accommodate increase demand. When the cost of that pipeline is included in the total costs, the cost savings is eliminated.

2.1.6 Separate Systems for Hebron and Bethlehem Alternative

This alternative, uses the same basic components of water supply, booster pump, and storage as the proposed action, but it constructs two transmission mains. One main will run from wells No. 12 and No. 11 south on Route 356 to the proposed Hebron reservoir. The other transmission main will run on Route 356 north from well No. 3 to the proposed Bethlehem reservoir. This alternative will require construction of 26.8 kilometers of large diameter transmission pipeline (600 & 900 mm diameter). The cost of this alternative will be less than the proposed action because it reduces the length of the transmission main and requires smaller pump capacity at the wells and the booster station.

Although this alternative requires less construction of transmission mains, and thus is less expensive than the proposed action, the small savings in cost come at the expense of system management flexibility.

Table 2.3
SUMMARY OF THE IMMEDIATE STAGE ALTERNATIVES

Item	Proposed Action	Minimum Pipe Diameter Alternative	Separate Systems for Hebron & Bethlehem
Water Sources	Well nos. 12, 11 & 3	Same as the proposed action	Same as the proposed action
Length and Size of Pipelines	28.9 km total 8 km of 600 mm 20.9 km of 900 mm	28.9 km total 2 km of 300 mm 2 km of 400 mm 4.3 km of 500 mm 8.2 km of 600 mm 12.4 km of 700 mm	26.8 km total 6.1 km of 600 mm 22.6 km of 900 mm
Size and Location of Reservoirs	10,000 m^3 Bethlehem 25,000 m^3 Hebron	Same as the proposed action	Same as the proposed action
No., Size, and Location of Pump Stations	1 pump station northeast of Hebron 3 booster pumps, one at each wellhead	Same as the proposed action	Same as the proposed action
Roads	0.16 km		
Source: Deliverables 28.01 and 29.01			

2.2 FACILITY MASTER PLAN

2.2.1 Alternative Development Process

The facility master plan elements are those structural measures that can be taken to satisfy the water supply needs in the Hebron-Bethlehem area for the years 2000, 2010, and 2020. The plan elements are source development, transmission mains, pump stations, and storage. Distribution systems are not included in the scope of the facility master plan.

Alternatives for water supply systems for the Hebron-Bethlehem service area are somewhat limited by locations of sources of supply, demand centers, and existing infrastructure including existing road systems and associated rights-of-way. In the Hebron-Bethlehem area, source development options include development of existing and planned wells, drilling and development of new wells, exchange of water for agricultural use, reuse of treated wastewater, importation of freshwater, desalination of water from the lower aquifer, and importation and desalination of sea water (from the Mediterranean or Red seas). Options for transmission lines, pump stations, and storage will be largely determined by the selection of sources and the demands for water. Alternative facility master plans for the years 2000, 2010, and 2020 were developed by using different sources of supply and associated transmission and storage facilities.

The Preliminary Report of the Water Supply Facility Master Plan for the Hebron-Bethlehem Service Area (Deliverable 25.01) contains a detailed description of each of the alternatives. The following summarizes those descriptions.

2.2.2 No Action

The no action alternative continues the use of the existing water supply and distribution system serving the Hebron-Bethlehem area (Figure 2.3) with the addition of the new well and pipeline being constructed for Hebron with GTZ funding.

The existing water supply system supplies 13 Mcm/yr. The new developments will add an additional 9 Mcm/yr, for a total supply of 22 Mcm/yr. These developments will improve system performance, but they will not extend service to the 71 communities which are not served by the current system.

2.2.3 Proposed Action

The proposed action is designed to meet anticipated water demand for the entire population of the Hebron-Bethlehem area. Table 2.4, at the end of this section, summarizes the proposed action.

<u>Year 2000</u>

The water demand in the larger Hebron-Bethlehem area for the year 2000 is projected to be 37.6 Mcm/yr. The existing system yield plus the immediate stage facilities and other ongoing or planned developments will provide 22 Mcm/yr. The facility master plan for the year 2000 calls for an additional 15 Mcm/yr of source development from six well sites in the Eastern Aquifer in the Al-'Izariyya area, east of Jerusalem. Two wells will be drilled at each site, one tapping the upper aquifer and the other the lower aquifer, for a total of 12 wells. The plan also calls for an

constructing 71.4 kilometers of transmission pipeline, two pump stations, and two regional reservoirs. These facilities will increase water in the total system and add the Al-'Izariyya area and the area southwest of Hebron to the system. A general layout of the proposed facilities for the year 2000 are shown in Figure 2.7.

Year 2010

The water demand in the year 2010 is projected to be 65 Mcm/yr, thus requiring the development of an additional 28 Mcm/yr of supply. To meet the additional demand, the facility master plan calls for development of two well fields in the Eastern Aquifer with eight wells producing 16 Mcm/yr, and three well fields in the Western Aquifer with eight wells producing 12 Mcm/yr.

To supply the new water to the communities in the Hebron-Bethlehem area the facility master plan calls for construction of 195.5 kilometers of transmission pipelines, six regional storage reservoirs, 96 local reservoirs ranging in size from 100 m^3 to 10,000 m^3, and four pump stations. A general layout for the 2010 facilities is shown in Figure 2.8.

Year 2020

By the year 2020 the proposed action calls for serving all of the Palestinian communities in the service area. Water demand in the Hebron-Bethlehem area at that time will be 97.8 Mcm/yr, requiring an additional 32.8 Mcm/yr over the supply developed by the year 2010. To meet this need the facility master plan calls for drilling 12 more wells at six well fields in the Western Aquifer. These wells are projected to produce 24 Mcm/yr. The additional 8.8 Mcm/yr will come from reuse of treated wastewater by industry and agriculture, which will free up fresh water for use in the domestic systems. By the year 2020 the areas served by the WSSA and Municipality of Hebron alone could be generating 29 Mcm/yr of wastewater. If the existing sewers were expanded and wastewater treatment facilities were built, the treated wastewater from these areas alone, traded for fresh water from industrial and agricultural uses, would just about meet the demand shortfall.

To deliver the water to the communities, the facility master plan for 2020 calls for construction of 106.3 kilometers of transmission pipeline, three new 5,000 m^3 regional reservoirs, 65 local reservoirs ranging in size from 50 m^3 to 10,000 m^3, and two new pump station. A general layout of the 2020 facility master plan is presented in Figure 2.9.

Table 2.4
SUMMARY OF THE FACILITY MASTER PLAN PROPOSED ACTION

Item	2000[a]	2010	2020
Water Sources	Eastern Aquifer 12 wells at Al'Izariyya 15 Mcm/yr	Eastern Aquifer 4 wells at Bani Na'im 10 Mcm/yr 4 wells at As-Sammu 2 Mcm/yr Western Aquifer 5 wells at Ar-Ramadin 10 Mcm/yr 2 wells at Ithna 4 Mcm/yr 1 well at Surif 2 Mcm/yr	Western Aquifer 3 wells at Kharas 6 Mcm/yr 3 wells at Beit Ula 6 Mcm/yr 2 wells at Al-Majd 4 Mcm/yr 2 wells at Dayr Samit 4 Mcm/yr 1 wells at Ithna 2 Mcm/yr 1 well at Surif 2 Mcm/yr Reuse of Treated Wastewater, 9 Mcm/yr
Transmission Pipelines (km)	78.6	194.5	106.3
Regional Reservoirs	1, 10,000 m^3 1, 5,000 m^3	6, 5,000 m^3	3, 5,000 m^3
Local Reservoirs	None	96 5, 100 m^3 17, 200 m^3 11, 300 m^3 22, 500 m^3 13, 1,000 m^3 12, 2,000 m^3 11, 5,000 m^3 5, 10,000 m^3	65 2, 50 m^3 9, 100 m^3 6, 200 m^3 8, 300 m^3 11, 500 m^3 16, 1,000 m^3 5, 2,000 m^3 5, 5,000 m^3 3, 10,000 m^3
Pump Stations	2	4	2

[a]In addition to existing, planned, and immediate stage facilities.

Source: Deliverable 25.02

2.2.4 Alternative 2

Alternative 2 provides the same amount of water as the proposed action, but differs in the source of additional water to meet demand after 2010. Instead relying upon groundwater and reusing treated wastewater, this alternative will supply the necessary water via a desalinization plant in Gaza. A general layout of alternative 2 is presented in Figure 2.10.

Year 2000

Same as Proposed Action.

Year 2010

The desalinization plant and conveyance system will be built in 2010. The desalinized water will be conveyed to a 50,000 m^3 storage reservoir at Tarqumya through a 2,500 millimeter-diameter, 80 kilometer transmission main. The conveyance system will have five pump stations and a 10,000 m^3 storage reservoir.

The water will be transmitted from Tarqumya to the communities in the Hebron-Bethlehem area via 158.5 kilometers of transmission pipeline. The system will include a main pump station at Tarqumya and six other pump stations, each with associated 5,000 m^3 balancing reservoirs. A 25,000 m^3 regional reservoir will be built at Battir junction, as well as 142 local reservoirs.

Year 2020

The facility master plan calls for an additional 38 kilometers of transmission pipeline to be constructed by the year 2020. Booster pumps will be added to the pump stations at Tarqumya, Khirbat Zif, and Deir Samit, and on the Tarqumya-Hebron and Tarqumya-Battir transmission pipelines. The facility master plan also calls for construction of a 10,000 m^3 regional storage reservoir at Dura for the year 2020.

2.2.5 Alternative 3

Like Alternative 2, this alternative provides the same amount of water as the proposed action, but the source of water is different. Water for this alternative will come from a potential project of a multi-national nature, which involves conveying sea water to the Dead Sea from either the Mediterranean Sea or the Red Sea and generating hydroelectric power. Part or all of this energy will be used to operate a desalinization plant, and to pump the desalinated water to the West Bank area, as well as to Jordan and to Israel. The individual facility components of this alternative have not been enumerated.

2.3 MITIGATION MEASURES

Mitigation measures are actions taken to address adverse impacts associated with project alternatives in order to resolve them wherever possible. This is performed by identifying those important issues associated with each alternative that, if modified in some fashion, make the project more acceptable. For this project, the identification of issues requiring mitigation has been developed using the concerns expressed during the environmental scoping sessions and the experience of the project team in other assignments.

2.3.1 Mitigation Measures Common to All Alternatives

The following mitigation measures are common to all alternatives. They should be incorporated into the immediate stage and facility master plan operational requirements, action plan, and technical specifications.

(a) Development of an Archaeological Resource Protection Program

The literature and walkover surveys conducted for the project area revealed the presence of some archaeological sites. Construction of water supply facilities has the potential of disturbing or

destroying these resources. Archaeological resources are priceless in some cases, therefore, special mitigation measures are necessary to identify and protect them. The objective of these measures is to minimize adverse impacts on both known and presently unknown resources. The mitigation measures proceed in a step-wise fashion, each step involving greater detail over smaller areas to insure that resources are identified, assessed, and protected in an appropriate fashion. The work begins with literature searches followed by field surface surveys of proposed project sites by trained professionals to determine the likely presence of important resources. The specific mitigation measures are as follows:

During the planning and design phases

Research the literature and contact archaeologists working in or familiar with the area to ensure that known archaeological sites are incorporated into the planning process.

Conduct reconnaissance surface surveys for all facility sites and pipe alignments that are not in roadways previously disturbed by construction. These walkover surveys are conducted for the purpose of determining if an area is likely to contain significant resources. If any such resources are noted, then decisions will need to be made whether to adjust the alignment and locations, or to conduct intrusive investigations.

Where warranted, qualified archaeologists should conduct intrusive investigations consisting of field excavations, and appropriate specimen collection, recording, and preservation.

Where intrusive investigations indicate the need to preserve the site in some manner, authorities should be consulted to determine if the facility should be relocated, or the site fully documented prior to construction.

During the construction phase

Immediate notification of appropriate authorities of the discovery of previously undocumented artifacts.

Retain services of a qualified archaeologist to assess unforseen circumstances.

The application of these measures will vary in intensity with different types of facilities. For example, since the location of water transmission and distribution mains can be adjusted to account for obstacles, the detailed examination of the routes of these alignments for archaeologically important resources will be conducted at the time of final design, when adjustments can be made to avoid important resources, without significantly altering the overall water system design. On the other hand, since major facilities, such as well sites, pump stations, treatment plants, and reservoirs, cannot be moved without corrupting the overall plan, it is important to conduct a more comprehensive assessment in the planning stage.

(b) Adoption of Design Standards to Minimize the Intrusive Character of Proposed Facilities

Water supply system facilities can be economically and efficiently designed using buildings and landscaping that are of an industrial character. However, the villages still have the special characteristics of the traditional Palestinian villages. These characteristics must be protected

from introducing exotic designs. Therefore, design standards shall be adopted to complement the local setting, rather than detract from it.

(c) Adoption of Design Standards to Minimize Noise in Residential Areas

During construction, noise in residential areas will be unavoidable, but it can be minimized through scheduling. Construction of facilities in residential areas should not be undertaken from sun down to sun rise.

Some of the facilities associated with water systems (e.g., pumps and generators) can cause irritating noise for nearby residents. These facilities should be located as far from residential areas as possible. Where facility noise may adversely impact nearby residents, noise attenuation systems should be required, as appropriate to the setting of the specific facility.

(d) Development of a Construction Control Program to Avoid Undue Disruption of Access and Services

The installation of the water distribution systems will entail major construction in close proximity to homes and businesses, raising the potential that abutters to the system could be unduly inconvenienced for a prolonged length of time. There will undoubtedly be some short term inconvenience and traffic disruption. To avoid undue inconvenience, the construction program should include the following:

Contract provisions that detail the sequence for construction of pipelines, such that local inconvenience is avoided to the maximum extent feasible.

Contract provisions that specify the method of construction in certain highly congested areas which will minimize disruption of access, such as trench-to-truck construction and provision of road plates to provide access over trenches.

Contract provisions that require the contractor to secure approval of construction staging and lay down areas.

(e) Development of a Construction Control Program to Avoid Undue Destruction of Cesspits

The installation of the water supply system facilities, especially pipelines, will entail destruction of cesspits constructed within private land and in the rights-of way of the roads. To avoid negative consequences, the construction program should include the following:

Residents should be notified to empty their cesspits prior to construction in the vicinity of these cesspits.

The contract should have provisions for reconstruction of destroyed cesspits after project completion and provision of alternative disposal methods during construction, such as connecting to nearby cesspits, provision of mobile wastewater storage tanks, or provision of portable latrines.

(f) Adoption of Design Standards to Minimize Soil Erosion and Destruction of Vegetation

Construction of water supply facilities and pipelines will disturb surface soil and vegetation and create the potential for soil erosion. To avoid excessive soil erosion, facility designs should provide for adequate runoff and drainage control during and following construction. Design standards should be adopted which:

Require the contractor to replace domestic and agricultural vegetation destroyed during construction.

Require the contractor to restore trench surfaces to a condition at least equal to that existing before work began.

Require adequate drainage and runoff control from roads.

(g) Avoid Groundwater Overdraft

Water resources should be managed so that withdrawals do not result in overdraft of available groundwater sources. The plan proposed as part of this project relies on the current available information on the safe yield of the Eastern and Western aquifers and on data available on the current extraction rates. However, developing a groundwater models for these aquifers is essential to fully understand their behavior. Mitigation of overdraft is proposed via development of a groundwater monitoring program, development of groundwater models, and development and implementation of a regional water exchange program. The monitoring and modeling measures are detailed in the monitoring section of this EA, Chapter 5. The groundwater monitoring program and models are intended to provide information for the system operators so that they can make adjustments in supply plans as appropriate. The regional water exchange program is described in section 4.2.2 of this EA.

(h) Adoption of Design Standards to Prevent Releases of Chlorine Gas and Minimize Potential Impacts

Chlorine gas is a poisonous gas. It will be used to chlorinate water at the wellheads before it enters the transmission mains. To prevent potentially serious threats to human health, design standards should be adopted which require that:

Chlorine gas systems operate under vacuum to prevent gas leakage.

Chlorinators be constructed entirely of materials resistant to the corrosive attack of chlorine gas.

Chlorine gas leak detectors with automatic alarm systems be installed inside the chlorination facilities.

(I) Adoption of Design Standards to Prevent or Contain Fuel Releases at Well Sites and Pump Stations

Many of the well sites and pump stations proposed for this project will require power from diesel generators. On-site storage tanks for diesel fuel should be fully contained.

(j) Shallow Groundwater Impact Assessment [4]

The potential for project activities in the Hebron-Bethlehem area to increase the contamination of shallow groundwater is a major but complex issue. There is general consensus that significant increases in the volume of water available for use will result in increased wastewater streams. There is also some consensus that in the long-term, in the Hebron-Bethlehem area, the answer to shallow groundwater contamination is the construction and operation of functioning wastewater treatment plants. There is no consensus, however, about the nature, distribution, magnitude and consequences of the impact -- if any -- that this particular project activity may have in the Hebron-Bethlehem area.

For this reason, the groundwater quality studies funded as part of the Water Resources Program will assess the relative contribution of the project -- if any -- to groundwater contamination. If it is determined that project activities are likely to have a significant adverse impact on the quality of shallow groundwater, appropriate alternatives for mitigating that impact will be assessed.

2.3.2 Mitigation Measures Implementation Responsibilities

The mitigation measures in this EA have been designed to prevent significant impacts. For them to be effective, they must be implemented. For the immediate stage activities, CDM/Morganti will be responsible for implementation. For the facility master plan activities, PWA will be responsible for implementation, although it may share the responsibility with donor agencies and their contractors.

[4]The language in this mitigation measure was called for by USAID in a memorandum from Thomas H. Stall, COTR, Water Resources Program, USAID/West Bank to Robert Thomas, CDM/Morganti, 20 March 1997.

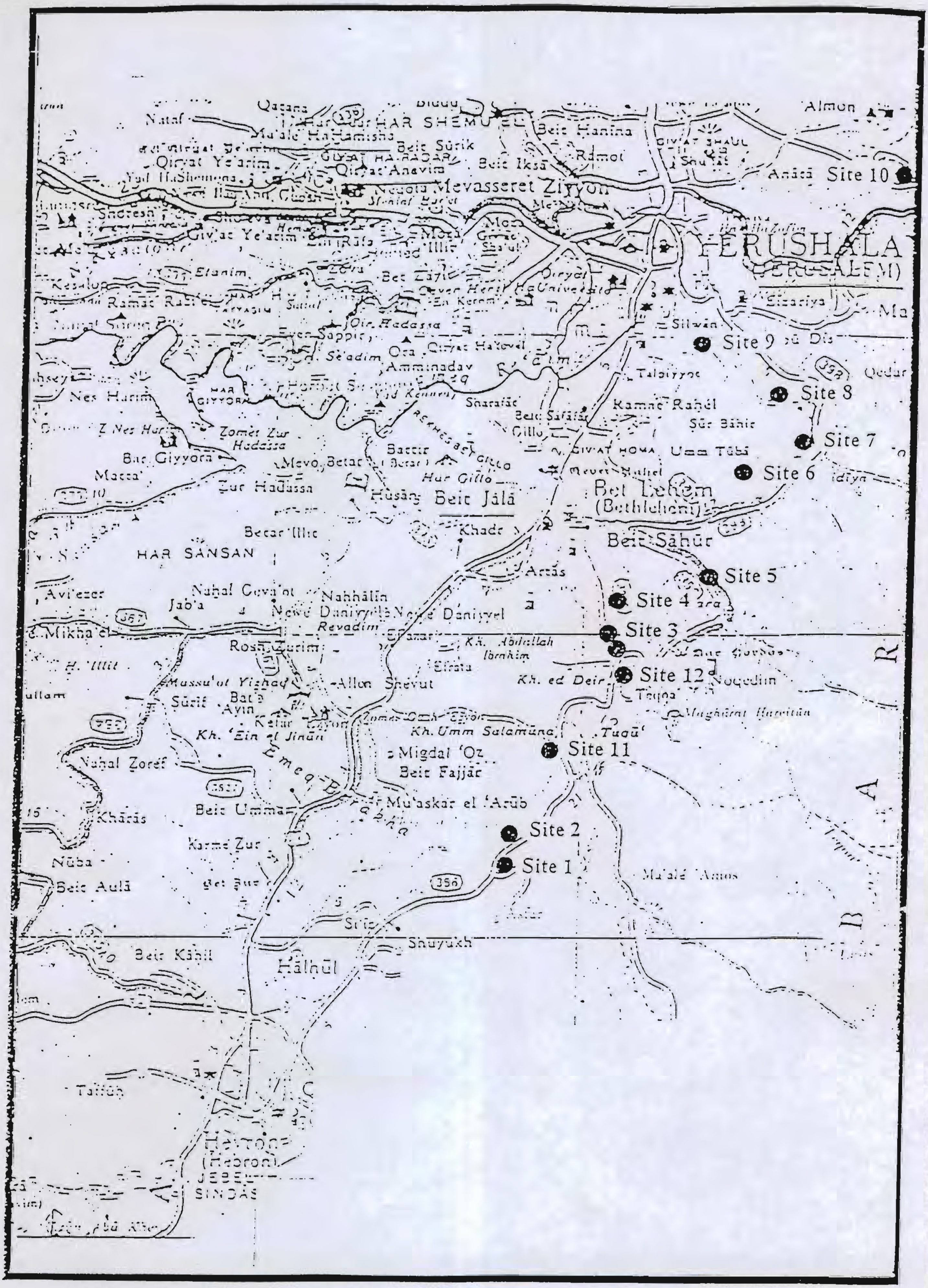

Figure 2-1
Locations of Potential Well Sites
for the Immediate Stage

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Definitions Panel

Run Number	Definitions of Options		Definitions of Options		Definitions of Options	
1a. Well Clusters	A	Site No. 1	F	Site No. 6	K	Site No. 12
Type of Option	B	Site No. 2	G	Site No. 7	L	Site No. 13
Prelim. Well Location - Herodian	C	Site No. 3	H	Site No. 8	M	
Range of Scores	D	Site No. 4	I	Site No. 9	N	
1 - 3	E	Site No. 5	J	Site No. 11	O	

Analysis Panel

Options and Scoring

	WTG FCTR	A[1] Raw	A[1] Wtd	B[2] Raw	B[2] Wtd	C[3] Raw	C[3] Wtd	D[4] Raw	D[4] Wtd	E[5] Raw	E[5] Wtd	F[6] Raw	F[6] Wtd	G[7] Raw	G[7] Wtd	H[8] Raw	H[8] Wtd	I[9] Raw	I[9] Wtd	J[11] Raw	J[11] Wtd	K[12] Raw	K[12] Wtd	L[13] Raw	L[13] Wtd	M Raw	M Wtd	N Raw	N Wtd	O Raw	O Wtd
LIKELIHOOD OF SUCCESS (+)	49.82	-	10.3	-	9.0	-	11.9	-	9.7	-	7.6	-	6.7	-	6.7	-	6.7	-	6.7	-	11.9	-	14.1	-	8.7	-	0.0	-	0.0	-	0.0
Water bearing aquifer	11.37	2	2.3	2	2.3	2	2.3	2	2.3	2	2.3	1	1.1	1	1.1	1	1.1	1	1.1	2	2.3	3	3.4	2	2.3		0.0		0.0		0.0
Favorable surface geology	11.55	2	2.3	1	1.2	2	2.3	2	2.3	1	1.2	1	1.2	1	1.2	1	1.2	1	1.2	2	2.3	3	3.5	2	2.3		0.0		0.0		0.0
Successful wells in area	6.49	3	1.9	3	1.9	3	1.9	1	0.6	2	1.3	1	0.6	1	0.6	1	0.6	1	0.6	3	1.9	3	1.9	2	1.3		0.0		0.0		0.0
Proper space between prod'n wells	8.45	3	2.5	2	1.7	3	2.5	3	2.5	1	0.8	3	2.5	3	2.5	3	2.5	3	2.5	3	2.5	3	2.5	1	0.8		0.0		0.0		0.0
Pump setting depth	7.62	1	0.6	2	1.5	2	1.5	2	1.5	1	0.8	1	0.8	1	0.8	1	0.8	1	0.8	2	1.5	3	2.3	2	1.5		0.0		0.0		0.0
Well permit already issued	4.35	1	0.4	1	0.4	3	1.3	1	0.4	3	1.3	1	0.4	1	0.4	1	0.4	1	0.4	3	1.3	1	0.4	1	0.4		0.0		0.0		0.0
ENVIRONMENTAL IMPACT (-)	-25.00	-	-3.5	-	-4.1	-	-2.9	-	-4.9	-	-5.3	-	-4.5	-	-4.5	-	-2.9	-	-2.9	-	-3.1	-	-2.5	-	-2.9	-	0.0	-	0.0	-	0.0
Possible contamination (sewage)	-9.76	1	-1.0	1	-1.0	1	-1.0	3	-2.9	3	-2.9	3	-2.9	3	-2.9	1	-1.0	1	-1.0	1	-1.0	1	-1.0	1	-1.0		0.0		0.0		0.0
Near residential area (land use)	-4.35	2	-0.9	2	-0.9	2	-0.9	2	-0.9	3	-1.3	1	-0.4	1	-0.4	2	-0.9	2	-0.9	1	-0.4	1	-0.4	2	-0.9		0.0		0.0		0.0
Near fertilized area (ag. contam.)	-5.95	2	-1.2	3	-1.8	1	-0.6	1	-0.6	1	-0.6	1	-0.6	1	-0.6	1	-0.6	1	-0.6	2	-1.2	1	-0.6	1	-0.6		0.0		0.0		0.0
Potential brackish water upconing	-4.94	1	-0.5	1	-0.5	1	-0.5	1	-0.5	1	-0.5	1	-0.5	1	-0.5	1	-0.5	1	-0.5	1	-0.5	1	-0.5	1	-0.5		0.0		0.0		0.0
COST IMPACT (-)	-25.18	-	-4.4	-	-4.4	-	-5.7	-	-5.0	-	-5.6	-	-6.2	-	-6.2	-	-6.3	-	-6.3	-	-4.4	-	-3.2	-	-3.8	-	0.0	-	0.0	-	0.0
Distance from highway	-6.37	1	-0.6	1	-0.6	3	-1.9	3	-1.9	2	-1.3	2	-1.3	2	-1.3	1	-0.6	1	-0.6	1	-0.6	1	-0.6	2	-1.3		0.0		0.0		0.0
Depth to drill	-6.07	2	-1.2	2	-1.2	2	-1.2	2	-1.2	3	-1.8	3	-1.8	3	-1.8	3	-1.8	3	-1.8	2	-1.2	1	-0.6	1	-0.6		0.0		0.0		0.0
Distance from demand area	-6.73	2	-1.3	2	-1.3	2	-1.3	1	-0.7	1	-0.7	2	-1.3	2	-1.3	3	-2.0	3	-2.0	2	-1.3	2	-1.3	2	-1.3		0.0		0.0		0.0
High pumping head	-6.01	2	-1.2	2	-1.2	2	-1.2	2	-1.2	3	-1.8	3	-1.8	3	-1.8	3	-1.8	3	-1.8	2	-1.2	1	-0.6	1	-0.6		0.0		0.0		0.0
TOTAL WEIGHTED NET SCORE		-	2	-	1	-	3	-	0	-	-3	-	-4	-	-4	-	-3	-	-3	-	4	-	8	-	2	-	0	-	0	-	0
TOTAL SCORE, % OF HIGHEST		-	28	-	6	-	39	-	-2	-	-39	-	-48	-	-48	-	-30	-	-30	-	52	-	100	-	23	-	NA	-	NA	-	NA
RANK		-	4	-	6	-	3	-	7	-	10	-	11	-	11	-	8	-	8	-	2	-	1	-	5	-	NA	-	NA	-	NA

NOTES

Likelihood of success refers to relative potential to yield approximately the target water production after development of the well. It does not imply any guarantee of success.

After preliminary location, any additional survey and other data will be used for confirmation of the top priority locations and to specifically site each well within its general location

Figure 2-2
Option Analysis Chart for Preliminary Well Location

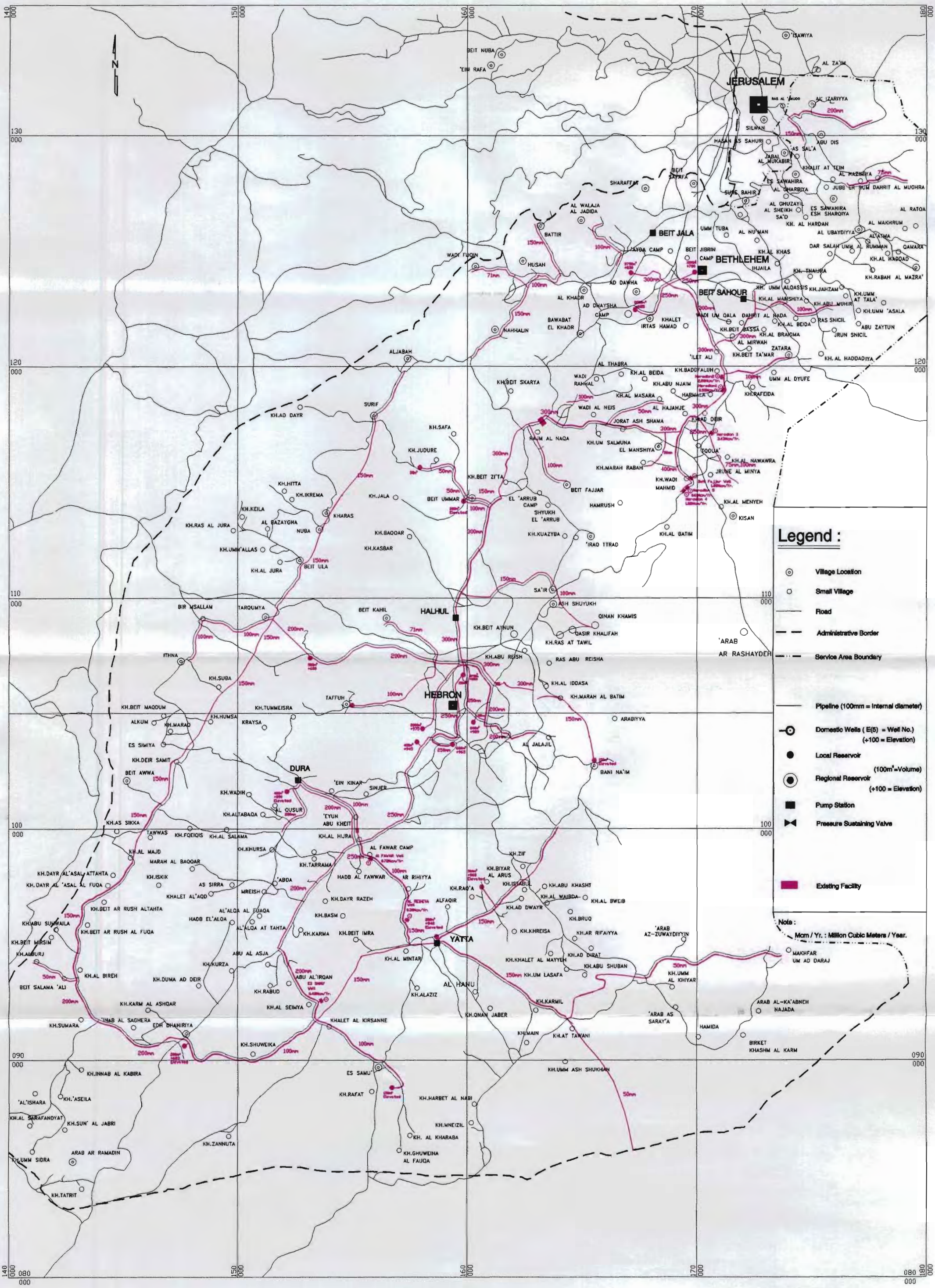

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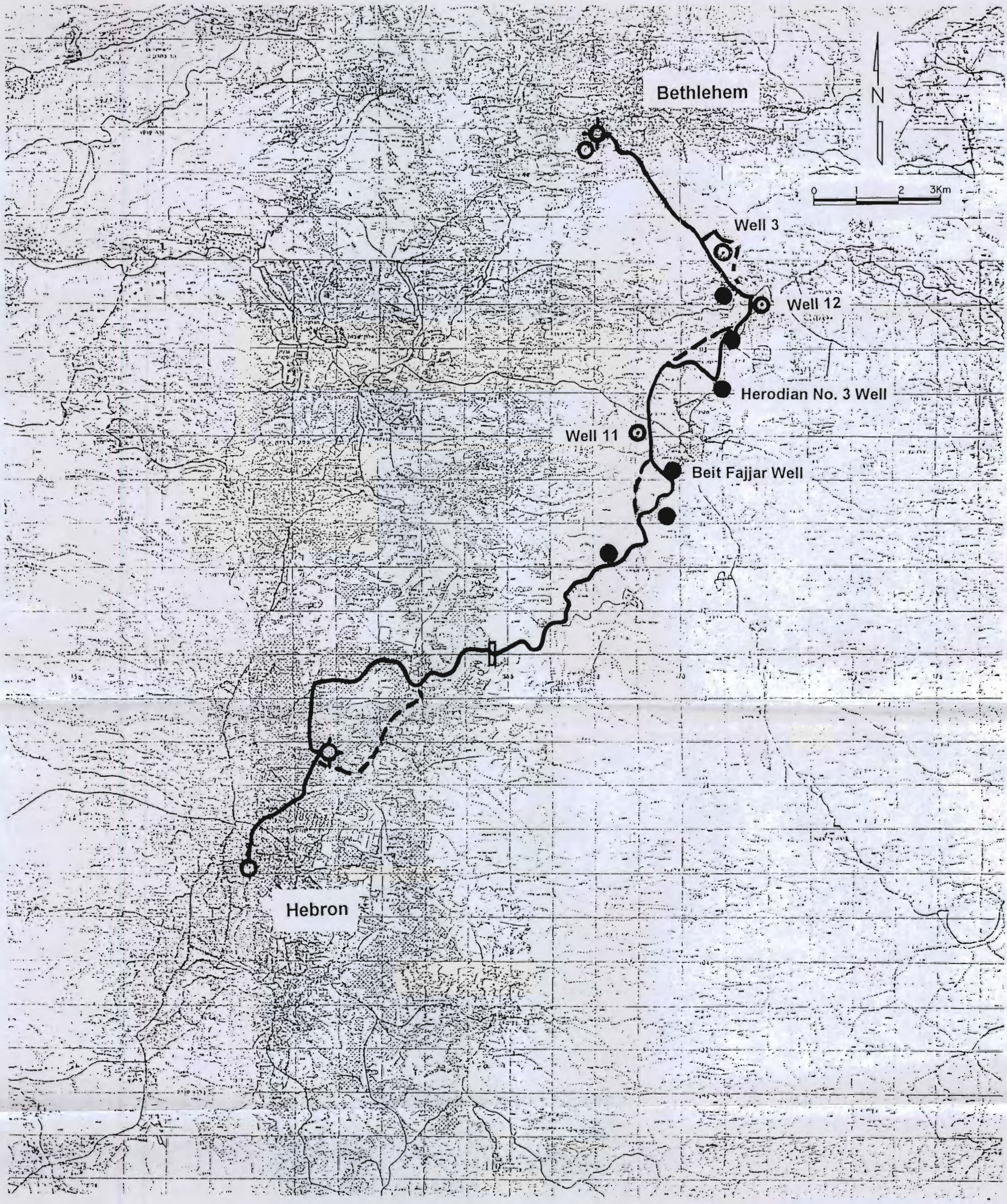
Figure 2-3
Existing Water Supply System



Proposed Wells
Existing Wells
Proposed Reservoir
Existing Reservoir
Proposed Route
Alternate Route
Proposed Booster

Figure 2-4
General Layout of the Immediate Stage Proposed Action

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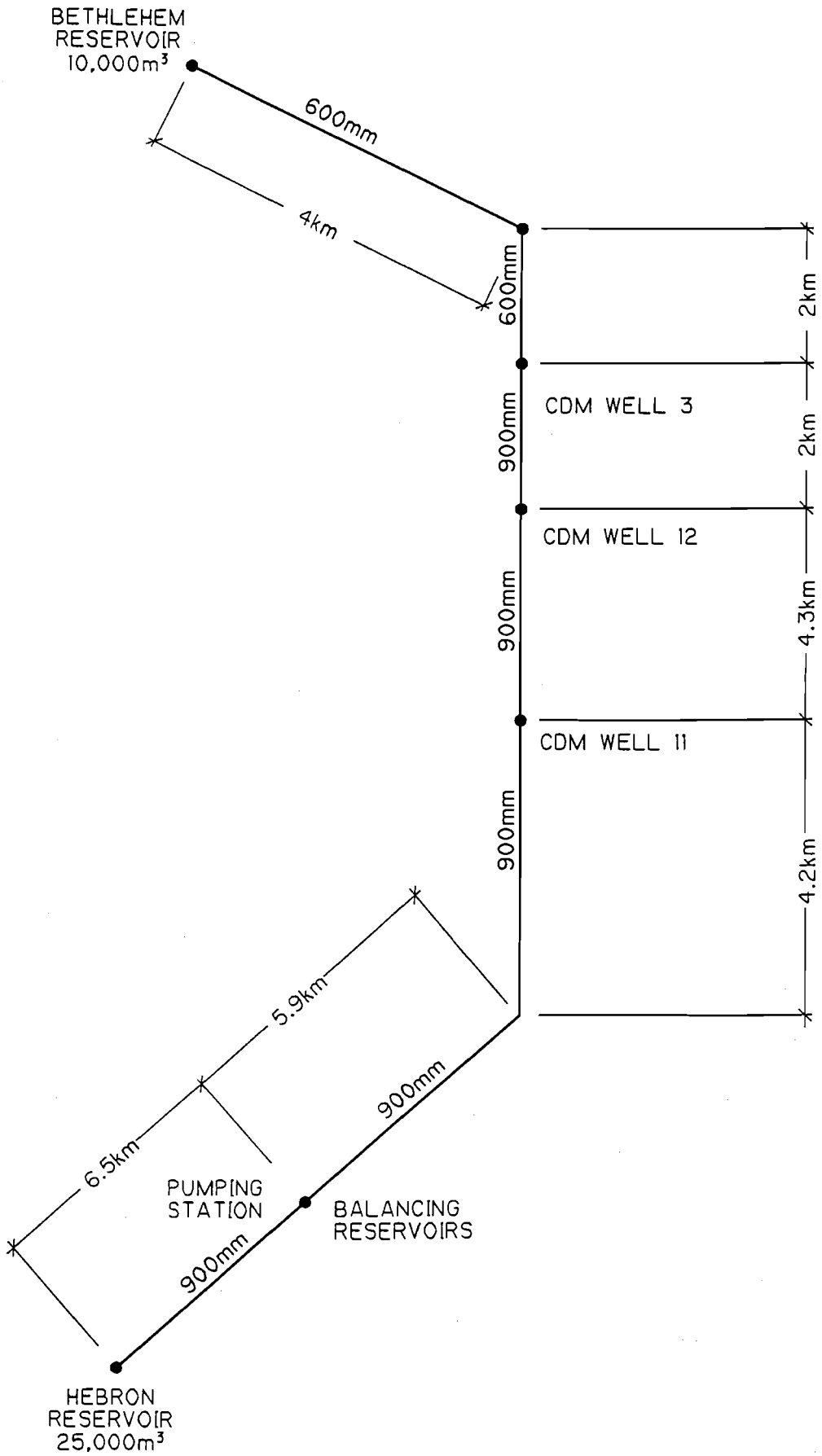

Figure 2-5
Schematic Layout of Immediate Stage Proposed Action

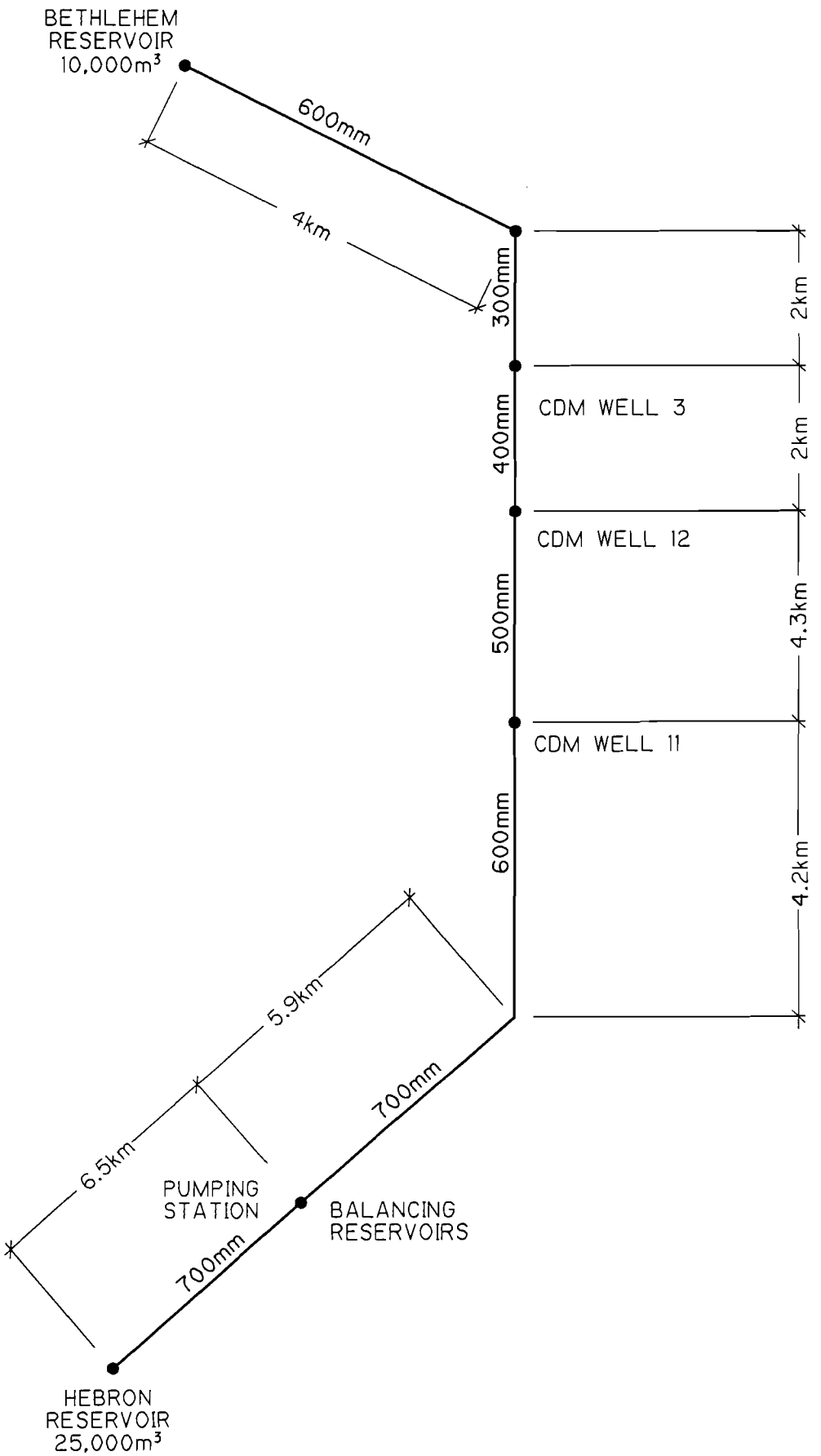

Figure 2-6
Schematic Layout of Immediate Stage
Minimum Pipe Diameter Alternative

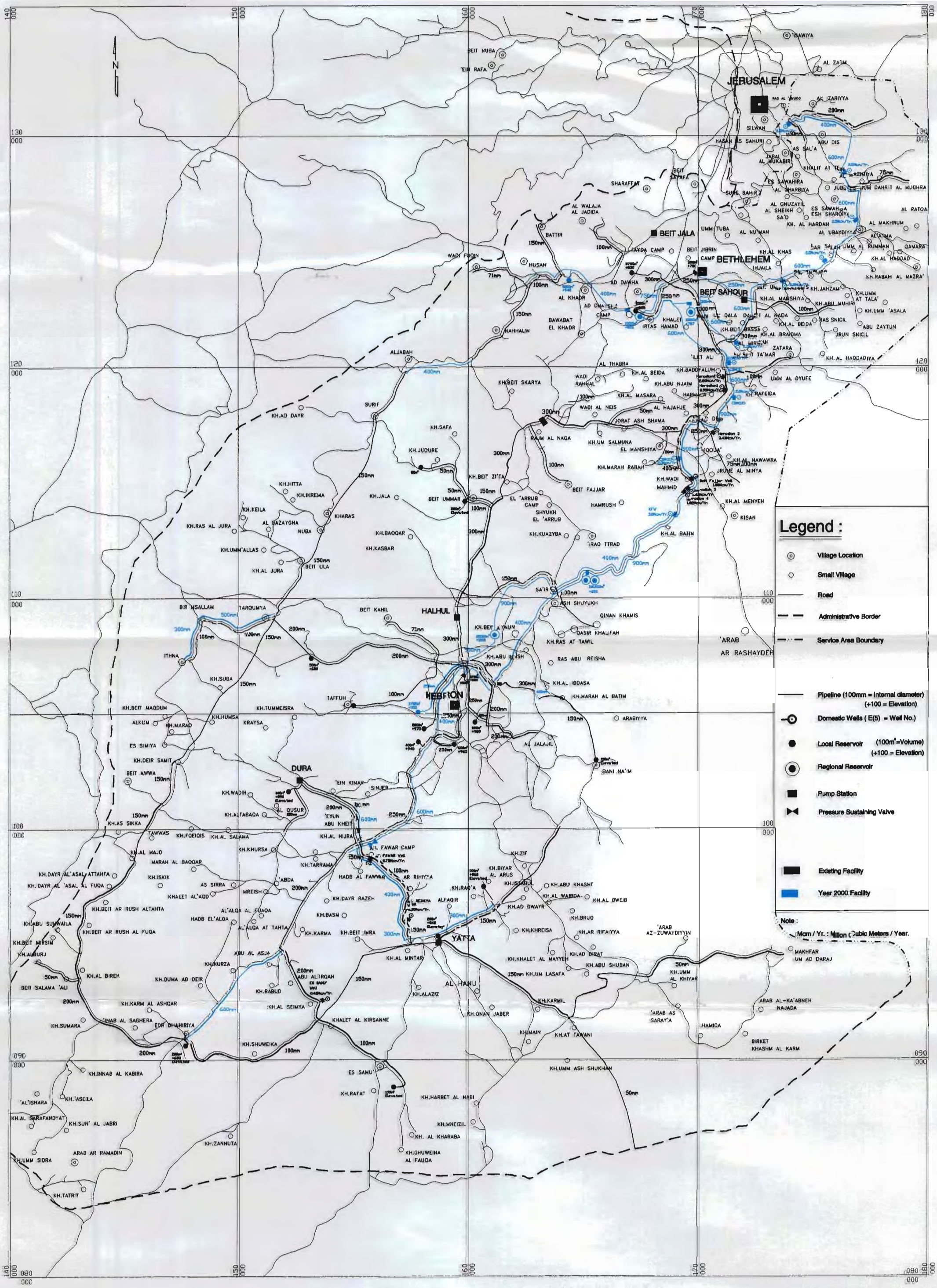

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Figure 2-7
Facilitie Master Plan Proposed
Option for the Year 2000

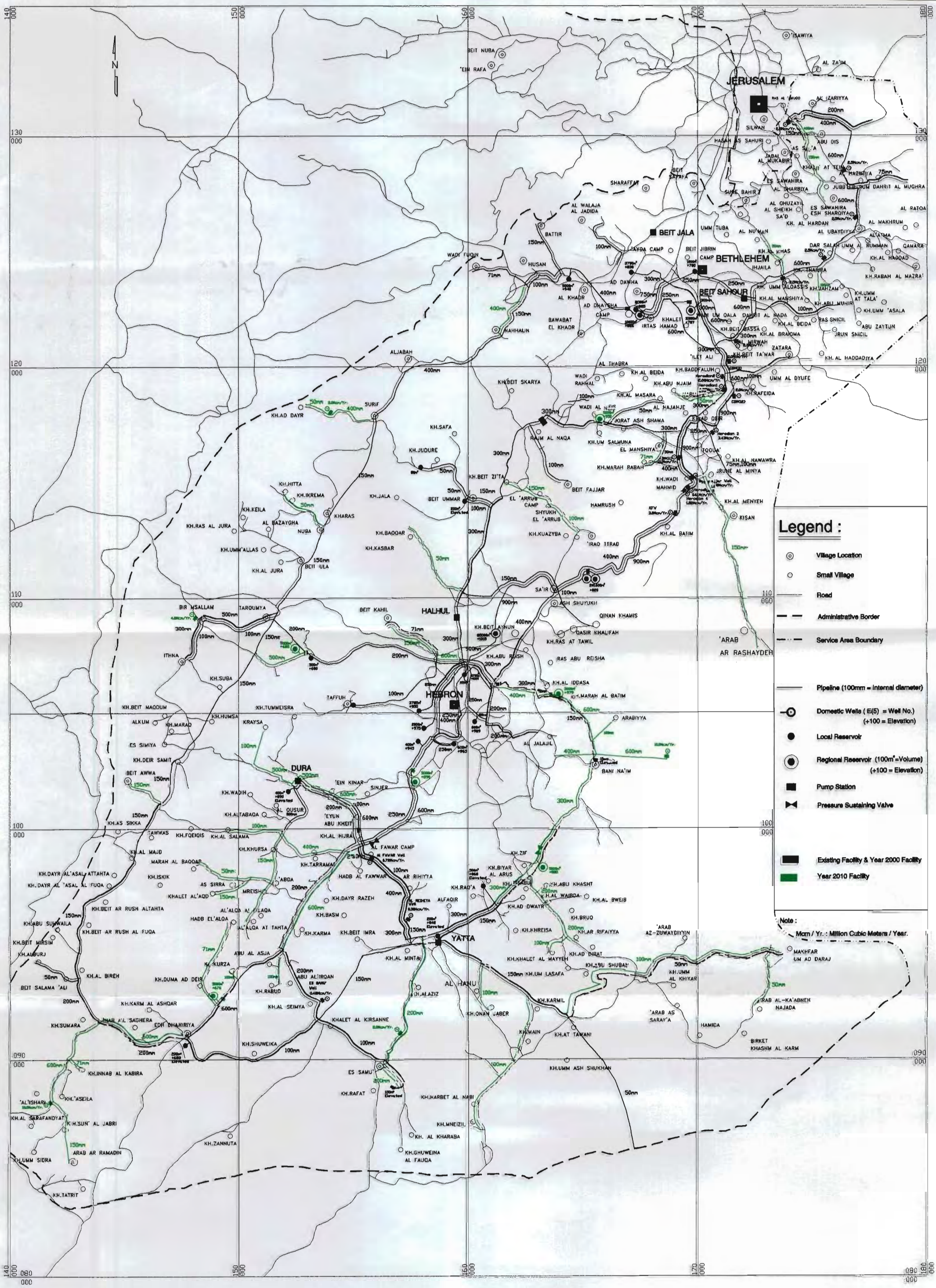
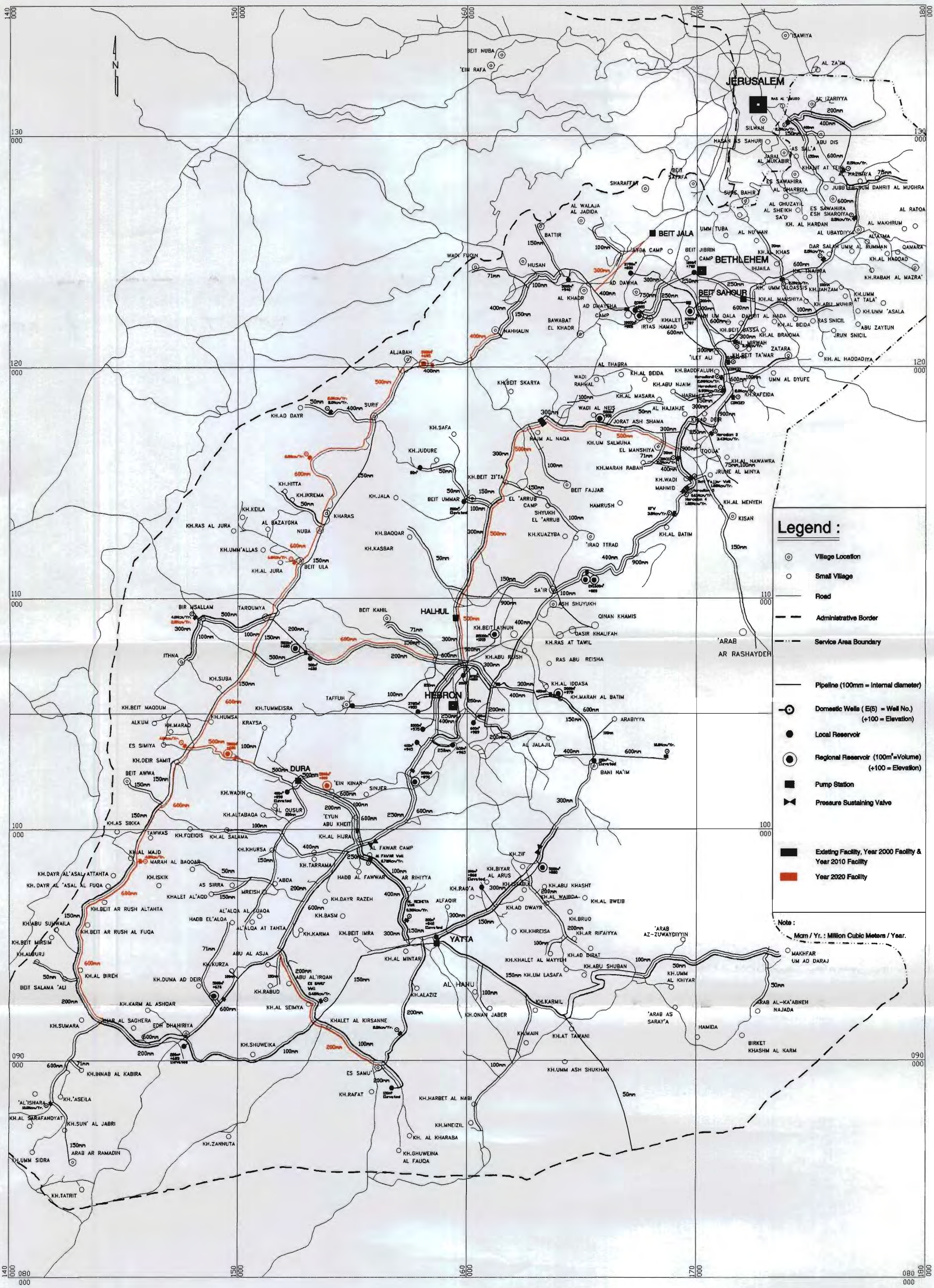


Figure 2-8
Facilitie Master Plan Proposed
Option for the Year 2010

CDM/Morganti



CDM/Morganti

Figure 2-9
Facilitie Master Plan Proposed
Option for the Year 2020

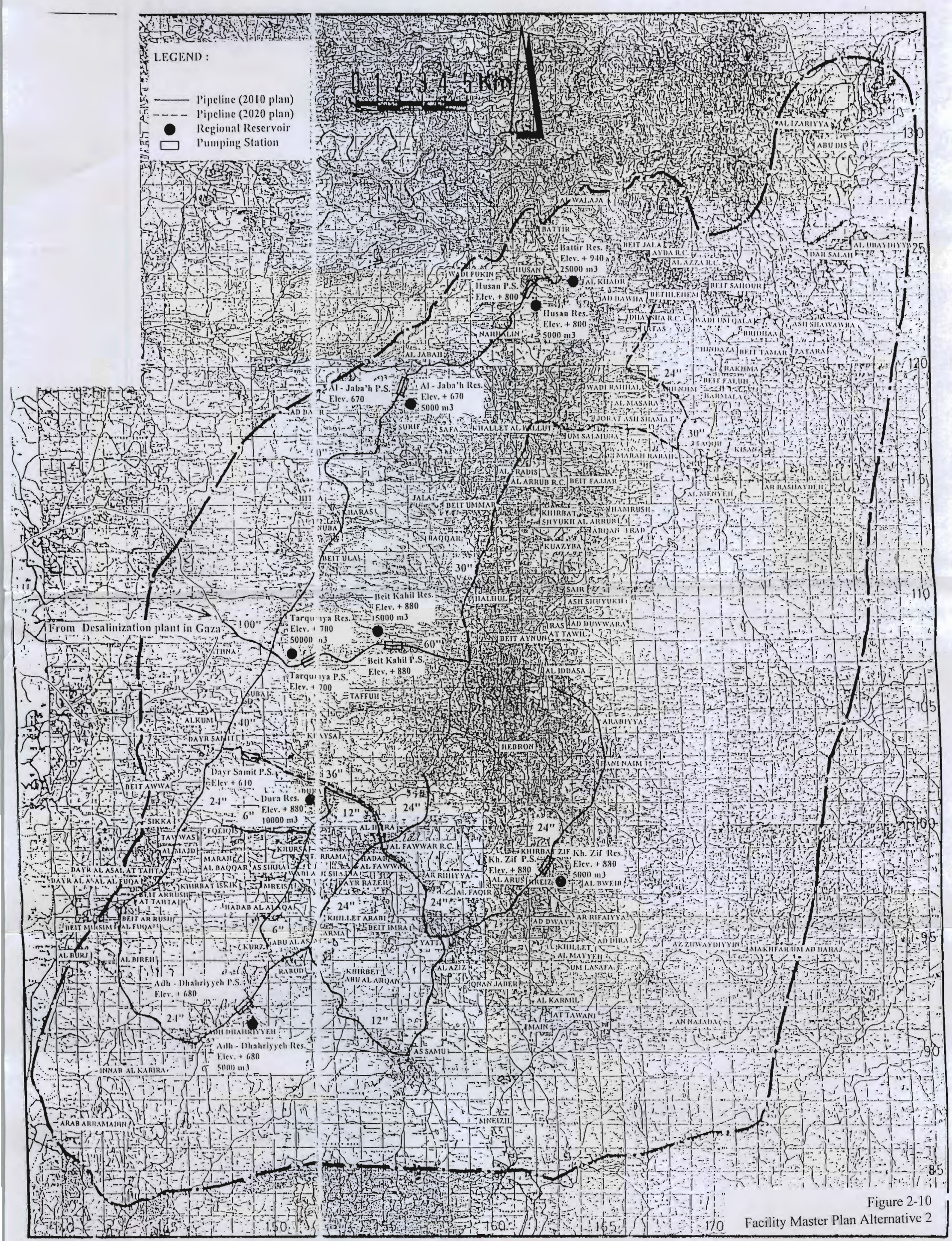


Figure 2-10
Facility Master Plan Alternative 2

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3. EXISTING ENVIRONMENT

This chapter describes the existing environment in the larger Hebron-Bethlehem area with specific information on the environment in the area to be served by the immediate stage facilities where necessary. The description includes the physical and natural environment, the built environment, and the Socio-economic environment.

3.1 PHYSICAL AND NATURAL ENVIRONMENT

3.1.1 Geography

The Bethlehem District is located eight kilometers south of Jerusalem city, in the southern part of the West Bank. It is bounded by the Hebron District to the south and southwest, the Dead Sea to the east and Israel to the west. The Hebron District is located 36 km south of Jerusalem City, in the southern part of the West Bank. It is bounded by Bethlehem District from the north and by the 1948 cease-fire line from the other directions.

The area of the West Bank is divided into five distinct physiographic zones on the basis of topography and climate. The five zones are the Jordan Valley zone, the Eastern Slopes, the Central Highlands, the Semi-Coastal zone and the Coastal Plains zone. The Hebron-Bethlehem area is located within the Central Highlands zone. This zone extends from Jenin in the north to Hebron in the south. It has an area of about 3,500 square kilometers and altitudes exceeding 1,000 meters above sea level. The western side of the region is mountainous, with a series of parallel anticlines, monoclines, and synclines that trend chiefly north-south and range in altitude between 800 and 1,000 meters above sea level. Eastward from the mountains, the topography slopes steeply to the Jordan Valley and the Dead Sea.

The main soil types in the Hebron and Bethlehem districts and their geological characteristics are presented in Table 3.1.

3.1.2 Climate

The West Bank has a Mediterranean climate characterized by long, hot, dry summers and short, cool, rainy winters, which are modified locally by altitude and latitude. January is the coldest month, with temperatures ranging from 5 °C to 10 °C. August is the hottest month, with temperatures ranging from 18 °C to 38 °C.

Annual rainfall in the Central Highlands zone ranges from 700 millimeters in the mountains to 400 millimeters in the foothills. About 70 percent of the average rainfall in the West Bank falls between November and March. The months of June through August are generally rainless. Rainfall is unevenly distributed, generally decreasing to the south and east and varies from season to season and from year to year. Precipitation is often concentrated in violent storms, causing flooding and erosion. During January and February, it may take the form of snow at the higher elevations of the central highlands, especially around Bethlehem. The mean number of rainy days per year is around 55 in the mountain range. The mean annual evaporation rate in the district reaches 1,400-2,600 mm.

Bethlehem District features a climate that ranges from Arid to semi-arid, with an increase in aridity towards the southern and southeastern direction across the Eastern Slopes in the Jerusalem desert. This climatic variation is due to the drastic drop in the elevation from the western to the eastern part of the district. While the western parts receive an average of 700 mm of rainfall annually, the eastern parts receive less than 100 mm. From late April to mid-June, the Hebron District is often hit by storms known as the Khamaseen. The Khamaseen originates from the Arabian desert and brings very hot dry winds full of sand and dust to the district. The mean range of annual relative humidity is 60-75 percent. The quantity of mean annual rainfall in Hebron District varies from year to year, while the rainfall reaches 1,027 mm in the wet years, it drops to 200 mm during the dry years. Mean daily evaporation varies from 2 mm in December to 8.5 mm in August[5].

[5]Applied Research Institute- Jerusalem 1995a

Table 3.1
SOIL TYPES AND THEIR CHARACTERISTICS IN THE HEBRON AND BETHLEHEM DISTRICTS

Soil Classification	Area (km^2)	Soil Type	Coverage
BETHLEHEM			
Bar Rocks and Desert Lithosols	153	Hard limestone, dolomite and chalks mother rocks	Eastern Parts
Brown Lithosols and Loessial Arid Brown Soils	156	Marl, chalk, limestone and conglomerates parent materials	Central
Brown & Pale Renzinas	96	Parent material is soft chalk, marl, hard chalk	Bethlehem, Beit Jala, Beit Sahour area and surrounding villages
Terra Rossa, and Brown and Pale Rendzinas Soil	7	Parent materials are dolomite, hard limestone; soft chalk, marl	Western part of Bethlehem
Brown Lithosol and Loessial Serozems	8	Parent materials are limestone, dolomite, chalk, flint	Eastern
HEBRON			
Bare rocks and desert Lithosols	23	Bare rocks, rarely small depth of soil	Eastern Border
Brown Lithosols & Loessial arid brown soils	122	Marl, chalk, limestone and conglomerates parent rocks.	Eastern Slopes
Terra Rossa, brown and pale Rendzinas	559	Parent material is soft chalk and marl.	Hilly Slopes, Valleys and Depressions
Terra Rossa, brown Rendzinas and pale Rendzinas	233	Terra rosa type, the parent materials are dolomite and hard limestone	Central Mountains
Brown Lithosols & Loessial Serozems	98	Parent rocks are limestone, dolomite, chalk and flint.	Moderate to Steep Hill
Dark Brown soils	18	The parent rocks are aeolian sediments, calcareous sandstone and medium to fine textured alluvial deposits.	Slopes

3.1.3 Water Resources Quality, Quantity, and Systems

Rainwater which falls over the Central Highlands zone flows to the east and west following the natural slopes of the mountain range. As the western slopes are gentler than the eastern slopes and enjoy more rainfall, the western groundwater aquifers have a higher recharge rate. Rainfall on the steep eastern slopes feeds the springs along the eastern escarpment and the deep seated aquifers along the Jordan Valley.

Most of the usable surface water is available through springs and seeps located at the foot of the mountain range in the western region. Only about one third of these springs and seeps have permanent discharge, while the rest flow only in the winter season and dry up in the summer.

There are three major spring systems in the Bethlehem area: Battir, Irtas, and Ein Fashkha. Each system is comprised of one or more springs which are used for both domestic and irrigation purposes. However, some of these springs are saline and require desalination before use. The annual discharge of fresh water from the springs is estimated at 483,000 m^3. The saline spring discharge is estimated to range from 45 to 80 Mcm/yr[6]. There are approximately 57 springs in the Hebron District which are freely used by the surrounding population without restrictions for small scale domestic and irrigation purposes.

The Bethlehem-Hebron area is underlain by the Western and Eastern Basins. Each basins contains two major fresh water aquifers: the Upper and Lower Cenomanian. The geologic formations in which the aquifers are located are complex, with significant folding, faulting, and fracturing. The major control elements in the aquifers are the fractures and faults associated with the north-south trending axes of the Ramallah and Hebron anticlines and the major gravity fault (graben) along the western side of the Jordan Valley and the Dead Sea.

Recharge of the Western and Eastern aquifers has not been fully studied. Estimates of recharge range from 70 to 175 Mcm/yr for the Eastern Aquifer[7] and 350 to 360 Mcm/yr for the Western Aquifer[8]. Schedule 7 of Article 40 of the Interim Oslo Peace Accords identifies the Western Aquifer as being fully assigned (no water remains for development). It identifies 78 Mcm/yr per year as "remaining to be developed from the Eastern Aquifer." The Interim Report of the Comprehensive Master Plan for Water Resources in the West Bank and Gaza Strip,[9] identified slightly different Palestinian groundwater withdrawal amounts than did Article 40 (Table 3.2), indicating that the Palestinians are using 2.5 Mcm/yr more than their assignment in the Western Aquifer and that only 71 Mcm/yr is available for development in the Eastern Aquifer. Much of the "available water" may be brackish or saline, associated with saline spring discharges in the Jordan Valley.

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[6]Applied Research Institute- Jerusalem 1995b

[7]Deliverable 18.01

[8]Deliverable 4.02

[9]Deliverable 4.02

Table 3.2
GROUNDWATER WITHDRAWALS FROM WELLS AND SPRINGS IN THE WESTERN AND NORTHEASTERN AQUIFERS

Western Aquifer		Eastern Aquifer	
Location and Type of Withdrawal	**Amount (Mcm)**	**Location and Type of Withdrawal**	**Amount (Mcm)**
Schedule 7 of Article 40			
Palestinian	22	Palestinian	54
Israel	340	Israel	40
TOTAL	362	To be developed	78
		TOTAL	172
Comprehensive Master Plan for Water Resources[a]			
Hebron, Agriculture	0.19	Hebron, Municipal and Industrial	1.30
Bethlehem, Agriculture	0.48	Hebron, Agriculture	0.13
Jenin, Municipal and Industrial	0.11	Bethlehem, Municipal and Industrial	11.10
Tulkarm, Municipal and Industrial	6.40	Bethlehem, Agriculture	0.38
Tulkarm, Agriculture	16.00	Nablus, Municipal and Industrial	3.00
Ramallah, Municipal and Industrial	0.85	Nablus, Agriculture	4.50
Ramallah, Agriculture	0.51	Ramallah, Municipal and Industrial	2.60
TOTAL	25.54	Ramallah, Agriculture	0.94
		Jericho,	1.10
		Jericho,	35.44
		Jerusalem,	0.61
		TOTAL	60.99

[a]Deliverable 4.02, Table 2.8

Ten domestic wells serve 80 of the 151 communities in the area, including all of the communities which will be served by the immediate stage activities (Table 3.3). In 1995 these wells pumped 13 Mcm and delivered 10.2 Mcm to the community distribution systems. Figure 2.3 illustrates the existing water resources in the project area. Losses in the local distribution systems are estimated to be from 30 to 60 percent of the total water supply[10].

Not all of the households in the communities served by the water system are connected to distribution systems. The Water Supply and Sewerage Authority (WSSA), which manages the

[10]Deliverable 25.02.

system in the Bethlehem area, serves about 90 percent of the population in its service area[11]. The Hebron system serves 95 percent of the city's population. Most of the communities which do not have piped water systems have populations below 1,000. These communities, as well as households within served communities which are not hooked up to distribution systems, must rely upon cisterns, water hauled from municipal systems, and local springs. Water in cisterns usually becomes available in December and is depleted by August.

Table 3.3
SOURCES OF WATER SUPPLY IN HEBRON-BETHLEHEM AREA

Well	Coordinates	Depth (m)	Aquifer	Static Water Level (mmsl)	Safe Yield (m^3/hr)	Pumpage 1995 (Mcm)	Usage	Owner
Herodian 1	170.90/118.30	350	Upper Cenomanian	n/a	120	0.9	Domestic	WBWD
Herodian 2	170.92/119.33	770	Lower Cenomanian	257.7	336	2.8	Domestic	WBWD
Herodian 3	170.85/117.22	800	Lower Cenomanian	305.35	400	3.4	Domestic	WBWD
Herodian 4	169.46/114.08	691	Lower Cenomanian	326.4	249	1.8	Domestic	WBWD
Herodian 5	169.46/114.12	350	Upper Cenomanian	n/a	78	0.6	Domestic	WBWD
Beit Fajjar	169.60/115.10	305	Upper Cenomanian	159.18	230	1.9	Domestic	WSSA
Ar-Rihiyya	157.20/096.26	495	Turonian	317	34	0.3	Domestic	WBWD
Sammu' 1	153.46/092.26	191	Turonian	158.5	50	0.4	Domestic	WBWD
Fawwar 1	156.20/098.15	100	Turonian	n/a	69	0.5	Domestic	Hebron Munic.
Fawwar 3	156.15/098.15	150	Turonian	n/a	48	0.2	Domestic	Hebron Munic.
Source: Deliverable 25.02								

The Bethlehem area water system is managed by WSSA. The system serves the communities of Bethlehem, Beit Jala, Beit Sahour, Ad-Dawha, Al-Walaja, Al-Khadr, Ayda Refugee Camp, Al-'Azza Refugee Camp, and Adhaysha Refugee Camp). Supply for the system comes from Herodian wells No. 1 and No. 2 and is pumped into the Bethlehem, Beit Jala, Al Mataleb and Ad-Adhaysha reservoirs. The Bethlehem and Beit Jala reservoirs are old and in need of repair, with water seepage a frequent problem. Water quality is generally good. Water in the system is currently delivered to many connected consumers on an intermittent basis, where consumers receive water for one or two days at 18 to 22 day intervals. An exception to this is Beit Sahour which receives water on a continuous daily basis because it is supplied from a separate well field.

[11]WSSA 1996

Many residents connected to the system must supplement deliveries with purchases from water tankers at a cost of about $5 per cubic meter.

Hebron gets 90 percent of its water supply from Herodian Well No. 3 and the Beit Fajjar well and 10 percent from Al-Fawwar Wells. Eight water storage tanks with a total capacity of 15,875 cubic meters serve Hebron city and the adjacent towns and villages. Water in Hebron is also distributed on an intermittent basis, where water is delivered to consumers every two weeks for one day. Tankered water is the main source of water to cover the shortfall in water supplies.

Table 3.4 presents some estimates of current municipal and industrial water use in the area. The relatively high use rates shown in the table for Hebron and WSSA are somewhat misleading because they include high unaccounted for components. With system losses of from 30 to 60 percent, actual per capita consumption rates could range from 36 to 63 L/c/d in Hebron and 43 to 76 in the WSSA service area. Domestic consumption would be less than this, because the values in Table 3.4 include public, livestock, and commercial/industrial uses. Throughout the area, consumption is constrained by available supply, so that the consumption rates cannot be interpreted as demand.

Table 3.4
ESTIMATES OF WATER USE IN 1995[a]

Location	Population	Use	
		Mcm/yr[b]	L/c/d
Hebron Municipality	94,758	3.1	90[c]
WSSA	~70,000	2.9	108[c]
Yatta	23,824	0.35	40
Others in Hebron Area	175,534	2.2	35
Others in Bethlehem Area	47,338	1.7	67
Total	**434,041**	**10.1**	**64**

[a]Include domestic, public, livestock, and commercial/industrial uses.
[b]Data from WBWD
[c]Very high unaccounted for component

Source: Deliverable 25.02

In developing water demand projections for the planning area, the engineering team assumed that per capita consumption would increase over the planning period to the WHO average rate for house connections in small communities (150 L/c/d)[12]. The WHO rate is for household consumption only, so the team increased the rate to account for public, livestock, and commercial/industrial water use, based on historical trends, allowing for slight increases in future public and commercial/industrial uses. The team allowed for leakage, wastage, meter losses, and other unaccounted-for water. In doing so the team used historic loss rates, but assumed that they would decrease as new systems came on line. The water use projection assumptions used by the

[12]WHO, 1993.

engineering team are summarized in Table 3.5. Projected water demand for the Hebron-Bethlehem area is shown in Tables 3.6 and 3.7.

Table 3.5
DEMAND PROJECTION ASSUMPTIONS

Target Year	Consumption Rates (L/c/d)					Overall Loss (%)[a]	Design Demand Rate (L/c/d)
	Domestic	Public	Livestock	Commercial/ Industrial	Total		
2000	75	7	13	7	102	40	170
2010	126	9	13	13	161	30	230
2020	158	12	13	20	203	25	270

[a]Includes leakage, wastage, meter losses, and other unaccounted-for water.

Table 3.6
POPULATION AND WATER DEMAND[a] (Mcm/yr) FORECASTS

Community	Year						
	1996	2000		2010		2020	
	Population	Population	Demand	Population	Demand	Population	Demand
Immediate Stage	160,682	224,079	13.9	286,850	24.1	367,190	36.2
Currently Served[b]	241,749	337,152	21.0	431,570	36.2	552,445	54.5
Not Currently Served	31,610	44,083	2.7	56,430	4.7	72,235	7.1
Total Area	**434,041**	**605,314**	**37.6**	**774,850**	**65.0**	**991,870**	**97.8**

[a]Demand = Water needed at the source to meet domestic, public, animal, commercial and industrial uses.
[b]The total population in these communities are not necessarily served by current systems.

Source: Deliverable 25.02, Appendix A

Table 3.7
POPULATION AND PROJECTED WATER DEMAND[a] (m^3/day) IN COMMUNITIES WHICH WILL BE SERVED BY THE IMMEDIATE STAGE FACILITIES

System	Community	1996	2000		2010		2020	
		Population	Population	Demand	Population	Demand	Population	Demand
WSSA, Herodian Complex Zone 2	Bethlehem	21,697	30,259	5,144	38,733	8,909	49,582	13,387
	Beit Jala	12,795	17,844	3,033	22,842	5,254	29,239	7,895
	Beit Sahour	12,258	17,095	2,906	21,883	5,033	28,012	7,563
	Ad-Dawha	3,395	4,735	805	6,061	1,394	7,758	2,095
	Al-Walaja	1,169	1,630	277	2,087	480	2,671	721
	Al-Khadr	4,357	6,067	1,031	7,778	1,789	9,957	2,688
	Ayda Refugee Camp	2,344	3,269	556	4,185	963	5,357	1,446
	Al-'Azza Refugee Camp	1,730	2,413	410	3,088	710	3,953	1,067
	Adhaysha Refugee Camp	6,179	8,617	1,465	11,031	2,537	14,120	3,812
	SUBTOTAL	65,924	91,929	15,628	117,688	27,068	150,649	40,675
Hebron Mun. Herodian Complex Zn. 3 Al-Fawwar Wells	Hebron	94,758	132,150	22,466	169,162	38,907	216,541	58,466
TOTAL		**160,682**	**224,079**	**38,093**	**286,850**	**65,975**	**367,190**	**99,141**
Total Mcm/year				**13.9**		**24.1**		**36.2**

[a]Demand = Water needed at the source to meet domestic, public, animal, commercial and industrial uses.

Source: Deliverable 25.02, Appendix A

3.2 THE BUILT ENVIRONMENT

3.2.1 Urban Land Use

The Hebron-Bethlehem area, with a total area of 1,283 km^2, includes within its boundaries 151 Palestinian towns and villages, and 47 Israeli settlements. It also includes 512 km^2 of Israeli-designated closed military areas on the eastern border. There are four declared nature reserves in the area, three in the Bethlehem District and one in the Hebron District. These reserves largely overlap with the closed military areas. Forests occupy 1,580 hectares. The land use areas in the Hebron and Bethlehem administrative districts are presented in Table 3.8.

Table 3.8
LAND USE CLASSIFICATIONS IN THE HEBRON AND BETHLEHEM DISTRICTS

Land Use Classification	Hebron (Hectares)	Bethlehem (Hectares)	TOTAL (Hectares)
Palestinian Built up Areas	3,750	2,000	5,750
Israeli Settlements	583	790	1,373
Closed Military Areas and Bases	20,335	31,040	51,375
Nature Reserves	689	4,800	5,489
Forests	1,200	380	1,580
Cultivated Areas	36,000	4,300	40,300
Other[a]	42,443	14,190	56,633
Total	**105,000**	**57,500**	**162,500**

[a]Grazing land, quarrying, unofficial waste dumping, and unused land.

Sources: Applied Research Institute - Jerusalem 1995a and 1995b

3.2.2 Agriculture

The 4,300 cultivated hectares in the Bethlehem District are situated primarily on Terra Rossa and Brown lithosols and are planted with wheat and barley, rain-fed olive groves, rain-fed vineyards, and irrigated vegetables such as cucumber, squash, eggplant, radish, beans, and barley. Rain-fed agriculture occupies 99 percent of the total cultivated areas in Bethlehem, with vineyards being the principal crop, planted on 58 percent of the total rain-fed area. Field crops, principally wheat and barley, occupy 32 percent of the rain-fed crop land.

In the Hebron District there are 36,000 hectares classified as cultivated areas. Less than one percent of this area is irrigated. Fruit crops occupy half of the cultivated area. Olive trees are the largest single crop, with 5,961 hectares of productive olive trees and 2,300 hectares of unproductive olive trees. Grapes are the second most important crop, occupying 5,182 hectares. Stone fruit orchards cover an area of 1,851 hectares. Other fruit crops include walnuts, pistachios, apples, pears, quince, and pomegranate.

Barley covers 53 percent of the total area of field crops, followed by wheat which covers 24 percent, and lentils covering 9 percent. The rest of the area is cultivated with bitter vetch, chickpea, sorghum, tobacco, and other field crops and forages. Vegetable production is very limited, it comprises four percent of the total cultivated area in the district. Approximately 82 percent of the vegetables are grown under rain-fed conditions (1,222 hectares) and the remaining 18 percent is irrigated (81 hectares).

3.2.3 Wastewater Quantity, Collection, and Treatment

The municipality of Hebron has a combined sewer system; however, it only serves 50 percent of the households. The sewer system is very old and has many problems with blockages and flooding, resulting in pooling of raw sewage in the streets. The sewer system has a rotating contact aerator for treatment, but the system is not operable. A pumping station to lift the sewage to a pond treatment system was installed in 1988, but it became inoperable two months after construction. Untreated sewage is currently discharged into Wadi As-Samn, south of the city.

The sewage system in Bethlehem is managed by the WSSA and serves 60 percent of Bethlehem, Beit Jala, Beit Sahour, and several nearby small villages. The remaining 30 percent use cesspits. The sewer system is currently being upgraded to serve 75 percent of the residents[13]. The wastewater from the sewer system is discharged, untreated, into Wadi Al-Wa'ar in Al-Shawawra and Ras El-Wad areas. Other wastewater streams from the Jerusalem area flow into Wadi El-Nar in the Bethlehem area. The Italian government and GTZ are funding a project under construction which will pump the flow in Wadi Al-Wa'ar into Wadi El-Nar. The water in Wadi El-Nar flows to the Dead Sea area where it is used by the Israelis for irrigation of palm trees. A study conducted by Balasha for the Israeli Ministry of Environment revealed that if a treatment plant was placed in Wadi Al-Wa'ar, the Herodian wells would be subject to contamination.

Most other communities in the Hebron-Bethlehem area are served by cesspits. Cesspits are usually emptied by vacuum tankers owned and operated by either the municipalities, UNRWA, or the private sector. Contents are disposed of at any available location, in many cases, in the streets and wadis. Open drains are most common form of wastewater collection in refugee camps, which are not served by a sewer. Domestic wastewater and storm water is collected in the open drains, it then flows outside the camp boundaries onto unattended land without any treatment.

The estimated 250 stone cutting facilities in the Bethlehem district utilize large quantities of water for cooling cutting saws. Some quarries use as much as 4,000 cubic meters of water annually. Simple primary treatment is performed in some of the stone cutting factories by collecting the generated wastewater in adjacent ponds to allow separation of particles by natural settling. The treated water is then collected from the top of the pond for reuse in the stone cutting process. The wastewater produced from other industries, is estimated at 10,000 cubic meters annually[14].

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[13]WSSA 1996

[14]Applied Research Institute- Jerusalem 1995b

3.2.4 Historical and Archaeological Heritage

The Hebron-Bethlehem area is famous for its archaeological sites and historic places. A cursory literature survey identified 230 archaeological sites in the Hebron-Bethlehem area. A brief description of these sites is included in Appendix A.

Activities in the immediate stage are limited to a small area between the cities of Hebron and Bethlehem. For this area an initial literature survey was conducted. Several archaeological sites were found to be located on both sides of the main road along which the proposed transmission main and well fields will be constructed. Table 3.9 lists and describes all of the sites identified in the immediate stage project area. Figure 3.1 shows the location of the sites in the immediate stage area, while Figure 3.2 shows all archaeological sites in the greater master planning area..

Table 3.9
ARCHAEOLOGICAL SITES IN IMMEDIATE STAGE AREA

ARCHAEOLOGICAL SITE	DESCRIPTION
Khirbat Zeita	Roman Pethzeth, walls, caves, reservoirs, press, and a well
Khirbat Beit Anun	Ancient Beit Anut, called Penthennium during the Roman period, remains of a church, columns, inscriptions, tower, reservoir, mosaic floor.
Khirbat Hindaza	Walls, rock-cut tombs, and presses
Khirbat Abu Riesh	Walls of a church, and inscriptions
Khirbat Tqu	Remains of walls, church, water canal, and inscriptions
Khirbat Ed-Deir	Remains of a church, a monastery, and mosaic floor
Khirbat al-Maniyya	Remains of a wall, wine press, wells, tombs, and canals
Khirbat Tell al-Frad is (Herodian)	The whole area is an archaeological site which contains all sorts of remains
Khirbat al-Natesh	Remains of wall foundations and a wine press
Khirbat Bad Falhiti	Remains of walls and tombs
al-Nabi al-Iss	Mosque and mausoleum
al-Nabi Yunus	Mosque and mausoleum
Halhul	Remains of buildings, mosaic floor and tombs

3.3 SOCIO-ECONOMIC ENVIRONMENT

3.3.1 Population and Economy

The total population in the Hebron-Bethlehem area is about 434,041. Current and projected population in the area is presented in Tables 3.6 and 3.7. There are 51 communities in the Bethlehem District with a total 1996 population of 113,013. Bethlehem, Beit Jala, and Beit Sahour constitute around 41 percent of the population in the district. All of the other

communities in the district have populations below 6,000, and 30 of the communities have populations below 1,000. The smallest village is Khirbat Al Theib with a population of only 53 people.

The 1996 population in the Hebron district is 294,116. Urban and semi-urban communities account for about 50 percent of the population, rural communities for about 46 percent, and refugee communities for four percent. Hebron is the largest community in the Hebron District. Its 94,758 residents comprise 32 percent of the total population of the district. Yatta is the second largest community with a population of 23,824. Five communities have populations near to or greater than 10,000 (Halhul, Ithna, Bani Na'im, Dura, Ad-Dhahriyyeh, and As-Sammu'). Sixty-four of the 97 communities in the district have populations below 1,000.

Three communities in the Jerusalem District are included in the Hebron-Bethlehem service area for this project. They are Al-'Izariyya with a population of 13,671, Abu Dis with a population of 8,916, and As-Sawahra Ash-Sharqiyyah with a population of 4,325. These communities are located east of Jerusalem and northeast of Bethlehem.

Comparison between present and previous population trend indicates that there is no clear urbanization trend as a result of significant movement from the villages to the larger towns. Instead of leaving their villages and moving to the towns, Palestinians generally commuted to work in neighboring towns or in Israel, or immigrated to work abroad, often leaving their families behind.

The main source of income in Bethlehem is tourism. The main source of income in Hebron is trade and marketing. The unemployment rate in the area is estimated at 40.5 percent. Approximately 91 percent of the employed work force have permanent employment, one percent has seasonal employment, and eight percent have part-time jobs. In some of the villages south of Bethlehem city most of the work force is concentrated in the stone industry and quarries. Major industrial activities in the Hebron District include stone and aggregate quarrying, stone and marble cutting, leather tanning, glass manufacturing, and shoemaking. People in rural areas depend primarily on agriculture for their income.

3.3.2 Public Health

Several new clinics have been established in rural areas to meet increasing demand for adequate medical services. Almost all new clinics were either funded by NGO's or charitable societies. Currently there are five main sectors offering public health services: private for profit, charitable organizations, NGO's, UNRWA which primarily serves the refugee camps, and the Palestinian Ministry of Health.

Public health is mainly threatened by the inadequate disposal of wastewater in the wadis nearby the residential areas. Open sewage channels are also public health concerns in the refugee camps in the Hebron-Bethlehem area. Some of the shallow wells in the area have been contaminated by wastewater disposal.

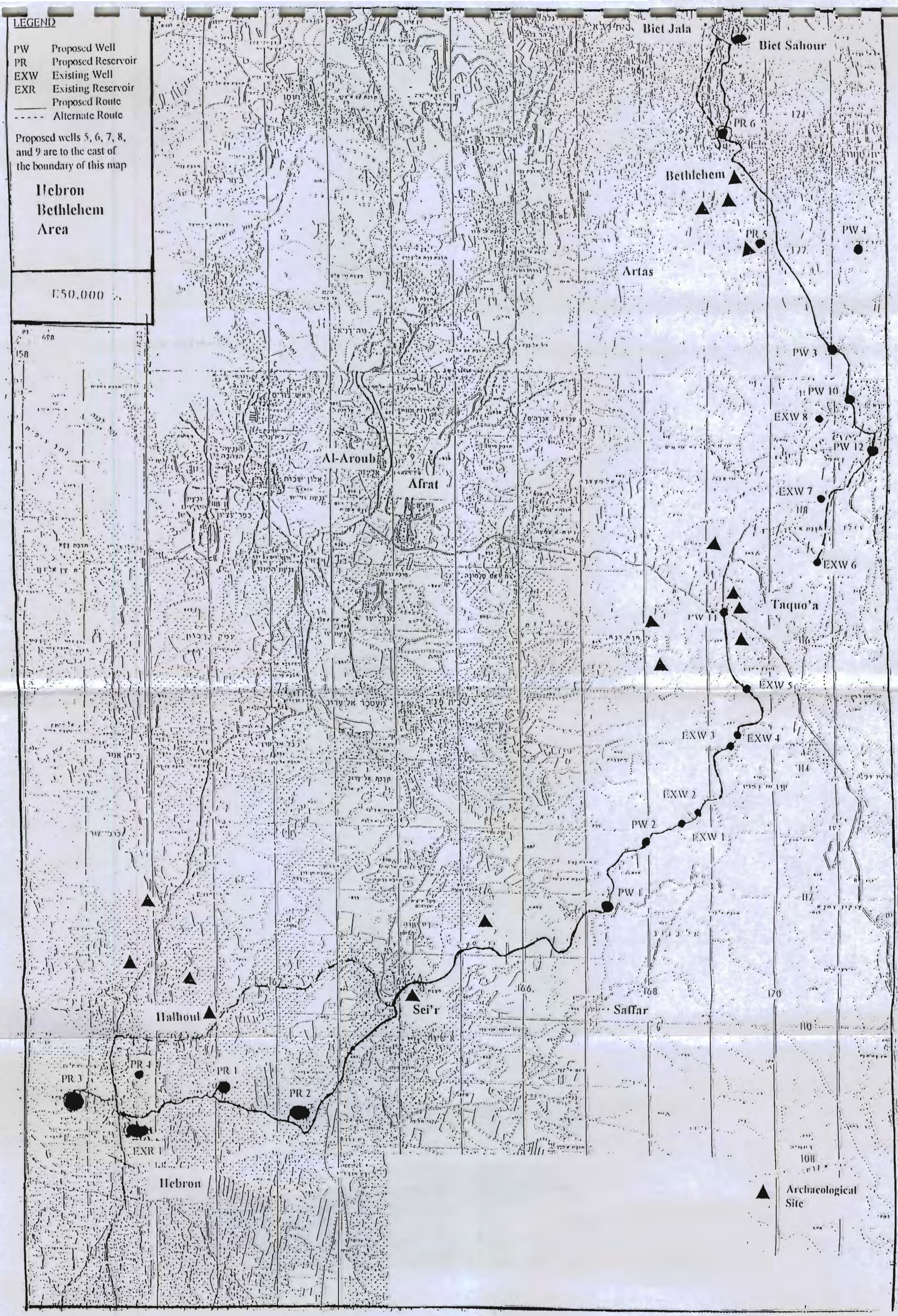

Figure 3-1
Archaeological Sites in the Immediate Stage Area

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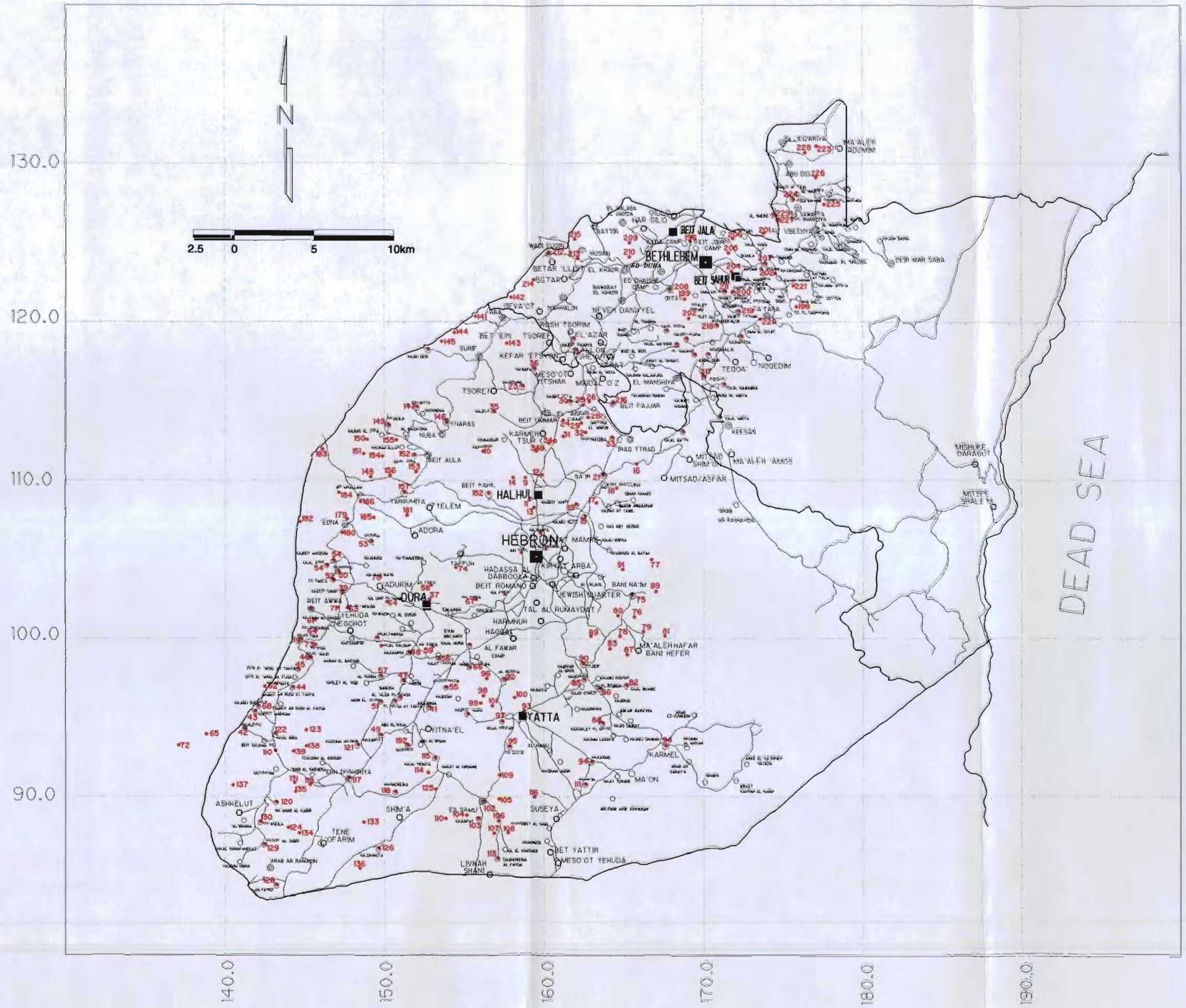

Figure 3.2
Archaeological Sites in The
Hebron-Bethelehem Master Plan
Service Area

4. ENVIRONMENTAL CONSEQUENCES

This section presents the environmental consequences associated with no action, the proposed actions, and alternatives for both the immediate stage and facility master plan. The assessment of consequences is based on the significant issues and their associated criteria.

4.1 IMMEDIATE STAGE

The consequences of the of no action, the proposed action, and the alternatives for the immediate stage are summarized in Table 4.2 at the end of this section.

4.1.1 No Action

Impacts on the Physical and Natural Environment

Because no action involves no new construction, it will not impact the vegetative cover and will not cause soil erosion. No action will not impact the sustainable use of groundwater resources since the withdrawals, even with the addition of the GTZ well, will be well within the amount of water available for development in the Eastern Aquifer.

Impacts on the Built Environment

The greatest impact of no action is on the hygiene of current users of the water system. In 1995 per capita consumption was estimated at 90 L/c/d in Hebron and 108 L/c/d in the WSSA Bethlehem area. Both of these estimates, however, were made using the total amount of water received by the Hebron Municipality and WSSA. If they are adjusted to account for in-system losses prior to reaching households (estimated at as much as 40 percent), and to account for public, livestock, and commercial/industrial uses, they would be 27 L/c/d and 38 L/c/d respectively. Even with the increased production already in the construction and planning phases, the water available for domestic consumption would still only be 43 L/c/d by the year 2000. This consumption level is well below the minimum WHO recommendation rate of 100 L/c/d for piped water connections and the typical WHO rate of 150 L/c/d[15]. The lack of adequate water means that there is insufficient water for sanitation needs, which poses risks to public health.

With no action, the users will continue to have inadequate and intermittent water service. Water will continue to be unavailable to many users during peak use periods due to inadequate pressure control. Intermittent supply will also continue to negatively impact water quality, due to the accelerated corrosion in the distribution pipelines caused by intermittent flows. Thus, impact will be magnified even more as the population in the area grows.

No action will not change the *status quo*, hence it will not increase wastewater flows, nor will it improve the current mis-management of wastewater flows which is most likely causing contamination of the upper aquifer. No action will not cause the destruction of cesspits, increase noise, nor cause destruction of archaeological resources.

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[15]WHO 1993

Impacts on the Socio-Economic Environment

Because no action requires no construction, it will not create traffic disruption due to construction, but it will continue the existing congestion caused by the water tankers carrying water to a huge number of consumers because of the intermittent and inadequate water supply system. No action requires no acquisition of land or changes in land use.

4.1.2 Proposed Action

Impacts on the Physical and Natural Environment

During the construction of wells, pump stations, storage tanks, and transmission mains, the proposed action will disturb 9.8 hectares of land (Table 4.1). This disturbance will remove vegetative cover and could lead to erosion. These potential impacts will be mitigated by implementation of the Design Standards to Minimize Soil Erosion and Destruction of Vegetation, described in section 2.3 of this EA.

Table 4.1
AREA DISTURBED BY THE PROPOSED ACTION

Facility	Number	Unit	Total (ha.)
Well Sites	3	3,600 m^2/site	1.08
Pump Station	1	3,300 m^2/site	0.35
Pipelines	28.9 km	2,000 m^2/km	5.78
Storage Reservoirs	10,000 m^3 25,000 m^3	7,200 m^2 17,500 m^2	2.47
Access Roads to Reservoirs	0.16 km	5,000 m^2/km	0.08
Total			**9.76**

The proposed action will not impact the sustainability of groundwater resources, as it calls for increasing total withdrawals by only 6 Mcm/yr, well below the amount of groundwater available for development in the Eastern Aquifer.

Impacts on the Built Environment

The proposed action will increase the amount for domestic consumption to 91 L/c/d (assuming the public, livestock, and commercial consumption rates and overall losses as reported in Table 3.5). Although this rate of domestic consumption is slightly below the WHO minimum level of 100 L/c/d, it is twice as much as current domestic consumption. This will provide users with more water on a more dependable basis, which should improve public health.

It is estimated that 80 percent of the water delivered to a household in the service area is discharged as wastewater. Increasing water supply will increase generated wastewater by an estimated 2.88 Mcm/yr, a 69 percent increase. Flows to the sewers will increase by 1.55 Mcm/yr, and flows to cesspits will increase by 1.33 Mcm/yr. Because the sewer systems have no

treatment, the increased flows into the sewer will increase the flows of raw sewage in Wadi Al-Wa'ar and Wadi El-Nar in the Bethlehem area and Wadi As-Samn south of Hebron. The increased flows in the wadis will extend current impacts further downstream and increase the amount of seepage from the wadis into the underlying aquifer.

Increased flows into cesspits will either increase seepage from the cesspits into the underlying aquifer, cause increased surface seepage, or cause increased cesspit pumping. Wastewater pumped from cesspits is often disposed of in nearby wadis, creating the potential for direct human contact and groundwater contamination.

The potential for project activities in the Hebron-Bethlehem area to increase the contamination of shallow groundwater is a major but complex issue. There is general consensus that significant increases in the volume of water available for use will result in increased wastewater streams. There is also some consensus that in the long-term, in the Hebron-Bethlehem area, the answer to shallow groundwater contamination is the construction and operation of functioning wastewater treatment plants. There is no consensus, however, about the nature, distribution, magnitude and consequences of the impact -- if any -- that this particular project activity may have in the Hebron-Bethlehem area.[16]

For this reason, the groundwater quality studies funded as part of the Water Resources Program will assess the relative contribution of the project -- if any -- to groundwater contamination. If it is determined that project activities are likely to have a significant adverse impact on the quality of shallow groundwater, appropriate alternatives for mitigating that impact will be assessed.

The construction of the pipelines will generally not cause destruction of cesspits in the road rights-of-way because most of the construction will occur outside of residential areas. The only areas where this may be an issue are routes close to the storage reservoirs. In these areas, the Construction Control Program to Avoid Undue Destruction of Cesspits, described in section 2.3 of this EA, will be implemented to mitigate the impacts.

The proposed action calls for the use of diesel generators at the three well sites and the booster station. The generators will be noisy. The sites, however, are located far from residential areas, so that the noise will not cause a nuisance.

The proposed sites for the wells, storage reservoirs, and pump station have been field examined by a trained archaeologist. No potential archaeological sites were identified during these visits. Field examination of the proposed pipeline route identified three areas of potential impact: Khirbat Hindaza, Khirbat Beit Anun, and Tell Al-Fried is (Herodian). At Khirbat Hindaza, three kilometers southeast of Bethlehem, there are ruins of walls, rock-cut tombs, and presses within five meters of the road. Khirbat Beit Anun, two kilometers southeast of Halhul, is a site with remains from the Iron Age, Hellenistic, Roman, Byzantine, and Medieval periods. At this site there are ruins of a church, columns, inscriptions, a tower, a reservoir, and a mosaic floor near the road. Herodian is a large archaeological site located six kilometers southeast of Bethlehem. The road along which the pipeline will be laid runs through Lower Herodian which is a complex

[16]The language in this and the following paragraph was called for by USAID in a memorandum from Thomas H. Stall, COTR, Water Resources Program, USAID/West Bank to Robert Thomas, CDM/Morganti, 20 March 1997.

including palaces, store rooms, a hippodrome, and a pool from Hellenistic, Roman, and Byzantine periods. Herodian is managed by the Israeli National Parks Authority.

The alignment of the pipeline through all three of these areas is in the road right-of-way, so that the archaeological resources may have already been disturbed. Nonetheless, to avoid unnecessary destruction of archaeological sites in these areas, a qualified archaeologist should field examine the specific alignment of the pipelines through these areas. If the results of these examinations indicate a high probability of uncovering archaeological resources, the archaeologist should be on site during construction to monitor excavations, and if necessary, to halt construction in the area pending recovery of artifacts. The authorities responsible for management of Herodian should be consulted with regarding pipeline alignment and construction through Lower Herodian.

To mitigate the impacts on archaeological resources which were not detected during the planning and design phases of this project, the "during construction phase" component of the Archaeological Resource Protection Program, described in section 2.3 of this EA, will be implemented.

Impacts on the Socio-Economic Environment

Construction of the proposed action will cause some traffic disruptions and temporarily limit access to some properties. These impacts cannot be totally avoided, but implementation of the Construction Control Program to Avoid Undue Disruption of Access and Services, described in section 2.3 of this EA, will mitigate the impacts.

The 69 percent increase in wastewater flows into cesspits will increase costs of cesspit pumping. Detailed information on cesspit performance in the Hebron-Bethlehem area is not available. If cesspits are functioning correctly, as infiltration pits, then increased wastewater flow will not increase pumping (pumping in these cases is used only to remove accumulated solids, which would not increase with increased flows). At the other extreme, the cost of pumping will increase by 69 percent for those cesspits which are merely wastewater holding tanks (because their porous surfaces are clogged or because they are built into solid rock). Assuming that half of the tanks are holding tanks and that the other half function correctly; and that the current pumping costs for a holding tank is 50 NIS/month[17]; a 69 percent increase in the cost of pumping would cost each household with a holding tank 414 NIS/yr, for a total of 3.3 million NIS per year in the project area. This is only a rough estimate, but it does indicate a potential significant increase cost to some households if water availability is increased. In regards to economic impact of increased pumping in the region, it is a wash. The costs of increased pumping to households is a direct and equal benefit to tank pumpers.

The pipeline routes are within road rights-of-way, and as such will not require any changes in land use or the need for acquisition. Most of the land is currently unused on which the wells, reservoirs, and pump station sites are located. The one exception is the Hebron Reservoir which is proposed on the site of an existing vineyard. The reservoir, however, will occupy only 0.7 hectare, hardly a major shift in land use in the area. Many of the proposed facility sites are also currently in private ownership, but at this time acquisition does not appear to be a problem or an undue burden to the project. Purchase prices of land will be negotiated with the owners to ensure fare compensation.

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[17]Discussions with residents in the West Bank indicated that 50 NIS per pumping was a common cost.

4.1.3 Minimum Pipe Diameter

This alternative uses the same basic components of water supply, storage and distribution of the proposed action. Although the diameters of the transmission pipes and sizes of pumps will be smaller, the environmental consequences of this alternative are nearly identical to those of the proposed action, with one exception. The exception is in the area of improved hygiene. In the year 2000, this alternative will deliver the same amount of water as the proposed action, providing 116 L/c/d. But as the population increases in the service area, this alternative will not be able to maintain or increase water availability, because of the smaller sizes of the pipe. The improvements in hygiene provided by this alternative, will not be sustainable without future construction of parallel pipelines.

4.1.4 Separate Systems for Hebron and Bethlehem

This alternative also uses the same basic components of water supply, storage, and distribution as the proposed action, except it has 2.1 kilometers less transmission pipeline, thus disturbing 0.3 less hectares than the proposed action. The reduction in pipeline length has the potential to reduce impacts on vegetative cover and soil erosion, and destruction of unknown archaeological sites. However, since under this alternative as well as the proposed action these potential impacts will be mitigated by implementation of the Design Standards to Minimize Soil Erosion and Destruction of Vegetation and the "during construction phase" component of the Archaeological Resource Protection Program, both described in section 2.3 of this EA, the potential decrease in impacts associated with this alternative will be insignificant.

4.1.5 Summary

The project is designed to address the most significant impact of taking no action: continuation of inadequate water supply to the residents in the Hebron-Bethlehem area. All of the action alternatives address this issue, by providing adequate water. The most significant impacts of any of the action alternatives are increased flow of wastewater and associated increased costs of cesspit pumping. Increasing water availability will increase wastewater flows. All of the other potential impacts of the project can and will be mitigated during implementation. The potential environmental and economic consequences of increasing wastewater flows, however, cannot be mitigated within the framework of this project. Mitigating these impacts will require investments in wastewater management, either in sewers and treatment facilities or in improved cesspit/septic tank designs. Such investments are beyond the scope of the current project.

Table 4.2 presents a summary of the environmental consequences of no action, the proposed action, and the alternatives for the immediate stage.

Table 4.2
SUMMARY OF THE ENVIRONMENTAL CONSEQUENCES FOR THE IMMEDIATE STAGE

Category	Issue	No Action	Proposed Action	Minimum Pipe Diameter	Separate Systems
Impacts on the Physical and Natural Environment	*Vegetative Cover and Soil Erosion*	No impact	Total Disturbed Area: 9.8 hectares. Well sites, pipelines, pump stations, and storage reservoirs. Potential impacts will be mitigated.	Same as Proposed Action	Total Disturbed Area: 9.4 hectares. Well sites, pipelines, pump stations, and storage reservoirs. Potential impacts will be mitigated.
	Sustainable Use of Groundwater Resources	No impact Increase withdrawal by 3 Mcm/yr Potential 43 Mcm/yr available	No impact Increase withdrawal by 6 Mcm/yr Potential 39.6 Mcm/yr available	Same as Proposed Action	Same as Proposed Action
Impacts on the Built Environment	*Improved Hygiene*	Consumption: 43 L/c/d Health Minimum: 100/L/c/d	Consumption: 91 L/c/d Health Minimum: 100/L/c/d Transmission system will be able to support growth in future consumption as the facility master plan is implemented.	Same as Proposed Action, except that over time the transmission system would not be able to maintain or support growth in the level of consumption.	Same as Proposed Action
	Increased Wastewater Flows	Baseline Flow Sewers: 2.25 Mcm/yr Cesspits: 1.92 Mcm/yr	Increased Flow Sewers: 1.55 Mcm/yr Cesspits: 1.33 Mcm/yr Increased volume of effluent discharges from sewers. Increased potential for groundwater contamination and seepage from cesspits.	Same as Proposed Action	Same as Proposed Action

Table 4.2 (Continued)

Category	Issue	No Action	Proposed Action	Minimum Pipe Diameter	Separate Systems
Impacts on the Built Environment (continued)	*Destruction of Cesspits During Construction*	No Impact	No Impact, no construction through communities.	Same as Proposed Action	Same as Proposed Action
	Noise	No Impact	Potential Impact from Generators at Wellheads and Pump Station. Impact mitigated by location far from communities.	Same as Proposed Action	Same as Proposed Action
	Destruction of Archaeological Resources	No Impact	Pipeline route crosses 3 sites: Khirbat Hindaza, Khirbat Beit Anun, & Tell Al-Fried is (Herodian). Coordination necessary with authorities at Herodian. Further archaeological reconnaissance necessary at the other two sites.	Same as Proposed Action	Same as Proposed Action
Impacts on the Socio-Economic Environment	*Traffic Disruption*	Continued current disruptions caused by water tankers.	Traffic and access will be disrupted during construction. Potential impacts will be mitigated. Reduced disruptions due to water tankers	Same as Proposed Action	Same as Proposed Action
	Increased Cost of Cesspit Pumping	No Impact	69% increase in flows to cesspits. High estimate: 3.3 million NIS/yr. Economic transfer within project area.	Same as Proposed Action	Same as Proposed Action

Table 4.2 (Continued)

Category	Issue	No Action	Proposed Action	Minimum Pipe Diameter	Separate Systems
Impacts on the Socio-Economic Environment (continued)	*Land Use/Acquisition*	No Impact	Pipelines, no impact, in road rights-of-way. Well and pump station sites may be private, currently unused land. Hebron Reservoir site is private vineyard. Bethlehem Reservoir site is unused land of unknown ownership.	Same as Proposed Action	Same as Proposed Action

4.2 FACILITY MASTER PLAN

Assessing the environmental impacts of the facility master plan is not as straight forward as assessing the impacts of the immediate stage facilities. With the exception of the recommendations for facility construction in the year 2000 beyond those proposed in the immediate stage, most of the proposed facilities will not be constructed for many years. The exact locations of these facilities are not known, making site specific determinations of impact impossible. Therefore, most of the following assessment is necessarily general, particularly in assessing the impacts of the proposed facilities for the year 2020.

The facilities proposed for implementation in the immediate stage are incorporated into the facility master plan, but because their impacts were assessed in the previous section, they are considered in this section as being part of the no action alternative. The following assessments of the action alternatives for the year 2000 are for the additional facilities proposed by the facility master plan.

4.2.1 No Action

Impacts on the Physical and Natural Environment

Because no action involves no new construction, it will not impact the vegetative cover and will not cause soil erosion. No action will not impact the sustainable use of groundwater resources since the withdrawals, even with the addition of the GTZ well, will be well below the amount of water available for development in the Eastern Aquifer.

Impacts on the Built Environment

As with the immediate stage, the greatest impact of no action is on the hygiene of current users of the water system. Even with the addition of the new wells currently under development and the immediate stage facilities, average domestic consumption in the area will be 34 L/c/d. The rate will be much higher in the municipality of Hebron and the area served by WSSA, but much lower in the remainder of the service area. This consumption level is well below the WHO recommendation of 100 L/c/d for piped water connections. The lack of adequate water means that there is insufficient water for sanitation needs, which poses risks to public health.

No action will not change the *status quo*, hence it will not increase wastewater flows, nor will it improve the current mis-management of wastewater flows which is most likely causing contamination of the upper aquifer. No action will not cause the destruction of cesspits, increase noise, nor cause destruction of archaeological resources.

Impacts on the Socio-Economic Environment

Because no action requires no construction, it will not create traffic disruption due to construction, but it will continue the existing congestion caused by the water tankers carrying water to a huge number of consumers who are not served by existing water systems, or who have intermittent and inadequate water supply systems. No action requires no acquisition of land or changes in land use.

4.2.2 Proposed Action

Impacts on the Physical and Natural Environment

During the construction of wells, pump stations, storage tanks, and transmission mains, the proposed action will disturb 21.3 hectares of land in the year 2000, 63.3 hectares in 2010, and about 35.3 hectares in 2020. These disturbances will remove vegetative cover and could lead to erosion. These potential impacts will be mitigated by implementation of the Design Standards to Minimize Soil Erosion and Destruction of Vegetation, described in section 2.3 of this EA.

The facility master plan calls for withdrawal from the Eastern Aquifer up to the sustained yield, and then a shift to the Western Aquifer and other, nontraditional sources. Although Article 40 indicates that the amount of water available for development in the Eastern Aquifer is 78 Mcm/yr, the facility master plan assumes that the amount available for Hebron-Bethlehem during the planning period is only 27 Mcm/yr. This lower amount was arrived at after making adjustments to the Article 40 assignment using the best available information. Deliverable 4.02 identified that Palestinian withdrawals from the Eastern Aquifer are greater than that assumed in Article 40, reducing the amount of water available for development to 71 Mcm/yr. From this amount, the volume of water currently under development or planned for the immediate stage (9 Mcm/yr) must be subtracted, leaving only 62 Mcm/yr. Some of the available water will be required to meet future uses in other districts. The planning team assumed that 6.6 Mcm/yr would be used in the future for municipal and industrial water in Ramallah and Jericho. This leaves 55.4 Mcm/yr for development, but some of that water is either saline or is flowing in the aquifer towards saline water where it will become brackish. These flow characteristics are not fully understood, making it currently impossible to intercept this water before it becomes brackish. The planning team assumed that 28.4 Mcm/yr of the available water was either saline, or technically unavailable, leaving only 27 Mcm/yr for use in the Hebron-Bethlehem planning area through the year 2020.

Table 4.3 presents current and projected Palestinian groundwater withdrawals and Article 40 assignments for the Eastern and Western aquifers. As the table indicates, implementation of the proposed action will contribute to overdraft of the Western Aquifer beginning in the year 2010. The overdraft can be avoided by implementing a regional exchange scheme whereby desalinated seawater or imported water is introduced into the Israeli national system, which is thereby enabled to supply water to communities currently dependent upon groundwater. The unit cost of delivering desalinated seawater or imported water to the proposed Hebron-Bethlehem water system would be higher than delivery to the Israeli water system[18]. It would be most economically efficient, therefore, to exchange desalinated seawater or imported water to be used in the Israeli system for groundwater to be used in the proposed Hebron-Bethlehem water system.

Current estimates of groundwater recharge and withdrawals are based on limited information. To improve this situation and enable better groundwater management, the groundwater monitoring program described in section 5.1.2 of this EA should be implemented.

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[18]The Israeli communities dependent upon the and Western Aquifer, and the transmission system which serves them, are generally nearer to the sea, both in elevation and linear distance than the Palestinian communities and the proposed Hebron-Bethlehem transmission system.

Table 4.3
PROJECTED GROUNDWATER WATER SURPLUSES OR SHORTAGES ASSOCIATED WITH THE PROPOSED ACTION

Type of Withdrawal	Current Withdrawals[a]	Withdrawal Projections[b]		
		2000	2010	2020
Eastern Aquifer System				
Hebron-Bethlehem, Municipal and Industrial	12.40	37.00	49.00	49.00
Hebron-Bethlehem, Agriculture	0.51	0.51	0.51	0.51
Nablus MP, Municipal and Industrial	3.00	0.00	0.00	0.00
Nablus, Agriculture	4.50	4.50	4.50	4.50
Ramallah MP, Municipal and Industrial	2.60	6.50	6.50	6.50
Ramallah, Agriculture	0.94	0.94	0.94	0.94
Jericho, Municipal and Industrial	1.10	2.47	4.37	6.27
Jericho, Agriculture	35.34	35.44	35.44	35.44
Jerusalem, Agriculture	0.61	0.61	0.61	0.61
Total Palestinian	*60.99*	*87.97*	*101.87*	*103.07*
Article 40 Interim Assignment Palestinian	54.00	54.00	54.00	54.00
Israeli	40.00	40.00	40.00	40.00
To be developed	78.00	78.00	78.00	78.00
Total	172.00	172.00	172.00	172.00
Surplus or (Deficit)[c]	**71.01**	**44.03**	**30.13**	**28.23**
Western Aquifer System				
Hebron-Bethlehem, Municipal and Industrial	0.00	0.00	16.00	40.00
Hebron-Bethlehem, Agriculture	0.67	0.67	0.67	0.67
Jenin, Municipal and Industrial	0.11	0.00	8.30	21.80
Tulkarm, Municipal and Industrial	6.40	15.32	27.46	39.60
Tulkarm, Agriculture	16.00	16.00	16.00	16.00
Nablus MP, Municipal and Industrial	0.00	2.00	16.90	30.80
Nablus Other, Municipal and Industrial		9.02	15.62	23.46
Ramallah MP, Municipal and Industrial	0.85	0.85	18.85	36.40
Ramallah Other, Municipal and Industrial		6.14	10.64	16.00
Ramallah, Agriculture	0.51	0.51	0.51	0.51
Total Palestinian	*24.54*	*50.51*	*130.95*	*225.24*
Article 40 Interim Assignment Palestinian	22.00	22.00	22.00	22.00
Israeli	340.00	340.00	340.00	340.00
Total	362.00	362.00	362.00	362.00
Surplus or(Deficit)[c]	**(2.54)**	**(28.51)**	**(108.95)**	**(203.24)**
Total				
Palestinian Use	*85.53*	*138.48*	*232.82*	*329.01*
Article 40 Interim Assignment Palestinian	76.00	76.00	76.00	76.00
Israeli	380.00	380.00	380.00	380.00
To be developed	78.00	78.00	78.00	78.00
Total	534.00	534.00	534.00	534.00
Palestinian Surplus or (Deficit)[c]	**68.47**	**15.52**	**(78.82)**	**(175.01)**
Regional Surplus or (Deficit)[d]	**448.47**	**395.52**	**301.18**	**204.99**

[a]From Deliverable 4.02, Table 2.8.
[b]Projection Assumptions:
Municipal and Industrial withdrawals for Bethlehem, Jenin, Nablus MP, and Ramallah MP are from the facility master plans (Deliverables 25.02, 34.02, 44a.01, and 44b.01).
Municipal and Industrial withdrawals for Tulkarm and Jericho are from Deliverable 4.02.
Municipal and Industrial withdrawals for Nablus Other and Ramallah Other are extrapolations from Deliverable 4.02, removing the master plan area demands and assuming that the remaining demand will be met with water from the Western Aquifer.
For this analysis, agricultural withdrawals and the Article 40 assignments are assumed to remain constant at existing levels.
[c]These are not necessarily physical surpluses or deficits, but merely represent comparisons between estimated uses and Article 40 assignments.
[d]This is a measure of whether the Palestinian demand exceeds regional groundwater availability, indicating whether an exchange scheme is feasible.

Impacts on the Built Environment

The proposed facility master plan will provide an average of 75 L/c/d for domestic consumption by the residents of the area in the year 2000, 126 L/c/d in 2010, and 158 L/c/d by 2020. Sometime between the year 2000 and the year 2010 the average consumption level in the area will exceed the WHO recommended minimum. The provision of more water will improve hygiene and public health in the area.

Providing more water will also generate more wastewater. By the year 2000 wastewater flows will increase by 67 percent , 10.8 to 18 Mcm/yr. From 2000 to 2010 wastewater discharge will double, increasing to 36.6 Mcm/yr. Although the rate of growth will slow after that, wastewater flows will still continue to increase, reaching 59 Mcm/yr by the year 2020. Unless extensive wastewater system construction occurs, most of the increased wastewater will be discharged to cesspits. Increased flows into cesspits will either increase seepage from the cesspits into the underlying aquifer, cause increased surface seepage, or cause increased cesspit pumping. Wastewater pumped from cesspits is often disposed of in nearby wadis, creating the potential for direct human contact and groundwater contamination.

If the existing sewer systems are not provided with wastewater treatment facilities, increased flows into the sewer will increase the flows of raw sewage in Wadi Al-Wa'ar and Wadi El-Nar in the Bethlehem area and Wadi As-Samn south of Hebron. The increased flows in the wadis will extend current impacts further downstream and increase the amount of seepage from the wadis into the underlying aquifer.

The potential for project activities in the Hebron-Bethlehem area to increase the contamination of shallow groundwater is a major but complex issue. There is general consensus that significant increases in the volume of water available for use will result in increased wastewater streams. There is also some consensus that in the long-term, in the Hebron-Bethlehem area, the answer to shallow groundwater contamination is the construction and operation of functioning wastewater treatment plants. There is no consensus, however, about the nature, distribution, magnitude and consequences of the impact -- if any -- that this particular project activity may have in the Hebron-Bethlehem area.[19]

[19]The language in this and the following paragraph was called for by USAID in a memorandum from Thomas H. Stall, COTR, Water Resources Program, USAID/West Bank to Robert Thomas, CDM/Morganti, 20 March 1997.

For this reason, the groundwater quality studies funded as part of the Water Resources Program will assess the relative contribution of the project -- if any -- to groundwater contamination. If it is determined that project activities are likely to have a significant adverse impact on the quality of shallow groundwater, appropriate alternatives for mitigating that impact will be assessed.

The construction of the pipelines for the year 2000 will generally not cause destruction of cesspits in the road rights-of-way because most of the construction will occur outside of residential areas. As the rate of construction increases in the year 2010, activities will begin to occur in smaller communities and the potential for cesspit destruction will increase. In these areas, the Construction Control Program to Avoid Undue Destruction of Cesspits, described in section 2.3 of this EA, will be implemented to mitigate the impacts.

The facility master plan activities in the year 2000 will be powered by electricity from diesel generators. The generators will be noisy. The sites, however, are located far from residential areas, so that the noise will not cause a nuisance. Exact locations of future facilities are not known, but if diesel generators are used in residential areas, the noise impacts will be mitigated by implementation of the Design Standards to Minimize Noise in Residential Areas, described in section 2.3 of this EA.

Because electrical energy will be generated on site in the year 2000, and the Design Standards to Prevent or Contain Fuel Releases at Well Sites and Pump Stations (described in section 2.3 of this EA) will be implemented, there is no impact associated with energy generation and transmission. The major developments proposed for the year 2010 and beyond, however, may draw upon the electric grid. The amount of energy required from the grid to operate system water pumps in the system will most likely be minuscule compared to domestic and industrial energy demands.

Because of the rich history in the Hebron-Bethlehem area, the potential exists for destruction of archaeological resources during construction of water facilities. Because the exact location of future facilities is not known, field examinations have not been conducted. To protect archaeological resources and mitigate any potential impacts, the Archaeological Resource Protection Program, described in section 2.3 of this EA, will be implemented.

Impacts on the Socio-Economic Environment

Construction of the proposed facilities will cause some traffic disruptions and temporarily limit access to some properties. These impacts cannot be totally avoided, but implementation of the Construction Control Program to Avoid Undue Disruption of Access and Services, described in section 2.3 of this EA, will mitigate the impacts.

Implementation of the facility master plan will provide more water to the area, which in turn will stimulate and sustain increased development. Increased development will improve the economic well being of the area residents, but it may also cause urban pollution, including air pollution, water pollution, solid waste disposal, and urban sprawl onto agricultural lands. These problems can be prevented or mitigated through urban planning and the development of environmental protection programs. The Palestinian National Authority is striving to meet these needs, and should be encouraged and supported in their efforts.

Doubling of wastewater flows by the year 2000 and again by 2010 will increase the costs of cesspit pumping. Using the same procedure as used to predict these increased costs for the immediate stage results in an estimate of 16 million NIS per year in increased pumping costs by the year 2000. This is admittedly a crude estimate, but it does highlight a potentially significant cost to some households of project implementation. As is the case with the immediate stage, these costs will be a transfer from households to pumper truck owners which will minimize its impacts on the regional economy.

Because the exact location of proposed future facilities is not known, the exact impacts on land use and acquisition cannot be assessed. However, because the area required for the systems is small compared to the total area of the region, the land use impacts are likely to be insignificant. For example, even the 2010 plan, which involves the most construction, will only impact 66.6 hectares.

4.2.3 Alternative 2

Alternative 2 has the same local impacts as the proposed action except in two areas: sustainable use of groundwater resources, and energy generation and transmission. Alternative 2 does not rely upon groundwater after the year 2010, so it will not impact this resource. Desalinization of sea water and conveying it from the coast to Tarqumya, however, will require a significant amount of energy. Development of the energy necessary could have significant negative environmental impacts.

The development of a major desalinization plant in Gaza may also pose significant impacts in the area of construction on both marine and terrestrial ecosystems and human communities. Creation of such a facility and the conveyance system necessary to deliver the water to Tarqumya would require its own environmental assessment.

4.2.4 Alternative 3

Although Alternative 3 derives its water from a different source, it raises the same environmental issues as Alternative 2. It will reduce the impact on the local groundwater resource, but may also cause several other impacts associated with its construction and operation which are beyond the scope of this assessment.

4.2.5 Summary

Although it is impossible to fully quantify the potential impacts of the facility master plan or to even adequately describe them qualitatively, if the mitigation measures presented in section 2.3 of this EA are implemented at the time of design and construction, the facilities should pose no significant impacts on the environment. As with the immediate stage facilities, some of the greatest potential impacts are associated with increasing wastewater flows. These impacts will need to be addressed in the future through wastewater management. The other potential impact of most concern is unsustainable use of the groundwater resource. This issue can only be addressed with development and implementation of a regional water exchange scheme involving all of the parties currently using the Eastern and Western aquifers. The regional scheme should include economically efficient exchanges of desalinated seawater for groundwater. A regional solution, in combination with implementation of the groundwater monitoring program proposed in the EA, should eliminate the potential for overdraft of the aquifer.

Table 4.4
SUMMARY OF THE ENVIRONMENTAL CONSEQUENCES FOR THE FACILITY MASTER PLAN

Category	Issue	No Action	Proposed Action	Alternative 2	Alternative 3
Impacts on the Physical and Natural Environment	*Vegetative Cover and Soil Erosion*	No Impact	2000 21.3 ha. Disturbed 2010 63.3 ha. Disturbed 2020 35.3 ha. Disturbed Potential Impacts will be mitigated.	2000 21.3 ha. Disturbed 2010 88.4 ha. Disturbed 2020 8.8 ha. Disturbed Potential Impacts will be mitigated.	2000 21.3 ha. Disturbed 2010 Undetermined 2020 Undetermined Potential Impacts will be mitigated.
	Sustainable Use of Groundwater Resources	No Impact Potential 39.6 Mcm/yr still available	No Impact, if a regional solution is developed and implemented involving economically efficient exchanges of treated seawater or other imported water for groundwater.	No Impact Only 15 Mcm/yr withdrawn from Eastern Aquifer beginning in year 2000. 39.6 Mcm/yr available All other water will come from Mediterranean Sea.	Same as Alternative 2
Impacts on the Built Environment	*Improved Hygiene*	2000 Domestic Consumption 34 L/c/d Health Minimum 100 L/c/d Beyond 2000 Without significant water development, L/c/d most likely will decline.	Domestic Consumption 2000 75 L/c/d 2010 126 L/c/d 2020 158 L/c/d	Same as Proposed Action	Same As Proposed Action

Table 4.4 (Continued)

Category	Issue	No Action	Proposed Action	Alternative 2	Alternative 3
Impacts on the Built Environment (continued)	*Increased Wastewater Flows*	No Impact Baseline 2000 Flow: 10.8 Mcm/yr	2000 7.2 Mcm/yr increase over baseline 2010 18.6 Mcm/yr increase over 2000 2020 22.4 Mcm/yr increase over 2010 Increased volume of sewage discharged from sewers. Increased potential for groundwater contamination and seepage from cesspits.	Same as Proposed Action	Same as Proposed Action
	Destruction of Cesspits During Construction	No Impact	Potential impact mitigated	Same as Proposed Action	Same as Proposed Action
	Noise	No Impact	Potential impact mitigated	Same as Proposed Action	Same as Proposed Action
	Energy Generation and Transmission	No Impact	2000 No Impact, electrical needs from diesel generators. Fuel tanks fully contained. 2010 Undetermined 2020 Undetermined	2000 Same as Proposed Action 2010 & 2020 Could be significant, including energy needs for desalinization.	2000 Same as Proposed Action 2010 & 2020 Could be significant, including energy needs for desalinization, even if some of the energy is self-generated.
	Destruction of Archaeological Resources	No Impact	Potential impact mitigated	Potential impact mitigated	Potential impact mitigated

Table 4.4 (Continued)

Category	Issue	No Action	Proposed Action	Alternative 2	Alternative 3
Impacts on the Socio-Economic Environment	*Traffic Disruption*	No Impact	Potential impact mitigated	Potential impact mitigated	Potential impact mitigated
	Induced Development	Will inhibit development	Will stimulate and support development which could cause urban air, water, and solid waste contamination. Require urban planning and environmental management.	Same as Proposed Action	Same as Proposed Action
	Increased Cost of Cesspit Pumping	No Impact	In the year 2000 could be as high as 16 million NIS/yr, and will increase in 2010 and 2020.	Same as Proposed Action	Same as Proposed Action
	Land Use/Acquisition	No Impact	Small total area affected	Same as Proposed Action	Same as Proposed Action

5. MONITORING PLANS

The implementation of the immediate stage and facility master plan activities raise a number of issues that are important to the successful functioning of these systems including the long-term adequacy of local water supply sources and adequate control and treatment of wastewater. These issues have been addressed in the basic design of the system, however, they warrant special monitoring programs to assure that they do not compromise the water supply systems. Monitoring is also necessary to ensure implementation of mitigation measures.

The purpose of the monitoring programs is to provide continual feedback on the design, construction and operation of the system, and to suggest strategies for dealing with the issues of concern where warranted. These plans complement the standard operating practices of the PWA by integrating concerns unique to the Hebron-Bethlehem area into routine operations. The plans supplement the basic design of the systems, and are intended to address conditions which cannot be fully understood at present, or which may arise in only unusual circumstances in the future.

The areas of specific focus for the monitoring programs are as follows:

- The development of a water resource monitoring plan, focused on the relationship of local demand for water and local sources of supply.
- The development of a domestic water quality monitoring program to ensure that the water systems are not contaminated by wastewater.
- The development of a monitoring program that ensures the implementation of the proposed mitigation measures.

5.1 WATER RESOURCES MONITORING

The project aims to provide sufficient water to meet demands through the year 2020 which is projected to be 97.8 Mcm/yr. The increases in the water demands are driven by a combination of increases in serviced population, increased per capita consumption of the serviced population (to raise the quantities of water supplied to the residents of the area to acceptable international standards), and increased usage associated with economic activities. The purpose of this monitoring plan is to consolidate all variables associated with the development of future supplies into a single, cohesive plan. The component parts of the plan include monitoring changes in demand patterns and monitoring resource sustainability.

5.1.1 Monitoring Changes in Demand Patterns

Future demand forecasts are predicated on increases in demand patterns for various sectors of the economy and decreases in leakage and unaccounted for losses. The purpose of monitoring demand patterns is to compare actual changes in demand to forecasts so that adjustments can be made to projections. The monitoring program will track demand patterns over time by producing a report that accounts for the total use of water by component, using pumping records, meter readings, and other available data. Trends should be tracked by component, to account for total usage, and at selected domestic accounts to monitor changes in per capita usage patterns. An example of a form that can be used to record the information is presented in Table 5.1. This form

should be produced on a quarterly basis, to provide constant feedback on system operations, and to develop data that provides information on quarterly consumption patterns. In filling the form out, it will be necessary to estimate certain factors, such as the population connected to the system, in order to compute factors comparable to those used in design.

On an ongoing basis the data contained in the forms can be plotted and used to guide management decisions. The following are a few examples of how the data could be used to respond to system changes and enhance operational effectiveness:

If the percentage of pumpage attributed to leakage and unaccounted for losses does not decline over time, this indicates a need for either additional sources of supply beyond those included in the plan, or the institution of an aggressive leak detection and repair program, or improved metering.

If the per capita usage of the domestic sector does not increase at the rate projected, then it may be possible to reallocate planned domestic demand to other sectors.

If overall demand is not increasing as projected, it may be possible to slow development of new sources.

Table 5.1
WATER USE RECORD OF INFORMATION

Summary Report on Water Uses for the Period __ to __				
	Number of Accounts	**Total Usage**	**Average Usage[1]**	**Design Usage**
Metered Uses				
Domestic				
Actual				
Estimated				
Commercial				
Actual				
Estimated				
Industrial				
Actual				
Estimated				
Agricultural				
Actual				
Estimated				
Total Metered				
Unmetered Uses				
Flushing				
Hydrant				
Other				
Total Unmetered				
Total Accounted				
Total Pumpage				
Estimated Losses				
Notes: 1. Per capita usage based on xx people served per meter.				

5.1.2 Monitoring Groundwater Quantity and Quality

The facility master plan calls for providing 97.8 Mcm/yr of water by the year 2020. Although the plan avoids overdraft of the Eastern Aquifer, its implementation will contribute to overdraft of the Western Aquifer beginning in 2010. The estimates of safe yield for the Eastern and Western aquifers are based on limited information. The actual safe yields may be greater or lesser than the current estimates. To provide PWA with better information on the safe yield of

the Eastern Aquifer, CDM/Morganti is developing a groundwater monitoring plan for the portion of the aquifer which lies below the West Bank[20]. The purposes of the groundwater monitoring program are to monitor groundwater levels, to determine the effect of pumping on the Eastern Aquifer, to identify new areas for potential well field development, to provide data for modeling safe yield, and to monitor water quality in the aquifer.

The plan calls for establishing six monitoring wells, capable of monitoring both the upper and lower aquifers, and identifies locations for an additional five well sites, should funding become available. Samples of abstraction, water table, and water quality will be taken at each well. Abstraction and water table measurements will be taken monthly. The type and interval for water quality measurements are presented in Table 5.2.

Table 5.2
WATER QUALITY SAMPLING AT GROUNDWATER MONITORING WELLS

Quarterly Field Measurements		
Electrical Conductivity	Odor	Redox Potential
Temperature	Color	Dissolved Oxygen
pH		
Quarterly Laboratory Parameters and Major Ions		
pH	Sodium	Sulphate
Electrical Conductivity	Potassium	Chloride
Total Hardness	Calcium	Nitrate
Total Dissolved Solids	Magnesium	Nitrite
Alkalinity	Bicarbonate	Ammonia
	Carbonate	Phosphate
Semiannual Biological Analyses		
Fecal Coliform	Total Coliform	

PWA should implement a similar groundwater monitoring and modeling program for the Western Aquifer. The data collected in the monitoring program should be screened, processed, and analyzed using the United Nations Groundwater for Windows package, which is currently used by the PWA. The results should be disseminated in the form of bulletins and reports to interested agencies. Since the Israelis as well as the Palestinians are using the Western Aquifer, data from both sides must be included in the model. The JWC should oversee that required measures are taken for the joint monitoring of the aquifer.

5.2 DOMESTIC WATER QUALITY MONITORING

The improper release of treated wastewater to the environment, either through agricultural reuse, malfunctioning cesspits, or planned or incidental discharge to a wadi, could raise public health concerns. Although the wastewater systems are not part of this project, they will have an impact on the proposed water supplies. The designs of the water supply systems have been developed with this concern in mind, by incorporating the possible increase in wastewater flows, the possible destruction of wastewater collection tanks, and the improper disposal of wastewater.

[20]Deliverables 20.01 and 20.02.

The continued effectiveness of the water supply systems is, however, dependent on the provision of potable water. This will require an ongoing program of sampling and analysis of water supplies to assure that the system is not affected by the wastewater flows. This will entail:

The use of chemical and biological analyses, at the tap as well as at production wells, to ensure that the quality of the water supplies has not been contaminated by wastewater flows. The parameters should include odor, nitrate, fecal coliform, and total coliform.

The posting of signs and routine patrolling of the area adjacent to the water supply facilities to ensure that wastewater is not being dumped in areas that could lead to groundwater contamination.

Working with other parties and donor agencies to ensure that wastewater collection, treatment, and disposal receive proper attention and has high priority.

5.3 MONITORING IMPLEMENTATION OF MITIGATION MEASURES

Many of the potential impacts of the proposed action are considered to be insignificant because of mitigation. It is therefore imperative that the mitigation measures be implemented. To this end, all mitigation measures in the EA should become contractual obligations of project implementation. For the immediate stage, the mitigation measures are being incorporated into the contract documents and specifications by CDM/Morganti. CDM/Morganti will also inspect construction sites to ensure that the mitigation measures are implemented. The PWA will have to do the same as it begins to implement the facility master plan.

5.4 SUMMARY OF MONITORING RESPONSIBILITIES

The responsibilities for implementing the monitoring programs are summarized in Table 5.3. This EA has proposed mitigation measures and monitoring programs which should ensure that the proposed actions will not significantly impact the environment. It has also identified responsibilities for their implementation. USAID can take the following steps to make sure that the mitigation measures and monitoring plans are implemented.

USAID can work with other donor agencies and institutions on institutional development of PWA to establish a continuous monitoring system within the authority and to build up their capacity to carry out the necessary monitoring activities. In addition, other institutions responsible for the protection of the environment (e.g., Directorate of the Environment of the Ministry of Planning) must be given responsibilities and capacity to monitor the environmental impacts of the project once it is in operation.

USAID, when approving the implementation of the water resources program, can stress to PWA the need to implement the proposed mitigation measures and monitoring plans as conditions for the success of the project and its components.

Table 5.3
SUMMARY OF THE MONITORING PLANS AND RESPONSIBILITIES

Monitoring Program	Immediate Stage			Facility Master Plan		
	Respon-sibility	Time Frame	Funds	Respon-sibility	Time Frame	Funds
Water Resources Monitoring						
Changes in Demand Patterns	PWA	Over the life of the resource	PWA in house	PWA	Over the life of the resource	PWA in house
Groundwater Quantity and Quality						
Sampling and Analysis	CDM/ Morganti	During construc-tion	USAID	PWA	Over the life of the resource	PWA in house
	PWA	Over the life of the resource	PWA in house			
Aquifer Modeling	CDM/ Morganti	During construc-tion	USAID	PWA	Over the life of the resource	PWA in house
Cooperation between Israelis and Palestinians in monitoring shared aquifers	JWC	Over the life of the resource	JWC in house	JWC	Over the life of the resource	JWC in house
Domestic Water Quality						
Sampling and Analysis Sign Posting and Patrolling	PWA & Local water authorities	Over the life of the resource	PWA in house Local in house	PWA & Local water authorit-ies	Over the life of the resource	PWA in house Local in house
Working With Other Agencies for Construction of Wastewater Systems	PWA & USAID	As soon as possible	PWA in house & Inter-national Donors	PWA	As soon as possible	PWA in house & Inter-national Donors
Implementation of Mitigation Measures	CDM/ Morganti & PWA	During construc-tion	USAID	PWA	Over the life of the resource	PWA in house & Inter-national Donors

6. RESOURCES

6.1 LIST OF PREPARERS

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Mr. Alan Schultz	Consulting Civil Engineer, 35 years of experience in water resources planning and hydraulic engineering.
Mr. Farouk Ghosheh	Mechanical Engineer, 34 years of experience in water resources planning, design and supervision.
Dr. Amjad Aliewi	Hydrogeologist, 14 years of experience in geology and hydrogeological modeling.
Mr. Richard Oglesby	Consulting Civil Engineer, 10 years of experience in planning and design of water supply and distribution systems.
Mr. Sami Barghouthi	Civil Engineer, 18 years of experience in sanitary engineering networks.
Dr. Marwan Abu-Khalaf	Senior Archaeologist, 18 years of experience in archaeological research and investigations.

6.2 LIST OF CONTACTS

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Jeffrey Goodson	USAID, Washington

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Deliverable 20.01, Groundwater Monitoring Plan

Deliverable 20.02, Location Maps for Sampling Locations

Deliverable 24.01, Well Development Study for the Immediate Stage of the Hebron-Bethlehem Water Supply System

Deliverable 25.01, Preliminary Report, Water Supply Facility Master Plan for the Hebron-Bethlehem Service Area

Deliverable 25.02, Final Report, Water Supply Facility Master Plan for the Hebron-Bethlehem Service Area

Deliverable 26.01, Scoping Session Handout for the Hebron-Bethlehem Area

Deliverable 26.02, Scoping Session Report for the Hebron-Bethlehem Area

Deliverable 26.05, Draft Environmental Assessment for the Hebron-Bethlehem Area Water Supply System

Deliverable 27.01, Final Engineering Design Report for Three Production Wells for Hebron-Bethlehem Area

Deliverable 28.01, Feasibility Study, Immediate Stage, Hebron-Bethlehem Service Area

Deliverable 29.01, Final Engineering Design Report , Immediate Stage, Hebron-Bethlehem Service Area

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APPENDIX A

DESCRIPTION OF ARCHAEOLOGICAL RESOURCES IN THE PROJECT AREA

ARCHAEOLOGICAL SITES IN THE HEBRON-BETHLEHEM MASTER PLAN SERVICE AREA

Hebron in an old site, it goes in it's history to the time of Abraham, about 1600 B.C. However, in it's sub-- there are sites, date by it's inaternials to the prehistoric periods. During the Roman period, the region of Hebron formed of small area composed of "Hebron" (Chevron) with it. Castle and Abraham House; Jerpinthus, which lies on the road between Halhul and Hebron today, Known by "Ramat Al Khalil;" Penthennim, the for it's field village locate today on the village of Beit Anin.

Archaeological Sites Around Hebron

1. Terbinttuns. Ramat Al-Khalil. It is located north of Hebron about 2 Km and 400 to the east of Hebron-Jerusalem road. Traditions included that Abraham (Peace be upon on him) lived on this spot and become the central market during the Roman period.

2. Khirbat al-Nasara.
   It is located, south west Ramat Al-Khalil, at the beginning of the road between Hebron and Beit Jibreen. It is composed of destroyed buildings, foundations, Aarelies, reservoirs.

3. Sabta.
   It is located in the north of Hebron near al-Maskubiyya. There are remains of buildings and tombs cut into rock.

4. Ain Sara.
   It is located in the north within the boundaries of Hebron. Its remains are composed of canal, reservoirs, baths, wine presses cut into the rock.

5. Khirbat Can'an.
   It is located in the south west of Hebron on the road, it is indicated that the can'anian Tower of Efiq was of Dura. It is composed of caves, Tombs, etc.

6. Khirbat Qulqis.
   It is located to the south. Its remains are composed of wells, reservoirs, wine press, paved with mosaic floor, Tombs cut into the rock.

7. Khirbat Hkura.
   It is located to the west of Deir at. Mas kubiyya (The Russian monastery). It is composed of wells, reservoirs, and caves cut into the rock.

8. Halhul is located 5 km north of Hebron. Its remains are composed of mosaic floor rock cut tombs.

9. Khirbat Burj Al-Sur.
It is located north west of Halhul. On its site, there was Khirbat Al-Tubaiqa- on the north west side there is Beit Sur village. The village is a Can'anite site and its name means (the house of the Rock). In the Roman period its name was (Path Sura). The remains of Beit Sur are composed of a tower, remains of buildings, tombs cut into the Rock. However, Khirbat al.Tubaiqa remains are composed of destroyed town with walls, destroyed houses, reservoirs, Tombs in caves.

10. Khirbat Kasbar
It is located to the west of Halhul. Its remains are composed of canals built of arches, foundations, reservoirs, rock cut pool.

11. Khirbat Man'in.
It is located to the west of the village. Its remains are composed of foundations, reservoirs, and rock cut caves.

12. Khirbat Beit Khiran.
It is located to the north of Halhul. Its remains are composed of buildings, arches, and reservoirs.

13. Khirbat Abi Al-Dubba.
It is located to the south of Halhul. Its remains are composed of buildings.

14. Khribat Maines.
It is located to the north west of Halhul. Its remains are composed of foundations, Tombs, reservoirs, roads of Al Shiyakh.

15. Khirbat Abi Al-Rish.
It is located to the south east of al-Shuyukh. Its remains are composed of church walls with two columns and arched reservoirs.

16. Khirbat Al-Rabi'ah.
North east of Al-Shuyukh. Its remains are composed of walls and an old Road.

17. Khirbat Al-Za'faran.
South east of Al-Shuyakh. Its remains are composed of building foundations.

18. Khirbat Al-Jaradat.
Near Al-Shuyukh. Its remains are composed of square shape foundations, caves, reservoirs and an ancient road.

19. Beit 'Anun.

20. D - 'Udaisa
It is located between al - Shuyukh and Hebron. Its remains are composed of a well, reservoir, and rock cut caves.

21. Sa'ir
It is located north east of Hebron. It is the Can'anite village of "Si'ur" and the Roman "Sior" which probably came from the Aramian word "Sar" "the rock". Its remains are composed of rock cut tombs.

22. Beit Kahil.
It is located to the north-west of Hebron, between Halhul and Tarqumya. Within its boundaries is Khirbat Al-Balarna. Its remains are composed of reservoirs, tombs, caves, and a press.

23. Khirbat Judur.
It is located to the north west of Beit Ummar. It was the Can'anite Judur (Castle) and the Roman Cadira. Its remains are composed of wells, niche, column, caves, reservoirs, and remains of an old road.

24. Khirbat Kufin.
It is located to the east of Beit Ummar. Its remains are composed of Shrine named "Mazar al Arba'in". It is said that it was for those who were killed in the fighting with the locates Crusaders; destroyed buildings, Mosque, arches, foundations, reservoirs, presses, and tombs.

25. Khirbat at Freidis.
It is located to the north east of Beit Ummar. Its remains are composed of a wall foundation, reservoirs, and a pool.

26. Khirbat Sha'ar (Deir Sha'ar).
It is located to the north east side of Beit Ummar. Its remains are composed of remains of churches with mosaic floor, buildings, tombs, caves, old road rock cut tombs, and olive presses.

27. Khirbat Beit Sawir.
It is located at the north side of Deir Al-Sha'ar to the west of Bethlehem-Hebron road. Its remains composed of: destroyed tower, reservoirs, cave.

28. Khirbat Marrina.
It is located at the south side of Deir Al-Sha'ar Its remains are composed of: destroyed buildings, Arches, well, caves.

29. Khirbat Zeifa.
It is located at the east side of khirbat Kufin. The site is also the Roman Pethzeth, its remains are composed of destroyed walls, caves, reservoirs, rock out tombs.

30. Khirbat Bit Za'ta.
It is located within the boundaries of Beit Ummar. Its remains composed of : destroyed walls, foundation, reservoirs, press, fire place.

31. Khirbat Tin Brin.
It is located to the south east of Beit Ummar. Its remains are composed of : Square fortification, Building, rock cut reservoirs.

32. Khirbat al - Dalba.
It is located to the south of al-'Arrub. Its remains composed of destroyed walls caves, mosaic floor, reservoir.

33. Khirbat Kweizba.
It is located to the east of Khirbat Tin Brin. Its remains composed of a tower, rock cut caves.

34a. Khirbat Al-Qit.
It is located south of the village. Its remains are composed of stones, reservoir, Tombs.

34b. Khirbat Um Al-Daraj or Khirbat Al-Zabiba.
It is located close to Khirbat Al-Qit. Its remains are composed of : rock cut reservoirs, tombs, foundations.

35. Khirbat Jala.
It is located 2 km south west of Beit Ummar. On its site there was the Arab Can'anite village " Gilo." Its remains are composed of: destroyed wells, foundation, caves.

36. Khirbat Saffa.
It is located within the Beit Ummar boundaries. Its remains are composed of : foundation, rock out reservoirs, columns.

37. Dura.
It is located to the south west of Hebron. Its remains are composed of: remains of a tower, mosaic floor, reservoir.

38. Beit Awwa.
It is located to the west side of Dura. Its remains are composed of: remains of buildings, Apse of a church, foundation, columns, rock out reservoirs.

39. Khirbat Deir Samit.
It is located to the north east of Beit Awwa. Its remains are composed of: foundation, caves, reservoirs.

40. Khirbat Al-Sikka.
It is located to the south of Beit Awwa. Its remains are composed of: foundation, reservoir, well, rock cut caves.

41. Khirbat Karma.
It is located south of Dura. Its remains are composed of foundation, reservoirs, presses.

42. Khirbat Al-Burj.
It is located south west of Dura, and also known by the name "Birkat Abi Tuq: and Qal'at Al-Burj. Its remains are composed of destroyed fortress, rock cut tunnd, caves, pool, foundation.

43. Beit Marsim.
It is located to the north east of Khirbat Al-Burj built by the Can'anite and named it Dabir (holy) and it was known as Kiryat sifer (The town of books) and kiryat Sinna" (Town of the Palm "Its remains are composed of: destroyed walls, foundation, mosaic floors, remains of a church become a Mosque (Al-Nabi Handal Shrine). North West of the site there in Khirbat Gimar), composed of caves and reservoirs. Also Khirbat al - Nasrani to the north of the site. Its remains are composed of buildings, reservoirs, caves, olive press. Other Khirabs: Khirbat Abi Al-Mulatham, and Khirbat Martina.

44. Beit Al-Roush Al-Tahta.
It is located to the north east of Beit Mersim.. Its remains are composed of destroyed walls, caves etc.

45. Khribat Deir Al-'Asal.
It is also Known as Khirbat Al-Shamiyya, located to the south west of Dura. Its remains are composed of destroyed buildings, church of three niches, caves, reservoirs, tombs, presses.

46. Khirbat Al-Majd.
It is located to the south west of Dura and north east of Deir Al-Asal. Its remains are composed of: caves, reservoirs, columns.

47. 'Abda.
It is located on the road between Hebron and Ad-Dhahriyyeh. Its remains are composed of: destroyed wells, reservoirs, caves.

48. Kharsa.
South of Dura, on its site there was the Roman Capharosa. Its remains are composed of foundations, reservoirs, well, carved stones etc.

49. Karza.
South of Dura. Its remains: destroyed buildings foundations, columns, reservoirs, well.

50. Khirbat Muwraq.
West Dura to the north close of Deir Samit. It remains; destroyed buildings, reservoirs, caves.

51. Al-Hadab.
South of Dura. It remains: rock out reservoirs and tombs.

52. Khirbat Al-Saima.
North west of Dura. It remains: buildings, reservoirs, door lintels, rock cut tombs.

53. Suba.
South east of Edna. Its remains are composed of destroyed wall, foundations, rock cut caves.

54. Al-Kom.
It is located to the north of Muwraq. Two Khirabs are close to this village. 1- Khirbat Firjas to the south of the village, with remains of foundation, caves, reservoirs. And Khirbat Beit Maqdoom, to the east of the village. Its remains reservoirs, walls, caves. On the site of Al-Kom there was the Roman town Maceda.

55. Deir Razih.
It is located south of Dura close to the Hebron Ad-Dhahriyyeh road. It remains are, walls, reservoirs, caves, rock cut tombs. To the north east of the site there is Khirbat Al-Jawf: remains of a church, columns, reservoirs, caves, tombs.

56. Turrama.
South of Dura. Its remains are: remains of a fortress, pool, rock cut caves.

57. Al-Sura.
South west of Dura. Its remains are of destroyed walls, caves, reservoirs, wine, press, rock cut, tombs.

58. Khirbat Fir'a.
North of Dura - foundation, rock cut caves etc.

59. Khirbat 'Imran.
South east of Dura. reservoirs, pottery shreds.

60. Khirbat Fqeiqis.
South west Dura. Caves, remains of an old road.

61. Khirbat Umm Al-Shaqaf.
South of Khirbat Al-Sikka. It is a Tel, its remains of foundations, reservoirs, rock out caves.

62. Khirbat Bannaya.
South west of Khirbat Al-Sikka. Foundations, rock cut reservoirs, caves.

63. Khirbat Al-Weilda.
West of Dura. Reservoirs, caves, well dressed stones.

64. Khirbat Shaduran.
South of Bat Awwa - remains of a church, columns, destroyed walls.

65. Khirbat Morran.
South west of Dura - remains of buildings, well dressed stones, reservoirs.

66. Khirbat Al-Dalba.
South east of Dura. Destroyed walls, foundations, reservoirs, tombs, caves.

67. Khirbat Al-Harayiq. remains of buildings, foundations reservoirs, rock cut pool, columns.

68. Khirbat Abi Suhwailah.
North east Beit Mersim. Foundations, press, caves, reservoirs.

69. Khirbat Umm Al-Mais.
West Dura. Caves, rock cut, reservoirs.

70. Khirbat Beit Ba'ir.
West of Dura. Destroyed walls, caves, reservoirs etc.

71. Khirbat Al-Qas'a.
East of Beit 'Awwa. Foundations, reservoirs, old road.

72. Khirbat Majadel.
South west of Dura. remains of buildings, columns rock cut reservoirs, caves.

73. Khirbat 'iTun.
Close to Khirbat Al-Sikka. remains of wells and foundations, rock cut caves.

74. Khirbat Al-Luza or Khirbat Jaradat.
South of Taffuh. Foundation, reservoir.

75. Bani Na'im.
It is located 8 km east of Hebron. It was established on an earlier spot called "Caphar Beruch", a fortified village during the Roman period. It remains mainly of old buildings architectural elements and al - Nabi Lut. Mosque.

76. Khirbat Al-Nabi Yaqin.
It is located 3 km south of Bani Na'im. It is a Mosque and shrine rectangular in shape 10 X 7m.

77. Khirbat Arabiyyia.
North of Bani Na'im. Tombs and reservoirs.

78. Khirbat Al-Minaizel.
South west Al-Nabi Yaqin. Caves, and rock cut tombs.

79. Khirbat Umm Rukba.
South of Bani Na'im. remains of buildings.

80. Khirbat Bani Dar.
West of Al-Nabi Yaqin. destroyed tower, foundations, reservoirs, caves.

81. Khirbat Al-Qaser.
South east of Bani Na'im. remains of buildings and reservoirs.

82. Khirbat Al-Bwaib.
South of Bani Na'im. remains of walls, reservoir.

83. Khirbat Umm Halasa.
South east of Bani Na'im. remains of Buildings, two wells.

84. Khirbat Za'tut.
South cast of Bani Na'im. Walls, Stones.

85. Khirbat Astabul.
Near Bani Na'im. On its site there was the Roman town "Aristobuleas". Its remains composed of destroyed wells, reservoir, caves, Columns, Rock cut Tanb, mosaic floors.

86. Khirbat Al-Wabda.
South east of Astabul. Walls, foundations.

87. Khirbat Salma.
South of Bani Na'im. foundation, stones.

88. Khirbat Khallat Al - Mayya.
South west of Khirbat Salma. remains of buildings, reservoirs, Stones.

89. Khirbat Sannut.
Foundation, rock cut reservoirs. It was a can'anite town.

90. Khirbat Zif.
North of Khirbat Astabul. destroyed walls foundations, reservoir, caves.

91. Khirbat Habrun Al-Luza.
North of Bani Na'im. Reservoirs, stones.

92. Ar-Rihiyya.
South of Hebron, the closest village to it in Yatta. Foundation, caves, reservoir.

93. Yatta.
South of Hebron. It is a can'anite town, and in this town lived the prophet Zakariyya and in it was born his son Yahya. It was visited by Mary when she came to visit her relative Alisabat the mother of Yahya. Its Roman name is "Ieteam. Foundations, tombs rock cut presses.

94. Al-Kamil.
South east of Yatta. It is a can'anite site, and its Roman name is "Chermela". Its remains are composed of: two churches, tower, rock cut tunnel, rock cut tombs, caves.

95. Khirbat Al-'Aziz.
South of Yatta on the road to As-Sammu'.It is the Roman "Kfar 'Aziz", remains of houses, roads, presses etc.

96. Rujm Al-Deir.
North West of Yatta. remains of aquar building on the mount and a well.

97. Khirbat Fattuh.
East of Yatta. remains of walls, caves, reservoirs.

98. Khirbat Al-Kafir.
North east of Yatta. walls, caves, reservoirs.

99. Khirbat Abi Shaban. East of Yatta. Foundation.

100. Khirbat Al-Dairat.
North of Abi Shaban. remains of buildings underfloor storage rooms, caves reservoirs.

101. Raqra north east Yatta.
Walls, reservoirs, caves.

102. Al-Samu'.
South of Hebron on its site there was the can'anite village "Ashtemu'" and the Roman "Asthemoe" and the crusader "Semoa". Its remains composed of tower, synagogue, foundation, tombs, caves etc.

103. Rafat.
South of As-Sammu'. Remains of a destroyed mosque, and buildings, wells, foundation, rock cut tombs. South of the village a site named Deir Rafat: Foundation of a monastery, reservoir, cave.

104. Khirbat Al-Markaz.
South of As-Sammu': reservoirs, stones, foundations, caves.

105. Khirbat Al-Thawani.
East of As-Sammu' foundation, wells, rock out tombs, lintels.

106. Khirbat Al-Qaryatain.
South east of As-Sammu': foundations of buildings, caves, reservoirs.

107. Khirbat Rujm Al-Sweif.
South of Al-Qaryatain. foundation, reservoirs, rock out caves.

108. Khirbat Bayud.
South east of As-Sammu': Caves, reservoirs.

109. Khirbat Majdal Ba'.
It is located between Yatta and As-Sammu': walls, reservoirs, tombs, old roads.

110. Khirbat Janaba.
West of Khirbat Al-Markaz: foundation, stone, caves, reservoirs.

111. Khirbat Ma'in.
East As-Sammu'. On its site there was the can'anite village "Maon"., it kept its name during the Roman period: Foundation of squared tower, reservoirs, well, rock cut tombs caves.

112. Khirbat Susieh.
East of As-Sammu': Foundations of buildings, gates columes, reservoirs, caves, lintels.

113. Khirbat Ghweineh Al-Tahta and Al-Fuqa. South of As-Sammu'. On their site there was the can'anite town "Anim" and the Roman "Anea". Its remains are composed of: walls, caves, reservoir, etc.

114. Khirbat Deir Shams.
North West of As-Sammu' between Yatta and Ad-Dhahriyyeh on its site there was the can'anite town "Danna": Destroyed walls, old roads, reservoirs, caves.

115. Khirbat Al-Sima.
North of Khirbat Deir Shams. Foundations, columns, reservoirs, caves.

116. Khirbat Al-Fakhit.
East of Al-Sammu'. Destroyed walls, reservoirs, caves.

117. Ad-Dhahriyyeh.
South west of Hebron. Its remains are composed of: a tower, caves, tombs, presses, reservoirs.

118. Shweikeh.
East of Ad-Dhahriyyeh: Destroyed buildings, wells, caves, rock out reservoirs.

119. Innab Al-Saghira.
West of Al-Dhahriyyeh: caves, reservoirs, stones.

120. Innab Al-Kabira.
South of Innab Al-Saghira: remains of a church, walls tower, foundation, reservoir, presses.

121. Dammat Al-(Dawma).
North of Ad-Dhahriyyeh, with the same name it was a can'anite town: remains of a church, foundation, tombs, reservoir, caves, rock out stairs.

122. Al-Bira.
West of Kufr Jul. The Rom "Pera."the can'anite "Shsmir": caves, walls, tombs.

123. Kufr Jul.
North west of Ad-Dhahriyyeh. Foundations, caves, columns pieces, presses, reservoirs.

124. Khirbat Al-Ras.
South west of Ad-Dhahriyyeh: caves, reservoirs, stones.

125. Khirbat Deir Al-Luz.
Between Ad-Dhahriyyeh: Foundations, presses, rock cut reservoirs.

126. Khirbat Zanuta.
South of Ad-Dhahriyyeh. It is a can'anite site, and Raman"Zanua":tower, reservoirs, columns, and inscruiphions.

127. Khirbat Umm Sira.
South of Ad-Dhahriyyeh. Foundations, caves, columns, reservoirs .

128. Khirbat Titreet.
Near Beit Shera, boders. Wall foundations, reservoirs stones, door lintels.

129. Khirbat Al-Ja'bare.
South of Ad-Dhahriyyeh: caves, reservoirs, rock out press, walls.

130. Khirbat 'Usailah.
South of Innab Al-Kabira: Stones, foundations, caves, old roads, oil press.

131. Khirbat Bud'ush.
West of Ad-Dhahriyyeh. Foundation, caves, rock cut reservoirs, pottery shreds.

132. Khirbat Rabud.
North east of Ad-Dhahriyyeh; walls, foundations reservoirs, caves.

133. Khirbat 'Attir.
South east of Ad-Dhahriyyeh. On its site there was "yatir" a can'anite village. It is also the Roman "Lethira": Destroyed buildings, foundations, caves, tombs, reservoirs, press etc.

134. Khirbat Umm Al-Dimna.
South of Ad-Dhahriyyeh: caves, reservoirs, stones, columns pieces.

135. Khirbat Al-Tell.
South of Khirbat Badghush: caves, reservoirs, remains of buildings.

136. Tel 'Arad.
South of Hebron, close to Beer Sheva borders: remains of walls, pottery shreds, reservoir, care.

137. Khirbat Tabkhana.
West of Ad-Dhahriyyeh. close to Beer Sheva borders. Buildings foundations, wine press, reservoirs, caves.

138. Khirbat Umm Baghla.
North west of Ad-Dhahviyyeh. Foundations, caves, reservoirs.

139. Khirbat Umm Al-Amad. Walls, caves, reservoirs rock cut wine press.

140. Khirbat Al-Rabiyya.
East of Douma, close to Umm Al-'Amad. It was the can'anite town "Arab".

141. Khirbat Al-Habik.
West of Jabia. Destroyed walls. rock cut reservoirs. rock cut will.

142. Khirbat Sanasin.
North of Jabra. Caves, tombs.

143. Al-Hubaila.
Northeast Surif : walls, foundation, church, mosaic floors columns.

144. Khirbat 'Illin.
North west Surif. Walls, foundations, caves.

145. Khirbat Abi Al-Shuk.
South west of Surif. Foundations, reservoirs wine press, remains of an old road.

146. Kharas.
North west of Hebron. Foundations, reservoirs, caves.

147. Khirbat Hatta.
North west Nuba: reservoirs, caves, wine presses.

148. Beit Nasib.
South west Beit Ula. On its site was the can'anite town Nasib (Statue) or (Columns) and it is the Roman "Nisibi". In this village there are: Khirbat Al-Burj on the north; foundations, reservoirs; Khirbat Beit Nasib Al-Sharqiyyah: destroyed Buildings, foundations, reservoirs; Khribat Beit Nasib Al-Gharbiyyah: square buildings rock cut tomb, reservoirs.

149. Khribat Qila.
North west of Beit Ula. On site there was the can'anite town "Qila" which means "fortress", and it is the Roman Cela: remains of foundations, reservoirs, rock cut tombs.

150. Khirbat Tawas.
North west of Beit Ula: remains of destroyed buildings foundation of a church with Apse, reservoirs, rock cut presses and old roads.

151. Khirbat Za'quqa.
West of Beit Ula. Remains of foundations, columns pieces, presses, reservoirs, rock cut caves.

152. Khirbat Al-Jura.
West of the village: foundations, wells, rock cut caves.

153. Khirbat Beit Lam.
South of Khirbat Al-Jura. Caves, ruined walls etc.

154. Khirbat Kharuf.
West of Beit Ula. Foundations, wells, press, rock and tombs.

155. Khirbat 'Atus.
North west of Beit Ula. reservoirs, caves foundation etc.

156. Khirbat Al-Safa.
Foundations, reservoirs, stones.

157. Tarqumya.
North east of Hebron. On its site was the can'anite village "Yaftah", it is the Roman "Tricomias" (The land of the four villages) and the crusader "Trakemia".

158. Beit Nattif.
North west of Hebron. It is the Roman " Beit Letepta" Its remains are composed of : foundations, tombs, reservoirs mosaic floor, remains of a Roman road.

*159 Khirbat Umm Al-Rius.
South east of the village: remains of a church, mosaic floor, ruined buildings, reservoirs, caves.

*160. Khirbat Umm Al-Jaj.
East of Beit Nattif. reservoirs, rock cut tombs, caves.

*161. Khirbat Al-Nabi Bulus.
North west. of Beit Nattif ruined buildings, foundations remains of a church.

*162. Khirbat Al-Burj.
East of Beit Nattif: reservoirs, tower, remains of a press.

*163. Khirbat Al-Yarmuk.
South of Khirbat Al-Nabi Bulus. It was the can'anite town "Yarmouth", and it is the Roman "Termucha" walls, foundations reservoirs, caves.

*164. Khirbat Al-'Abed.
North of Beit Nattif: ruined buildings, reservoirs, stones.

*165. Khirbat Jadraya.
South of the village. Foundations, rock cut reservoir, oil press.

*166. Khirbat al-Sheikh Ghazi.
South east of Beit Nattif; Shrine with a dome, ruined streets, caves, reservoirs, press. etc.

*167. Khirbat Al-Tabbana.
East of Beit Nattif: walls, foundations, rock cut reservoirs.

168. Khirbat Al-Malkatha.
South of Khirbat Umm Al-ruins of buildings, caves, reservoirs.

169. Khirbat Umm Al-Dhiyyab.
North of Beit Nattif: foundations, rock cut reservoirs.

170. Khirbat Zannu".
North of Beit Nattif. remains of buildings, reservoirs, press, old roads.

171. Khirbat Umm Burj.
North west of Hebron. ruined walls, caves, reservoirs, etc.

172. Khirbat Deir Al-Muse.
West of Khirbat Umm Burj - ruined walls, reservoirs, tombs.

*173. Khirbat Qarma.
North east of Khirbat Umm Burj: ruined buildings, rock cut tombs, wells old road, caves.

*174. Khirbat Huran.
North Khirbat Deir Al-Muse. Caves, reservoirs, presses.

*175. Khirbat Al-Wawiyya.
West of Khirbat Umm Burj. Buildings foundations, reservoirs, press, rock cut, caves.

*176. Khirbat Drusiya.
North west of Khirbat Umm Burj: tower caves, reservoirs.

*177. Khirbat Umm Al-Suwaid.
North of Umm Burj: Foundation, walls, reservoirs, press of mosaic floor.

*178. Khirbat Jamrura.
South of Umm Burj: It was the Roman "Gemmrunis", and the crusaders " Jarmovara" ruins of walls, caves, reservoirs.

179. Al-Kharrisa.
A small village within Ithna borders. Its remains are composed of: foundations of building, remains of small church, columns, rock cut reservoirs.

180. Khirbat Umm Al-Amad (Khirbat Al-Ghanaiem).
South of Al-Kharrisa: destroyed Byzantine church, remains of a monastery, caves, rock cut wine press, rock cut reservoirs.

181. Khirbat Al-Tayba.
Between Ithna and Halhul: rock cut tombs, remains of buildings. It was the Roman. "Caphaetobas".

182. Khirbat Al-Jura.
West of Ithna: remains of buildings, wells, rock cut caves.

183. Khirbat Shabraqa. ruined rectangular buildings reservoirs, rock cut tombs.

184. Khirbat Beit 'Ilm.
West of Khirbat Shabraqa: ruins of buildings, caves, reservoir, rock cut canal.

185. Khirbat Al-Khanazir.
Between Ithna and Deir Nahas: reservoirs, caves, remains of well and buildings.

186. Khirbat Abi Rakhim.
West of Khirbat Al-Khanazir: Reservoirs, caves etc.

187. Zakariyya.
North west of Hebron. Khirbat Tel Zakariyya, south of the village. Its remains are the accumulation of the tel, caves etc. Khirbat Al-Sharia north east of Zakariyya. Foundations. reservoirs, caves. Khirbat Al-Saqhir. West of Khirbat Al-Shar'a. ruined walls, saquared buildings, rock cut caves.

188. Ajjur.
North west of Hebron. Foundation close to the site, there are archaeological sites.

189. Khirbat Al-Sur.
South of Ajjur: Walls, reservoirs, caves lintels, Roman roads.

190. Khirbat Aqbar.
South of Ajjur. Foundation reservoirs caves, and stones.

191. Khirbat Al-Mrasim.
East of Ajjur: Foundation, pottery shreds, mosaic.

192. Khirbat Al-Nuwaitef.
South East Al-Ajjar, wells, foundation, old road. rock cut reservoirs.

193. Khirbat Al-'Adas.
South East of Al-Ajjar. Destroyed walls, columns, reservoirs, press. other site Jannabu Al-Fuqa, Januabu Al-Tahta.

- Khirbat Shwaika, Khirbat Qiuya, Khirbat Beit Safad. Khirbat Umm Al-Basal Khirbat Umm Turus. Khirbat Saba', Khirbat Rabba, Khirbat Umm Al-" Undan. Khirbat Umm Al-Luz Khirbat Al-Sheikh Madkkur, Khirbat Sufiyya.

194. Khirbat Al-Raas.
South east of Ajjur. destroyed walls, columns, reservoirs, press. Other site Jannabu Al-Fuqa, Januabu Al-Tahta.

- Khirbat Shuraika, Khirbat Qiuya, Khirbat Beit Safad. Khirbat Al-Khan, Khirbat Umm Al-Basal, Khirbat Umm Tunus, Khirbat Saba', Khirbat Rabba, khirbat Umm Al-'Umdan, Khirbat Umm Al-Luz, Khirbat Al-Sheikh Madhkur, Khirbat Sufiyya.

196. Rachel Tomb.
Two km north Bethlehem. Rachel is the mother of Joseph and Benjamin, the sons of Jacob. This is the spot where she died while giving birth to Benjamin. It is a room covered with a dome. The site is respected by the three monotheistic religions: Islam, Christianity and Judaism.

197. Deir Mar Ilyas.
Between Bethlehem and Jerusalem founded by the Patriarch Anastanius.

198. Al-Fradis Mount.
Four km south east of Bethlehem. Built by Herod on the mount, palaces, fortresses, walls etc.

199. Solomon Pool.
South west Bethlehem. Three pools.

200. Khirbat Bassa.
South of Bethlehem. It was the Roman "Bethlehem": destroyed walls, rock cut tombs.

201. Khirbat Mazmuryya.
North east of Bethlehem. Foundations, reservoirs, caves.

202. Khirbat Al-Bira.
South of Solomon pools: remains of buildings, presses of oil, wine, floor mosaic, reservoirs, rock cut caves.

203. Khirbat Siyar Al-Ghanam.
East of Beit Sahur: remains of wall, reservoirs, mosaic floor, tombs.

204. Beit Sahur.
Shepherd field, caves, reservoirs, tombs, reservoirs of monasteries, mosaic floors.

205. Khirbat Umm Al-'Asafir.
North of Beit Sahur: Rock cut caves, remains of walls.

206. Khirbat Luqa.
North of Beit Sahur. ruined buildings, reservoirs, rock cut pool.

207. Khirbat Qassis.
East of Beit Sahur. Foundations, rock cut reservoirs, tombs.

208. Irtas.
3 km south of Bethlehem. It is an archaeological site, remains of canals, walls etc.

209. Khirbat Al-Qasir.
North of Al-Khader: remains of buildings, reservoirs, rock cut tombs, remains of canal.

210. Khirbat Umm Al-Shaqaf.
East of Hussan: remains of foundations, wine press, rock cut reservoirs, pottery shreds, rock cut tombs.

211. Khirbat Umm Al-Qal'a.
West of Husan: remains of destroyed walls, foundations, stones.

212. Wadi Fukin.
West of Bethlehem: remains of buildings, a church, rock and caves and wells.

213. Khirbat Tibra.
13 km west of Bethlehem: walls, foundations rock cut tombs.

214. Khirbat Al-'Iid.
South of Wadi Fukin: reservoirs, rock cut tombs.

215. Khirbat Al-'Abhar.
North of Wadi Fukin: Foundation , stones.

216. Beit Fajjar.
South east Bethlehem: remains of foundations, mosaic floors, press, rock cut tombs, caves, etc.

217. Khirbat Taqua'.
East of Taqua': Buildings, remains of a church, columns, caves, rock cut tombs.

218. Khirbat Badfaluh.
West of Tel Herod and south of Beit Sahur: Destroyed walls, reservoirs.

219. Khirbat Beit Tu'mur.
North of Badfaluh: square basin, rock cut tombs.

220. Khirbat Al-Natesh.
Beside Khirbat Beit Tu'mur. Destroyed walls.

221. Khirbat Al-Dawara.
Caves, and destroyed walls.

222. Umm Al-'Amad.
South east of Tel Herod: remains of destroyed walls, columns.

223. Khirbat Umm Al-Jamal.
On the road to Jericho, close to Al-'Izariyya. Remains of wells, pottery shreds.

224. Khirbat Jub Al-Rum.
West of As-Sawahra ash-Sharqiyyah. Remains of mosaic, walls.

225. Khirbat Abu Suwwaneh.
Tombs, ruins of building, mosque.

226. Khirbat Al-Khrayib.
South of Abu Dis. Remains of caves, walls, pottery shreds.

227. Khirbat Al-Hardan.
South east of As-Sawahra ash-Sharqiyyah. Oil press, walls and ruins of buildings.

228. Khirba Al-Raghabreh.
South east of Al-' Izariyya. Remains of architectural date back to several periods.

229. Khirbat Al-Sheikh Sa'el.

230. Khirbat Al-Za'rara.

*Outside the boundary of the service area.