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JAPAN INTERNATIONAL COOPERATION AGENCY

DAMASCUS CITY WATER SUPPLY AND SEWERAGE AUTHORITY
SYRIAN ARAB REPUBLIC

THE STUDY
ON
THE DEVELOPMENT OF WATER SUPPLY SYSTEM
FOR
THE DAMASCUS CITY

PHASE I

VOLUME IV

FINAL REPORT
SUPPORTING REPORT

APPENDIX D, E, F, G, H, I, J

FEBRUARY 1997

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ESTIMATE OF PROJECT COST

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Currency Exchange Rate : US$1 = SL 42 = Yen 108

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ABBREVIATIONS

Organizations

ACSAD	-	The Arab Center for the Studies of Arid Zone and Dry Lands
BRGM	-	Bureau de Reche rche Geologique et Miniere, France
CBS	-	Central Bureau of Statistics
CGE	-	Compaginie Generale des Eaux, France
DAWSSA	-	Damascus City Water Supply and Sewerage Authority
EDWSSR	-	Establishment of Drinking Water Supply and Sewerage in the Rural Province of Damascus
EPEF	-	Establishment Public Des Eau De Damas (Figeh)
HISAT	-	Higher Institute of Applied Sciences and Technology
JICA	-	Japan International Cooperation Agency
MOHU	-	Ministry of Housing and Utilities
MOI	-	Ministry of Irrigation
SAR	-	Syrian Arab Republic
SPC	-	The State Planning Commission
WHO	-	World Health Organization

Others

EIA	-	Environmental Impact Assessment
EIRR	-	Economic Internal Rate of Return
GDP	-	Gross Domestic Product
IEE	-	Initial Environmental Evaluation
NPV	-	Net Present Value
O&M	-	Operation and Maintenance
PE	-	Polyethylene
PVC	-	Polyvinyl Chloride
SCADA	-	Supervisory Control and Data Acquisition (System)
UFW	-	Unaccounted for Water
VAT	-	Value Added Tax

ABBREVIATIONS OF MEASUREMENT

Length

mm	=	millimeter
cm	=	centimeter
m	=	meter
km	=	kilometer

Electrical Measurement

V	=	Volt
A	=	Ampere
Hz	=	Herz
W	=	Watt
kW	=	kilowatt
MW	=	Megawatt

Area

cm^2	=	square centimeter
m^2	=	square meter
ha	=	hectare
km^2	=	square kilometer

Other Measures

%	=	percent
HP	=	horsepower
°C	=	Celcius degree

Volume

cm^3	=	cubic centimeter
l	=	liter
m^3	=	cubic meter
MCM	=	million cubic meter

Derived Measures

l/s	=	liter per second
m^3/s	=	cubic meter per second
m^3/h	=	cubic meter per hour
m^3/d	=	cubic meter per day
lpcd	=	liter per capita per day
kWh	=	kilowatthour
MWh	=	megawatthour
kVA	=	kilovolt ampere
mg/l	=	milligram per liter
μg/l	=	microgram per liter
meq/l	=	milliequivalents per liter
μS/cm	=	microsiemens per centimeter

Weight

mg	=	milligram
g	=	gram
kg	=	kilogram

Time

s	=	second
min	=	minute
h	=	hour
d	=	day
y	=	year

Currency

US$	=	US Dollar
SL	=	Syrian Pound

CURRENCY EQUIVALENT

(as of September 1996)

US$ 1 = SL 42

TRANSLITERATIONS OF ARABIC PLACE NAMES (1/2)

عباسيين	Abasiyin	بيت جن	Beit Jenn
أبو زاد	AbuZad	بيت تيما	Beit Tima
أشرفية	Achrafye	برزة	Berze
عين عوينات	Ain Awenad	بلودان	Bloudan
عين بدا	Ain Beda	بقين	Boukein
عين حبيب	Ain Habib	دحاديل	Dahadil
عين حداد	Ain Hadad	دار المعلمات	Dar al Moalimat
عين حاروش	Ain Haroush	داريا	Daraya
عين حور	Ain Hour	دير مقرن	Deir Moukaren
عين عيسى	Ain Issa	دير العشاير	Deir al Ashayer Shahour
عين نورية	Ain Nourieh	حوض التشتيت	Dissipation Basin
عين رضوان	Ain Roudwan	دربل	Dourbol
عين صبا	Ain Saba	دمر	Dummar
عين صالح	Ain Saleh	عسالي	El Esaly
عين الباردة	Ain el Baradeh	الفوار	El Fawar
عين الخضرة	Ain el Khadra	الفيض	El Feid
عين المالحة	Ain el Malha	حفيرية	El Hafirieh
عين الصاحب	Ain el Saheb	الهامة	El Hame
عين التينة	Ain el Tineh	العرق	El Irk
أكراد	Akrad	الشواط	El Shuwhat
جامع القصاب	Al Aksab Mosque	عش الورور	Esh al Warwar
الضاحية	Al Dahia	فاسريا	Fasraya
الخضرة	Al Khadra	نبع الفيجة	Figeh Spring
المشارع	Al Mashare	فراسكين	Fraskin
القزاز	Al Qazzaz	الغوطة	Ghouta
السهل	Al Sahl	حفير الفوقة	Hafir el Foka
عرطوز	Artooz	حاليا	Halaya
قدم عسالي	Asalie Kadam	حسيبة	Hassibeh
الاعوج	Awaj	حسينية	Huseiniyeh
باب مصلى	Bab Mosallah	ابن النفيس	Ibn Alnafeas
باب شرقي	Bab Sharki	ابن عساكر	Ibn Assaker
باب السلام	Bab el Salam	جناني	Janani
شارع بغداد	Baghdad Street	جرمانا	Jaramana
بردى	Barada	جمرايا	Jemarya
بساتين	Basateen	جوبر	Jobar
بسيمة	Bassime	جوبر عكاش	Jobar Akache

TRANSLITERATIONS OF ARABIC PLACE NAMES (2/2)

جوبر عمادية	Jobar Imadye
جوبر قباني	Jobar Kabani
جرجانية	Jourjaniyeh
قابون	Kaboon
قدم	Kadam
كفرسوسة	Kafar Souseh
كفر العواميد	Kafar el Awamid
قنوات	Kanawat
قاسيون	Kassioun
قطنا	Katana
الكرش	Kersh
خان الفندق	Khan el Founduk
خورشيد	Khorshead
قدسيا	Kudsaya
كيوان	Kywan
لوان	Lawan
معلولا	Maaloula
معرونة	Maaroune
مضايا	Madaya
مهدي بن بركة	Mahadi Bin Baraka
شارع المالكي	Malki street
مزرعة	Mazraa
ميسلون	Meisaloun
منبج	Membej
مزة	Mezze
ميدان	Midan
منين	Mnin
مخيم	Mokhayam
مهاجرين	Mouhajreen
النبوع	Naboua
نهر عيشة	Naher Esheh
ناظم باشا	Nazem Basha
النبك	Nebk
أمية	Omayad
أمويين	Oumawiyin
منطقة الرئاسة	Presidential Area
قطيفة	Qutayfeh
رنكوس	Rankous
رأس الحاجب	Ras Hasib
رأس الوادي	Ras el Wadi
الرازي	Razy
ريمة	Rimeh
ركن الدين	Rukn Aldyn
سعسع	Saasaa
صفصافة	Safsafi
سردا	Sarada
ساروجة	Sarouja
صيافي	Sayafeh
سبيراني	Sebrani
صيدنايا	Sednaya
شاغور	Shaghour
شخاب	Shakhab
ينابيع جانبية	Side Spring
سومرية	Somareyeh
سيرونكس	Syronics
طبالة	Tabbaleh
طبيبة	Tabibiyeh
تضامن	Tadamoun
تقادم	Takadom
تلمسية	Talmasieh
تكية	Tekieh
المدينة القديمة	The Old City
تشرين	Tishreen
المدينة الجامعية	University City
وادي مروان	Wadi Marwan
الوالي	Wali
يعفور	Yaafoor
يرموك	Yarmouk
زبداني	Zabadani

APPENDIX D

WATER QUALITY AND ENVIRONMENT

APPENDIX D

WATER QUALITY AND ENVIRONMENT

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1. INTRODUCTION

1.1 Objectives of the Study

(1) Strategic development of water resources (water quality)

Recent social and economical growth of Damascus is putting significant pressure on the environment of the area. Many water resources discussed in the water resources section are vulnerable to such pressure, and pollution by sewage, industrial waste, fertilizer, or pesticide are jeopardizing the future of precious resources. The ever increasing water demand is also forcing DAWSSA to use water with less desirable quality.

To develop effective master plan projects for water supply, it is essential to :

i) identify major water quality problems
ii) evaluate existing and promising water resources
iii) formulate projects to improve present water quality conditions

A series of water quality studies were conducted to fulfill these objectives.

(2) Environmental evaluation of proposed projects

To improve the present water supply condition, a number of projects were proposed in Chapters 5 and 6 of the Main Report. In Chapter 6 of this Appendix, whether the implementation of these projects are environmentally sound or not was evaluated. The components of the study include :

i) Initial Environmental Examination of Proposed Projects
ii) Environmental Screening of Proposed Projects
iii) Scoping for the Feasibility Study level EIA

2. GENERAL CHARACTERISTICS OF THE AREA

2.1 Natural Setting of the Area

The following natural characteristics of the study area are potentially important to the water quality.

i) Limestone : The amount of divalent cations, i.e., Ca^{2+} and Mg^{2+}, determines the hardness of water. The dissolution of limestone releases calcium ion to the aqueous environment:

$$CaCO_3 + CO_2 + H_2O \rightarrow Ca^{2+} + 2HCO_3^-$$

releases calcium ion which is responsible for water hardness. Limestone is abundant in the study area, thus there is a potential that the hardness is high in the study area. However, hardness depends on various physical and chemical conditions, such as the contact time, temperature, existence of other ions, and so forth.

ii) Gypsum : Gypsum ($CaSO_4$) or other sulfur containing mineral seems to exist in Dummar area located in the western part of the city, although the extent is not known. Dissolution of gypsum also releases hardness to water.

iii) Climate : The climate of the study area is semi-aridic. Because evaporation exceeds the precipitation, accumulation of salt in surface water may occur. However, the evidence of salinity problem in the study area was not very prominent.

2.2 Human Activities Associated with Water Pollution

The pollution of water in the study area can be attributed mainly to the following sources.

i) waste water from household and commercial activities
ii) excessive fertilizer and pesticide use in agriculture
iii) industrial waste

2.2.1 Household and Commercial Activities

Table D-2.1 summarizes the estimated population per administrative district and the estimated load of environmental pollutants from households. There are considerable uncertainties in these estimates because (1) large number of illegal residents, and (2) the unit loads strongly depend on the income level, habits, and other factors of households. There are also numerous shops, restaurants, and other commercial establishments in Damascus. Because sewerage, septic tanks, and other forms of water treatments are limited, a large part of the household and commercial wastewater is discharged to the nearby rivers.

2.2.2 Agriculture

The basin of Zabadani area is known for intensive agricultural activities. In the city, the agricultural areas are found in the Mazraa area (north part of the city), and in the Kafar Souseh area (south west part of the city). The outskirts of Damascus are also agricultural areas.

(1) Fertilizer

In these areas, fertilizers are used extensively. The amount of fertilizers used in Syria is estimated in Table below.

The use of various fertilizers in 1990.

element	manure	chemical (type)	total
nitrogen	71.2 kg/ha	28.1 kg/ha (ammonium nitrate, urea, ammonium sulfate, complex fertilizer)	99.3 kg/ha
phosphorous	41.6 kg/ha	16.8 kg/ha (conc. superphosphate, complex fertilizer)	58.4 kg/ha
potassium	1.7 kg/ha	0.8 kg/ha (potassium sulfate)	2.5 kg/ha

source: JICA, 1992

Approximately 70% of chemical nitrogen fertilizer used in 1990 was manufactured in Syria, while 16% of chemical phosphorous fertilizer was produced in Syria. All chemical potassium fertilizer was imported in 1990 (JICA, 1992).

(2) Pesticide

Pesticides are also widely used to protect agricultural products, especially fruit trees. According to a report compiled by JICA (1992), 3019 tons of insecticides/herbicides were imported in 1990. Brief interviews with the local farmers revealed that aluminum sulfate, dimethylthio-N-monomethylamid, and possibly many other chemicals are used on regular basis in Zabadani area.

Decision No. 10 (1990) prohibits the import and use of the following 33 pesticides in Syria from health risk consideration:

Table List of pesticides banned by Decision No. 10 (1990)

- aldicarb	- H.H.D.N.	- arsenical compounds	- BHC
- cadmium compounds	- cyanide compounds	- carbofuran	- chlordane
- cyanofenphos	- cyhexatin	- DDTs	- diazinon
- dibromochloro	- dinoseb	- endosulfan	- endrin
- EPN	- heptachlor	- leptophos	- dicofol
- dieldrin	- oxyamyl	- paraquat	- fenamiphos
- fonofos	- prothoate	- 2,4,5-T	- bromoxynil compounds
- daminozide	- ethyl parathion	- mierctic compounds	- flurine compounds
- dioxin compounds			

Despite this legal control of pesticides import and use, a large amount of illegal pesticides has been smuggled from Lebanon. The types and amount of the pesticides used in the area are difficult to estimate. Since 1990, at least the following pesticides have been found in groundwater samples around Damascus: lindane, dieldrin, captane, tetrachlorvinphos, etylparathion, chlordane, DDE, DDT, qalendring, heptachlor, methoxychlor, DDD, α-BHC and β-BHC.

2.2.3 Industries

Table D-2.2 summarizes major industries in Damascus. The east side of the city, especially Kaboon and Ghouta areas are the main industrial areas. The control over the disposal of industrial waste is minimal in the study area. Raw industrial sewage is being dumped directly into the rivers. This uncontrolled dumping of industrial waste is contributing to the deterioration of surface water quality in Damascus. Of main concern is the release of toxic substances, such as heavy metals, that could lead to serious health problems. To control industrial discharge, the Ministry of the State for Environment recently formulated the industrial discharge standard, and the enforcement of this standard has been initiated, starting from newly established industries.

2.2.4 Sewerage

The construction of the sewerage system (capacity 485 million m^3/day) is underway, and will be completed in 1998. This will reduce the uncontrolled release of household and commercial wastewater considerably. To implement biological treatment, sewage has to be free of toxic chemicals. The Ministry of State for the Environment is tying to enact an industrial water standard so that the industrial waste water will nor harm the biological system in the sewerage treatment plant.

2.2.5 Asbestos

In the past, asbestos cement pipes have been widely used throughout the world for drinking water supply. However, the health effect of inhaled asbestos is well known. According to DAWSSA, no asbestos pipes are used in Damascus.

2.3 Environmental Administration of Water Resources

Water is very precious in Syria, and protection of water resources has one of the highest priorities in environmental administration in Syria. The following laws and regulations are particularly important to the environmental protection of water resources for Damascus.

(1) Law : Environmental Protection Act

The fundamental environmental law in Syria, "Environmental Protection Act", is currently being formulated. The following articles (draft) are particularly pertinent to the environmental aspects of water resources.
- Chapter II, Article 2-a: need for water quality standards
- Chapter II, Article 3: prohibition of pollution of surface water and aquifers
- Chapter III : Environmental Impact Assessment

The enforcement of this law is a challenging task that Syrian government will face in the next decade.

(2) Law No. 45 : Drinking Water Standard

The Syrian drinking water standard (Appendix) is the oldest environmental standard in Syria. It was enacted in 1973, and has been amended most recently in 1994. It generally follows the WHO drinking water standard guideline (1994).

(3) Industrial Discharge Standard

In accordance with the draft Environmental Law, Article 3, a new regulation on industrial discharge standard has been formulated by the Ministry of State for Environment. Under this regulation, polluting industries are mandated to treat their waste water to the acceptable level set by the law.

The enforcement of this law will improve the environmental condition of industrial areas of Damascus (e.g., Jobar). The government is planning to implement this law from new industries. The proposed law only regulate the concentrations of substances in the discharge, and not the mass released by industries. Such regulation will end up increasing the total water consumption. For this reason, the amendment of the proposed law is being considered.

(4) Law 10: Protection of Figeh Aquifer

Law 10 was enacted in 1989 to protect Figeh spring. It consists of 12 articles and defines two kinds of protection zones, which are summarized in Table below. The protection zone is shown in Figure D-2.1.

Table Protection of Figeh Aquifer

name of protection zone	area	regulations
Direct Protection Zone	Immediate vicinity of the area	no works (agriculture, industry, tourism, construction etc.) except sewage facility to protect the area. Villages inside the protection zone can carry out limited activities such as unirrigated cultivation without using pesticides and/or fertilizers, limited cattle husbandry, and repairing existing houses.
Boundary Protection Zone	770 km^2	same as above

(5) Decision No. 919 : Protection of Barada Spring

Issued by the Ministry of Irrigation in 1986 to protect Barada Spring. The decision consists of 4 articles, article 1 defines two protection zones, which are shon in Figure D-2.1. They are summarized in Table below.

Protection of Barada Aquifer

name of protection zone	area	regulations
First Protection Zone	Immediate vicinity of the area	Prohibition of any construction of civil works, use of polluted waste water for irrigation, storage of garbage, and storage and use of chemical pesticides.
Second Protection Zone	770 km^2	Prohibition of construction, civil works, storage of garbage, and waste water leakage.

(6) Decision 10 : Prohibition for the Import and Use of Chemical Pesticides in Syria

Issued by the Ministry of Agriculture in 1980, it prohibits the import and use of the 33 pesticides in Syria from health risk consideration. Environmental Protection Act, Chapter II, Article 4 also supports this decision.

(7) EIA

Uncontrolled development often leads to environmental disaster. To realize environmentally sound development, those who issue the permit or authorization to a development activity have to be informed about the potential environmental impact of the proposed activity. This assessment of potential environmental impact by the proposed activity is the aim of EIA. Another important objective of EIA is to suggest any alternative plans or mitigating measures to the decision makers so that the proponent of the project can make the project as environmentally sound as possible. Under the Environmental Protection Act, Chapter III, EIA is now mandatory for projects with potentially large environmental impact.

Protection of water resources is one of the most important goals of EIA in Syria. The following special considerations are incorporated in the EIA Decree.

- According to the Annex 2 of EIA Decree (Draft), water basins which have a hydraulic connection with permanent or semi-permanent usable surface water or usable aquifers are designated as sensitive areas. For any major project in such area, EIA is likely to be obligatory.

- EIA is compulsory for all major water polluting activities or activities that use significant amount of water. They are listed in the Annex I of the EIA Decree (Draft).

- EIA is compulsory for the following water supply activities.

Water supply activities with compulsory EIA.

Activity	Criterion for EIA requirement
groundwater wells	yield ≧ 10 MCM/year
artificial or controlled infiltration of water	capacity ≧ 10 MCM/year
reservoirs	water pipelines with a diameter of more than 1 m and length of more than 10 km

3. WATER QUALITY STUDIES

3.1 General Introduction

A series of water quality studies were conducted to elucidate the water quality conditions of the study area. The studies have the following two components.

i) Analysis of Historical Water Quality Data : Historical water quality data provide valuable information about how the water quality changed in time. In this set of analyses, existing water quality data were collected, compiled, and analyzed.

ii) Field Water Quality Studies : The field water quality studies were designed to investigate the present water quality conditions in detail. The studies consist of field survey, sampling, physical/chemical/biological analysis of water samples, and analysis of results.

3.2 Existing Data

3.2.1 Groundwater Quality

Since 1968, DAWSSA's water quality testing laboratory (DAWSSA lab) has carried out numerous water quality analyses for the DAWSSA water supply systems. Table below summarizes the types of routine water quality monitoring program by the DAWSSA lab.

Routine water quality monitoring at DAWSSA.

Analysis	items	location	number of analyses in 1995
General Water Quality Monitoring	turbidity, EC, TDS, temp., pH, TH, TH/Mg, TAC, major cations, major anions, residual chlorine, total bacteria, total coliform	10 primary well fields, Figeh	386
Sanitary Condition Monitoring	residual chlorine, total bacteria, total coliform	all reservoirs, tap water from 34 districts in Damascus	5,974
Heavy Metal Analyses	Pb, Cd, Cr, Cu, Zn, Fe, Mn	several locations	several samples

note : EC (electrical conductivity), TDS (total dissolved solid), TH (total hardness), TH/Mg (Mg hardness).

In addition to DAWSSA, a few foreign teams have conducted sporadic water quality studies in the past. For example, BRGM (Bureau Research Geology and Mining, France) in association with DAWSSA investigated the water quality around Damascus in 1990-1991, as a part of the comprehensive water resources studies for Damascus city.

Despite the abundance of historical water quality data, analysis of the collected data has not been done, partly because the data have not been compiled. As a part of this study, selected historical data were compiled in the Data Book.

Reliable data on heavy metals, pesticides, pathogens, virus, algae in water are scarce. There exist large variations in the existing data, in part, due to the lack of adequate data quality control. Therefore, the existing record was not analyzed in detail. The results of BRGM study is summarized in Appendix.

3.2.2 Surface Water Quality

The main river system in the study area is the Barada river and its network. The water quality of Barada river network has been routinely monitored at 35 monitoring points by the Ministry of Irrigation. A part of the water quality data collected by the Ministry of Irrigation was compiled in Appendix, and was analyzed in Section 3.4.

3.3 Field Water Quality Studies

3.3.1 Introduction

To obtain current water quality data, three sets of field water quality studies were carried out.

3.3.2 General Water Quality Study

To obtain general water quality data in the study area, 126 samples from 75 location were analyzed for physical, chemical, and biological characteristics. The sampling locations were selected (Figures D-3.1a-c, Table D-3.1) to investigate the general water quality of the study area. The sampling locations were determined on the basis of the following criteria:

- areal sampling density
- land use
- geology
- hydrology
- amount of the water resources used
- existing data

- level of pollution
- water supply network

Among these 75 locations, 53 were selected from wells and springs (groundwater samples), 11 were selected from taps and distribution systems, and 11 samples were selected to assess the surface water quality.

These water samples were analyzed for 30 items given in Table D-3.2. The water quality analyses were carried out at the DAWSSA water quality testing laboratory, except for water temperature, pH, nitrite ion (NO_2^-), ammonium ion (NH_4^+), taste, and color, which were analyzed on-site by using the portable water analyzer (Kyoritsu WAS-D2).

3.3.3 Heavy Metals and Pesticides Analyses

In June/July, 1996, 10 and 7 samples were analyzed for heavy metals and for pesticides respectively. The locations of the sampling sites for heavy metals and pesticides, as given in Figures D-3.1a-c and Table D-3.1, were decided by considering the land use, importance of the water resources for water supply, and historical records.

The heavy metal elements and pesticides analyzed in this study are given in Table D-3.3. The analyses were carried out at the Higher Institute of Applied Sciences and Technology (HIAST) in Syria. HIAST is one of the best analytical laboratories in Syria. The analytical methods used at HIAST are modified AWWA (American Water Works Association) Standard Methods: a HPLC method for chlorinated pesticides, a GC method for organo-nitrogen/phosphorous pesticides, and a flame/flameless AA method for heavy metals. The heavy metal samples were also analyzed at the DAWSSA water quality testing laboratory.

After the initial investigation, two chlorinated pesticides were found from the Oumawiyin samples. Therefore, additional samples were taken from the reservoir (before chlorination) as well as from each of the 13 wells in Oumawiyin well field on September, 2. The analysis was conducted at HIAST.

Because some pesticides were found in the second investigation, the confirmation of these results was desired. Another two samples were taken from the reservoir (after chlorination) and well #2 on September, 25, and were analyzed at HIAST and Residual Pesticide Research Institute in Japan. To bring the samples back to Japan, solid extraction was carried out by using reverse-phase (C-18) solid extraction cartridge system (Varian). The solid extraction cartridges were washed with methanol followed by phosphorous buffer solution (pH 7). The water samples were extracted at their natural pHs (around 7.5).

3.3.4 Sanitary Condition Monitoring

In June, 1996, 433 samples were analyzed for total bacteria count, total coliform count, and residual chlorine concentration. The analysis was carried out at DAWSSA.

3.3.5 Quality Assurance and Quality Control (QA/QC)

i) QA/QC at DAWSSA

DAWSSA laboratory does not adopt any systematic QA/QC protocol. Nevertheless, DAWSSA laboratory maintains its data quality by cross-examining newly obtained data with the historical data in rather empirical manner. Such situation is very common, even in the laboratories in developed nations. If any abnormal result is observed, or if the variations in analyses are large, repeated multiplicative analysis is performed. The microbalance (Mettler) is periodically serviced, and all stock standard solutions are replaced periodically. DAWSSA should, however, adopt some form of systematic QA/QC procedure in near future.

ii) QA/QC at HIAST

The analysis of pesticides and heavy metals requires even tougher QA/QC because the analytical procedures are often complex and the concentrations of pesticides and heavy metals in water samples are extremely low. HIAST, at which the samples were analyzed for pesticides and heavy metals, is one of the best research institutes in Syria. As a part of its QA/QC procedure, HIAST is adopting the GEMS program of WHO, which is essentially an external standardization program, for general water quality analyses, pesticide analyses, and heavy metal analyses. HIAST also implements a set of standard procedures to monitor internal data quality.

In addition to the QA/QC effort at HIAST, we conducted a cross-examination of two samples at HIAST and at the Residual Pesticide Research Institute (RPRI) in Japan. In this examination, same water samples that were analyzed at HIAST were extracted using Varian C-18 Solid Extraction Cartridge, and were analyzed at RPRI. For extraction efficiency control, a set of standardized aqueous solutions (spiked with known amount of pesticides) were analyzed by using the same analytical protocol.

3.4 Results of Water Quality Studies

3.4.1 Collected Data

Tables D-3.4, D-3.5, D-3.6, and Figure D-3.2 show the water quality data obtained in this study. Historical water quality data are compiled in Databook 9c-9e and Figure D-3.8.

type of study		location	source
Historical Water Quality	groundwater	Databook 9c	DAWSSA (1980-1996), BRGM (1991)
	surface water	Databook 9d	Ministry of Irrigation (1994)
	pesticides and heavy metals	Databook 9e	BRGM (1991)
Present Condition	groundwater (general)	Table D-3.4	this study
	surface water	Table D-3.4	this study
	potable water	Table D-3.4	this study
	present water quality statistics	Table D-3.5	this study
	pesticides and heavy metals	Table D-3.6	this study
	sanitary condition	Figure D-3.2	this study

3.4.2 Hydrochemisry of Water Resources

Figures D-3.3a-c show the trilinear diagrams of water quality data in 1995/6. The chemistry of waters in Barada and Figeh areas (Figure D-3.3a) is calcium bicarbonate type with a variable percentage of magnesium. Waters in the eastern part of Damascus (Figure D-3.3b) are hydrochemically homogeneous. On the other hand, hydrochemistry of University well field (Figure D-3.3c) is markedly different from the hydrochemistry of other wells.

Based on the field water quality studies conducted in June - August, 1996, statistical analysis of hydrochemistry data was attempted. In Figure D-3.4, a dendrogram of hydrochemistry data is presented. In this diagram, the statistical distances of data are presented as a "tree". The water resources that have similar hydrochemistry belong to the same branch. Water resources with very different water chemistry branch out in the early stage of the branching. For the analysis, the normalized concentrations of Ca, Mg, K, Na, HCO_3, SO_4, and Cl were used. From the figure, it is evident that:

i) Hydrochemistry of water from mountain areas, i.e., Zabadani, Figeh, and Hermon areas, is statistically different from the hydrochemistry of water from Damascus.

ii) Hydrochemisry of water from the western hill foot of the city (Dummar, Communication Center, and University) is also different from the hydrochemistry of other water resources.

These analysis were used to group together the water resources with similar water quality, regional geology, land use, and other environmental characteristics as shown below.

List of Water Quality Groups

Area	Group	Representative Water Resources
Zabadani	Barada	Barada wells
	Zabadani	Zabadani Wells
Figeh	Figeh Main	Figeh Main Spring
	Figeh Valley	Ain Haroush, Deir Moukaren, Figeh Side Spring
Hermon - Houran	Mountain (Hermon)	Yaafoor, Knasa, Shebani, Beit Jenn
	Flat Land (Houran)	Katana, Near Artooz, Tabibiyeh
Damascus	Western High	Dummar, Mezze, University
	Kafar Souseh	Kafar Souseh
	Oumawiyin	Oumawiyin
	South Damascus	Kadam Railway, Takadom, Karem Taha
	East Damascus	Mazraa, Jobar, Kaboon, Ibn Assaker

3.4.3 Public Health Aspects of Water Quality

(1) Bacteriological aspect of water quality

(i) Groundwater

On the basis of the field survey conducted in June and August, 1996, it was found that the total bacteria counts at most existing production wells were < 100 counts/100 mL. However, Ain Haroush, Figeh Side Spring, and Halabneh were highly contaminated with bacteria. The total bacteria counts at these wells were higher than 2000 counts/100 mL in both June and August, 1996. They also had high coliform counts (> 1000 counts/100 mL). These water resources appear to be poorly protected from the local microbial pollution problems.

Figure D-3.5 shows the seasonal variations of the total bacteria and total coliform counts (1995) at the Energy Dissipation Basin which is a water reservoir at which waters from Barada, Deir Moukaren, Ain Haroush, Figeh Side Spring and Figeh Main Spring are mixed. The bacteria counts are high in dry season.

(ii) Surface water

The total bacteria counts of surface water samples in 1996 were in the order of 10^3 - 10^5 counts /100 mL. The coliform counts were also high suggesting that the surface water is highly contaminated by sewage.

(iii) Potable water

In June, 1996, no bacteria or coliform was found from the distribution system in 1996. 93 % of samples (total 433 samples) contained 0.1 - 0.4 mg/L of residual chlorine, and less than 3 % of the samples contained < 0.1 mg/L of residual chlorine (Figure D-3.2). This result proves that the disinfection system is effectively eliminating the bacteria in the water supply system. In the past, DAWSSA did not experience any major outbreak of water borne diseases. It was noted that some distribution networks are old and the water pressure is low. They are prone to secondary pollution by sewage and other local pollution problems even the water is free from pollution at the source. Improvement of local networks are recommended.

(2) Human health related inorganics

(i) Groundwater

In 1996, the concentrations of nitrate, which was the dominant form of nitrogen in groundwater, were generally below 10 mg-NO_3/L in less densely populated mountain areas (Zabadani, Figeh, and Hermon). On the other hand, the nitrate concentrations in South Damascus (e.g., Kadam Railway) were as high (45 mg-NO_3/L) as the WHO drinking water standard (50 mg-NO_3/L). The contour diagram of nitrate concentration is given in Figure D-3.6c. This is one of the most important water quality problems in Damascus.

Historical change in nitrate concentrations for selected wells is given in Figure D-3.7c. The nitrate level in Figeh water has been low, and the level has not been changed much in the last a few decades. The groundwater in Oumawiyin has similar trend . The nitrate levels in Mazraa have been somewhat high (around 25 mg/L). However, the level has not changed appreciably in the last 10 year. The largest change in the nitrate level occurred in the south Damascus area (e.g., Kadam Railway). Due to the scattering of data, it is difficult to detect any systematic trend. DAWSSA changed the analytical method for nitrate in 1992, and this appears to be a part of reason for the large increase in nitrate concentration in 1992 - 1993. The growing pollution problem in the southern part of the city was also supported by the change in chloride concentration in the area.

The levels of heavy metal concentrations in groundwater were generally low (Table D-3.6), and all groundwater samples satisfied the Syrian Drinking Water Standard for heavy metals. In 1991, BRGM reported an elevated level (22.9 μg/L) of lead at University. However, the concentration of lead at University wellfield was below detection limit (6.8 μg/L) this time.

(ii) Surface water

Ammonia has been the dominant form of nitrogen in surface water. The nitrogen concentration (as mg of element nitrogen/L) increased from about 1 mg-N/L at Barada Spring to 25 - 70 mg-N/L in downstream of Damascus. This increase in nitrogen is mainly caused by the discharge of sewage and industrial waste water into the rivers.

Figure D-3.8d shows the seasonal change in ammonium concentration. The ammonium concentration increases significantly in the dry season (July - February). This is because the flux of rivers decreases significantly in dry season due to the natural seasonal decrease in recharge, irrigation, and abstraction of subterranean water by wells.

The heavy metal concentrations of surface water (Barada river) were about an order of magnitude higher than the ones of groundwater (June, 1996). An extremely high level of chromium (40 mg/L) was found in Dabaghat, which is the tannery area (Table D-3.6). The test at the site did not show hexavalent chromium, Cr (VI), indicating that the chromium exist mainly in reduced form, presumably as Cr (III). Although Cr (III) is less toxic than Cr (VI), Cr (III) can be oxidized to Cr (VI) during chlorination. It is highly likely that similar heavy metal pollution problems exist in other industrial areas of Damascus.

(iii) Potable water

The nitrate concentrations of tap waters from DAWSSA system were relatively low (4 to 15 mg-NO_3/L) in June. However, as the production from city wells increased in dry season, the nitrate concentration of supplied water also increased. This change was evident in the Kadam Railway area where the nitrate concentration was as high (45 mg-NO_3/L) as the WHO Drinking Water Standard (50 mg-NO_3/L) in August.

(3) Human health related organics

(i) Groundwater

The study indicated the potential of pesticide pollution at Oumawiyin. In total three sets of studies were conducted to investigate this suspected pesticide problem at Oumawiyin. The results are given in Table D-3.6. According to the reports by HIAST for the second investigation, the concentrations of aldrin, dieldrin, heptachlor, and fenitrothion exceeded the Syrian or Japanese Drinking Water Standards. Therefore, additional samples were taken on Sept. 25, 1996, and were analyzed at HIAST and RPRI in Japan for cross-examination. While HIAST reported 0.84 μg/L of dieldrin for the reservoir sample, the GC-MS analysis at RPRI did not find any pesticide. Anticipating such difficulty in cross-examination, known amount of pesticides spiked in aqueous solutions was extracted using the same extraction method : reversed (C-18) phase solid extraction at neutral pH. A reversed phase extraction system is suitable for highly hydrophobic organic chemicals, such as chlorinated pesticides examined this time. However, the result of the extraction efficiency test at RPRI was low. This means that the pesticides in the sample were not effectively extracted to the reversed phase of the solid extraction system. Therefore, it is premature to conclude that the levels of pesticide in the samples were below the detection limit.

No pesticides were detected from other wells and springs studied this time. Nevertheless, routine monitoring of pesticide and other toxic organic chemicals in all water resources is strongly recommended because many highly toxic pesticides banned by Decision 10 (1980) are still in use (e.g., carbofuran is used at Tishreen Park where Oumawiyin well field is located).

(ii) Surface water

Chlorinated pesticides were found (Table D-3.6) from surface waters (DDT and DDE in Tekieh, and DDE, methoxychlor, lindane, and heptachlor in Dabaghat). Tekieh is located downstream of Zabadani agricultural area and there are many factories in Dabaghat area.

(4) Aesthetic aspect of water quality

(i) Groundwater

More than 85 % of the raw groundwater samples examined this time satisfied the aesthetic aspect of Syrian Drinking Water Standard. The data statistics (minimum, maximum, percentiles at 10, 20 50, 80, and 90) are given in Table D-3.5. Approximately 10 % of the groundwater samples did not satisfy the Syrian Drinking Water Standard for color or turbidity (before chlorination), and approximately 5 % of the groundwater samples did not satisfy the criteria for hardness and sulfate. Major aesthetic problems are rather localized to the following regions: high hardness / sulfur in Dummar - University area, and high hardness in South Damascus area (e.g., Kadam Railway). In addition, relatively high salinity (Na, Cl, and EC) in Mezze area was noted. Some groundwater in Mezze are known to contain 3 to 4 g/L of total dissolved solid. The contour diagrams of electric conductivity, total hardness, sulfate, and chloride are given in Figures D-3.6a-d.

(ii) Surface water

Surface water in Damascus had strong sewage odor, gray - black in color, and turbid. The data statistics are given in Table D-3.5. Na, SO_4 and Cl concentrations in industrial areas (Dabaghat and Jobar) were orders of magnitude higher than the ones at Barada Spring. The field pH in the industrial area were also exceptionally high (9.4 in Jobar in June, and 9.0 in Dabaghat in August) due to the discharge of alkaline industrial waste water.

(iii) Potable water

Except for one sample from Kadam (color problem), all samples from the DAWSSA's distribution system satisfied the aesthetic aspect of Syrian Drinking Water Standard. The data statistics are given in Table D-3.5. The hardness level in Kadam area was as high (440 mg $CaCO_3$/L) as the Syrian Drinking Water Standard (500 mg $CaCO_3$/L) in August, while it was much lower (200 mg $CaCO_3$/L) in June. Other aesthetic water qualities were also low in August. This is because the low quality water from the local wells (Kadam Railway) has been pumped since July to supplement the water from Figeh in dry season (also see section on nitrogen). The complaints from the customers are usually on high hardness, color, and turbidity in summer; our results were in good agreement with the complaints.

(5) Overall quality of the supplied water

In Table D-3.7, the annual volume averaged quality of the water supplied by DAWSSA is given. The yield from each well was estimated from the estimated yield for 1995. The quality of individual water resource was assumed to be constant throughout the year, and was estimated from the results of the field water quality study.

It is evident that the overall quality of the supplied water is high, as nearly 80 % of the water is available from Figeh Main Spring. However, the quality of the supplied water varies significantly by season, and by region. Our study indicated that the water supplied to certain regions (e.g., Kadam) changes from 100 % Figeh Water in wet season to essentially 100 % local water in dry season.

4. EVALUATION OF WATER RESOURCES

4.1 Suitability of Water Resources

In this section, the water qualities of existing and promising water resources are evaluated with respect to their suitability for sources of drinking water. The Syrian Drinking Water Standard and WHO Drinking Water Standard Guideline is used as the criteria for the judgment. If the water quality is not ideal for drinking, the natural, social, and economical reasons are discussed. Water resources with major water quality problems, or the areas where the water quality will potentially deteriorate in the future are summarized in Figure D-3.9.

4.1.1 Groundwater

i) Zabadani Area

- Barada Group : The Barada wells, which now supplies water for Damascus in dry season, provide water with adequate quality for drinking. No pesticide was found from Barada Spring this time. However, Zabadani is an intensive agricultural area and tourism in the area is growing rapidly. The protection of Barada wells in future will require strict enforcement of land use control (Decision 919, 1986) and integrated source control on fertilizer, pesticide, and sewage.

- Zabadani Group : The water qualities of other wells in Zabadani valley are generally good. However, shallow irrigation wells showed elevated nitrate concentration, presumably due to the fertilizer use in the area. Some wells are known to have bacteriological problems. Environmental zoning is recommended to protect precious water resources from agriculture and tourism development.

ii) Figeh Area

- Figeh Main Spring : The water quality of the main Figeh main spring is superb, and it satisfies the Syrian Drinking Water Standard for all items examined this time. Our study detected no pesticide at Figeh main spring, although there are some reports with detectable pesticides in the past. As the main source of drinking water for Damascus, the protection of Figeh aquifer has the highest priority over any other development in the area. A strict enforcement of the land use control (Law 10, "Protection of Figeh Spring", 1989) shall be observed.

- Figeh Valley Group : The total bacteria and coliform counts at Figeh Side Spring, Deir Moukaren and Ain Haroush were considerably high. Consequently the microbial counts at the Energy Dissipation Basin, where waters from Figeh, Barada wells, Ain Haroush, and Deir Moukaren are mixed and sent to Damascus, were also high. These wells appeared to be poorly protected from the local microbial pollution problems. The source of the pollution seems to be sewage from the local villages or recharge of contaminated Barada river. To protect these wells, an adequate waste water management program is needed for the villages in the Figeh valley.

iii) Hermon and Houran Areas

- Mountain Area : Water quality in Hermon Mountains was generally very good, and was comparable to Figeh Main Spring. No bacteriological study was conducted this time.

- Flat Land Area : Water quality in Houran area was also quite good, although hardness in some resources (e.g., Katana 51) was somewhat higher (370 mg-$CaCO_3$/L). No bacteriological study was conducted this time.

iv) Damascus City

- West High Group : Water quality in the western perimeter of Damascus (south of Barada River) is low, apparently for geological reasons. The hardness and sulfur concentration (as sulfate) in Dummar are higher than the Syrian Drinking Water Standard (500 mg-$CaCO_3$/L for hardness and 250 mg-SO_4/L for sulfate). Existence of corrosive sulfide was also noted in this area. Mezze area is known for high salinity (EC, Na, and Cl). University well field has mixture of these problems, namely high hardness and high sulfate (as high as the Syrian Drinking Water Standard), and relatively high chloride concentration.

- Oumawiyin Group : Across the Barada River from University well field, Oumawiyin well field has very good general water quality. The groundwater quality at the National Museum was also high. The water quality at Shoukry al Qouwatly Street is also expected to be good. However, chlorinated pesticides (dieldrin and heptachlor) were found from Oumawiyin in July, 1996. Therefore, a detailed environmental study is being carried out. If the pesticide problem persists, the use of any pesticides in Tishreen Park, where the Oumawiyin well field is located, will be stopped, and the use of all contaminated wells are suspended.

- Kafar Souseh Group : The water quality at Kafar Souseh is characterized by slightly higher hardness and nitrate concentration than those of Oumawiyin group. Water resources at Kanawat Garden is expected to be similar.

- South Damascus Group : The major water quality problems in this area are high hardness and high nitrate concentration, both of them are as high as, or even higher than, the Syrian Drinking Water Standard. Consequently the supplied water quality in this area deteriorates almost to the permissible limit of the Syrian Drinking Water Standard in dry season, when the local wells are pumped to supplement the Figeh water. The sources of nitrate problem seem to be seepage of untreated sewage and fertilizer use in the southwest part of the city. The source of hardness is unknown, but apparently geological. Because the water treatment for nitrate (nitrate removal) is very expensive, blending with Figeh water is the last and only option to make use of the local water resources, if the water quality becomes unacceptable. The water quality in this part of the city will need constant attention in the future.

- East Damascus Group : The general water qualities in Mazraa, Kaboon, Jobar, Ibn Assaker and other areas of Damascus are good enough to satisfy the Syrian Drinking Water Standard.

4.1.2 Surface Water

- Zabadani Area : DDT and DDE were found from the water samples collected at Tekieh (Table D-3.6). Because the ban on these chemicals was enacted only 6 years ago, and Zabadani area is very close to the Lebanon border, it is possible that these chemicals are still in use, or may be used until recently. Otherwise the general surface water quality in this area is reasonably good, and the nitrate level is still low for surface water.

- Figeh Area : Barada river in Figeh area is polluted by local sewage and dumped waste. This pollution problem is especially pronounced in dry season when the flux of the natural river decreases. The filthy condition of the river is evident from the high coliform counts and the high ammonium concentrations. Surface water in this area is not suitable for a water resource of drinking water. To protect water resources in Deir Moukaren, Ain Haroush, and Figeh Side Spring, the water quality of Barada River needs to be improved. The most effective approach is sewage control.

- Damascus Area : The water qualities of Barada river, Tora river, and Yazid river deteriorate rapidly as the rivers flow through the city. Due to the pollution problems, surface water in Damascus will not be suitable for drinking, even after basic water treatment. Ammonia concentrations are as high as 80 mg-NH_4/L, and heavy metals and pesticides were also found.

A major chromium pollution exists in Dabaghat, where tanning industries are concentrated. The area should be thoroughly investigated for chromium pollution, and appropriate remediation measures should be taken immediately. The use of chromium containing water for irrigation also should be stopped.

(3) Overall evaluation of water resources

The current water qualities of existing and promising water resources are summarized as follows.

Groundwater

Area	Group	Aspect of Water Quality			
		Microbial Aspects 1)	Health Related Inorganics 2)	Health Related Organics 3)	Aesthetic Aspects 4)
Zabadani	Barada	good	good	good	excellent
	Zabadani	fair	fair - good	not known	fair - good
Figeh	Figeh Main	excellent	good - excellent	good - excellent	excellent
	Figeh Valley	fair	good	good	good
Hermon - Houran	Mountain	unknown	unknown	unknown	good - excellent
	Flat Land	unknown	unknown	unknown	good - excellent
Damascus	West High	good	good	unknown	not acceptable
	Oumawiyin	good	good	not acceptable 6) ?	good
	Kafar Souseh	good	good	unknown	good
	South	good - fair	fair - not acceptable	unknown	fair - not acceptable
	East	good	good	good	good

Surface Water

Area	Aspect of Water Quality			
	Microbial Aspects 1)	Health Related Inorganics 2)	Health Related Organics 3)	Aesthetic Aspects 4)
Barada Spring	good	good	good	excellent
Tekieh	fair	fair	not acceptable	good
Figeh	not acceptable	not known	not known	not acceptable
Damascus	not acceptable	not acceptable	not acceptable	not acceptable

note : 1) total bacteria/coliform counts.
2) heavy metals, nitrate/nitrite/ammonia.
3) pesticides.
4) temp., odor, color, pH, EC, hardness, major ions, turbidity.
5) not acceptable : does not satisfy Syrian/WHO drinking water standard.
6) potential pesticide problem.

5. PLANS OF IMPROVING PRESENT CONDITIONS

5.1 Overall Approach

In this section, strategies to improve current water quality conditions will be discussed. Water quality problems are generally very complex, and no single approach will solve all the problems. Beside DAWSSA, a number of government bodies are interested in the water quality issues, and they have already launched various projects to improve water quality of the study area. To develop effective master plan projects that DAWSSA can implement, therefore, these factors have to be taken into consideration.

The selection of the master plan projects was practiced in two stages. In the first stage, a preliminary screening was performed based on the following steps.

- step 1 : identification of potential approaches
- step 2 : identification of ongoing or planned projects by DAWSSA and other government bodies
- step 3 : screening of potential projects based on the urgency, effectiveness, and implementability.
- step 4 : selection of candidate projects for master plan

This chapter focuses on this first stage screening processes.

In the second stage, further analysis was performed on the selected candidate projects. In this stage, projects proposed from perspectives other than water quality, e.g., water resources, water demand, unaccounted for water, etc., were integrated to develop final candidates for the master plan projects. Much detailed analysis based on the cost-benefit/economic analysis and environmental impact analysis, were performed. This second stage screening is explained in Section 5.6 of the Main Report.

5.2 Identification of Potential Approaches

5.2.1 Controlling the Release of Contaminants

i) Sewerage system : In Damascus, wastewater from households, commercial establishments and industries are being discharged to nearby rivers and to the ground without treatment. The acute need for sewerage system has been recognized by the city, and the construction of sewerage system including the treatment plant is underway. Recently the Ministry of State for Environment launched a comprehensive sewage control program for Barada / Awaj basins. The program aims at controlling release of raw sewage to the environment through installing septic tanks and small scale sewage treatment plants in the area.

ii) Control on fertilizer and pesticide use : Overuse of fertilizer and pesticide needs to be controlled. In particular, the use of pesticides in the basins of important water resources, e.g., Figeh and Barada, is a major concern. Although the import and use of highly toxic pesticides is banned by Decision 10 (1990), these chemicals have been used until today.

iii) Control of discharge of industrial waste : The Ministry of State for Environment recently formulated a law to control industrial waste. Under the current plan, the industries are supposed to treat industrial waste water to the acceptable industrial discharge standard set by the proposed law, and the treated industrial waste water is retreated at the sewage treatment plant which is under construction. The removal of toxic chemicals is crucial to the operation of the sewage treatment plant.

5.2.2 Protection of Water Resources

i) Protection of Barada Spring Aquifer : Zabadani area is an intensive agricultural area, and a large amount of fertilizer and pesticides is used in the area. The development of resorts in Zabadani is also a threat to the water quality of Barada spring. To protect the aquifer of Barada spring, the Ministry of Irrigation issued Decision No. 919 in 1986.

ii) Protection of Figeh Spring Aquifer : Law 10 was enacted in 1989 to protect Figeh spring. The current protection zone protects over 770 km^2 of the Figeh catchment area.

iii) Protection of Wells in Damascus : Considering the locations of existing wells in densely populated Damascus, it will be difficult to secure large protection zones around wells in Damascus. However, the land use around wells may be controlled. Development of major polluting industries around wells should be discouraged.

iv) Protection of Individual Wells : Many wells owned by DAWSSA are rather old or poorly constructed. Consequently, they are vulnerable to the local pollution problems. Wells that are highly polluted by microbes.

- casing : to protect a well from being contaminated by more polluted water near the surface, a sturdy casing should be placed at least 30 meters from the surface.

- strainer : the placement of strainers should be carefully designed to avoid withdrawing polluted water. Before deciding the depth of strainer, the vertical distribution of .... and their water quality needs to be investigated.

- ceiling : although most wells are sealed at the surface, the ceiling needs to be free of leaks from the surface. The level of ceiling and observation hole shall be above the ground level to prevent contamination of the well by runoff.

5.2.3 Water Blending and Advanced Water Treatment

i) Blending : The water quality studies revealed that the major water quality problems that require immediate attention are rather localized to South Damascus and Western High regions. In these regions, the levels of nitrate, hardness, or sulfate are as high as the drinking water standard. If the levels of contamination become unacceptable, the use of these resources has to be sustained. On the other hand, the studies also showed that water from Figeh Main Spring has good quality, which may be used to dilute the contaminated water. This approach will save the existing water resources from becoming unavailable due to water quality problems.

ii) Softening : Water with a total hardness of 85 to 100 mg/L as $CaCO_3$ are considered most suitable for domestic purposes. The process of removing hardness is called "softening", and lime-soda ash softening, ion-exchange, reverse-osmosis, electroosmosis, and crystallization are the available technologies for softening. Lime-soda softening is most cost effective for a large system. The disposal of sludge is the main drawback of this method.

iii) Nitrate Removal : Nitrate may be removed with ion exchange (anion exchange), biological treatment, reverse osmosis, or electroosmosis. It is well known, however, nitrate removal is very costly. Under the normal water use condition, the removal of nitrate is rarely practiced.

iv) Heavy Metal and Pesticide Removal : The conventional technology to remove heavy metals and pesticides from water is activated carbon treatment. It is well known that activated carbon treatment is very costly. Furthermore, human health is at risk if the system fail to satisfy the required specification. Therefore, it is the best to avoid the use of water contaminated with heavy metals or pesticides.

5.2.4 Detailed Environmental Study

Detailed water quality studies are recommended. For groundwater quality, three dimensional distribution and transport of pollutants have to be elucidated. German Technology Corp. is about to launch a program with ACSA to study groundwater pollution problems in Damascus. For surface water, the extent of pollution by toxic industrial waste, e.g., chromium pollution in Dabaghat, should be carried out as soon as possible.

5.2.5 Improvement of Water Quality Testing

It is an essential requirement for every water supply authority to ensure public health and safety. However, DAWSSA's water quality testing laboratory has a limited capacity and can only analyze 30 samples/day for general water quality. The laboratory does not analyze for pesticides, disinfection by-products, and pathogens. Many of the analytical instruments are old, and unreliable, and in general, repair services and replacement parts are unavailable. The laboratory must be upgraded in order to provide regular and comprehensive water quality testing.

5.2.6 Improvement of Water Pipes

Some distribution pipes are old and are prone to secondary contamination from local pollution. For example, a tap water sample from Kadam was contaminated by oil, while this problem did not exist a few hundred meters away. Apparently a part of the local distribution network was the source of this localized problem. Replacement or repair of local distribution network is recommended.

5.2.7 Reinforcement of Existing Water Resources / Development of New Water Resources

i) Reinforcement of Existing Water Resources : If more water is available from the existing water resources, DAWSSA does not have to use substandard water . The available reinforcement schemes are discussed in Section .

ii) Development of New Water Resources : Development of new water resources will also enable DAWSSA to use less water from contaminated wells. In section , water resources development plans are laid out in detail.

5.3 Preliminary Screening of Potential Master Plan Projects

In the first stage screening of potential master plan projects are based on the following criteria:

i) Effectiveness : The effectiveness of the project to improve water quality is assessed.

ii) Urgency : Certain projects are urgently needed.

iii) Implementability : Whether the proposed project can be implemented or not is judged in terms of the following aspects.

- cost-benefit/economic aspect : The economical feasibility of the project is considered.

- technical aspect : Some projects require highly sophisticated technologies that would make the implementation of the project difficult.

- social and institutional aspect : The implementation of the proposed project may be the responsibility of other government body. Or, there exist legal, social, or cultural factors that prevent DAWSSA to implement the program.

The results of the preliminary screening is given in Table D-5.1.

5.4 Projects Selected for the Second Stage Screening

The following two projects were selected as candidates for the second stage screening.

5.4.1 Improvement of Water Quality Testing

It is an essential requirement for every water supply authority to ensure public health and safety. The frequency of water quality test depends on the population served, volume of supplied water, water quality, and the reliability of the system. The review of DAWSSA's water testing record (Table D-5.2) demonstrated that the capacity of DAWSSA water testing laboratory, which can test maximum 30 samples/day for general water analysis and maximum 50 samples/day for bacteriological analysis, is not sufficient. With the deterioration of water quality, the demand for water testing will increase in the future, and new types of testing, e.g., pesticide analysis, will also be required. Based on the recommended capacity in Table D-5.2, the following reinforcement programs in human resources, training, space, and equipment are suggested.

(1) Staffing

Currently there are 8 staff members at the laboratory handling almost entire water quality testing. The testing is labor intensive, and the staff are considerably busy. The shortage in staff is one of the major factors that limit the testing capacity.

To meet the growing demand for water testing, the number of stuff should be doubled in the next 20 years. A specific reinforcement plan is given in Table D-5.3.

(2) Training/Education

The staff have general knowledge in chemistry and biology which is required for routine physical, chemical, and biological analyses. However, DAWSSA lab will not be able to implement more sophisticated analysis (pesticide, specialized biological analysis, etc.), which will become increasingly important in the next 20 years, unless DAWSSA takes the initiative in the training of laboratory staff.

- The lack of trained personnel is the leading reason why sophisticated chemical analysis has been so difficult in Syria. Instrumentation is much simpler problem.
- It takes at least one year of working (hands-on) experience before a technician learns enough about a sophisticated instrument.
- These specialized analyses have steep learning curves. Without directions of experienced analytical chemist, it is impossible to acquire such knowledge and experience.

DAWSSA is urged to launch a series of training programs for the laboratory staff. Examples of such programs are given in Table D-5.4.

(3) Space/Facility

The laboratory is situated in the basement of the old DAWSSA building. There are 6 small rooms in the laboratory, and 5 of them are connected in series, with a common entrance in the front of the building. The total area of the laboratory is about 130 m^2. These 6 rooms are used as an office, a laboratory for physical and chemical analyses, a laboratory for bacteriological analyses, a reagent storage room, a room for atomic absorption instrument, and a room for gas chromatography. There is no storage room. The lack of emergency door or window in the case of fire or explosion was noted.

A normal laboratory technician uses about 25 to 30 m^2 of space. The current laboratory is too small for any expansion of the laboratory capacity. The laboratory space has to be expanded first before the reinforcement of staff and equipment can take place. Table D-5.5 shows a suggested size of new water testing laboratory. A sample layout of the new laboratory is given in Figure D-5.1.

(d) Equipment

The lack of equipment is one of the major problems at DAWSSA lab. Table D-5.6 lists the analytical equipment a water testing laboratory should have. Many existing instruments at DAWSSA lab were provided by the European study team in early 1990's. These instruments are getting old, and many of them are out of order. The routine maintenance/repair services of existing instruments are virtually non-existing.

i) Analytical Equipment : Table D-5.6 summarizes the estimated number of various equipment needed at the DAWSSA lab. There are a number of equipment that have to be provided immediately. These instruments have to be purchased first. Because the existing laboratory is too small to house a lot of equipment, and because equipment has limited life, usually several years, it is not possible nor wise to procure all equipment at once. The purchase should be made on the priority basis, which should be reviewed every half year. Furthermore, it is extremely important to work out the training, maintenance, and repair plan at the time of purchase. A special service agreement should be arranged with the manufacturer: the maintenance and repair services should be promptly available in Damascus.

ii) Computer : The laboratory staff have no access to a computer for data handling and storage. All calculations are done either by hand or by a pocket calculator. All data are logged in notebooks. The data handling and record-keeping take up a large part of their time. There is a personal computer (Gateway) in the laboratory, but it is dedicated to a mass spectra database for GC-MS. If they analyze 50 samples a day for 20 items, the number of data is already 1,000. They need at least two personal computers and a printer for data processing.

iii) Mobile/Satellite Water Testing Service : In the current system, all samples are brought in from the sites. This system is not particularly efficient, as many tests can be done immediately on-site. In particular, in the event of emergency, such as accidental lack of residual chlorine in the distribution system, or epidemic of water-borne disease, it is essential to test as many water samples as possible. All drivers for sampling should be provided with portable water testing equipment and a cellular phone, to conduct on-site testing (Mobile Water Testing Service). The equipment may also be used as a backup when the main equipment in the laboratory does not work. In addition, all major distribution reservoirs should be equipped with basic water quality monitoring equipment (Satellite Water Testing Service), and the operator of reservoirs and fringe wells must be trained to conduct simple water testing.

5.4.2 Water Quality Control in South Damascus

High hardness and high nitrate concentration are the major water quality problems in the area. To abide these problems, a series of counter measures are considered here. As a pilot project, Kadam Railway well field was selected. Similar approaches are applicable to other wells.

(1) Constraint

The water quality in the area has to be improved without changing the local water pressure, or the local supply volume because the existing water supply system is not designed to handle high water pressure. The improvement of entire water supply network system is an option which may be considered in the future. However, such a large scale project is costly, and is difficult to implement immediately.

(2) Approach

The 5 approaches considered here are summarized in Table D-5.7. They are based on the water treatment and water blending.

6. ENVIRONMENTAL IMPACT ASSESSMENT OF PROPOSED PROJECTS

6.1 Environmental Consideration

A development project can cause significant and irreversible damage to the environment. To minimize adverse environmental impact by a development project, a series of environmental considerations have to be practiced in the course of planning, formulation, and implementation of the project. Table below shows various forms of environmental considerations.

Project and Environmental Consideration.

Stages of Project Implementation		Environmental Consideration
Preparatory Study		Preliminary Environmental Survey
Full-scale Study	Master Plan Study	Initial Environmental Examination (IEE)
	Feasibility Study	Environmental Impact Assessment (EIA)
Detailed Design		Design of Environmental Protection Measures
Construction		Implementation of Environmental Protection Measures
Operation		Environmental Monitoring

source : JICA Environmental Consideration Guideline, IX Water Supply, 1994

6.2 EIA in Syria

The overall structure for implementation of EIA is currently being developed with the assistance of METAP (Mediterranean Environmental Technical Assistance Program). This effort, which is financed by the World Bank and the European Investment Bank, is to formulate the EIA decree (Databook 9), general EIA guideline, specific EIA guidelines for various sectors, EIA procedures, and organizations for EIA.

An EIA is a set o procedures that is carried out by the following actors:
- the project proponent
- the permitting authority
- local authority
- stake holders (the potentially affected groups)
- the EIA unit at central or water basin level
- EIA consultant
- the Environmental Committee of the Governate

The flow of EIA procedures is given in Figure D-6.1.

For a number of activities, an EIA is mandatory. Such activities are defined in the EIA Decree (Databook 9). For example, the following water supply activities require EIA.

Water supply activities with compulsory EIA.

Activity	Criterion for EIA requirement
groundwater wells	yield ≧ 10 MCM/year
artificial or controlled infiltration of water	capacity ≧ 10 MCM/year
reservoirs	water pipelines with a diameter of more than 1 m and length of more than 10 km

For other activities, it is up to the decision of the GCEA/EIA-unit to decide whether an EIA is required. According to the Annex 2 of the draft EIA Decree, water basins which have a hydraulic connection with permanent or semi-permanent usable surface water or usable aquifers are designated as sensitive areas. For any major project in such area, EIA is likely to be obligatory.

6.3 Environmental Screening of Proposed Projects

6.3.1 Objectives

A number of projects were proposed in Chapter 5 of the main report. These projects are expected to bring positive environmental impacts (e.g., improved public health condition through safe drinking water supply), while some of them may damage the environment significantly. As a part of comprehensive project evaluation scheme (Section 5.6 of Main Report), therefore, the environmental impact of each project was assessed. The objectives of this master plan level environmental impact assessment (Initial Environmental Examination) are the followings :

i) assess the environmental impacts of the proposed project
ii) screen out projects with large negative environmental impact

6.3.2 IEE

Because Syria has the EIA regulations, the criteria for IEE were selected based on the Syrian EIA guideline, JICA Environmental Consideration guideline, and characteristics of the area. The following 5 aspects of environmental impacts were considered important.

Criteria for IEE.

Criteria	Example of environmental impact
1. Natural Environment	water : exploitation of water resources other : destruction of local vegetation and wild life
2. Public Health and Pollution	construction : noise, vibration, increase in traffic, dust operation : quality of supplied water, increase in hygiene, health standard, subsidence
3. Waste	disposal of various waste produced by the project, increase in waste water
4. Local Socio-Economic Change	water right, change in life style, local economy, and other factors
5. Cultural Asset	damage to historical and cultural asset (see Figure B-2.2 for the distribution of cultural assets).
Overall Assessment	overall environmental impact

Among the most important issues are :

i) Water quality of supplied water
ii) Exploitation of water resources

The results of the assessment is given in Table D-6.1. In general, the environmental impacts by the proposed projects seem to be small, and the proposed projects have significantly large positive environmental impact in public health.

6.3.3 Projects with High Environmental Impacts

- Water Quality Control in South Damascus, option 2 : This option considers the blending of water from Kadam Railway at Eastern Reservoir. Any project that involves transport of contaminant is considered undesirable. In addition, this scheme has the risk of contaminating the entire water supply system of Easter Reservoir.

- Reinforcement of Existing Water Resources, Damascus Well, Kadam Railway : Water from Kadam Railway contains elevated level of hardness and nitrate. If the water quality becomes unacceptable, countermeasures suggested in 1.9 Water Quality Control in South Damascus have to be considered.

- Reinforcement of Existing Water Resources, Damascus Well, Oumawiyin : There is a potential of pesticide pollution in Oumawiyin. Further investigation is strongly recommended.

- Reinforcement of Existing Water Resources, Damascus Well, University : Water from University well field contains high level of hardness and sulfate. Increased production from University will decrease the overall water quality of supplied water.

- Reinforcement of Existing Water Resources, Damascus Wells, Dummar : Water from Dummar contains high levels of hardness and sulfate. Increased production from Dummar will decrease the overall water quality of supplied water.

6.4 Environmental Examination of Master Plan Projects

In Chapter 6, a number of master plan projects were proposed, and their environmental impacts were semi-quantitatively evaluated in Section 5.6.7. According to the IEE (Section 5.6.7), most of these projects do not pose significant negative environmental impacts. To implement these projects, however, much detailed environmental impact assessments (EIAs) have to be conducted in the Feasibility Studies.

The proposed scope of the work for the Feasibility Study level EIAs are summarized in Table D-6.2. The components of the EIAs were selected based on the guideline for EIA by JICA. The following factors are considered crucial for the Feasibility Study level EIA.

6.4.1 Social Environment

- Cultural Asset : Damascus is an ancient city, and there are numerous known and yet-to-be-discovered cultural assets.

- Water Right : The allocation of the resources have to be coordinated with other parties.

- Public Health : Public health is the most important aspect of the social environmental impact. The water supplied by these projects has to be safe.

- Waste : Potential problems are the disposal of excavated soil and the increase in waste water.

6.4.2 Natural Environment

- Groundwater : Projects A-3 (Supply Improvement Projects) and Projects B-2 (Water Resources Development) may exploit regional groundwater resources. The extent of the exploitation has to be evaluated at the regional level.

- Surface Water : Although the proposed projects will not use surface water, exploitation of groundwater resources will affect the surface water (e.g., Barada river, Awaj river). Surface water is rare in the study area, and loss of surface water environment will cause secondary environmental impacts, such as loss of indigenous fish and amphibian species. The surface water pollution problems are also expected to be worsen.

- Flora and Fauna : The exploitation of groundwater resources in Hermon area may lead to the loss of indigenous flora and fauna that rely on the precious water resources in the area.

- Air Pollution : During construction, the release of dust and other SPM (suspended particulate matter) has to be minimized.

- Water Pollution : The increase in the water supply leads to the increase in the waste water. The projects have to be designed such that the whole life-cycle of supplied water does not cause significant environmental impact. In project 3.1 (Water Quality Testing Improvement), a new laboratory was proposed. The disposal of waste water from the laboratory has to be regulated, as it may contain various toxic chemicals such as heavy metals and pesticides.

- Noise and Vibration : The level of noise and vibration has to be minimized during the construction.

TABLES

Table D-2.1 Release of Nitrogen and Phosphorous from Each Administrative District

Area	District	Population	Area	Density	Nitrogen*	Phosphorous**
		person	km2	person/km2	kg/year	kg/year
Villages	Figeh	3975	0.44	9034	1.45E+04	2.90E+03
	Al Khadra	2231	0.12	18592	8.14E+03	1.63E+03
	Bassime	468	0.18	2600	1.71E+03	3.42E+02
	Ashrafye Wadi	3311	0.27	12263	1.21E+04	2.42E+03
	Judayde	4464	0.53	8423	1.63E+04	3.26E+03
	Hame	21570	0.56	38518	7.87E+04	1.57E+04
	Jemarya	2034	0.05	40680	7.42E+03	1.48E+03
	Kudsaya	43398	1.58	27467	1.58E+05	3.17E+04
	Takadom	36750	0.55	66818	1.34E+05	2.68E+04
	Millitary Area	14040	0.85	16518	5.12E+04	1.02E+04
	Maaraba	n.a.	n.a.	n.a.	n.a.	n.a.
Damascus	Ruku Aldyn	166768	4.37	38162	6.09E+05	1.22E+05
	Mouhajreen	77461	3.63	21339	2.83E+05	5.65E+04
	Mezze	110002	13.28	8283	4.02E+05	8.03E+04
	Cafarsousse	96021	12	8002	3.50E+05	7.01E+04
	Kanawat	66761	2.69	24818	2.44E+05	4.87E+04
	Kadam	64175	3	21392	2.34E+05	4.68E+04
	Midan	143579	2.96	48506	5.24E+05	1.05E+05
	Old City	18493	1.45	12754	6.75E+04	1.35E+04
	Shaghour	65631	4.7	13964	2.40E+05	4.79E+04
	Sarouja	117617	3.49	33701	4.29E+05	8.59E+04
	Yarmouk	214689	2.27	94577	7.84E+05	1.57E+05
	Jobar	104106	6.42	16216	3.80E+05	7.60E+04
	Berze	75899	6.73	11278	2.77E+05	5.54E+04
	Kaboon	51592	4.97	10381	1.88E+05	3.77E+04
	Dummar	49415	4.73	10447	1.80E+05	3.61E+04
	Kassion Mountain	n.a.	n.a.	n.a.	n.a.	n.a.
	Total				5.67E+06	1.13E+06

n.a. : population data not available
* : total-N load assuming 10 g/day/person
** : total-P load assuming 2 g/day/person

Table D-2.2 Major Polluting Industries in Damascus (BRGM, 1991)

area	major polluting industries	size of operation	effluent treatment
Harneh and Doumar	detergent, asbestos cement, brewery	10 major polluting industries employing 1,700 workers	no; discharge to Barada river and Tora river
Kaboon	textile, food canning, electronics, washing machine	largest industrial area in Damascus;131 industries in total; 38 major polluting companies employing 11,750 workers	limited; discharge to Tora river
Harasta	yeast	6 polluting industries	no; discharge to Tora river
Old City	dye, metal plating, meatal casting	numerous small industries	no; discharge to Banias river and Barada river
East Ghouta	match, weaving, dyeing, rubber, food cannning, meat (slaughterhouses), pharmaceutical	12 major polluting industries	no; discharge to Barada river
East Ghouta Tannery	tannery	at least 85 tanneries, 17 major tanneries	limited; discharge to Barada river
Ibn Assaker Industrial Complex	metal plating, plastic, food	21 polluting factories	limited; discharge to Banias river
Sit Zeinab Road	textile, tile, plastic, electroplating	a textile factory employing 2,000 workers; small facotries	limited
Tarik El Keswa	battery, tile, food, utensils, ceramics, metal plating		limited; discharge to Banias river and Sit Zeinab canal

source : BRGM report, 1991

Table D-3.1 (1/2) Sampling Locations

Area	#	name	Jun-96	Jul-96	Aug-96	Heavy Metal	Pesticide	water source	remarks
Zabadani Area	1	Barada Spring	O	-	O	O	O	groundwater	A major spring. and the source of Barada river.
	2	Barada Well 1 (#4)	O	-	O	-	-	groundwater	A major water resources. Produces about 7% of total DAWSSA water.
	3	Barada Well 2 (#3)	O	-	O	-	-	groundwater	A major water resources. Produce about 8% of total DAWSSA. Well #3 is located in the eastern part of the well fields, and the closest to the spring.
	4	Zabadani Well 1 (irrigation)	O	-	-	-	-	groundwater	An Arabic well used by local farmers. 15 m deep. Near DAWSSA well field #1. A shallow well in intensive agricultural zone in Zabadani.
	5	Zabadani Well 1' (irrigation)	O	-	-	-	-	groundwater	A well located near Zabadani Well 1, and is used by local farmers. 120 m deep.
	6	Zabadani Well 1" (irrigation)	-	-	O	-	-	groundwater	An Arabic well used by local farmers. A shallow (6 m) well in intensive agricultural zone of Zabadani.
	7	Zabadani Well 1"' (irrigation)	-	-	O	-	-	groundwater	An Arabic well used by local farmers. A shallow (15 m) well in intensive agricultural zone of Zabadani.
	8	Zabadani Well 2 (irrigation)	O	-	O	-	-	groundwater	A well used by local farmers. Near DAWSSA well filed #2. A well in intensive agricultural zone in Zabadani. 100 m deep.
	9	Zabadani Well 3 (irrigation)	O	-	O	-	-	groundwater	A well used by local farmers. Near DAWSSA well filed #3. A well in intensive agricultural zone in Zabadani. 85 m deep.
	10	Sarada Spring	O	-	-	-	-	groundwater	A potential waer resource (spring) near the Syria-Lebanon border.
	11	Ain Blrk	O	-	-	-	-	groundwater	A potential water resource (spring) in Zabadani.
	12	Naboua	O	-	-	-	-	groundwater	A potential water resource (spring) in Zabadani.
Figeh Area	13	Figeh Main Spring	O	-	O	O	O	groundwater	The main water resources which produces over 80% of water used by DAWSSA.
	14	Figeh Side Spring	O	-	O	-	-	groundwater	A spring next to the main Figeh spring.
	15	Ain Haroush	O	-	O	-	-	groundwater	A well field near Figeh spring
	16	Deir Moukaren	O	-	O	-	-	groundwater	A well field in Deir Moukaren.
	17	Barada Water at Figeh	-	-	O	-	-	groundwater	The water sample from Barada wells. Collected at the Energy Dissipation Basin before mixing.
	18	Energy Dissipation Basin	O	-	O	-	-	groundwater	Mixture of Barada, Figeh, Deir Moukaren and Ain Haroush waters. Before chlorination.
Damascus Area	19	Mazraa (mix)	O	-	O	O	O	groundwater	One of 8 main well fileds in Damascus.
	20	Mazraa (#11)	O	-	O	-	-	groundwater	One of the most polluted wells in Mazraa well fields.
	21	Ibn Assaker (mix)	O	-	O	O	O	groundwater	One of the 8 main well fields in Damascus.
	22	Oumawlyin (mix)	O	-	O	O	O	groundwater	One of the 8 main well fileds in Damascus.
	23	Oumawlyin (#6)	O	-	O	-	-	groundwater	A well located in Tishreen Park.
	24	Jobar (well 12)	O	-	O	O	O	groundwater	One of the 8 main well fields in Damascus.
	25	Kaboon (well)	O	-	O	-	-	groundwater	One of the 8 mian well fields in Damascus.
	26	Kadam Railway (mix)	O	-	O	-	-	groundwater	One of the 8 main well fields in Damascus.
	27	Kadam Railway (# 5)	O	-	O	-	-	groundwater	A well in Kadom Railway well field.
	28	University (#13)	O	-	O	O	-	groundwater	One of the 8 main well fileds in Damascus.
	29	University (#11)	O	-	O	-	-	groundwater	One of the most polluted well in University well field.
	30	Kadam Store (mix)	O	-	O	-	-	groundwater	One of the 8 main well fields in Damascus.
	31	Dummar (private irrigation)	O	-	O	-	-	groundwater	A privately owned well, located near DAWSSA well field which is currently under development. 100 m deep.
	32	Takadom (municipal)	O	-	O	-	-	groundwater	A shallow well used for a swimming pool. Located near a DAWSSA well filed which is currently under development.
	33	Kachkoul (Fringe 1)	O	-	O	-	-	groundwater	DAWSSA Fringe well
	34	Halabneh (Fringe 6)	O	-	O	-	-	groundwater	DAWSSA Fringe well
	35	Burg al Zahera (Fringe 7)	O	-	O	-	-	groundwater	DAWSSA Fringe well
	36	Daf al Ward (Fringe 9)	O	-	O	-	-	groundwater	DAWSSA Fringe well
	37	Karem Taha (Fringe 11)	O	-	O	O	-	groundwater	DAWSSA Fringe well
	38	Kafar Souseh (Fringe 23)	O	-	O	-	-	groundwater	DAWSSA Fringe well
	39	Amid School (Emergency 51)	O	-	O	-	-	groundwater	An emergency well located on the northern hight of the city.
	40	Communication Center	-	-	O	-	-	groundwater	A deep (160 m) private irrigation well in Mezze area.
	41	Yabugha	-	-	O	-	-	groundwater	A government owned well in central Damascus.
	42	National Museum		O		-	-	groundwater	A well in the National Museum.
Hermon - Houran Area	43	Beit Jenn	O	-	-	-	-	groundwater	A potential water resource (spring) in Golan Height.
	44	Beit Jenn Pool	-	O	-	-	-	groundwater	A potential water resource (spring) in Golan Height.
	45	Beit Jenn River	-	O	-	-	-	groundwater	A potential water resource (spring) in Golan Height.
	46	Talmasieh	O	-	-	-	-	groundwater	A potential water resource near Syria - Jordan border.

Table D-3.1 (2/2) Sampling Locations

Area	#	name	Jun-96	Jul-96	Aug-96	Heavy Metal	Pesticide	water source	remarks
	47	Membej	O	-	-	-	-	groundwater	A potential water resource near Syria - Jordan border.
	48	Near Artooz	O	-	-	-	-	groundwater	A potential water resource in the southwest suburb of Damascus.
	49	Katana 50	O	-	-	-	-	groundwater	A potential water resource in the southwest suburb of Damascus.
	50	Katana 51	O	-	-	-	-	groundwater	A potential water resource in the southwest suburb of Damascus.
	51	Shebani	-	O	-	-	-	groundwater	A potential water resource in Hermon Mountain.
	52	Knasa	-	O	-	-	-	groundwater	A potential water resource in Hermon Mountain.
	53	Yaafoor	O	-	-	-	-	groundwater	A potential water resource in northern Hermon Mountain.
	54	Tabibiyeh	-	O	-	-	-	groundwater	A potential water resource in the sourth of Damascus.
Networks	55	Energy Dissipation Basin	O	-	O	-	-	network	Mixture of water from Barada, Figeh, Deir Moukaren, and Ain Haroush, which is sent to the Wali reservoir. After chlorination.
	56	Wali Reservoir	O	-	O	-	-	network	The main reservoir (capacity 69,000 m^3) from which water from Figeh and Barada is distributed to Dmascus.
	57	Western Reservoir II.O	O	-	O	-	-	network	A major reservoir with capacity 42,700 m^3.
	58	Eastern Reservoir II.E	O	-	O	-	-	network	A major reservoir with capacity of 28,000 m^3, located in the Berze area.
	59	Mezze (tap)	O	-	O	-	-	network	Tap water samples colleted from a restaurant (June) and from Communication Center (August) in Mezze Medium pressure zone.
	60	Berze (tap)	O	-	O	-	-	network	A tap water sample collected from a utility building in Berze Medium Pressure zone.
	61	Tabbaleh (tap)	O	-	O	-	-	network	A tap water sample collected from a shop in Damascus Center Low zone.
	62	Kadam (tap)	O	-	O	-	-	network	A tap water sample collected from a gas station in Damascus Center Low zone.
	63	Arnauot Street (tap)	O	-	O	-	-	network	A tap water sample collected from Damascus Center Low zone.
	64	Jobar (tap)	O	-	O	-	-	network	A tap water sample collected from a shop in Damascus Center Low zone.
	65	Kafar Souseh (tap)	O	-	O	-	-	network	A tap water sample collected at the Kafar Sousseh well station in Damascus Center Low zone.
Barada River	66	Tekieh	O	-	O	-	O	river	Downstream of intensive agricultural area of Zabadani.
	67	Haroush	O	-	-	-	-	river	Near Ain Haroush well field.
	68	Figeh	O	-	O	-	-	river	Upstream of Figeh springs.
	69	University	O	-	O	-	-	river	Upstream of Damascus.
	70	Al Jourah	O	-	O	O	-	river	Downstream of the resdiential and commercial area of the city.
	71	Dabaghat	O	-	O	O	O	river	Downstream of the industrial area of the city.
	72	Gota Road	O	-	O	-	-	river	Downstream of the industrial area of the city.
Tora River	73	Tishreen Park	O	-	O	-	-	river	Upstream of Damascus.
	74	Jaoubar	O	-	-	-	-	river	Downstream of the resdiential and commercial areas of the city.
Yazid River	75	Shamy Hosppital	O	-	O	-	-	river	Upstream of Damascus.
	76	Massaken Barzeh	O	-	O	-	-	river	Industrial zone along Yazid river.

note: O a sample was taken; - no sample was taken.

Table D-3.2 (1/2) Analyzed Items

Item	Symbol	Unit	Method	In-situ Measurement	Comments
Water Temperature	Temp.	℃	thermometer	○	
Odor		-	sniff test	○	
Taste		-	tasting test	○	Analysis was limited to chlorinated water from water supply system.
Color		degree	portable color comparator	○	It measues the intensity of yellow-brown color: 1 degree = aqueous solution containing 1 mg/L Pt and 0.5 mg/L Co solution).
Turbidity		NTU/degree	turbidimeter (Hach 2100A) and portable turbidity comparator	○	
Filed pH	pH		ion selective pack test	○	This is the pH under field condition. The pressure of CO_2 is usually higher underground, and pH may be lower than RpH.
Equilibrium pH	RpH		colorimeter (Wallace & Tiernan Type 1000)		pH in equilibrium with atmosphere.
Electrical Conductivity	EC	μS/cm	EC meter (Hach dr/2)		It is an estimate of ion cocentration.
Total Evaporation Residue		mg/L (105 ℃)	balance		Sum of dissolved and suspended (e.g., clays) materials in water.
Total Dissolved Solids	TDS	mg/L	calculation		It was estimated from the concentrations of major ions.
Ion Balance		meq/L	calculation		This was calculated from the concentrations of major ions to verify the accuracy of analysis in terms of electrical neutrality.
Major Cations					
Calcium	Ca^{2+}	mg/L	EDTA titration		The properties of colloids, such as hardness and flocculation of clays, are affected. The study area is rich in Ca.
Magnesium	Mg^{2+}	mg/L	EDTA titration		The properties of colloids, such as hardness and flocculation of clays, are affected.
Sodium	Na^{+}	mg/L	flame photometer (Corning 410)		
Potassium	K^{+}	mg/L	flame photometer (Corning 410)		
Major Anions					
Cloride	Cl^{-}	mg/L	$AgNO_3$ titration		Cl concentration is often associated with human activities.
Sulfate	SO_4^{2-}	mg/L	turbidity (Hellige 950)		
Bicarbonate	HCO_3^{-}	mg/L	calculation		Estimated from the alkalinity and pH.
Carbonate	CO_3^{2-}	mg/L	calculation		Estimated from the alkalinity and pH.
Total Alkalinity	TAC	meq/L	HCl titration		Amount of acid required to reduce the pH to 4.3. Usually reflect the amount of carbonate/bicarbonate, and other weak electrolytes.
Total Hardness	TH	mg/100 mL as CaCO3	EDTA titration		Hardness is an indication of amount of soap precipiated by the water, mainly due to Ca and Mg ions. Water with extremely high hardness causes diarrhea, and reduces the effectiveness of soap.
Magnesium Hardness	TH/Mg		EDTA titration		Hardness caused by magnesium.

Table D-3.2 (2/2) Analyzed Items

Saturation Index	SI		calculation from ion composition		SI estimates the CaCO3 precipitation or dissolution tendencies. Water with SI > 0 is oversaturated with CaCO3 and may cause scaling problem. Water with SI < 0 is undersaturaed with CaCO3, and may be corrosive.
Nitrogen					
Ammonium	NH_4-N	mg/L	ion selective pack test Nesller reagent (qualitative)		Formed by the degradation of nitrogen-containing organic matter. Indicates the pollution by sewage.
Nitrite	NO_2-N	mg/L	ion selective pack test	○	Formed by oxydadtion of NH_3 form nitrogen. Indication of pollution by sewage.
Nitrate	NO_3-N	mg/L	colorimetry (Lovibond AF386)		Formed by oxydation of NH4 and NO2 form nitrogen. Indicates pollution by sewge.
$KMNO_4$ demand		mg $KMnO_4$/L	titration		Measure of oxidizable organic matter in water. Indicates pollution by sewage.
Metals					
Iron	Fe	mg/L	atomic absorption (Varian SpectrAA-10)		Iron level may indicate the corrosion problem.
Manganese	Mn	mg/L	atomic absorption (Varian SpectrAA-11)		Forms insoluble precipiation in water supply system.
Sanitary Condition					
Total bacteria count		CFU/100mL	plate, Tergitol 7-Agar		The count relects the contamination of human and animal origin.
Total coliform count		CFU/100mL	plate,Tergitol 7-Agar		An ideal indicator for water contaminated with pathogenic bacteria.
Residual Chlorine	Cl2	mg/L	DPD method, Wallace & Tiernan photometer, colorimeter		Measure of sterilization status.

Table D-3.3 Heavy Metals and Pesticides Analyzed in This Study

substance	item
heavy metals	Pb, Cd, Cr, Cu, Zn, Fe, Mn, Hg, Ni, Co
pesticides	- chlorinated pesticides lindane, dieldrin, aldrin, DDT, DDE, methoxychlor, heptachlor, endosulfan - organo-nitrogen/phosphorous pesticides chlorpyrifos, fenitrothion, chlorpyrifos-methyl, bromophos, dichlorvos, methidathion, dimethoate, methylparathion

Table D-3.4 (1/9) Results of General Water Quality Analyses

Area	#	name	sampling date	chlorination	temp. (air)	temp. (water)	EC	odor	taste	color	field turbidity	lab turbidity	field pH	lab pH	total hardness	Ca
			y/m/d		°C	°C	μS/cm			degree	degree	NTU			mg CaCO3/L	mg/L
Syrian Std.						5 - 25	1500	acceptable	acceptable	15 TCU	5	5	6.5-8.5	6.5 - 8.5	500	
WHO Guideline										(15 TCU)	(5 NTU)	(5 NTU)				
Japanese Std.								acceptable	acceptable	5	2	2 degree	5.8-8.5	6.5 - 8.5	300	
Zabadani Area	1	Barada Spring	96/6/17	no	24	14	375	no	-	2	< 1	1.0	7.3	7.5	200	64
			96/8/22	no	30	16	325	no	-	2	1	0.5	8.1	7.7	190	56
	2	Barada Well 1 (#4)	96/6/17	no	20	14	325	no	-	2	< 1	1.0	7.3	7.5	190	60
			96/8/22	no	22	14	325	no	-	< 2	< 1	0.5	7.8	7.7	190	56
	3	Barada Well 2 (#3)	96/6/17	no	29	15	375	no	-	2	< 1	1.0	7.4	7.5	200	64
			96/8/22	no	24	15	350	no	-	< 2	< 1	1.5	7.4	7.7	190	56
	4	Zabadani Well 1 (irrigation)	96/6/17	no	24	17	475	no	-	2	1 to 2	1.0	7.3	7.5	260	80
	5	Zabadani Well 1' (irrigation)	96/6/17	no	24	17	550	no	-	2	2	0.5	7.1	7.3	300	92
	6	Zabadani Well 1'' (irrigation)	96/8/22	no	22	19	675	algae	-	5	4	3.5	7.5	7.5	460	132
	7	Zabadani Well 1''' (irrigation)	96/8/22	no	22	14	890	algae	-	2	1	2.5	7.4	7.3	460	128
	8	Zabadani Well 2 (irrigation)	96/6/17	no	26	18	475	plastic	-	> 10	2	7.5	7.0	7.3	260	80
			96/8/22	no	23	18	475	plastic	-	5	2-5	3.5	7.4	7.3	250	76
	9	Zabadani Well 3 (irrigation)	96/6/17	no	26	18	775	no	-	2 to 5	2	1.0	7.3	7.5	420	124
			96/8/22	no	23	17	425	no	-	< 2	< 1	1	7.6	7.5	240	72
	10	Sarada Spring	96/6/18	no	-	-	450	-	-	-	-	0.5	-	7.5	260	76
	11	Ain El Irk	96/6/18	no	-	-	275	-	-	-	-	0.5	-	7.9	170	40
	12	Naboua	96/6/18	no	-	-	475	-	-	-	-	1.0	-	7.3	270	84
Figeh Area	13	Figeh Main Spring	96/6/18	no	24	11	275	no	no	< 2	< 1	1.0	7.3	7.9	150	40
			96/8/24	no	19	13	290	no	no	2	1	0.5	7.8	7.9	150	40
	14	Figeh Side Spring	96/6/18	no	24	12	325	no	no	2 to 5	< 1	2.0	7.7	7.7	180	52
			96/8/24	no	22	14	390	no	-	2	1	2	7.8	7.7	210	60
	15	Ain Haroush	96/6/18	no	24	14	450	no	-	5	5	5.5	7.3	7.5	250	76
			96/8/24	no	20	15	490	no	-	2 - 5	1	5	7.2	7.5	260	76
	16	Deir Moukaren	96/6/20	no	-	-	425	-	-	-	-	2.0	-	7.7	250	68
			96/8/24	no	20	16	450	no	-	2 - 5	2	2	7.8	7.7	230	60
	17	Barada Water at Figeh	96/8/24	no	20	16	350	iron	-	> 10	> 5	15	8.0	7.9	180	52
	18	Energy Dissipation Basin	96/6/18	no	22	15	325	no	no	5	< 1	2.0	7.5	7.7	180	52
			96/8/24	no	22	14	325	no		2	< 1	1.5	8.0	7.7	180	48
Damascus Area	19	Mazraa (mix)	96/6/16	no	24	16	750	no	-	< 2	< 1	3.5	7.0	7.5	380	92
			96/8/21	yes	28	17	750	no	no	< 2	1	0.5	8.1	7.3	370	96
	20	Mazraa (well #11)	96/6/16	no	24	16	700	no	-	< 2	< 1	0.5	7.2	7.5	350	88
			96/8/21	no	28	16	690	no	no	2	1	0.5	8.3	7.5	310	80
	21	Ibn Assaker (mix)	96/6/16	yes	30	17	725	no	-	2	2	0.5	7.3	7.6	350	104
			96/8/21	no	21	17	725	no	-	< 2	1	0.5	7.1	7.3	330	96
	22	Oumawyin (mix)	96/6/23	no	24	15	575	no	-	2	< 1	1.0	7.2	7.5	320	92
			96/8/25	no	29	16	600	no	-	2	1	1	7.4	7.3	320	92
	23	Oumawyin (well #6)	96/6/19	no	30	16	575	no	-	< 2	1	2.5	7.2	7.5	290	88
			96/8/25	no	29	17	625	no	-	< 2	< 1	1	7.7	7.3	320	100
	24	Jobar (well #12)	96/6/16	no	30	16	775	no	-	2	1	0.5	7.0	7.3	410	116
			96/8/21	no	32	17	750	no	-	2	2	0.5	7.1	7.3	400	116
	25	Kaboon (well #1)	96/6/16	no	32	16	700	soil-like	-	< 2	1	12.0	7.4	7.5	390	84
			96/8/21	no	25	18	675	no	-	2	2	0.5	7.7	7.5	350	68
	26	Kadam Railway (mix)	96/6/15	no	32	21	950	no	-	2 to 5	2 to 5	8.0	7.2	7.3	480	128

note - : not measured

Table D-3.4 (2/9) Results of General Water Quality Analyses

Area	#	name	sampling date	chlorination	temp. (air)	temp. (water)	EC	odor	taste	color	field turbidity	lab turbidity	field pH	lab pH	total hardness	Ca
			y/m/d		℃	℃	µS/cm			degree	degree	NTU			mg CaCO3/L	mg/L
Syrian Std.						5 - 25	1500	acceptable	acceptable	15 TCU	5	5	6.5-8.5	6.5 - 8.5	500	
WHO Guideline										(15 TCU)	(5 NTU)	(5 NTU)				
Japanese Std.								acceptable	acceptable	5	2	2 degree	5.8-8.5	6.5 - 8.5	300	
			96/8/20	yes	25	17	900	no	no	< 2	1.5	0.25	7.7	7.2	450	124
	27	Kadam Railway (well # 5)	96/6/15	no	27	19	975	no	-	> 10	5	7.5	7.3	7.3	500	132
			96/8/20	no	28	17	900	no	-	2	2	0.5	7.1	7.2	460	124
	28	University (well # 13)	96/6/19	no	29	17	1150	no	-	< 2	< 1	0.5	7.0	7.3	490	136
			96/8/25	no	20	17	1150	no	-	2	< 1	1	7.2	7.3	480	140
	29	University (well # 11)	96/6/19	no	29	17	1400	no	-	< 2	< 1	0.5	7.0	7.3	530	146
			96/8/25	no	22	17	1475	no	-	2	< 1	1	7.3	7.4	520	148
	30	Kadam Store (mix)	96/6/15	no	32	18	850	no	-	< 2	< 1	1.5	7.0	7.3	440	128
			96/8/20	no	24	18	875	no	-	< 2	1	0.5	7.0	7.2	420	116
	31	Dummar (private irrigation)	96/6/19	no	26	16	1250	sulfur	-	> 10	> 5	15.0	7.1	7.3	660	188
			96/8/25	no	24	16	1175	sulfur	-	> 10	> 5	55	7.5	7.3	640	188
	32	Takadom (municipal)	96/6/15	no	29	22	775	no	-	2	1	1.5	7.2	7.3	380	104
			96/8/20	no	25	18	800	no	-	< 2	2	0.25	7.4	7.2	380	112
	33	Kachkoul (Fringe 1)	96/6/15	no	29	17	775	no	-	2	< 1	1.5	7.4	7.5	370	116
			96/8/20	no	24	17	725	no	-	2	1	0.25	7.4	7.4	360	112
	34	Halabneh (Fringe 6)	96/6/15	no	27	17	800	no	-	< 2	1	1.0	7.2	7.3	390	116
			96/8/20	no	24	18	800	no	-	2 - 5	2	1.25	7.4	7.2	390	116
	35	Burg al Zahera (Fringe 7)	96/6/15	no	28	17	700	no	-	2	< 1	0.5	7.1	7.5	360	104
			96/8/20	no	24	17	700	no	-	2	1	0.5	7.7	7.3	350	100
	36	Daf al Ward (Fringe 9)	96/8/15	no	27	18	700	no	-	5	< 2	1.0	7.1	7.3	360	104
			96/8/20	no	24	17	700	no	-	< 2	2	0.25	7.4	7.2	350	104
	37	Karem Taha (Fringe 11)	96/6/16	no	29	18	900	no	-	2	< 1	1.0	6.9	7.3	480	116
			96/8/21	no	24	18	900	no	-	2	1.5	1.0	7.0	7.3	480	116
	38	Kafar Souseh (Fringe 23)	96/6/24	no	26	16	775	no	-	2	< 1	1.5	7.5	7.5	370	108
			96/8/25	no	23	17	800	no	-	< 2	< 1	1.5	7.3	7.3	390	108
	39	Amid School (Emergency 51)	96/6/19	no	23	16	650	metallic	-	> 10	> 5	60	7.5	7.5	330	92
			96/8/20	no	23	17	675	no	-	< 2	< 1	6.5	7.4	7.7	300	56
	40	Communication Center	96/8/27	no	25	15	1125	no	-	> 10	> 5	20	6.7	8.0	220	44
	41	Yabughe	96/8/12	no	-	-	592	-	-	-	-	1.2	-	7.4	297	91
	42	National Museum	96/7/30	no	-	-	525	-	-	-	-	0.5	-	7.7	280	80
Hermon - Houran Area	43	Beit Jenn	96/6/30	no	-	-	225	-	-	-	-	2.5	-	8.1	120	36
	44	Bit Jenn Pool	96/7/30	no	-	-	290	-	-	-	-	1.0	-	7.7	150	40
	45	Bit Jenn River	96/7/30	no	-	-	290	-	-	-	-	1.5	-	7.7	150	40
	46	Talmasieh	96/6/30	no	-	-	325	-	-	-	-	1.5	-	7.5	170	56
	47	Membej	96/6/30	no	-	-	300	-	-	-	-	1.0	-	7.5	160	52
	48	Near Artooz	96/6/30	no	-	-	525	-	-	-	-	1.0	-	7.5	270	88
	49	Katana 50	96/6/30	no	-	-	300	-	-	-	-	1.0	-	7.7	180	60
	50	Katana 51	96/6/30	no	-	-	700	-	-	-	-	1.0	-	7.5	370	120
	51	Shebani	96/7/2	no	-	-	575	-	-	-	-	1.0	-	7.5	330	88
	52	Knasa	96/7/2	no	-	-	400	-	-	-	-	1.0	-	7.7	220	68
	52	Yaafoor	96/6/30	no	-	-	350	-	-	-	-	1.0	-	7.7	190	64
	53	Yaafoor	96/6/30	no	-	-	350	-	-	-	-	1.0	-	7.7	190	64
	54	Tabbiyeh	96/7/2	no	-	-	525	-	-	-	-	1.5	-	7.5	290	92

note - : not measured

Table D-3.4 (3/9) Results of General Water Quality Analyses

Area	#	name	sampling date	chlorination	temp. (air)	temp. (water)	EC	odor	taste	color	field turbidity	lab turbidity	field pH	lab pH	total hardness	Ca
			y/m/d		℃	℃	μS/cm			degree	degree	NTU			mg CaCO3/L	mg/L
Syrian Std.						5 - 25	1500	acceptable	acceptable	15 TCU	5	5	6.5-8.5	6.5 - 8.5	500	
WHO Guideline										(15 TCU)	(5 NTU)	(5 NTU)				
Japanese Std.								acceptable	acceptable	5	2	2 degree	5.8-8.5	6.5 - 8.5	300	
Networks	55	Energy Dissipation Basin	96/6/18	yes	24	14	325	no	-	5	< 1	2.0	7.7	7.7	180	52
			96/8/24	yes	22	14	325	no	-	2	< 1	1.5	8.0	7.7	180	48
	56	Wali Reservoir	96/6/20	yes	25	14	350	chlorine	no	2	< 1	2.0	7.6	7.7	190	52
			96/8/26	yes	25	14	325	no	no	< 2	< 1	1.0	7.6	7.9	190	52
	57	Western Reservoir II.O	96/6/20	yes	20	13	350	chlorine	no	5	1	4.0	7.3	7.7	190	52
			96/8/26	yes	20	14	325	no	no	< 2	< 1	1.0	7.7	7.9	190	52
	58	Eastern Reservoir II.E	96/6/20	yes	24	15	375	chlorine	no	2	< 1	2.0	7.6	7.7	210	56
			96/8/26	yes	20	15	325	no	-	2	< 1	1.0	7.7	7.9	190	52
	59	Mezze (tap)	96/6/23	yes	24	16	325	no	no	2	1	2.0	7.4	7.7	190	52
			96/8/27	yes	-	-	460	-	-	-	-	1.0	-	7.9	230	64
	60	Berze (tap)	96/6/23	yes	25	17	500	no	no	2 to 5	1	1.5	7.2	7.7	260	72
			96/8/28	yes	26	17	325	no	no	< 2	< 1	3.5	7.7	7.7	200	56
	61	Tabbaleh (tap)	96/6/23	yes	31	19	700	no	no	2	1	1.0	7.4	7.5	350	104
			96/8/28	yes	27	19	700	no	no	2 - 5	2	1.5	7.7	7.5	350	104
	62	Kadam (tap)	96/6/23	yes	26	15	375	no	no	2	1	3.5	7.6	7.7	200	56
			96/8/28	yes	27	21	860	no	-	> 10	> 5	0.5	7.5	7.5	440	116
	63	Amauout Street	96/8/28	yes	27	22	875	no	no (salt?)	2	1.5	1.0	7.4	7.5	440	116
	64	Jobar (tap)	96/8/28	yes	25	18	750	no	no	2	1	1.5	7.4	7.3	400	112
	65	Kafar Souseh (tap)	96/6/19	yes	25	16	-	no	-	5 to 10	1	-	7.5	-	-	-
Barada River	66	Tekieh	96/6/17	no	28	17	375	algae - fish	-	> 10	< 2	3.5	8.0	7.9	200	64
			96/8/26	no	24	18	375	algae	-	> 10	2	15	7.8	7.7	210	64
	67	Haroush	96/6/18	no	24	17	425	sewage	-	10	2	3.0	8.0	7.9	220	68
			96/8/26	no	-	-	-	-	-	-	-	-	-	-	-	-
	68	Figeh	96/6/18	no	25	16	500	sewage	-	> 10	> 5	9.0	7.8	7.5	250	76
			96/8/24	no	23	18	475	sewage	-	> 10	> 5	100	8.0	8.1	200	60
	69	University	96/6/22	no	24	17	675	sewage	-	> 10	> 5	25	7.8	7.5	300	88
			96/8/27	no	25	20	730	sewage	-	> 10	> 5	20	7.7	7.5	330	96
	70	Al Joursh	96/6/22	no	30	22	925	sewage	-	> 10	> 5	> 1000	7.8	7.5	280	112
			96/8/27	no	30	23	700	sewage	-	> 10	> 5	100	8.0	7.3	290	76
	71	Dabaghat	96/6/22	no	32	22	1025	sewage	-	> 10	> 5	> 1000	8.2	7.9	300	80
			96/8/27	no	30	22	2500	dead animal	-	> 10	> 5	150	9.0	8.3	250	64
	72	Gota road	96/6/22	no	30	21	750	sewage	-	> 10	> 5	> 200	7.3	7.5	260	72
			96/8/27	no	28	22	800	sewage	-	> 10	> 5	200	8.3	7.5	290	84
Tora River	73	Tishreen Park	96/6/22	no	24	17	625	sewage	-	> 10	> 5	25	7.9	7.7	310	92
			96/8/25	no	30	22	650	sewage		> 10	> 5	25	8.5	7.9	310	88
	74	Jobar	96/6/23	no	31	22	850	oil	-	> 10	> 5	> 1000	9.4	> 10	120	24
			96/8/27	no	-	-	-	-	-	-	-	-	-	-	-	-
Yazid River	75	Shamy Hosppital	96/6/22	no	24	18	625	sewage	-	> 10	> 5	> 100	8.1	7.7	290	80
			96/8/27	no	25	24	600	sewage	-	> 10	> 5	25	8.7	8.1	290	84
	76	Massaken Barzeh	96/6/22	no	31	23	325	sewage	-	> 10	> 5	50	7.6	7.5	240	64
			96/8/27	no	29	25	720	sewage	-	> 10	> 5	200	7.4	7.3	230	60

note - : not measured

Table D-3.4 (4/9) Results of General Water Quality Analyses

Area	#	name	sampling date	Mg	Na	K	NH4	total cation	total alkalinity	HCO3	CO3	SO4	Cl	NO3	NO2	total anion
			y/m/d	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L	mg/L	mg/L	mg/L	mg/L	mg-NO3/L	mg-NO2/L	meq/L
Syrian Std.					200		0.05					250	250	44	0.03	
WHO Guideline					(200)		(1.5)					(250)	(250)	50	3	
Japanese Std.					200								200	10 mg-N(NO3+NO2)/L		
Zabadani Area	1	Barada Spring	96/6/17	10	4	0.5	N	4.2	3.6	220	0	13	8	4	< 0.02	4.2
			96/8/22	12	3	0.5	< 0.1	4.0	3.6	220	0	15	8	4	< 0.02	4.5
	2	Barada Well 1 (#4)	96/6/17	10	4	0.5	N	4.0	3.4	210	0	13	8	4	< 0.02	4.0
			96/8/22	12	3	0.5	< 0.1	4.0	3.6	220	0	9	8	4	< 0.02	4.3
	3	Barada Well 2 (#3)	96/6/17	10	4	0.5	N	4.2	3.6	220	0	13	8	4	< 0.02	4.2
			96/8/22	12	3	0.5	< 0.1	4.0	3.6	220	0	15	8	4	< 0.02	4.5
	4	Zabadani Well 1 (irrigation)	96/6/17	15	7	1.5	N	5.6	4.2	260	0	32	14	5	0.05	5.4
	5	Zabadani Well 1' (irrigation)	96/5/17	17	7	1.0	N	6.3	4.8	290	0	26	16	17	< 0.02	6.0
	6	Zabadani Well 1'' (irrigation)	96/8/22	32	18	1.0	0.1	10.0	6.6	400	0	92	42	35	0.15	11.5
	7	Zabadani Well 1''' (irrigation)	96/8/22	34	16	1.0	< 0.1	9.9	6.6	400	0	68	38	35	0.15	10.8
	8	Zabadani Well 2 (irrigation)	96/5/17	15	7	1.5	N	5.6	4.2	260	0	32	14	5	< 0.02	5.4
			96/8/22	15	4	1.5	< 0.1	5.2	4.2	260	0	32	12	6	< 0.02	5.7
	9	Zabadani Well 3 (irrigation)	96/6/17	27	13	0.5	N	9.0	6.0	370	0	47	36	37	< 0.02	8.7
			96/8/22	15	5	1.0	< 0.1	5.1	4.2	260	0	28	10	6	< 0.02	5.5
	10	Sarada Spring	96/6/18	7	3	0.5	-	4.5	2.4	150	0	134	6	6	-	5.5
	11	Ain El Irk	96/6/18	17	3	0.5	-	3.5	2.8	170	0	18	6	4	-	3.4
	12	Naboua	96/6/18	15	5	0.5	-	5.7	4.6	280	0	26	12	15	-	5.7
Figeh Area	13	Figeh Main Spring	96/6/18	12	2	0.5	N	3.1	2.8	170	0	6	4	4	< 0.02	3.1
			96/8/24	12	2	0.5	< 0.1	3.1	2.8	170	0	5	6	4	< 0.02	3.3
	14	Figeh Side Spring	96/6/18	12	3	0.5	N	3.7	3.4	210	0	10	6	4	< 0.02	3.9
			96/8/24	15	4	0.5	< 0.1	4.4	3.8	230	0	16	8	5	< 0.02	4.7
	15	Ain Haroush	96/6/18	15	6	1.0	N	5.3	4.6	280	0	24	10	8	< 0.02	5.5
			96/8/24	17	6	1.0	< 0.1	5.5	4.6	280	0	25	10	5	< 0.02	5.8
	16	Deir Moukaren	96/6/20	20	7	1.0	N	5.4	4.4	270	0	21	10	5	< 0.02	5.2
			96/8/24	19	6	0.5	< 0.1	4.9	4.4	270	0	22	10	4	< 0.02	5.5
	17	Barada Water at Figeh	96/8/24	12	3	0.5	< 0.1	3.7	3.4	210	0	12	10	4	< 0.02	4.3
	18	Energy Dissipation Basin	96/6/18	12	3	0.5	N	3.7	3.4	210	0	10	6	4	< 0.02	3.9
			96/8/24	15	3	0.5	< 0.1	3.7	3.4	210	0	12	8	4	< 0.02	4.2
Damascus Area	19	Mazrea (mix)	96/6/16	37	21	1.0	N	8.6	6.0	370	0	29	44	25	< 0.02	8.3
			96/8/21	32	23	1.0	< 0.1	8.4	6.0	370	0	25	38	25	< 0.02	9.2
	20	Mazrea (well #11)	96/6/16	32	25	1.0	N	8.1	5.4	330	0	35	40	28	< 0.02	7.7
			96/8/21	27	27	1.0	< 0.1	7.4	5.4	330	0	32	30	25	< 0.02	8.2
	21	Ibn Assaker (mix)	96/6/16	22	21	6.0	N	8.1	6.0	370	0	26	34	20	< 0.02	7.9
			96/8/21	22	22	7.0	< 0.1	7.7	6.0	370	0	25	36	20	< 0.02	9.0
	22	Oumawiyin (mix)	96/6/23	22	16	1.0	N	7.1	5.4	330	0	35	24	9	< 0.02	7.0
			96/8/25	22	17	1.0	< 0.1	7.2	5.4	330	0	31	30	15	< 0.02	8.1
	23	Oumawiyin (well #6)	96/6/19	17	17	1.0	N	6.6	5.2	320	0	33	26	4	< 0.02	6.7
			96/8/25	17	18	1.5	< 0.1	7.2	5.4	330	0	30	36	8	< 0.02	8.3
	24	Jobar (well #12)	96/6/16	29	15	1.0	N	8.9	6.6	400	0	23	34	25	< 0.02	8.4
			96/8/21	27	16	1.0	< 0.1	8.7	6.6	400	0	22	34	25	< 0.02	9.4
	25	Kaboon (well #1)	96/6/16	44	15	1.0	N	8.5	6.2	380	0	31	30	25	< 0.02	8.1
			96/8/21	44	17	0.5	< 0.1	7.8	5.8	350	0	31	28	25	< 0.02	8.4
	26	Kadam Railway (mix)	96/6/15	39	25	1.5	N	10.7	7.2	440	0	48	54	45	< 0.02	10.5

note -: not measured

Table D-3.4 (5/9) Results of General Water Quality Analyses

Area	#	name	sampling date	Mg	Na	K	NH4	total cation	total alkalinity	HCO3	CO3	SO4	Cl	NO3	NO2	total anion
			y/m/d	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L	mg/L	mg/L	mg/L	mg/L	mg-NO3/L	mg-NO2/L	meq/L
Syrian Std.					200		0.05					250	250	44	0.03	
WHO Guideline					(200)		(1.5)					(250)	(250)	50	3	
Japanese Std.					200								200	10 mg-N(NO3+NO2)/L		
			96/8/20	34	18	1.0	< 0.1	9.8	6.8	410	0	41	50	45	< 0.02	11.2
	27	Kadam Railway (well # 5)	96/6/15	41	25	2.0	N	11.1	7.4	450	0	50	54	45	0.07	10.7
			96/8/20	36	17	1.0	< 0.1	10.0	6.8	410	0	45	50	45	< 0.02	11.3
	28	University (well #13)	96/6/19	37	88	3.5	N	13.7	5.6	340	0	200	126	25	< 0.02	13.7
			96/8/25	32	64	3.0	< 0.1	13.3	5.4	330	0	196	110	25	< 0.02	16.4
	29	University (well #11)	96/6/19	34	140	6.0	N	16.3	5.4	330	0	310	160	20	< 0.02	16.7
			96/8/25	36	140	5.5	< 0.1	16.6	4.8	290	0	300	166	35	< 0.02	21.3
	30	Kadam Store (mix)	96/6/15	29	23	3.0	N	9.9	6.6	400	0	50	46	35	< 0.02	9.5
			96/8/20	32	18	2.0	< 0.1	9.2	6.6	400	0	44	46	35	< 0.02	10.7
	31	Dummar (private irrigation)	96/6/19	46	60	1.5	N	15.8	5.0	310	0	450	84	5	0.07	16.9
			96/8/25	41	48	1.5	< 0.1	14.9	4.8	290	0	400	64	9	0.04	17.0
	32	Takadom (municipal)	96/6/15	29	26	1.5	N	8.7	6.6	400	0	36	36	25	< 0.02	8.7
			96/8/20	24	22	1.0	< 0.1	8.6	6.6	400	0	34	40	25	< 0.02	10.0
	33	Kachkoul (Fringe 1)	96/6/15	20	27	8.5	N	8.8	6.6	400	0	26	40	25	< 0.02	8.6
			96/8/20	19	24	6.0	< 0.1	8.4	6.6	400	0	27	38	25	< 0.02	9.8
	34	Halabneh (Fringe 6)	96/6/15	24	26	6.0	N	9.0	6.8	420	0	31	36	25	< 0.02	9.0
			96/8/20	24	22	4.5	< 0.1	8.9	6.8	410	0	32	38	25	0.03	10.0
	35	Burg al Zahera (Fringe 7)	96/6/15	24	18	6.0	N	8.1	6.0	370	0	33	30	25	< 0.02	8.0
			96/8/20	24	16	4.0	< 0.1	7.8	6.0	370	0	34	30	25	< 0.02	8.9
	36	Daf al Ward (Fringe 9)	96/6/15	24	19	4.0	N	8.1	6.4	390	0	24	28	18	< 0.02	8.0
			96/8/20	22	17	2.5	0.2	7.8	6.4	390	0	25	28	15	< 0.02	8.8
	37	Karem Taha (Fringe 11)	96/6/16	46	21	1.0	N	10.5	7.6	460	0	33	50	25	< 0.02	10.1
			96/8/21	41	23	1.0	< 0.1	10.2	7.2	440	0	31	50	33	< 0.02	11.3
	38	Kafar Souseh (Fringe 23)	96/6/24	24	22	8.0	N	8.5	5.8	350	0	43	38	27	< 0.02	8.1
			96/8/25	29	24	8.5	< 0.1	9.1	6.2	380	0	44	38	35	< 0.02	9.9
	39	Amid School (Emergency 51)	96/6/19	24	19	1.0	N	7.4	5.0	310	0	27	46	25	< 0.02	7.4
			96/8/20	39	19	0.5	< 0.1	6.8	4.6	280	0	25	42	25	0.03	8.0
	40	Communication Center	96/8/27	27	180	1.0	< 0.1	12.3	4.0	240	0	200	136	25	< 0.02	16.5
	41	Yabugha	96/8/12	17	20	2.8	-	6.9	5.6	340	0	24	25	15	-	7.8
	42	National Museum	96/7/30	20	14	1.5	-	6.3	5.0	310	0	30	20	2	-	6.3
Hermon - Houran Area	43	Beit Jenn	96/6/30	7	2	0.0	-	2.5	2.2	130	0	19	2	0	-	2.6
	44	Bit Jenn Pool	96/7/30	12	4	1.0	-	3.2	2.8	170	0	11	6	2	-	3.2
	45	Bit Jenn River	96/7/30	12	4	1.0	-	3.2	2.8	170	0	11	6	2	-	3.2
	46	Taimasieh	96/6/30	7	9	1.0	-	3.8	3.2	200	0	10	10	4	-	3.8
	47	Membej	96/6/30	7	9	1.0	-	3.6	3.0	180	0	10	8	4	-	3.5
	48	Near Artooz	96/6/30	12	17	0.2	-	6.1	4.6	280	0	44	26	5	-	6.3
	49	Katana 50	96/6/30	7	4	0.5	-	3.8	3.0	180	0	8	10	4	-	3.5
	50	Katana 51	96/6/30	17	17	2.5	-	8.2	5.6	340	0	28	46	25	-	7.9
	51	Shebani	96/7/2	27	4	1.0	-	6.8	3.6	220	0	160	8	0	-	7.2
	52	Knaan	96/7/2	12	5	1.5	-	4.6	3.6	220	0	25	10	15	-	4.7
	52	Yaafoor	96/6/30	7	5	0.2	-	4.0	3.2	200	0	13	10	2	-	3.9
	53	Yaafoor	96/6/30	7	5	0.2	-	4.0	3.2	200	0	13	10	2	-	3.9
	54	Tabibiyeh	96/7/2	15	12	1.5	-	6.4	4.2	260	0	64	20	15	-	6.4

note - : not measured

Table D-3.4 (6/9) Results of General Water Quality Analyses

Area	#	name	sampling date	Mg	Na	K	NH4	total cation	total alkalinity	HCO3	CO3	SO4	Cl	NO3	NO2	total anion
			y/m/d	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L	mg/L	mg/L	mg/L	mg/L	mg-NO3/L	mg-NO2/L	meq/L
Syrian Std.					200		0.05					250	250	44	0.03	
WHO Guideline					(200)		(1.5)					(250)	(250)	50	3	
Japanese Std.					200								200	10 mg-N(NO3+NO2)/L		
Networks	55	Energy Dissipation Basin	96/6/18	12	3	0.5	N	3.7	3.4	210	0	10	6	4	< 0.02	3.9
			96/8/24	15	3	0.5	< 0.1	3.7	3.4	210	0	12	8	4	< 0.02	4.2
	56	Wali Reservoir	96/6/20	15	3	0.5	N	4.0	3.4	210	0	12	8	4	< 0.02	4.0
			96/8/26	15	3	0.5	< 0.1	3.9	3.4	210	0	11	8	4	< 0.02	4.2
	57	Western Reservoir II.O	96/6/20	15	3	0.5	N	4.0	3.4	210	0	12	8	4	< 0.02	4.0
			96/8/26	15	3	0.5	< 0.1	3.9	3.4	210	0	11	8	4	< 0.02	4.2
	58	Eastern Reservoir II.E	96/6/20	17	4.5	0.5	N	4.4	3.8	230	0	15	10	4	< 0.02	4.4
			96/8/26	15	3	0.5	< 0.1	3.9	3.4	210	0	11	8	4	< 0.02	4.2
	59	Mezze (tap)	96/6/23	15	3	0.5	N	4.0	3.4	210	0	12	8	4	< 0.02	4.0
			96/8/27	17	15	0.5	< 0.1	5.3	3.6	220	0	34	20	4	< 0.02	5.6
	60	Berze (tap)	96/6/23	20	10	1.0	N	5.7	4.4	270	0	17	20	15	< 0.02	5.6
			96/8/28	15	3	0.5	< 0.1	4.2	3.4	210	0	10	8	4	< 0.02	4.2
	61	Tabbaleh (tap)	96/6/23	22	24	9.0	N	6.3	6.2	380	0	31	36	15	< 0.02	8.1
			96/8/28	22	23	5.5	< 0.1	8.2	6.4	390	0	28	34	25	< 0.02	9.4
	62	Kadem (tap)	96/6/23	15	4	0.5	N	4.2	3.6	220	0	13	10	4	< 0.02	4.2
			96/8/28	36	23	1.0	< 0.1	9.8	6.6	400	0	44	46	45	< 0.02	10.9
	63	Amauout Street	96/8/28	36	23	1.0	< 0.1	9.8	6.6	400	0	44	46	45	< 0.02	10.9
	64	Jobar (tap)	96/8/28	29	17	1.0	< 0.1	8.8	6.6	400	0	20	32	25	< 0.02	9.3
	65	Kafar Souseh (tap)	96/6/19	-	-	-	N	-	-	-	-	-	-	-	< 0.02	-
Barada River	66	Tekieh	96/6/17	10	4	0.5	N	4.2	3.6	220	0	13	8	4	0.1	4.2
			96/8/26	12	5	1.0	0.1	4.5	3.6	220	0	16	8	0	0.4	4.4
	67	Haroush	96/6/18	12	6	2.5	N	4.8	4.0	240	0	20	10	11	0.4	4.6
			96/8/26	-	-	-	-	-	-	-	-	-	-	-	-	-
	68	Figeh	96/6/18	15	15	2.5	N	5.7	4.8	290	0	29	14	4	0.15	5.8
			96/8/24	12	21	3.0	10	5.0	4.2	260	0	25	20	0	0.4	6.0
	69	University	96/6/22	20	22	5.0	Y	7.1	6.0	370	0	44	38	-	< 0.02	8.1
			96/8/27	22	38	4.5	14	8.4	6.2	380	0	64	48	0	< 0.02	10.4
	70	Al Jourah	96/6/22	0	72	10	Y	9.0	6.2	380	0	64	118	-	0.15	10.9
			96/8/27	24	38	5.5	8	7.6	6.0	370	0	42	46	0	0.04	9.6
	71	Dabaghat	96/6/22	24	84	5.5	Y	9.8	6.0	370	0	72	140	-	0.4	11.5
			96/8/27	22	360	9.0	80	20.9	6.8	410	0	580	250	0	> 2	33.5
	72	Gota road	96/6/22	20	36	6.5	Y	7.0	6.2	380	0	45	52	-	< 0.02	8.6
			96/8/27	19	44	7.5	35	7.9	7.0	430	0	50	46	0	< 0.02	10.8
Tora River	73	Tishreen Park	96/6/22	20	20	4.0	N	7.2	5.6	340	0	44	36	-	0.02	7.5
			96/8/25	22	42	4.0	7	8.1	5.8	350	0	41	42	0	0.02	9.1
	74	Jobar	96/6/23	15	170	6.5	Y	10.0	9.0	130	200	42	38	-	0.7	14.1
			96/8/27	-	-	-	-	-	-	-	-	-	-	-	-	-
Yazid River	75	Shamy Hosppital	96/6/22	22	20	4.0	N	6.8	5.8	350	0	44	36	-	0.15	7.7
			96/8/27	19	28	3.5	4	7.1	5.4	330	0	35	36	0	< 0.02	8.3
	76	Masaaken Barzeh	96/6/22	20	23	6.0	Y	6.0	5.8	350	0	34	34	-	0.8	7.4
			96/8/27	19	40	8.0	30	6.6	6.4	390	0	26	46	0	< 0.02	9.6

note - : not measured

Table D-3.4 (7/9) Results of General Water Quality Analyses

Area	#	name	sampling date	evaporation residue	Saturation Index	total bacteria	total coliform	KMnO4 demand	Fe	Mn
			y/m/d	mg/L		CFU/100mL	CFU/100mL	mg-O2/L	μg/L	μg/L
Syrian Std.				1000		200	N.D.	COD < 2	300	100
WHO Guideline				(1000)			N.D.		(300)	500
Japanese Std.				500		100	N.D.	2	300	50
Zabadani Area	1	Barada Spring	96/6/17	215	0.07	80	10	0.1	6	0.9
			96/8/22	209	0.25	1000	800	0.1	8	0.5
	2	Barada Well 1 (#4)	96/6/17	205	0.02	5	1	0.1	10	0.5
			96/8/22	203	0.22	1	0	0.0	9	0.5
	3	Barada Well 2 (#3)	96/6/17	215	0.08	1200	500	0.2	7	0.9
			96/8/22	209	0.23	800	200	0.1	8	0.5
	4	Zabadani Well 1 (irrigation)	96/6/17	285	0.26	28	2	0.5	7	0.5
	5	Zabadani Well 1' (irrigation)	96/6/17	335	0.16	0	0	0.1	10	0.5
	6	Zabadani Well 1'' (irrigation)	96/8/22	553	0.63	5000	500	0.5	10	1.0
	7	Zabadani Well 1''' (irrigation)	96/8/22	522	0.35	2000	1000	0.5	10	1.0
	8	Zabadani Well 2 (irrigation)	96/6/17	285	0.04	1200	50	0.5	10	1.0
			96/8/22	274	0.06	125	0	0.0	8	1.0
	9	Zabadani Well 3 (irrigation)	96/6/17	470	0.57	5000	1000	1.0	7	1.0
			96/8/22	265	0.22	4000	400	0.1	8	1.0
	10	Sarada Spring	96/6/18	315	-	-	-	-	-	-
	11	Ain El Irk	96/6/18	175	-	-	-	-	-	-
	12	Naboua	96/6/18	300	-	-	-	-	-	-
Figeh Area	13	Figeh Main Spring	96/6/18	155	0.13	6	0	0.0	7	0.6
			96/8/24	155	0.16	0	0	0.0	8	0.5
	14	Figeh Side Spring	96/6/18	190	0.14	2000	1000	0.1	10	0.5
			96/8/24	224	0.26	3000	2000	0.2	10	0.5
	15	Ain Haroush	96/6/18	285	0.23	3000	2000	0.1	7	0.5
			96/8/24	281	0.24	3500	2500	0.1	8	0.5
	16	Deir Moukaren	96/6/20	270	-	1000	600	0.1	10	0.5
			96/8/24	256	0.35	1500	1000	0.1	9	0.5
	17	Barada Water at Figeh	96/8/24	197	0.40	175	30	0.1	8	0.5
	18	Energy Dissipation Basin	96/6/18	190	0.18	2500	1000	0.1	7	0.5
			96/8/24	194	0.13	3500	2500	0.1	8	0.5
Damascus Area	19	Mazraa (mix)	96/6/16	435	0.42	9	4	0.1	11	0.8
			96/8/21	423	0.26	0	0	0.0	12	1.0
	20	Mazraa (well #11)	96/6/16	415	0.36	3	1	0.1	10	0.8
			96/8/21	387	0.33	2	0	0.1	10	1.0
	21	Ibn Assaker (mix)	96/6/16	420	0.50	0	0	0.0	10	1.0
			96/8/21	411	0.27	0	0	0.0	10	0.5
	22	Oumawiyin (mix)	96/6/23	365	0.37	6	1	0.0	7	1.0
			96/8/25	373	0.19	2500	10	0.0	8	1.0
	23	Oumawiyin (well #6)	96/6/19	345	0.36	185	10	0.1	7	1.0
			96/8/25	375	0.24	130	40	0.0	8	1.0
	24	Jobar (well #12)	96/6/16	445	0.35	2	1	0.1	11	1.0
			96/8/21	442	0.37	0	0	0.0	11	1.0
	25	Kaboon (well #1)	96/6/16	420	0.42	149	4	0.1	9	1.0
			96/8/21	390	0.31	0	0	0.0	9	1.0
	26	Kadam Railway (mix)	96/6/15	560	0.49	25	2	0.1	12	1.0

note - : not measured

Table D-3.4 (8/9) Results of General Water Quality Analyses

Area	#	name	sampling date	evaporation residue	Saturation Index	total bacteria	total coliform	KMnO4 demand	Fe	Mn
			y/m/d	mg/L		CFU/100mL	CFU/100mL	mg-O2/L	μg/L	μg/L
Syrian Std.				1000		200	N.D.	COD < 2	300	100
WHO Guideline				(1000)			N.D.		(300)	500
Japanese Std.				500		100	N.D.	2	300	50
			96/8/20	521	0.30	0	0	0.0	11	1.0
	27	Kadam Railway (well # 5)	96/6/15	575	0.48	68	7	0.1	12	1.0
			96/8/20	526	0.29	0	0	0.0	11	1.0
	28	University (well #13)	96/6/19	790	0.32	2	1	0.1	10	1.0
			96/8/25	755	0.32	300	200	0.1	9	1.0
	29	University (well #11)	96/6/19	995	0.31	6	1	0.0	9	1.0
			96/8/25	978	0.36	1300	300	0.1	10	1.0
	30	Kadam Store (mix)	96/6/15	520	0.41	0	0	0.0	10	1.0
			96/8/20	494	0.28	5	0	0.0	10	1.0
	31	Dummar (private irrigation)	96/6/19	990	0.36	1500	500	0.1	10	1.0
			96/8/25	899	0.34	85	25	0.1	10	1.0
	32	Takadom (municipal)	96/6/15	460	0.39	1500	10	0.2	6	1.5
			96/8/20	460	0.27	13	3	0.1	6	1.0
	33	Kachkoul (Fringe 1)	96/6/15	465	0.57	15	0	0.1	7	0.5
			96/8/20	453	0.46	40	10	0.1	8	0.5
	34	Halabneh (Fringe 6)	96/6/15	475	0.39	2000	15	0.1	7	1.0
			96/8/20	469	0.29	10000	5000	0.1	9	1.0
	35	Burg al Zahera (Fringe 7)	96/6/15	425	0.49	0	0	0.1	9	1.5
			96/8/20	417	0.28	0	0	0.0	9	1.0
	36	Def al Ward (Fringe 9)	96/6/15	420	0.33	87	3	0.1	7	1.0
			96/8/20	409	0.22	50	20	0.1	8	1.0
	37	Karem Taha (Fringe 11)	96/6/16	525	0.42	125	12	0.1	10	0.5
			96/8/21	515	0.41	10	0	0.1	11	0.5
	38	Kafar Souseh (Fringe 23)	96/6/24	450	0.47	600	100	0.0	11	0.5
			96/8/25	476	0.31	825	600	0.1	10	0.1
	39	Amid School (Emergency 51)	96/6/19	390	0.36	225	60	0.1	20	1.0
			96/8/20	347	0.32	415	25	0.2	15	1.0
	40	Communication Center	96/8/27	735	0.37	10000	5000	0.1	15	0.5
	41	Yabugha	96/8/12	365	-	285	18	-	-	-
	42	National Museum	96/7/30	320	-	-	-	-	-	-
Hermon - Houran Area	43	Beit Jenn	96/6/30	135	-	-	-	-	-	-
	44	Bit Jenn Pool	96/7/30	165	-	-	-	-	-	-
	45	Bit Jenn River	96/7/30	165	-	-	-	-	-	-
	46	Talmasieh	96/6/30	195	-	-	-	-	-	-
	47	Membej	96/6/30	185	-	-	-	-	-	-
	48	Near Artooz	96/6/30	335	-	-	-	-	-	-
	49	Katana 50	96/6/30	185	-	-	-	-	-	-
	50	Katana 51	96/6/30	430	-	-	-	-	-	-
	51	Shebani	96/7/2	400	-	-	-	-	-	-
	52	Knasa	96/7/2	250	-	-	-	-	-	-
	52	Yaafoor	96/6/30	200	-	-	-	-	-	-
	53	Yaafoor	96/6/30	200	-	-	-	-	-	-
	54	Tabbiyeh	96/7/2	350	-	-	-	-	-	-

note - : not measured

Table D-3.4 (9/9) Results of General Water Quality Analyses

Area	#	name	sampling date	evaporation residue	Saturation Index	total bacteria	total coliform	KMnO4 demand	Fe	Mn
			y/m/d	mg/L		CFU/100mL	CFU/100mL	mg-O2/L	μg/L	μg/L
Syrian Std.				1000		200	N.D.	COD < 2	300	100
WHO Guideline				(1000)			N.D.		(300)	500
Japanese Std				500		100	N.D.	2	300	50
Networks	55	Energy Dissipation Basin	96/6/18	190	0.17	0	0	0.0	7	0.5
			96/8/24	194	0.13	0	0	0.0	8	0.5
	56	Wali Reservoir	96/6/20	200	0.16	0	0	0.0	10	0.5
			96/8/26	197	0.36	0	0	0.0	9	0.5
	57	Western Reservoir II.O	96/6/20	200	0.15	0	0	0.0	10	0.5
			96/8/26	197	0.36	0	0	0.0	9	0.5
	58	Eastern Reservoir II.E	96/6/20	225	0.24	0	0	0.0	9	0.6
			96/8/26	197	0.38	0	0	0.0	9	0.5
	59	Mezze (tap)	96/6/23	200	0.19	0	0	0.0	7	0.5
			96/8/27	264	-	0	0	0.0	9	0.5
	60	Berze (tap)	96/6/23	290	0.43	0	0	0.0	10	1.0
			96/8/28	200	0.24	0	0	0.0	9.5	0.5
	61	Tabbaleh (tap)	96/6/23	430	0.54	0	0	0.0	7	1.0
			96/8/28	437	0.55	0	0	0.0	10	1.0
	62	Kadam (tap)	96/6/23	215	0.23	0	0	0.0	7	0.5
			96/8/28	513	0.62	0	0	0.0	10	1.0
	63	Arnauout Street	96/8/28	513	0.63	0	0	0.0	10	1.0
	64	Jobar (tap)	96/8/28	438	0.37	0	0	0.0	10	1.0
	65	Kafar Souseh (tap)	96/6/19	-	-	-	-	-	-	-
Barada River	66	Tekieh	96/6/17	215	0.51	5000	3000	0.5	15	1.5
			96/8/26	216	0.33	30000	15000	1.0	-	-
	67	Haroush	96/6/18	255	0.57	10000	5000	0.4	13	0.7
			96/8/26	-	-	-	-	-	-	-
	68	Figeh	96/6/18	300	0.27	5000	3000	0.7	20	1.5
			96/8/24	269	0.76	10000	5000	1.0	-	-
	69	University	96/6/22	400	0.43	50000	25000	1.1	-	-
			96/8/27	462	0.51	50000	30000	1.2	-	-
	70	Al Jourah	96/6/22	565	0.60	80000	40000	1.2	-	-
			96/8/27	415	0.25	60000	30000	1.3	-	-
	71	Dabaghat	96/6/22	590	0.84	100000	50000	1.3	-	-
			96/8/27	1492	1.09	90000	80000	1.5	-	-
	72	Gota road	96/6/22	425	0.41	50000	25000	1.4	-	-
			96/8/27	465	0.54	80000	50000	1.5	-	-
Tora River	73	Tishreen Park	96/6/22	390	0.61	70000	25000	1.2	-	-
			96/8/25	416	0.88	10000	5000	1.2	-	-
	74	Jobar	96/6/23	570	-	50000	30000	1.4	-	-
			96/8/27	-	-	-	-	-	-	-
Yazid River	75	Shamy Hosppital	96/6/22	385	0.58	50000	25000	0.5	-	-
			96/8/27	371	1.07	35000	25000	1.2	-	-
	76	Massaken Barzeh	96/6/22	380	0.37	70000	25000	1.3	-	-
			96/8/27	395	0.21	40000	35000	1.0	-	-

note - : not measured

Table D-3.5 (1/2) Results of General Water Quality Analyses (Statistics)

	percentile	temp. (air)	temp. (water)	EC	color	field turbidity	lab turbidity	field pH	lab pH	total hardness	Ca	Mg	Na	K	NH4
		°C	°C	µS/cm	degree	degree	NTU			mg CaCO3/L	mg/L	mg/L	mg/L	mg/L	mg/L
Syrian Std.			5 - 25	1500	15 TCU	5 NTU	5	6.5-8.5	6.5-8.5	500			200		0.05
WHO Guideline					(15 TCU)								(200)		(1.5)
Japanese Std.					5	2		5.8-8.5		300			200		
Groundwater	min.	19	11	225	< 2	< 1.0	0.25	6.7	7.2	120	36	7	2	0.0	< 0.1
	10	22	14	325	< 2	< 1.0	0.5	7.0	7.3	180	52	11	3	0.5	< 0.1
	20	22	15	350	< 2	< 1.0	0.5	7.1	7.3	190	59	12	4	0.5	< 0.1
	50	24	17	650	2	1.0	1.0	7.3	7.5	320	91	22	16	1.0	< 0.1
	80	29	18	810	4	2.0	2.5	7.7	7.7	412	116	32	23	2.6	< 0.1
	90	30	18	930	9	4.4	7.3	7.8	7.7	472	128	38	27	5.8	< 0.1
	max.	32	22	1475	> 10	8.0	60	8.3	8.1	660	188	46	180	8.5	0.20
Distribution System	min.	20	13	325	< 2	< 1.0	0.5	7.2	7.3	180	48	12	3	0.5	< 0.1
	10	20	14	325	< 2	< 1.0	1.0	7.4	7.5	187	52	15	3	0.5	< 0.1
	20	22	14	325	2	< 1.0	1.0	7.4	7.5	190	52	15	3	0.5	< 0.1
	50	25	15	363	2	1.0	1.5	7.6	7.7	200	56	15	4	0.5	< 0.1
	80	27	19	700	4	1.0	2.0	7.7	7.8	350	104	22	21	1.0	< 0.1
	90	27	20	783	5	1.7	3.5	7.7	7.9	412	113	31	23	2.4	< 0.1
	max.	31	22	875	> 10	> 5	4.0	8.0	7.9	440	116	36	24	9.0	< 0.1
Surface Water	min.	23	16	325	10	< 2	3	7.3	7.3	120	24	0	4	0.5	0.1
	10	24	17	375	> 10	2.0	8	7.7	7.5	200	60	12	8	2.4	3.2
	20	24	17	465	> 10	> 5	19	7.8	7.5	218	64	12	19	2.9	5.8
	50	28	22	663	> 10	> 5	75	8.0	7.7	270	76	20	32	4.8	10
	80	30	22	810	> 10	> 5	240	8.3	7.9	300	88	22	50	7.6	32
	90	31	23	935	> 10	> 5	2000	8.7	8.1	310	92	22	93	8.6	44
	max.	32	25	2500	> 10	> 5	2000	9.4	8.3	330	112	24	360	10	80

Table D-3.5 (2/2) Results of General Water Quality Analyses (Statistics)

	percentile	total alkalinity meq/L	HCO3 mg/L	CO3 mg/L	SO4 mg/L	Cl mg/L	NO3 mg-NO3/L	NO2 mg-NO2/L	evapo. residue mg/L	saturation index	total bacteria CFU/100mL	total coliform CFU/100mL	KMnO4 demand mg/L	Fe µg/L	Mn µg/L
Syrian Std.					250	250	44	0.03	1000		200	N.D.	COD < 2	300	100
WHO Guideline					(250)	(250)	50	3	(1000)			N.D.		(300)	500
Japanese Std.						200	10 mg-N(NO3+NO2)/L		500		100	N.D.	10	300	50
Groundwater	min.	2.2	130	0	5	2	0	< 0.02	135	0.02	N.D.	N.D.	0.0	6	0.1
	10	3.1	188	0	11	7	4	< 0.02	190	0.13	N.D.	N.D.	0.0	7	0.5
	20	3.6	220	0	15	8	4	< 0.02	209	0.22	2	N.D.	0.0	8	0.5
	50	5.0	310	0	29	28	15	< 0.02	387	0.32	125	N.D.	0.1	9	1.0
	80	6.6	400	0	44	44	25	< 0.02	480	0.41	1700	540	0.1	10	1.0
	90	6.6	400	0	117	52	35	< 0.02	557	0.47	3100	1000	0.2	11	1.0
	max.	7.6	460	0	450	166	45	0.15	995	0.63	10000	5000	1.0	20	1.5
Distribution System	min.	3.4	210	0	10	6	4	< 0.02	190	0.13	N.D.	N.D.	0.0	7	0.5
	10	3.4	210	0	11	8	4	< 0.02	196	0.16	N.D.	N.D.	0.0	7	0.5
	20	3.4	210	0	11	8	4	< 0.02	197	0.17	N.D.	N.D.	0.0	7	0.5
	50	3.5	215	0	13	9	4	< 0.02	208	0.36	N.D.	N.D.	0.0	8	0.5
	80	6.3	386	0	30	33	21	< 0.02	434	0.51	N.D.	N.D.	0.0	10	0.8
	90	6.6	400	0	37	39	31	< 0.02	460	0.58	N.D.	N.D.	0.0	10	1.0
	max.	6.6	400	0	44	46	45	< 0.02	513	0.63	N.D.	N.D.	0.0	10	1.0
Surface Water	min.	3.6	130	0	13	8	0	< 0.02	215	0.21	5000	3000	0.4	13	0.7
	10	4.0	220	0	20	10	0	< 0.02	251	0.26	9500	4800	0.5	13.4	0.9
	20	4.7	256	0	26	19	0	< 0.02	294	0.35	10000	5000	0.5	13.8	1.0
	50	5.9	350	0	42	38	0	0.13	397	0.54	50000	25000	1.2	15	1.5
	80	6.2	380	0	53	49	3	0.40	485	0.79	72000	36000	1.3	18	1.5
	90	6.8	392	0	65	120	4	0.71	572	0.91	81000	50000	1.4	19	1.5
	max.	9.0	430	200	580	250	11	4.00	1492	1.09	100000	80000	1.4	20	1.5

Table D-3.6 (1/5) Heavy Metal and Pesticide Analysis (July 17-18, 1996)

Element	Date	Lead	Cadmium	Chromium	Copper	Iron	Manganese	Mercury	Nickel	Cobalt
Symbol		Pb	Cd	Cr	Cu	Fe	Mn	Hg	Ni	Co
Unit	(y/m/d)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)
Syrian Std.		10	5	50	1000	300	100	1	200	-
WHO Guidelines		10	3	50	2000	-	500	1	20	-
Japanese Std.		50	10	50 (Cr VI)	1000	300	50	0.5	10	-
detection limit		6.8	0.88	0.74	7.5	6.5	0.83	1.91	11.8	2.6
Barada Spring	96/07/17	n.d.	n.d.	n.d.	6.48	10.7	1.44	n.d.	n.d.	n.d.
Figeh Main Spring	96/07/18	n.d.	n.d.	n.d.	7.2	40	n.d.	n.d.	n.d.	n.d.
Mazraa (Mix)	96/07/17	n.d.	n.d.	3.44	5.77	217	n.d.	n.d.	n.d.	n.d.
Ibn Assaker (Mix)	96/07/17	n.d.	n.d.	n.d.	7.88	15.3	n.d.	n.d.	n.d.	n.d.
Oumawiyin (Mix)	96/07/17	n.d.	n.d.	n.d.	7.34	86.7	n.d.	n.d.	n.d.	n.d.
Jobar (well #12)	96/07/17	n.d.	n.d.	n.d.	n.d.	22.1	n.d.	n.d.	n.d.	n.d.
University (well #11)	96/07/17	n.d.	n.d.	7.39	7.5	164.2	n.d.	n.d.	n.d.	n.d.
Karem Taha	96/07/17	n.d.	n.d.	n.d.	8.28	248	n.d.	n.d.	n.d.	n.d.
Al Jourah (river)	96/07/17	7.23	n.d.	1.23	10.1	432	37.7	n.d.	45.8	n.d.
Dabaghat (river)	96/07/17	n.d.	n.d.	40100	6.97	661	82.6	n.d.	n.d.	n.d.

n.d. : not detected

Table D-3.6 (2/5) Heavy Metal and Pesticide Analysis (July 17-18, 1996)

1. Chlorinated Pesticides

Name	Date	Aldrin	DDT	DDE	Methoxy chlor	Dieldrin	Lindane	Heptachlor	Endosulfan
Unit	(y/m/d)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)
Syrian Std.		0.03	-	-	20	0.03	2	0.1	-
WHO Guidelines		0.03	2	-	20	0.03	2	0.03	-
Japanese Std.		-	-	-	-	-	-	-	-
detection limit		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Barada Spring	96/07/17	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Figeh Main Spring	96/07/18	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Mazraa (Mix)	96/07/17	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ibn Assaker (Mix)	96/07/17	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin (Mix)	96/07/17	n.d.	n.d.	n.d.	n.d.	1.14	n.d.	4.83	n.d.
Tekieh (river)	96/07/17	n.d.	0.392	0.277	n.d.	n.d.	n.d.	n.d.	n.d.
Dabaghat (river)	96/07/17	n.d.	n.d.	0.211	1.63	n.d.	16.4	5.35	n.d.

n.d. : not detected

2. Organo-Nitrogen/Phsophorous Pesticides

Name	Date	Chlorpyrifos	Fenitrothion	Chlorpyrifos-methyl	Bromophos	Formothion	Dichlorvos	Methidathion	Dimethoate	Methyl parathion
Unit	(y/m/d)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)
Syrian Std.		-	-	-	-	-	-	-		-
WHO Guidelines		-	-	-	-	-	-	-	-	-
Japanese Std.		-	3	-	-	-	10	-	-	-
detection limit		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Barada Spring	96/07/17	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Figeh Main Spring	96/07/18	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Mazraa (Mix)	96/07/17	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ibn Assaker (Mix)	96/07/17	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin (Mix)	96/07/17	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Tekieh (river)	96/07/17	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Dabaghat (river)	96/07/17	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

n.d. : not detected

Table D-3.6 (3/5) Heavy Metal and Pesticide Analysis (Sept. 2, 1996)

1. Chlorinated Pesticides

Name	Date	Aldrin	DDT	DDE	Methoxy chlor	Dieldrin	Lindane	Heptachlor	Endosulfan
Unit	(y/m/d)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)
Syrian Std.		0.03	-	-	20	0.03	2	0.1	-
WHO Guidelines		0.03	2	-	20	0.03	2	0.03	-
Japanese Std.		-	-	-	-	-	-	-	-
detection limit		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Oumawiyin #1	96/09/02	n.d.	n.d.	n.d.	n.d.	5.7	n.d.	n.d.	n.d.
Oumawiyin #2	96/09/02	n.d.	n.d.	n.d.	n.d.	9.3	n.d.	17.2	n.d.
Oumawiyin #3	96/09/02	0.3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #4	96/09/02	n.d.	n.d.	n.d.	n.d.	5.1	n.d.	35.5	n.d.
Oumawiyin #5	96/09/02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #6	96/09/02	n.d.	n.d.	n.d.	n.d.	4.9	n.d.	32.7	n.d.
Oumawiyin #8	96/09/02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #9	96/09/02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #10	96/09/02	n.d.	n.d.	n.d.	n.d.	2.3	n.d.	55.7	n.d.
Oumawiyin #11	96/09/02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #12	96/09/02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #13	96/09/02	0.2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #14	96/09/02	n.d.	n.d.	n.d.	n.d.	2.3	n.d.	n.d.	n.d.
Reservoir	96/09/02	n.d.	n.d.	n.d	n.d.	12.4	n.d.	5.1	n.d.

n.d. : not detected

Table D-3.6 (4/5) Heavy Metal and Pesticide Analysis (Sept. 2, 1996)

2. Organo-Nitrogen/Phsophorous Pesticides

Name	Date	Chlorpyrifos	Fenitrothion	Chlorpyrifos-methyl	Bromophos	Formothion	Dichlorvos	Methidathion	Dimethoate	Methyl parathion
Unit	(y/m/d)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)
Syrian Std.		-	-	-	-	-	-	-	-	-
WHO Guidelines		-	-	-	-	-	-	-	-	-
Japanese Std.		-	3	-	-	-	10	-	-	-
detection limit		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Oumawiyin #1	96/09/02	n.d.	99	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #2	96/09/02	n.d.	48	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #3	96/09/02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #4	96/09/02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #5	96/09/02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #6	96/09/02	n.d.	39	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	3.8
Oumawiyin #8	96/09/02	n.d.	52	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #9	96/09/02	n.d.	37	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #10	96/09/02	n.d.	67	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #11	96/09/02	n.d.	48	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #12	96/09/02	n.d.	27	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #13	96/09/02	n.d.	71	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Oumawiyin #14	96/09/02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Reservoir	96/09/02	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

n.d. : not detected

Table D-3.6 (5/5) Heavy Metal and Pesticide Analysis (Sept. 25, 1996)

1. Chlorinated Pesticides

Name	Date	Aldrin	DDT	DDE	Methoxy chlor	Dieldrin	Lindane	Heptachlor	Endosulfan
Unit	(y/m/d)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)
Syrian Std.		0.03	-	-	20	0.03	2	0.1	-
WHO Guidelines		0.03	2	-	20	0.03	2	0.03	-
Japanese Std.		-	-	-	-	-	-	-	-
detection limit		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Oumawiyin (mix)	96/09/25	n.d.(HIAST) n.d.(RPRI)	n.d.(HIAST)	n.d.(HIAST)	n.d.(HIAST)	0.84 (HIAST) n.d.(RPRI)	n.d.(HIAST)	n.d.(HIAST) n.d.(RPRI)	n.d.(HIAST)
Oumawiyin (well #2)	96/09/25	n.d.(HIAST) n.d.(RPRI)	n.d.(HIAST)	n.d.(HIAST)	n.d.(HIAST)	n.d.(HIAST) n.d.(RPRI)	n.d.(HIAST)	n.d.(HIAST) n.d.(RPRI)	n.d.(HIAST)

n.d. : not detected

HIAST : Higher Institute of Applied Sciences and Technology, Syria

RPRI : Residual Pesticide Research Institute, Japan

2. Organo-Nitrogen/Phsophorous Pesticides

Name	Date	Chlorpyrifos	Fenitrothion	Chlorpyrifos-methyl	Bromophos	Formothion	Dichlorvos	Methidathion	Dimethoate	Methyl parathion	Carbofuran
Unit	(y/m/d)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)	(μg/L)
Syrian Std.		-	-	-	-	-	-	-		-	5
WHO Guidelines		-	-	-	-	-	-	-	-	-	5
Japanese Std.		-	3	-	-	-	10	-	-	-	-
detection limit		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05
Oumawiyin (mix)	96/09/25	n.d.(HIAST)	n.d.(HIAST) n.d.(RPRI)	n.d.(HIAST)	n.d.(HIAST)	n.d.(HIAST)	n.d.(HIAST)	n.d.(HIAST)	n.d.(HIAST)	n.d.(HIAST)	n.d.(RPRI)
Oumawiyin (well #2)	96/09/25	n.d.(HIAST)	n.d.(HIAST) n.d.(RPRI)	n.d.(HIAST)	n.d.(HIAST)	n.d.(HIAST)	n.d.(HIAST)	n.d.(HIAST)	n.d.(HIAST)	n.d.(HIAST)	n.d.(RPRI)

n.d. : not detected

HIAST : Higher Institute of Applied Sciences and Technology, Syria

RPRI : Residual Pesticide Research Institute, Japan

Table D-3.7 Annual Volume Averaged Quality of Supplied Water

Item	Unit	Syrian Std.	Vol. Ave. Conc.**
EC	μS/cm	1500	350
pH		6.5-8.5	7.7
Total Hardness	mg $CaCO_3$/L	500	190
Ca	mg/L	-	51
Mg	mg/L	-	14
Na	mg/L	-	4.5
K	mg/L	-	0.77
Total Alkalinity	meq/L	-	3.4
HCO_3	mg/L	-	205
SO_4	mg/L	250	9.7
Cl	mg/L	250	9.7
NO_3	mg/L	44	6.9
Total Bacteria	count/100 mL	200	140*
Total Coliform	count/100 mL	n.d.	60*
$KMnO_4$ Demand	mg O_2/L	2	0.016
Fe	μg/L	300	8.0
Mn	μg/L	100	0.6

- : no standard
n.d. : not detected
* : before disinfection
** : calculated from estimated annual yield of each well for 1996 and the results of field water quality study (June - Sept., 1996)

Table D-5.1 (1/2) Screening of Water Quality Related Projects

approach	project	urgency	effectiveness	feasibility	remarks
Controlling Release of Contaminants	Sewerage system	high	high	medium	Currently being developed. It will improve the environmental condition significantly.
	Control on Fertilizers and Pesticides use	medium	medium	low	The implementation is beyond the control of DAWSSA.
	Control on Discharge of Industrial Waste	high	high	low	Release of toxic substances (e.g., heavy metals) have to be stopped. Beyond the control of DAWSSA.
Protection of Water Resources	Protection of Barada Spring Aquifer	medium	medium	medium	The protection of Barada aquifers may be reinforced.
	Portection of Figeh Spring Aquifer	medium	medium	medium	The protection of Figeh aquifers may be reinforced.
	Protection of Wells in Damascus	medium	medium	medium	Control on the land use around well fields will reduce the level of contamination. In the city, it will be difficult to secure large protection zones.
	Protection of Individual Wells	high	high	high	Some wells in Damascus are poorly constructed, and are subjected to pollution by surface water. Proper installation of casing and strainer are desired.
Water Blending and Advanced Water Treatment	Blending	high	medium	high	A cost effective approach to make substandard water consumable. However, it is not an ultimate solution to the pollution problems.
	Softening	high	high	medium	Doable. The economical feasibility is the key issue.
	Nitrate Removal	high	high	medium	Technologies exist. But, it will be costly.
	Heavy Metal and Pesticide Removal	medium	medium	medium	Technologies exist. Serious health risks are involved. It will be costly.
Detailed Environmental Study	Detailed Environmental Study	high	medium	medium	The extent of groundwater pollution needs to be studied in detail in 3-D, covering as many wells as possible. It should include the development of transport model that can be used to formulate effective well allocation and water quality control plans.
Improvement of Water QualityTesting	Improvement of Water Quality Testing	high	high	high	The existing water testing facility is not adequate to test water for over 1.5 million people. It lacks basic analytical equipment. Automation and computerization (e.g., construction of water quality data base) are also desired.

Table D-5.1 (2/2) Screening of Water Quality Related Projects

	Replacing Sterilization Equipment	high	high	high	Some waters from city wells are heavily contaminated with bacteria. The existing sterilization equipment may be replaced with reliable one.
Improvement of Water Pipes	Improvement of Water Pipes	medium	medium	medium	Replacement of old distribution pipes will reduce the risk of local pollution.
Reinforcement of Existing Water Resources / Development of New Water Resources	Reinforcement of Existing Water Resources	high	medium	high	It will reduce the amount of substandard water required to meet the water demand.
	Development of New Water Resources	high	high	medium	It will reduce the amount of substandard water required to meet the water demand.

Table D-5.2 Current and Suggested Capacity of Water Quality Testing

Test	Item	Current Capacity	Recommended Capacity (by 2015)
general bacteriological quality	general bacteria, coliform, residual chlorine	50 samples/day	250 samples/day
specialized biological study	pathogens, viruses	none	20 samples/day
general physicochemical quality	temperature, turbidity, pH, EC, TDS, hardness, major cations/anions, NO_3^-, $KMnO_4$ demand	30 samples/day	100 samples/day
human health related	heavy metals	5 samples	50 samples/day
	pesticides	none	10 samples/day
	disinfection by-product analyses	none	30 samples/day
emergency tests	general bacteriological and physical/chemical analyses	none	50 locations

Table D-5.3 Suggested Reinforcement of Laboratory Staff

job description	current number	suggested number	comments
Administration and Data Processing	1	3	Director, and data analysts (computer operator).
Routine Analyses Physical / Chemical Microbiological	 3 2	 4 4	The large parts of their jobs are routine. These tasks can be done by junior chemists and biologists with 4-year college education.
Heavy Metal, Pesticide, Disinfection-Byproduct Analyses	1	2	The analyses of heavy metals, pesticides, and disinfection byproduct (e.g. halogenated hydrocarbon) require experienced chemists who are familiar with instrumentation.
Specialized Microbiological Analyses	0	2	Currently only the total bacteria count and the total coliform count are tested. However, the capability to conduct specialized microbiological assay (pathogens, virus) will be needed.
Driver	3	5	The drivers should be trained for on-site testing.

Table D-5.4 Suggested Special Training for Water Quality Testing

Program Name	Suggested Program	target year
Pesticide Extraction	Learn solid and liquid-liquid extraction method at HIAST	1997
GC-MS analysis	Take a series of training course (1 month) at DAWSSA from an invited technician from Varian using the existing system. Analyze real water samples.	1997
Virus and Pathogen analysis	Visit a water testing laboratory and take a series of training course (1 month).	1998
Automated Ion Analysis with Ion Chromatography	Take a series of intensive training course (3 weeks) at a manufacturer.	1999
Computer	Mandatory short program on word-processing and spreadsheet	1997 - 2015

Table D-5.5 Suggested Laboratory Space for DAWSSA

room	suggested area m^2	remarks
administration	20	Office space
physical / chemical analysis	100	This room has to be separated from other rooms as chemical fume may be produced during testing. A draft chamber is needed. If a large amount of organic solvents is used, a separate room with sufficient ventilation is needed.
microbiological / biological analysis	80	Some growth media have strong odor. It has to be ventilated. A walk-in constant temperature room would increase the capacity for biological/microbiological studies.
instrumental analysis	30	For GC-MS and AA work.
data analysis	30	For data processing and computer work.
storage	40	In separate sections, chemicals, samples, gas cylinders, and unused lab equipment are stored.

Table D-5.6 List of Equipment Needed at A Water Quality Testing Laboratory

equipment	current		needed		comments
	number	condition	number	urgency	
glassware		old, not enough		medium	
thermometer	2	working, need more	6	medium	For general use.
water sampler	-		2	medium	For sampling from wells with no pump.
balance	2	old, time for replacement	4	high	An microbalance, and a few general electric balances are needed.
turbidimeter	1	working, not reliable, time for replacemnt	2	high	Needed for daily analyses.
EC meter	1	working, time for replacement	2	high	Needed for daily analyses.
pH meter	2	no battery, primitive	2	high	Needed for daily analyses.
residual chloride analyzer	2	working	2	high	Needed for daily analyses.
DO meter	1	not reliable	2	high	Needed for daily analyses.
spectrophotometer	1	not working	2	high	Very urgently needed.
automatic titrator	-		2	medium	It will speed up titration.
hot plate	-		2	medium	General use.
magnetic stirrer	-		5	high	General use
sterilizer	1	working	1	medium	For microbiological study.
autoclave	1	working, capacity is small	1	medium	General use.
shaker	-		1	medium	General use.
colony counter	1	working	2	medium	For microblal counting.
microscope	1	too old (1961)	1	medium	General use, especially biological studies.
centrifuge	-		1	medium	Generl use.
incubator	2	working	2	medium	A constant temperature room is an option.
constant temperature bath	-		1	medium	General use.
density meter	-		1	medium	General use.
vacuum pump	1	working	2	medium	General use.
furnace	-		1	medium	General use.
refrigerator / freezer	1	working, the capacity is not sufficient	3	medium	For sample storage. A freezer is also needed.
fraction collector	-		2	medium	Handy for automation of analyses.
draft chamber	1	working, need another for pesticide analysis	3	high	Definitely needed for pesticide analyses.
ion chromatography	-		1	high	For automated analyses of cations and anions.
flame photometer	1	working, only for sodium and potassium	-	low	It may be replaced with an ion chromatography
AA	1	working, need spare lamps	1	low	It need sa routine maintenance
HPLC	-		1	low	It will complement GC system
GC	-		1	low	For routine analyses of chlorination byproduct.
GC-MS	1	not utilized	1	low	need routine maintenance
rotary evaporator	-		1	high	For pesticide analyses
solid extraction system	-		1	high	For pesticide analyses
liquid-liquid extration system	-		1	high	For pesticide analyses
pure water generator	1	The current distillation system is not sufficient to conduct trace chemical analyses.	1	high	For general use.
automated glassware washer	-		1	low	It will increase the overall efficiency of testing.
portable water analyzer					
complete set	-		1	high	For on-site testing/backup.
partial set	-		10	medium	For satellite testing services.
cabinet (explosion proof)			3	high	For organic solvent, acid/base, pesticide and heavy metal reagents
fire extinguisher			1/room	high	For safty.
eye washer			1/room	high	For safety precaution.
Standard Method Books	1	A recent one is needed.	1	high	The most recent edition of AWWA manual is needed.

based on "Guideline for Water Supply Facility Design", JWWA, 1990

Table D-5.7 Suggested Projects to Improve Water Quality in South Damascus

Option	Name	Description	Advantage	Disadvantage	Major Work Involved
Option 1	On-site Blending	The water from the Eastern Reservoir will be blended with the water from the Kadam Railway well field at the Kadam Railway Reservoir.	- Less costly than option 2 or option 3.	- Decrease in yield from wells.	Construction - A pipe line between the Eastern Reservoir and the Kadam Railway Reservoir. Operation - Pumping
Option 2	Off-site Blending	The water from the Kadam Railway well field is pumped up to the Eastern Reservoir, and mixed with the water from Figeh.	- No change in yield.	- High construction and operation cost. - Contamination of entire water system from the Eastern reservoir.	Construction - A pipe line between the Kadam Railway Reservoir and the Eastern Reservoir. Operation - Pumping against gradient
Option 3	Water Treatment	Nitrate in water is removed by anion exchange treatment.	- No change in yield.	- Very high construction and operation cost.	Construction - Water treatment facility. Operation - Water treatment.
Option 4	Suspension of Well Operation	The operation of wells with unacceptable water quality is suspended.	- No work needed.	- Decrease in yield from wells.	Construction - No. Operation - No.
Option 5	No Change	The normal operation is continued assuming that the water quality continuously to be acceptable.	- No work needed. - No change in yield.	- The water quality may not be acceptable.	Construction - No. Operation - No.