FIGURES

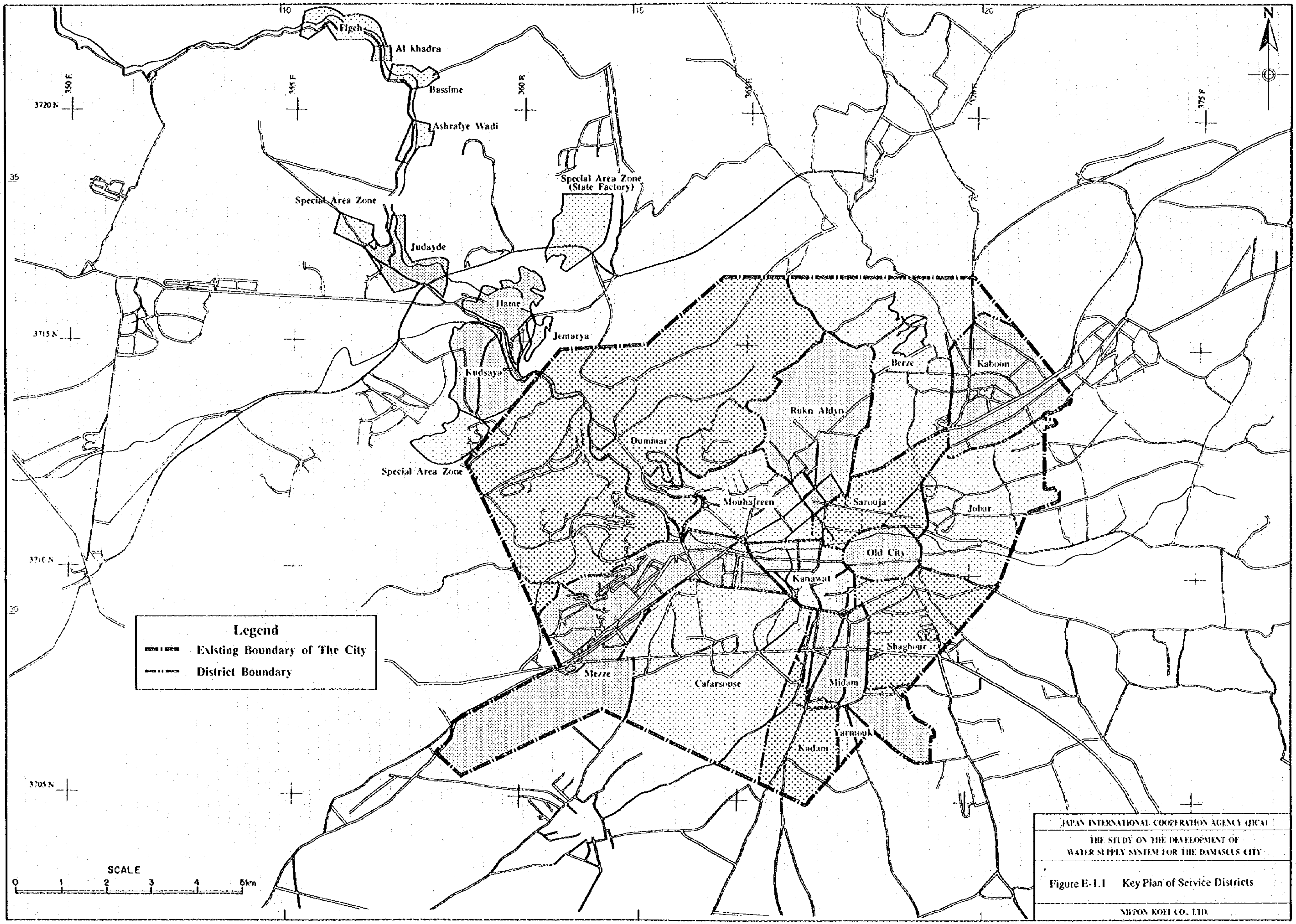
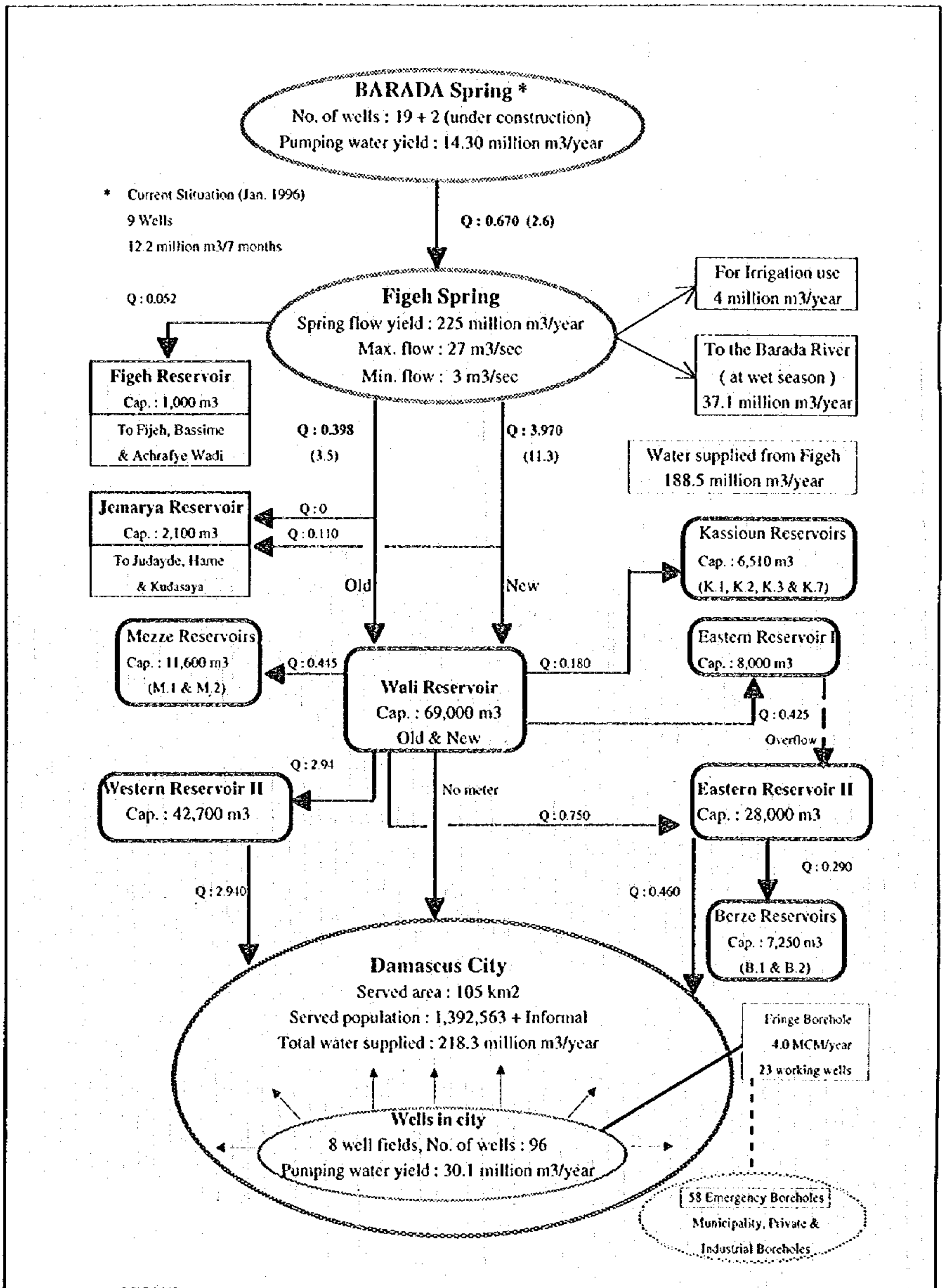


Figure E-1.1 Key Plan of Service Districts



LEGEND

Q : Average flow (m3/sec)
(Max. Flow m3/sec)
Cap. : Capacity
( ) : Reservoir in Damascus City
K.1 : Official code of Reservoir

(Source : DAWSSA)

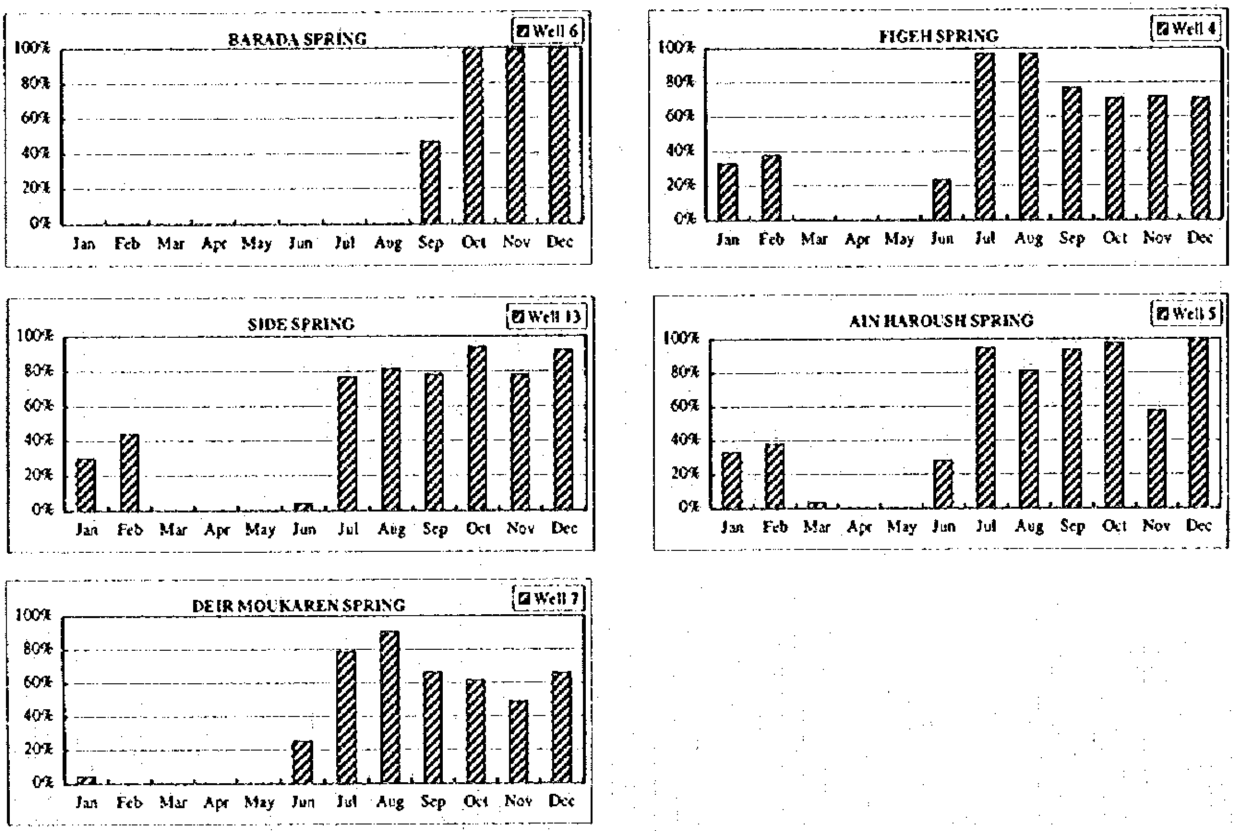
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

Figure E-1.2 Existing Water Supply System in Damascus (on Jan. 1996)

NIPPON KOEI CO., LTD.

(WELL PUMP IN SPRING)



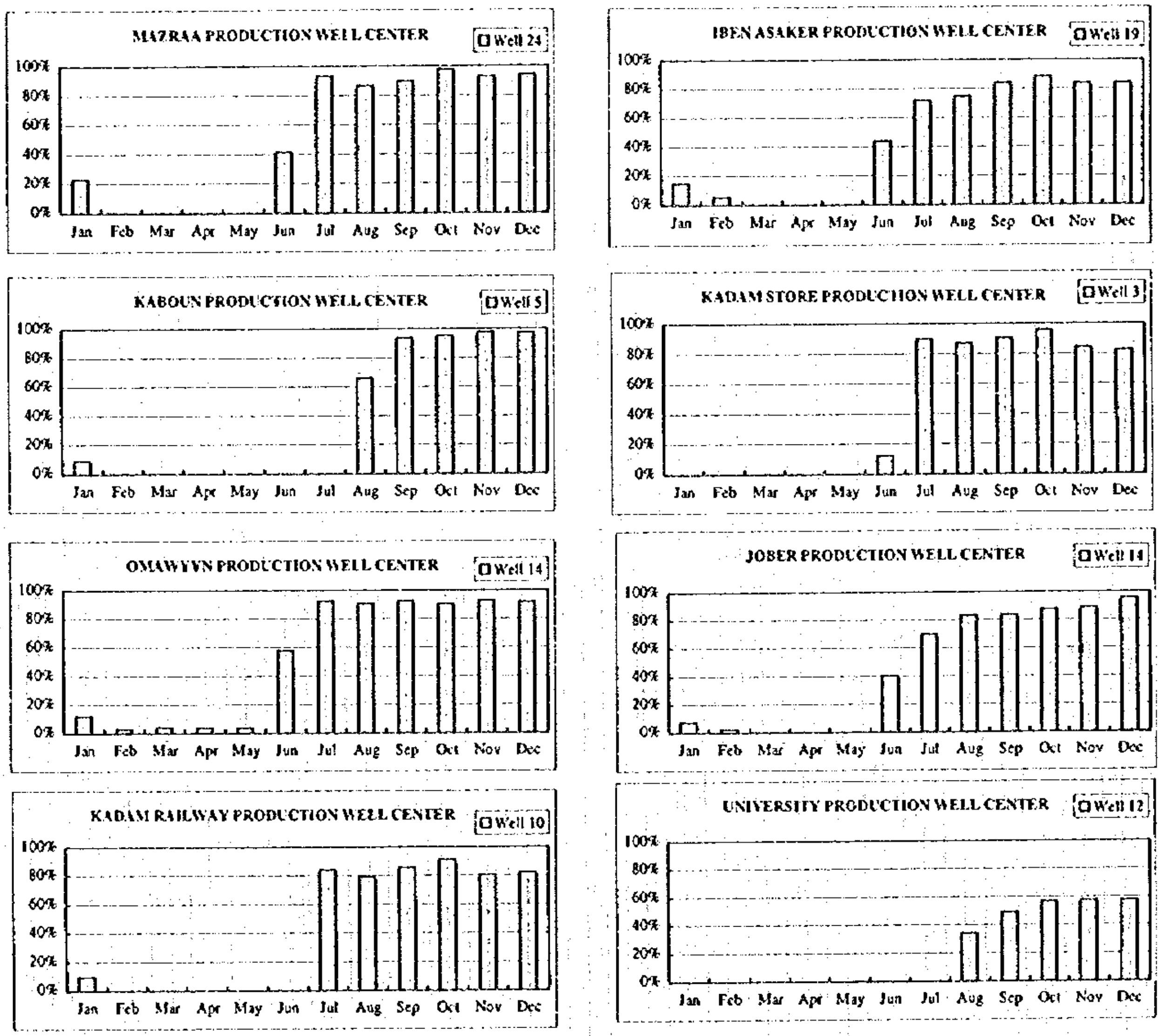
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

Figure E-3.1 Monthly Pump Operation in 1995
(Well Pump in Spring)

NIPPON KOEI CO., LTD.

(WELL PUMP IN PRODUCTION WELL CENTER)

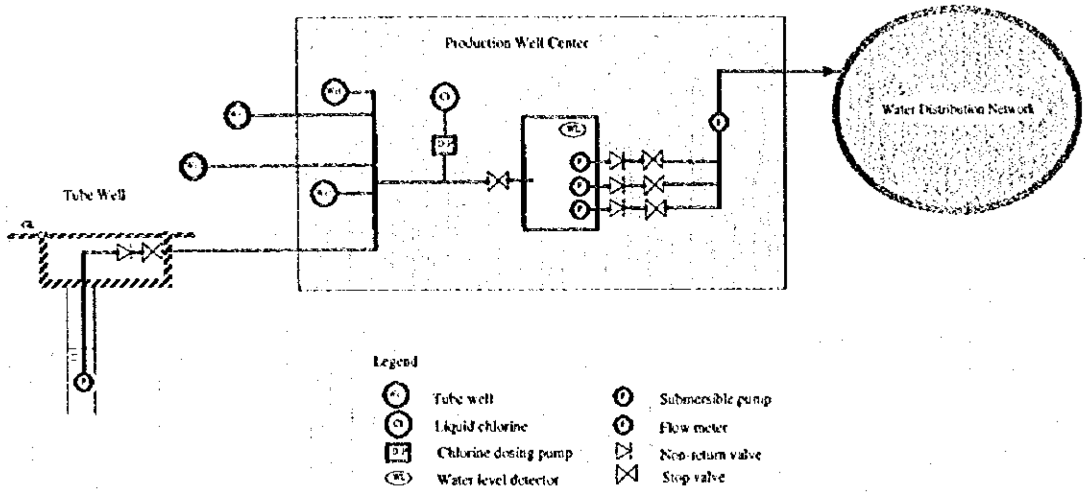


JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

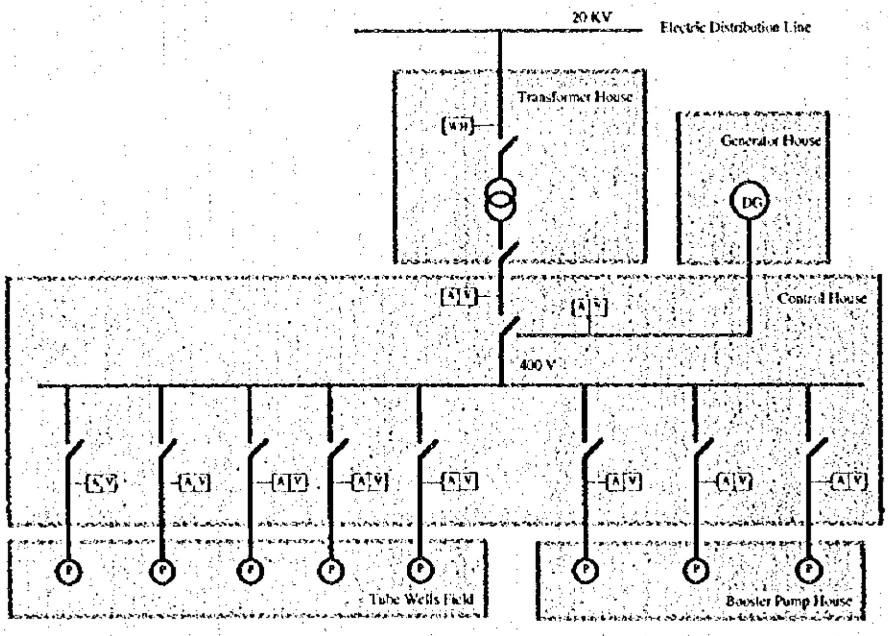
THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY

Figure E-3.2 Monthly Pump Operation in 1995 (Well Pump in Production Well Center)

NIPPON KOEI CO., LTD.

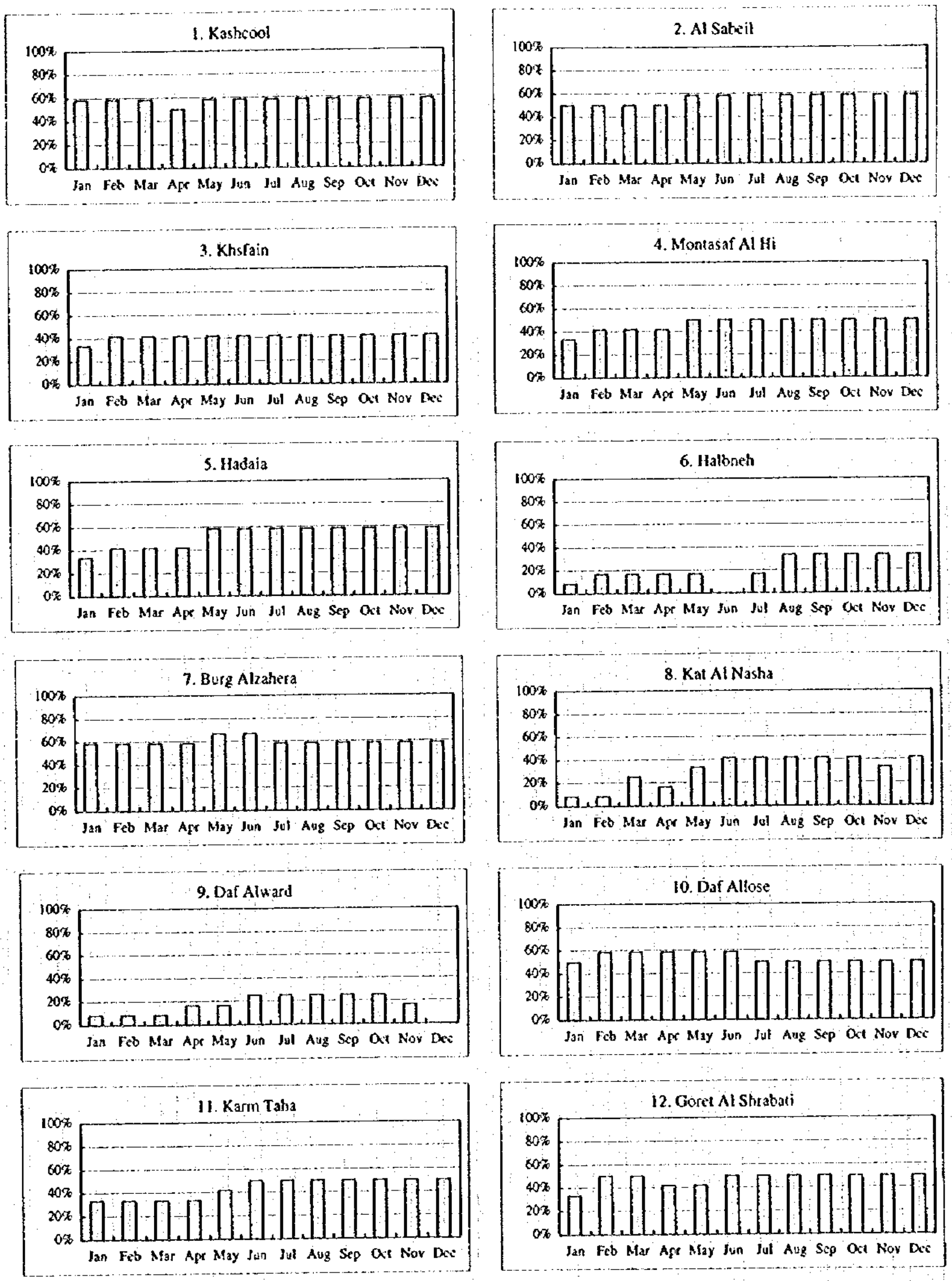


Typical System Diagram



Typical Electric One Line Connection Diagram

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY
Figure E-3.3 Typical System Diagram of Production Well Center
NIPPON KOEI CO., LTD.

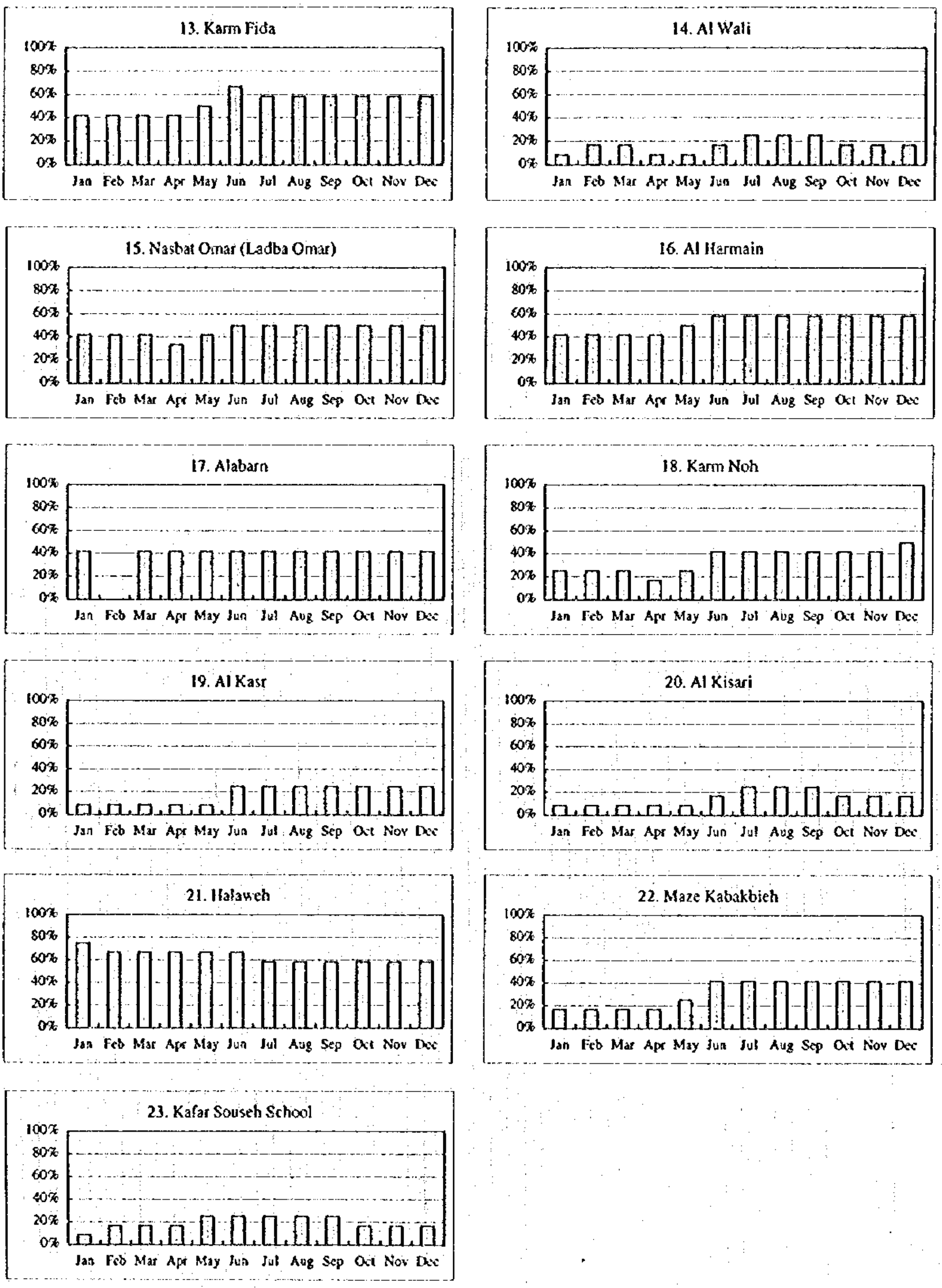


JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

Figure E-3.4 (1/2) Operation Rate of Fringe Wells in 1995

NIPPON KOEI CO., LTD.

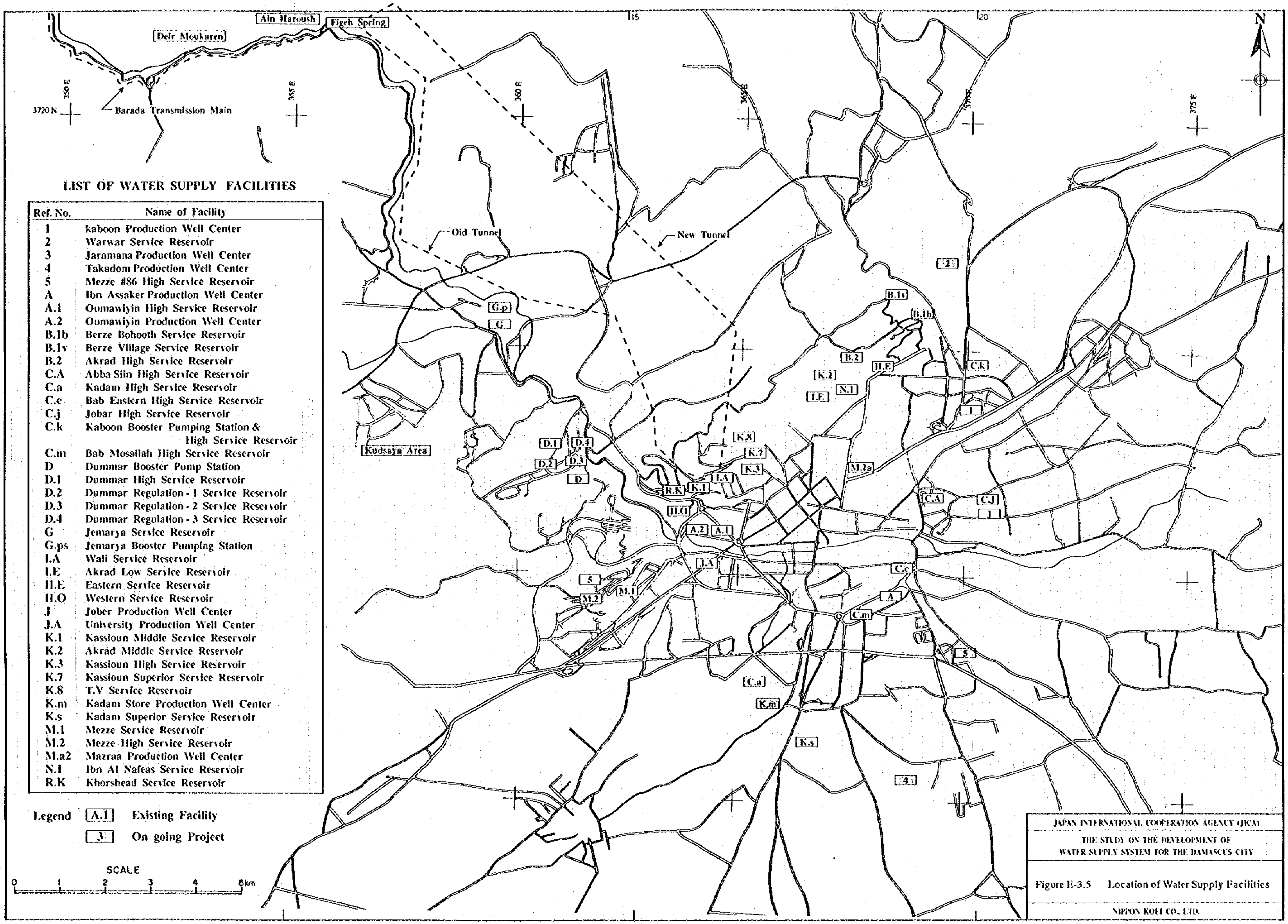


JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

Figure E-3.4 (2/2) Operation Rate of Fringe Wells in 1995

NIPPON KOEI CO., LTD.



LIST OF WATER SUPPLY FACILITIES

Ref. No.	Name of Facility
1	kaboon Production Well Center
2	Warwar Service Reservoir
3	Jaramana Production Well Center
4	Takadom Production Well Center
5	Mezze #86 High Service Reservoir
A	Ibn Assaker Production Well Center
A.1	Oumawiyin High Service Reservoir
A.2	Oumawiyin Production Well Center
B.1b	Berze Bohooth Service Reservoir
B.1v	Berze Village Service Reservoir
B.2	Akrad High Service Reservoir
C.A	Abba Siin High Service Reservoir
C.a	Kadam High Service Reservoir
C.e	Bab Eastern High Service Reservoir
C.j	Jobar High Service Reservoir
C.k	Kaboon Booster Pumping Station & High Service Reservoir
C.m	Bab Mosallah High Service Reservoir
D	Dummar Booster Pump Station
D.1	Dummar High Service Reservoir
D.2	Dummar Regulation - 1 Service Reservoir
D.3	Dummar Regulation - 2 Service Reservoir
D.4	Dummar Regulation - 3 Service Reservoir
G	Jemarya Service Reservoir
G.ps	Jemarya Booster Pumping Station
I.A	Wali Service Reservoir
I.E	Akrad Low Service Reservoir
H.E	Eastern Service Reservoir
H.O	Western Service Reservoir
J	Jober Production Well Center
J.A	University Production Well Center
K.1	Kassioun Middle Service Reservoir
K.2	Akrad Middle Service Reservoir
K.3	Kassioun High Service Reservoir
K.7	Kassioun Superior Service Reservoir
K.8	T.V Service Reservoir
K.m	Kadam Store Production Well Center
K.s	Kadam Superior Service Reservoir
M.1	Mezze Service Reservoir
M.2	Mezze High Service Reservoir
M.a2	Mazraa Production Well Center
N.1	Ibn Al Nafeas Service Reservoir
R.K	Khorshead Service Reservoir

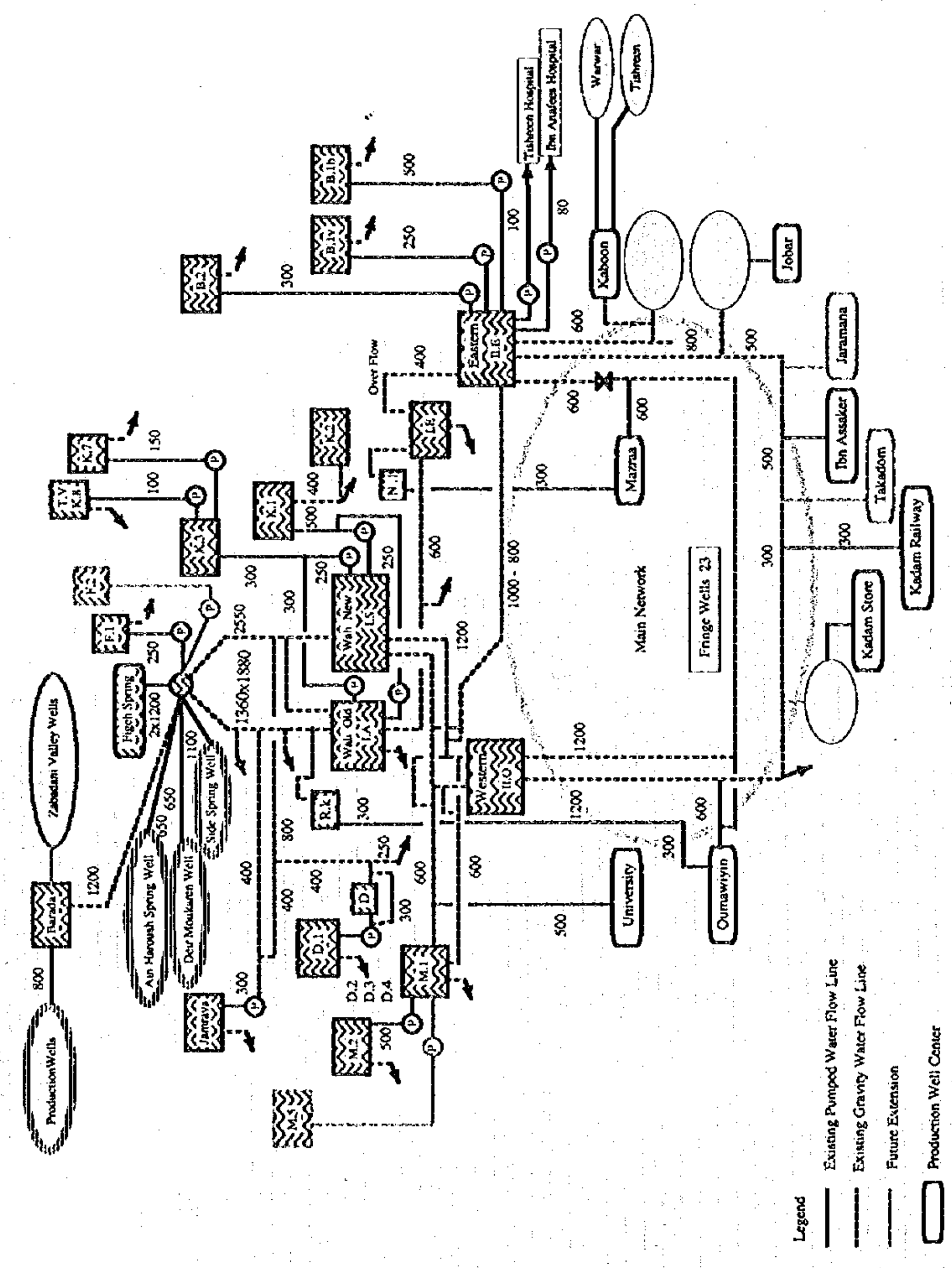
Legend [A.1] Existing Facility
[3] On going Project

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

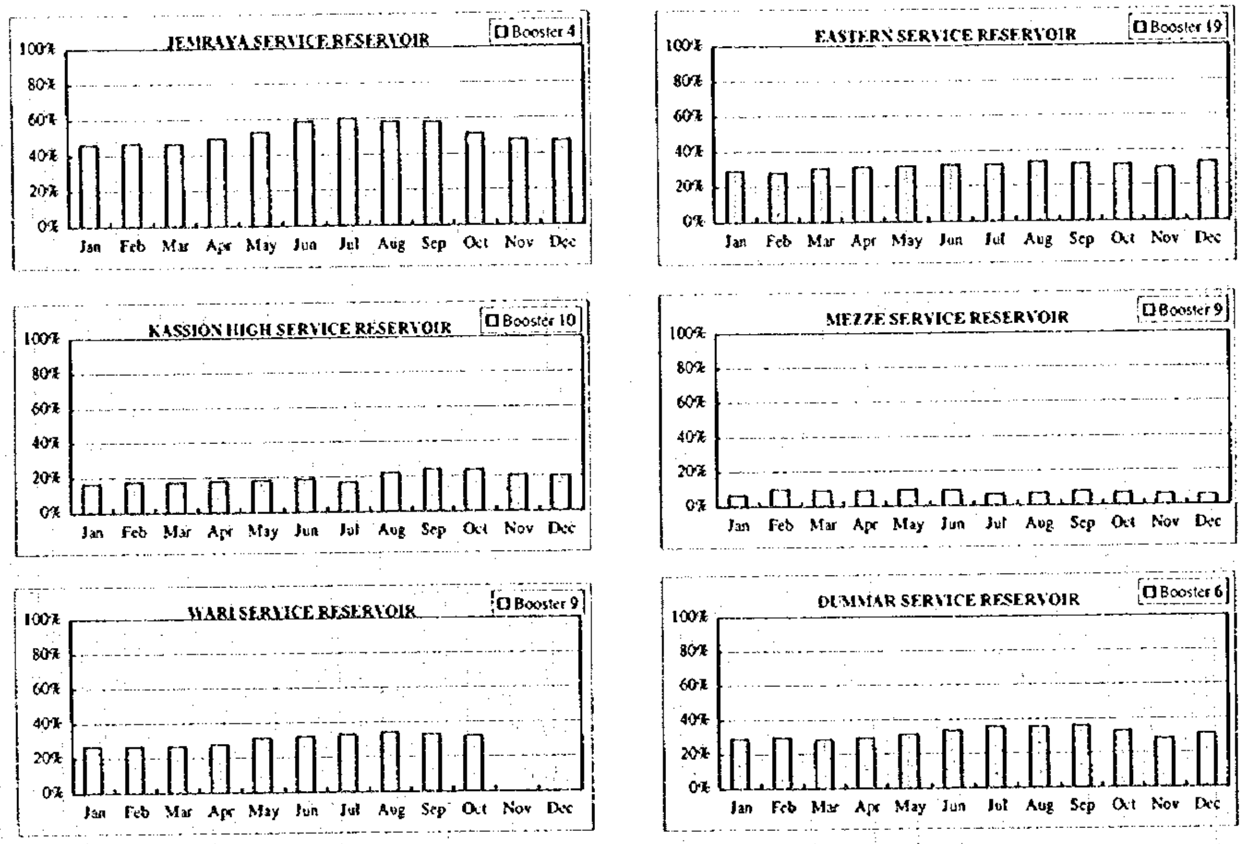
Figure E-3.5 Location of Water Supply Facilities

NIPPON KOEI CO., LTD.



JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY
Figure E-3.6 Schematic Diagram of Water Supply System
NIPPON KOEI CO., LTD.

(BOOSTER PUMP IN SERVICE RESERVOIR)



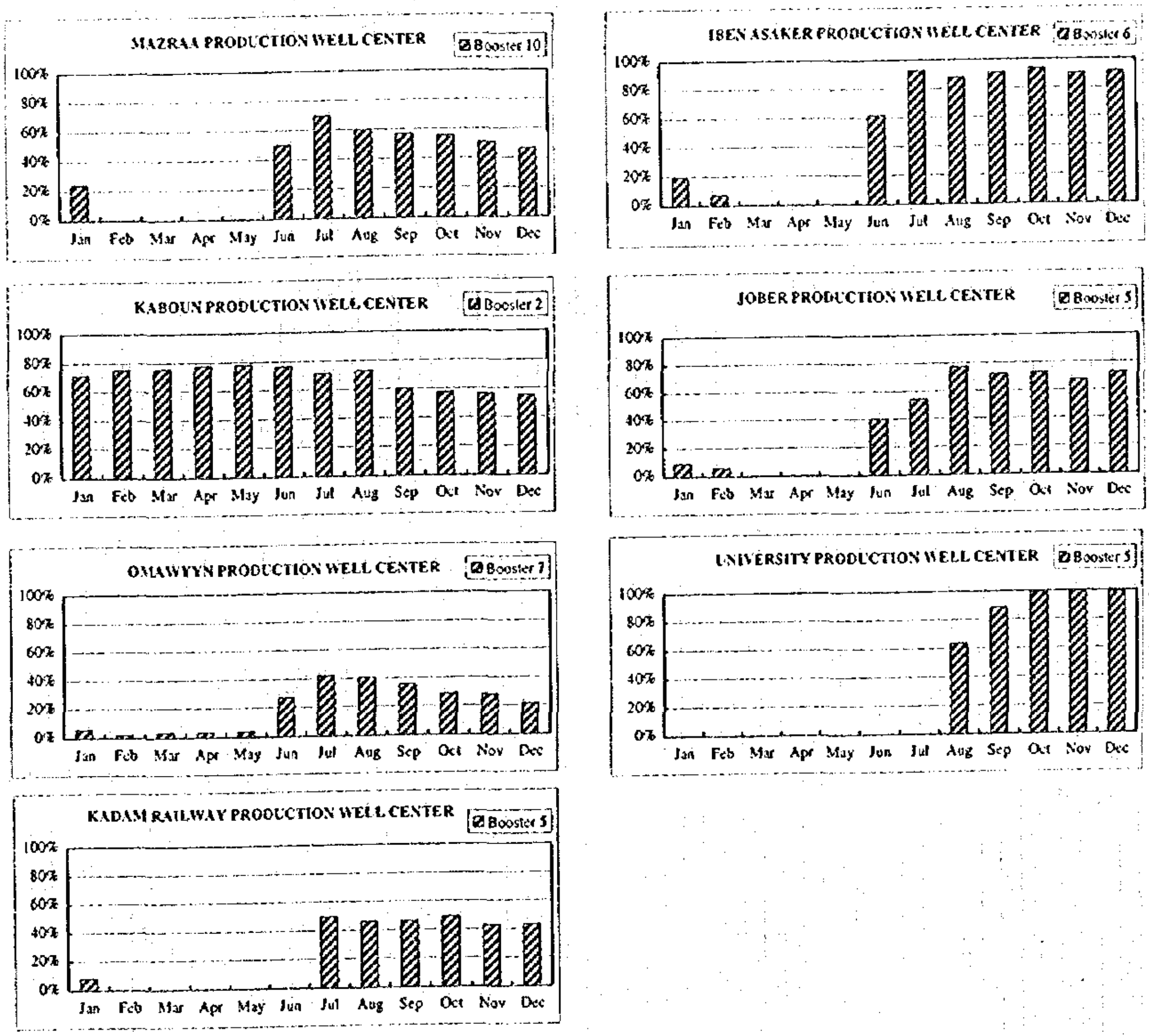
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

Figure E-3.7 Monthly Pump Operation in 1995 (Booster Pump in Service Reservoir)

NIPPON KOEI CO., LTD.

(BOOSTER PUMP IN PRODUCTION WELL CENTER)



JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

Figure E-3.8 Monthly Pump Operation in 1995 (Booster Pump in Production Well Center)

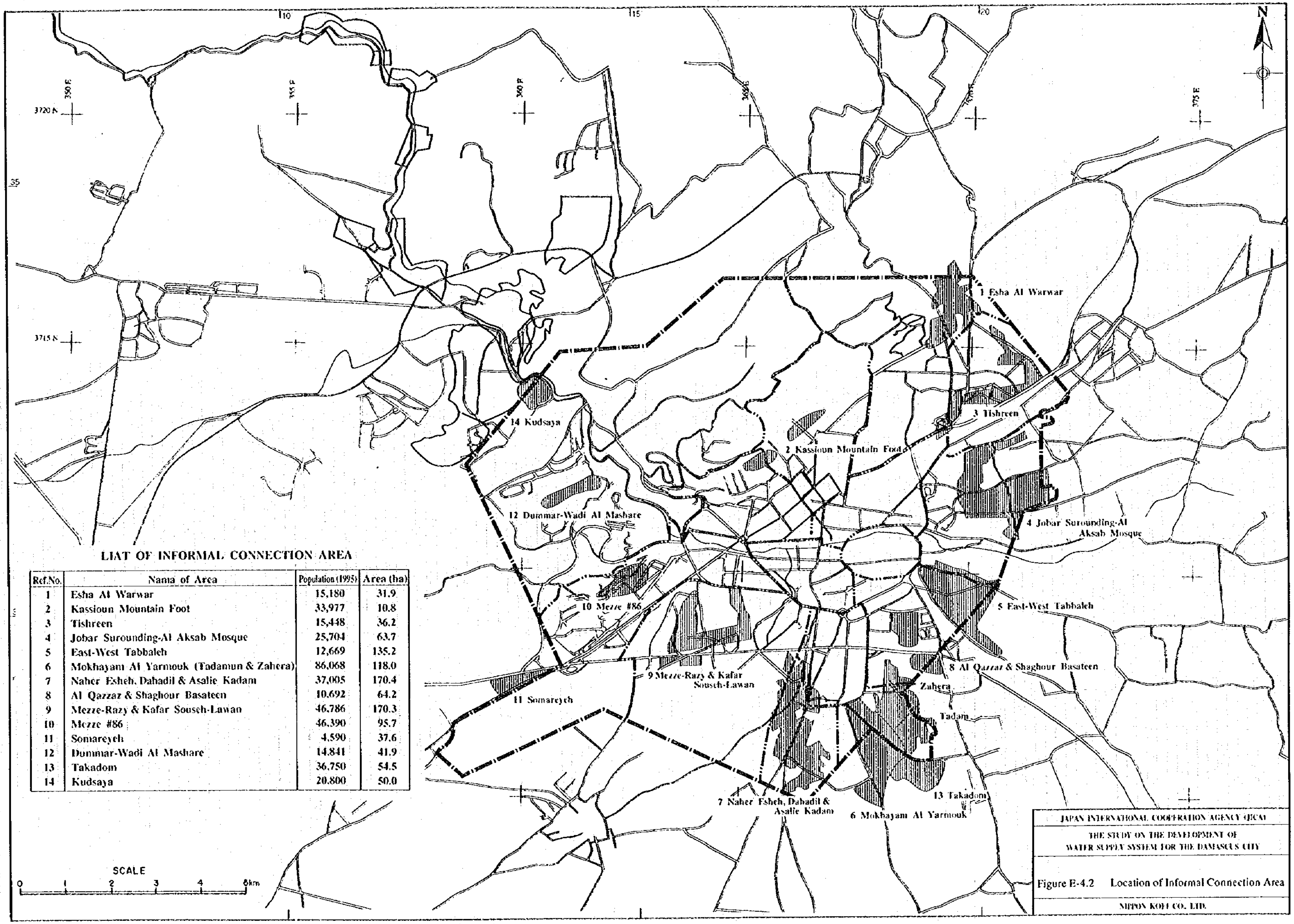
NIPPON KOEI CO., LTD.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

Figure E-4.1 Pressure Zones and Official Area No.

NIPPON KOEI CO., LTD.



LIAT OF INFORMAL CONNECTION AREA

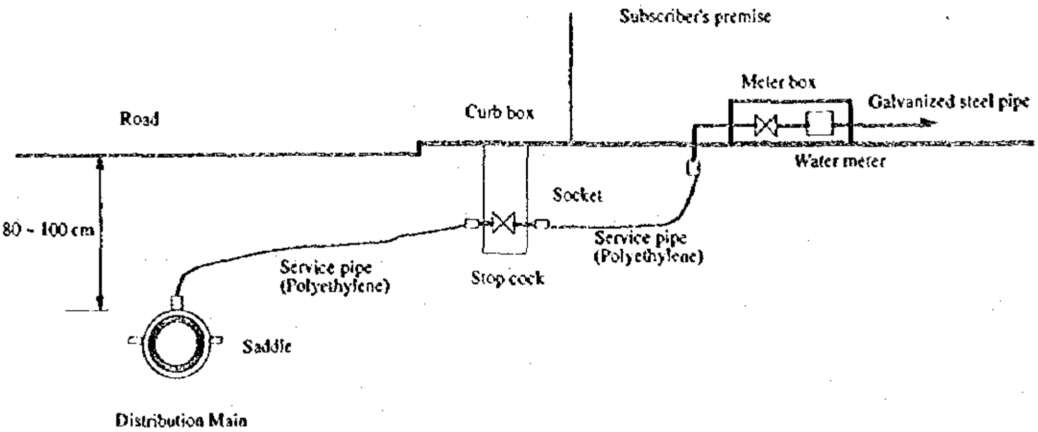
Ref.No.	Nama of Area	Population (1995)	Area (ha)
1	Esha Al Warwar	15,180	31.9
2	Kassioun Mountain Foot	33,977	10.8
3	Tishreen	15,448	36.2
4	Jobar Surounding-Al Aksab Mosque	25,704	63.7
5	East-West Tabbaleh	12,669	135.2
6	Mokhayam Al Yarmouk (Tadamun & Zahera)	86,068	118.0
7	Naher Esheh, Dahadil & Asalie Kadam	37,005	170.4
8	Al Qazzaz & Shaghour Basateen	10,692	64.2
9	Mezze-Razy & Kafar Souseh-Lawan	46,786	170.3
10	Mezze #86	46,390	95.7
11	Somareyeh	4,590	37.6
12	Dummar-Wadi Al Mashare	14,841	41.9
13	Takadom	36,750	54.5
14	Kudsaya	20,800	50.0

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

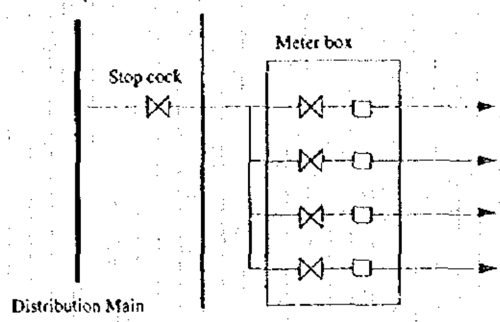
THE STUDY ON THE DEVELOPMENT OF WATER SUPPLY SYSTEM FOR THE DAMASCUS CITY

Figure E-4.2 Location of Informal Connection Area

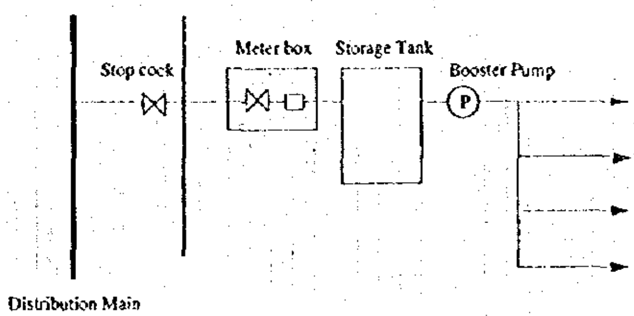
NIPPON KOEI CO., LTD.



House connection type for new building



House connection type for tall building

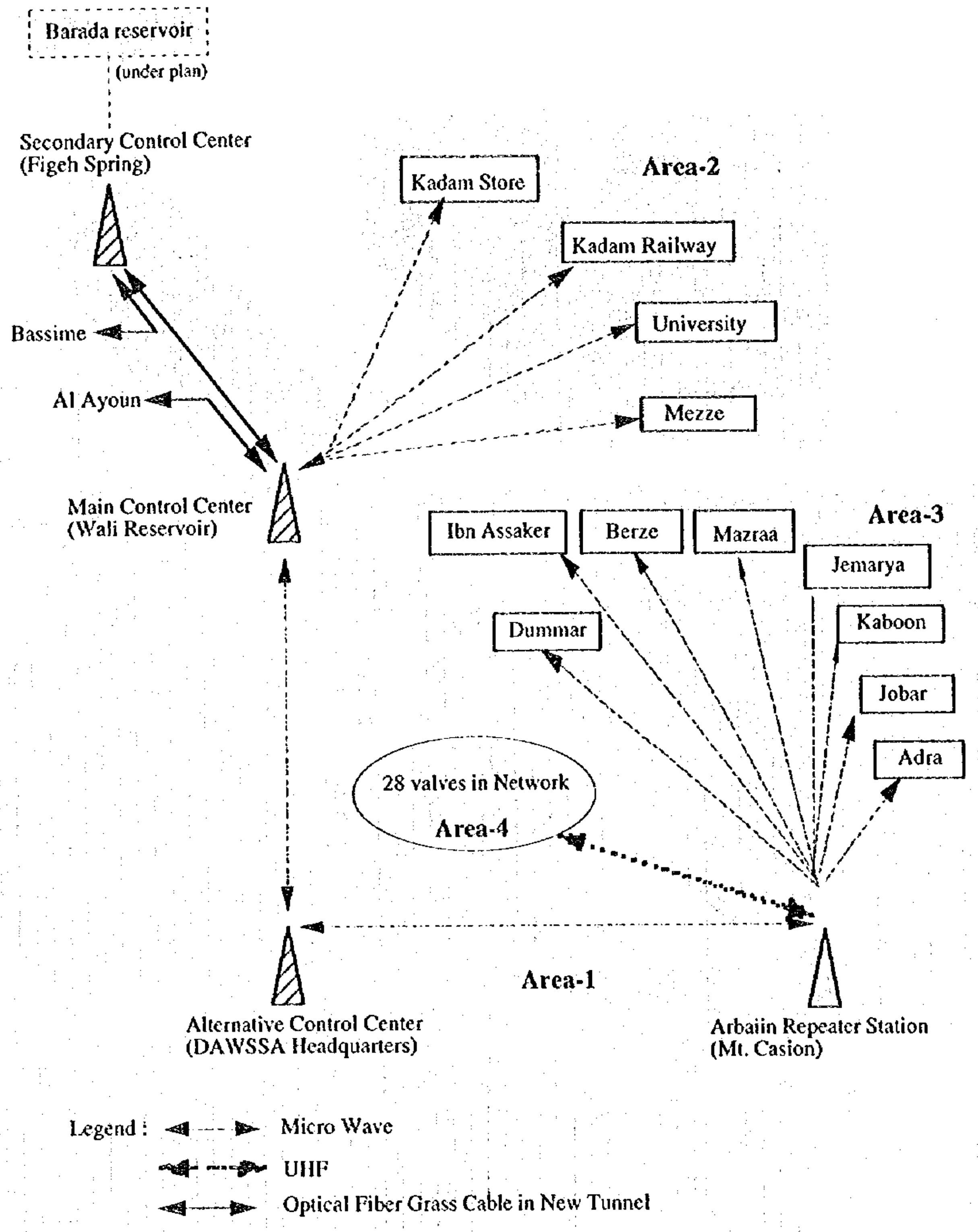


JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

Figure E-4.3 Typical House Connection

NIPPON KOEI CO., LTD.



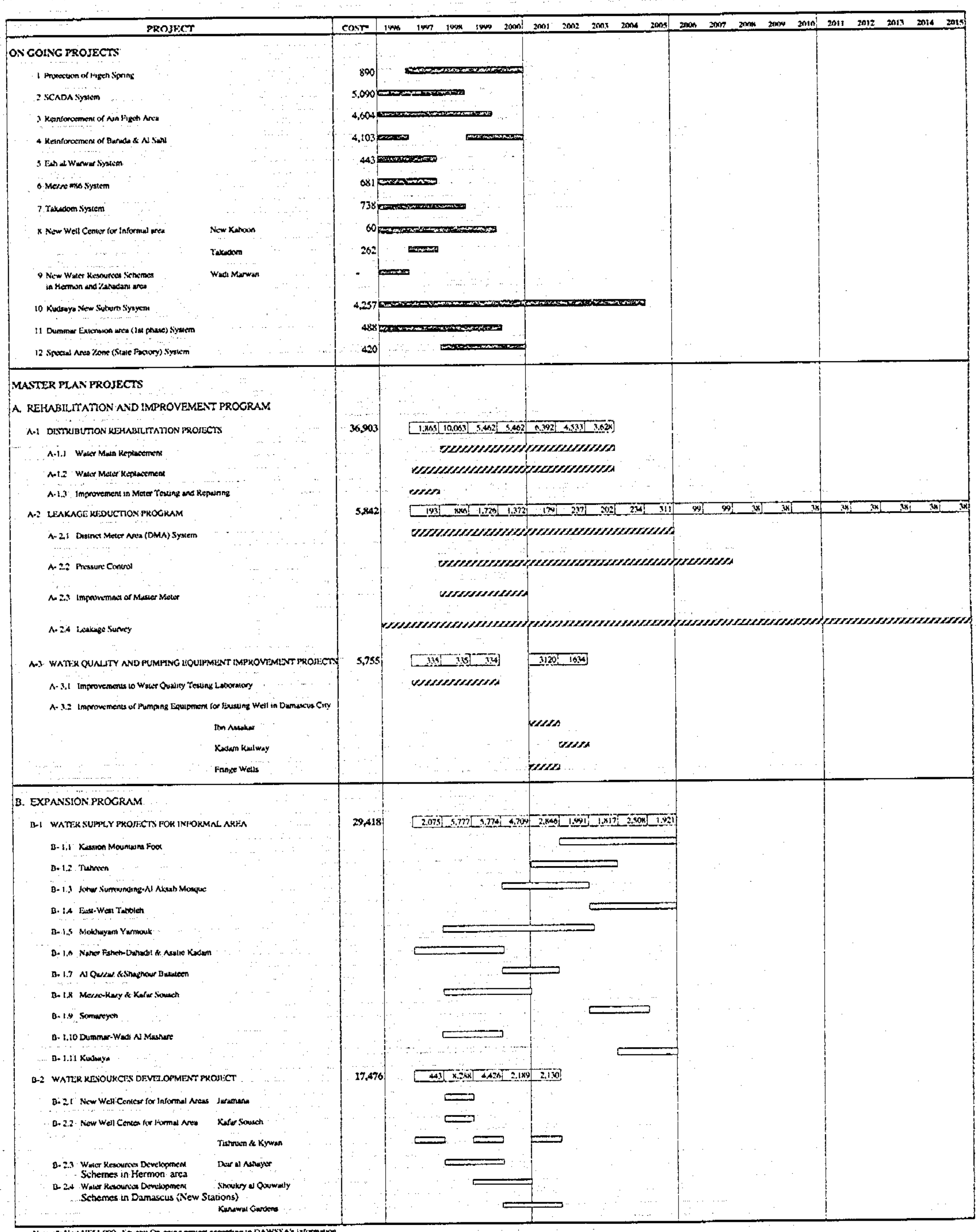
Note : Existing PABX (private automatic branch exchanger) will be used for back-up system.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

Figure E-4.4 Schematic Diagram of SCADA System

NIPPON KOEI CO., LTD.



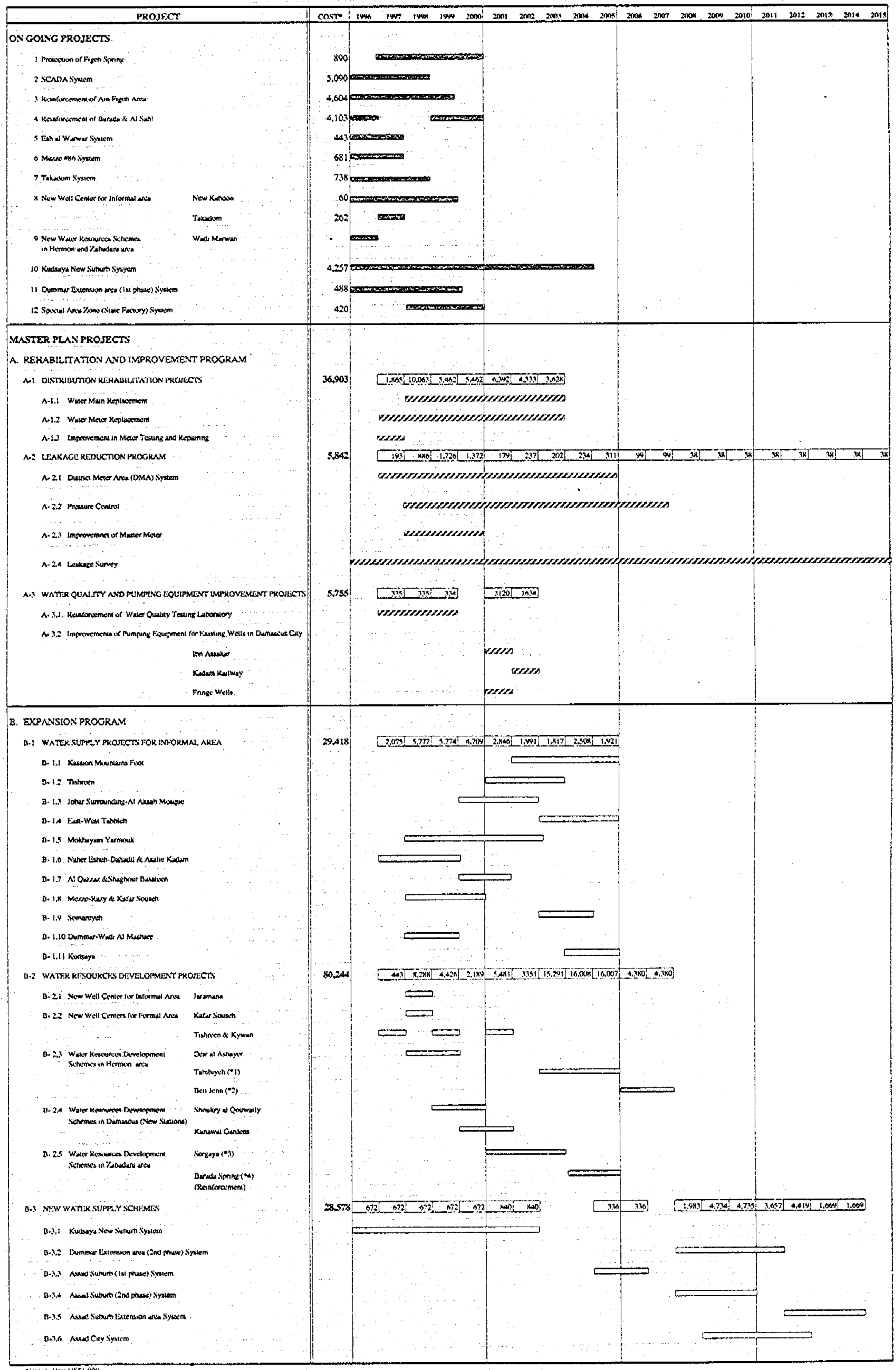
Note :*: Unit US$1,000, Source: On going project according to DAWSSA's information.
** Constant price as of September 1996 for Master Plan

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

Figure E-6.1 Projects Implementation Schedule (Proposed Plan)

NIPPON KOEI CO., LTD.



Note 1. Unit US$1,000
2. Source of "On going project" is according to DAWSSA's information.
3. Option-1 is excluded (*1), (*2), (*3) and (*4).
4. Option-2 is included (*1), (*2) and (*3).
5. Option-3 is included (*4) only.
6. Option-4 is included (*1), (*2), (*3) and (*4).
7. Constant price as of September 1996 for Master Plan

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

Figure E-6.2 Projects Implementation Schedule (Alternative Plan)

NIPPON KOEI CO., LTD.

APPENDIX F

UNACCOUNTED FOR WATER

APPENDIX F

UNACCOUNTED FOR WATER

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1. INTRODUCTION

The unaccounted for water study was carried out to assess the current situation in Damascus, and formulate recommendations for reducing the unaccounted for water figure. The objectives of the study were to :

i) Identify the present condition of unaccounted for water in Damascus

ii) Make recommendations and set achievable targets for the reduction of UFW

iii) Make recommendations of measures to be used for the reduction of UFW

2. COMPONENTS OF UFW

Unaccounted for Water (UFW) can be described as, that water which is the difference between that supplied and that which is accounted for. There are four main categories of UFW which are listed below :

2.1 Meter Malfunction

The malfunction of water meters is of great concern. One problem is that the meters which are currently installed appear to under register at Q Min and quite a number of them are subject to vandalism. Some of the meters are not read because there is difficulty in getting access to read the meter because they are located within the boundary of the property or situated in a locked up environment. Some meters are impossible to read because the meter reading dial is defaced, is scratched, or is affected by ultra violet rays, or has inside condensations causing the meter reading dial to be unreadable.

2.2 Informal Use

The use of water at these sites, of which there are 14 is water which has been taken illegally and for which no payment is being received. In addition to the water which is taken, there are substantial leaks in these areas, most of which has been caused by the use of inferior materials or bad workmanship in making the connection.

No control of these connections is apparent, indeed many individuals have made connections in the reservoir grounds with DAWSSA's full knowledge.

2.3 Religious and Public Fountains

Water which is used at the mosques is considered necessary for the cleansing of visitors to the mosque before entry and no charge for such water consumption is made. Public fountains have been provided free for use by the general public but most of them have no meter and are a constant source of water misuse and waste .

2.4 System Losses

This comprises of leakage from the distribution system, none of which is measured and some of which remains hidden underground often for many years. Leakage can be from main pipe joints, main pipe fractures or from service connecting pipes. Every day leaks are reported and repaired and it is estimated that there are over three thousand leaks attended to each year.

This figure appears to be on the low side when compared to other major cities and must be questionable.

3. APPROACH OF THE STUDY

3.1 Meter Malfunction

Water losses through meter malfunction is considerable. The method of calculating these losses was to identify total numbers of metered connections and total number of defective meters and calculate the percentage of failures and estimated losses. Figures were provided by the billing section of DAWSSA.

3.2 Informal Use

The method of calculating water losses at the informal sites was to identify total population for each area and apply a per capita allowance.

This allowance is based on the results of an interview survey carried out by the study team. This figure does not include system losses at the informal housing areas which is quite substantial.

3.3 Religious and Public Fountain Use

The method used for calculating losses for the mosques, is based on a sample survey covering 4% of the Mosques whereby information from meter readings was used to arrive at an average metered consumption figure. This figure was substantiated by consumption figures that were provided by DAWSSA. With regard to public fountain use, a consumption figure was provided by members of DAWSSA and the figures are shown in the findings section of this document.

3.4 System Losses

The method used for calculating system losses was to carry out a daily water balance calculation (see 5.5) using the total water production and deducting total billed water, an allowance for religious and public fountain use, an allowance for meter malfunction, and an allowance for informal use. The balance is assumed to be network system losses.

4. FIELD SURVEY

4.1 General

During this assignment, various attempts were made to measure the system using an ultra sonic type meter. The results from these measurements were encouraging, however, doubt about the integrity of the system (and in some cases) the quality of the mains records was raised. Domestic metering in two areas was surveyed over a six month measuring period together and comprehensive details are shown in Table F- 4.1

A measured survey of one informal site together with a leak detection exercise was carried out to identify leaks and visual observations of the system was carried out.

4.2 Survey Areas

The location of the system loss surveys are shown in location map Figure F- 4.1 and were carried out at the following sites :

i) Berzze Village Reservoir	(Reservoir zone)
ii) Esh Al Warwar	(Informal Housing Area)
iii) Mahadi Bin Barakeh/Malki Street	(Leakage survey in roads)
iv) Dar Al Moalimat/Rukn Aldyn	(Meter Survey of houses)
v) The Army Camp - Tishreen	(Leakage Survey at Camp)
vi) Hejaz Railway Station public fountain	(Public Fountain)

4.3 Survey Methods

During the field surveys, a variety of instruments were used to detect and measure flow rates. The ultra sonic flow meters were used to measure volumes of water passing through various pipelines. These are solid state electronic meters that measure velocity and converts this into volumetric units. The Mentor sensor is a precise electronic listening device which picks up leak noises in the pipeline and converts the sounds into electrical signals to produce a graph. Each mentor has a number of magnetic sensors that are placed at strategic points on the pipeline and identify the location of any leaks.

Traditional sounding techniques were used whereby the operator used a listening bar/stick to identify any sounds normally associated with leaks. In addition, the leak noise correlator was also used in tracking down leaks.

The leak noise correlator is a computerized leak locator with two microphones (sensors) which are used to determine leak noise levels in the pipeline. It utilizes the technique of cross correlation to determine the difference in time taken between the leak noise reaching the two sensors and is very good at eliminating unwanted or background noises which propagate from the pipeline.

4.4 Findings

4.4.1 Berzze Village Reservoir

Berzze village reservoir supplies an area covering Berzze area, the informal housing area of Esh Al Warwar and parts of Tishreen. Most of the system consists of old pipelines and a substantial number of sluice valves missing. The water mains records did not resemble the actual system but efforts to remedy this are currently being addressed. Measurements were carried out using the ultra sonic meters on the main inlet pipe to the reservoir (250mm) and the main outlet pipe from the reservoir (250mm) which is the pipe that supplies Berzze village reservoir zone.

These measurements were taken during the hours of 12 midnight to 04.15 hours, when it is assumed that most people are sleeping. Consumption would therefore be at its lowest. However, the minimum night time consumption was 275,000 liters per hour. Using a normal calculation for determining leakage levels, the following is a breakdown of results :

Minimum Night Time Flow	275,000 Liters/Hour
Assumed Number of Properties	15,000
Less legitimate night time allowance of 1.9 Liters/Property/Hour	28,500
Leaving a balance of	246,500 Liters/Hour
Therefore Assumed Leakage = 16.43 Liters/Property/Hour or	5,916 m^3/day

After allowing for genuine night time use, it would appear that in this one area, the magnitude of losses = 2.17 MCM/Year

Following the measurement of Berzze Village Reservoir, the leakage team was mobilized and a number of small leaks were located. It was found that a lot of water fittings were either inaccessible or did not exist, making the whole process of leak detection difficult.

In the search for leaks, it was discovered that an army camp with 50 personnel in occupation was using in excess of 300,000 liters/day. (12,500 Liters/Hour) Most of the losses were attributed to overflowing storage tanks which had no control valve fitted. Steps are currently being taken to resolve the problems at the army camp.

Of the total night time flow of 275,000 liters, only 65,500 liters (23.81%) has been accounted for so far, which indicates that the information about the system and its integrity is questionable and requires additional clarification.

4.4.2 Esh Al Warwar

The informal connection site at Esh El Warwar is located about one kilometer from Berzze village reservoir and is supplied by a single 75mm cast iron main. At the terminal end of this pipe, there are many informal connections with little booster pumps to supply the elevated area's of the system. The 75mm main was measured and a total of 588,000 Liters/Day (constant 24,500 Liters/Hour) was recorded as passing through the Ultra Sonic Meter between the hours of 00.00 to 4.00 am. It is evident that this rate of flow is the maximum rate that the 75mm main is capable of delivering.

The 75mm cast iron main that supplies Esh Al Warwar is obviously undersized, and as a result, the flow is severely restricted to the site. The result is that most of the properties connected to this main are experiencing problems in getting a constant 24 hour supply. In simple terms, there are two many connections off this main.

Generally, a free for all situation has developed, whereby, those houses with the better pump and piping arrangements will get their water first, leaving those with inferior piping/pumps to draw water later on. Therefore, the whole process of delivering water to these properties is ineffective.

Clearly the 75mm main is inadequate and is now in the process of being considered for replacement. In addition to the general mayhem that exist at this location, there are quite a number of visible leaks which are quite significant. This is compounding the problem of supplying water to Esh Al Warwar. The net result is that a constant 24.5 m^3 is being abstracted at this point (24 Hours/Day).

4.4.3 Mahadi Bin Barakeh & Malki Street

The Mentor sensor was used to determine leakage on two water mains, a 600 mm main in Mahadi Bin Barakeh and a 400mm main in Malki street. Electronic sensors were placed on 9 valves in Mahadi Bin Barakeh and on 7 valves in Malki street. Three leaks were discovered, one was a leaking sluice valve and the other two were on air valves off the 600mm main. Leakage was estimated by visual means only, but equated to a loss of approximately 25 liters/minute ($36m^3$/day).

4.4.4 Dar Al Moalimat & Ruku Aldyn

This was a study on per capita consumption at Dar Al Moalimat and Ruku Aldyn and was spread over a 6 month period. The results of which gave a fair indication that there was an average meter failure rate of 32%. In total there were 143 properties which had a meter malfunction. Based on an average consumption rate of 1,230 liters/property/day, losses can therefore be assumed to be $176m^3$/day. Meter survey details are attached as Data Book 5 a -b.

4.4.5 The Army Camp at Tishreen

The army camp at Tishreen is mainly derelict and there are approximately 50 personnel living there. The army camp receives its water from Berzze village reservoir and during investigations into high night time use it was noticed that the main meter reading for the army camp was abnormally high. Further investigations revealed that there were a number of overhead tanks that were constantly overflowing and also taps that were continuously running.

Based on normal consumption patterns, the usage should have been $9m^3$/day. However, the actual consumption was in excess of $300m^3$/day. Therefore losses can be assumed as being $291m^3$/day. Work is ongoing at the army camp to stop the leakage/wastage.

4.4.6 Hejaz railway station public fountain

The public fountain outside Hejaz railway station is located almost opposite the DAWSSA headquarters building and is in constant use. There are four open pipes without any form of control device and a timed measurement of 36 liters/minute was carried out. The fountain is running continuously for 24 hours per day and losses are calculated at $38m^3$/day.

During the study period, an understanding of the current situation has emerged. In unaccounted for water terms, five of the six surveys revealed a rate of leakage/losses which , (when calculated) represent a total of 2.35 MCM (1.07% of total supply).

5. UNACCOUNTED FOR WATER

5.1 Informal Use

The informal housing areas are the homes for displaced persons and the like who have constructed and made illegal connections to the nearest water main so as to obtain a water supply. Many of these connections are dangerous and are badly connected which results in high leakage rates, in addition, nobody is paying for any water that is received.

There has been no enforcement by local government to restrict or control how these sites have been developed, consequently the proportion of refugees has grown. In recent years DAWSSA have recognized that there is a need to change the status of these sites from informal status to formal status. Not only are there substantial amounts of leaks, but all of the water being consumed at these sites is unregistered.

In total there are 14 such sites with a population exceeding 406,000. Estimates for water consumption represents approximately 13.6% of water which is supplied In an effort to address the informal connection sites problem DAWSSA have already embarked on a program to formalize a number of areas. Work has commenced at one such site Mezze #86 and should be completed by the year end. In the absence of real information for leakage rates at these sites, an estimate can only be made at this time.

Using an average leakage rate of 15.84 m^3/leak/day and an incident rate of 1 leak/28 connections, then a figure of 2,298 leaks for all of the informal sites can be used.

Therefore : Estimated losses = 2,298 connections x 15.84m^3 = Losses of 36,400m^3/day. (46.32% of Informal use) This is equal to estimated losses of 13.29 MCM (5.37% of total water supplied).

The table below provides details of the informal sites :

Number of Informal Areas	14	
Population	406,900	27%
Connections	64,350	28%
Consumption m^3/day	78,581	12%
Leakage rate	36,400	5.3%

5.2 Religious and Public Use

Use of water by the general public is confined to 115 public stand taps which are located at various points in the system. Some of these taps are metered and have been taken over by private individuals. However, the majority of them remain un- metered. A number of these public taps have been monitored over a 3 month period with average consumption in the order of 2 m^3/day. Other public taps are located in most of the public parks and gardens throughout the city and it was observed that they are a constant source for misuse and waste.

DAWSSA have in the past tried to remedy the problem by installing a number of spring loaded taps but apparently these taps were stolen.

Another part of the public use water calculation is the water that is provided by Mosques and churches. There are over 500 hundred mosques and churches which are located throughout the city and they vary in size. A sample survey covering 4% of Mosques over a 1 month period shows that the average consumption per mosque is in the order of 4m^3/day. Details of the survey are shown in Table F-5.1

The mosques and public fountains are in a special category that will not incur charges in the future, however, they should be subject to periodic inspections so as to minimize the waste of water. During the field study, it was noted that there was excessive misuse of water at some locations (especially in Mouhajreen) where the local mosque was providing water to a local bathing establishment and there was no control devices fitted. The waste of water from this establishment was astronomical and was running continuously all day. DAWSSA staff seemed unconcerned about such wastage and seemed to accept that these things were the norm for Damascus.

Estimated losses from the mosques is equal to :	0.79 MCM
Estimated losses from the public fountains is equal to :	3.03 MCM
Estimated total losses is equal to :	3.82 MCM

5.3 Underestimation and Inaccuracy of Meters

Underestimation and inaccuracy of meters is one of the major factors in the unaccounted for water calculation. With an average meter failure rate of 44% for Governmental/Industrial consumers and an average failure rate of 33.5% for domestic meters, a huge amount of revenue is being lost each year. The most common meter in use for domestic purposes is a locally manufactured meter called the Doris meter and is based on an earlier design of a French meter.

5.3.1 Total Numbers of Malfunctioning Meters

According to the meter billing department the total numbers of meters which are malfunctioning is 84,112 the majority of which are domestic meters. Some of these meters are meters which have low quarterly consumption but others are meters that are broken.

DAWSSA currently have a number of meter repair teams who replace meter which have been reported as defective, however, it would appear that there are more meters being reported as being defective as are being repaired.

Recently, DAWSSA have engaged the services of an outside contractor to replace a 1000 meters on a fixed contract rate over a specified period of 45 days. Subject to a satisfactory outcome, it is expected that this practice will continue throughout this year and probably be extended for the next few years. This work is additional to the work already being undertaken by DAWSSA's current meter repair teams and is slowly making some impact on the current backlog.

The table below shows each category and percentage failure.

Description of Meter	Numbers Malfunctioned	Percentage rate of Total
Domestic	37,472	37%
Domestic with Water Rights	27,281	30%
Commercial	17,030	56%
Industrial	1,113	48%
Governmental	1,216	40%
Total Meters Malfunctioned	84,112	

Meter malfunction can be caused by a number of factors and reports from the meter repair shop suggest that quite a proportion of them are damaged by vandals. Other factors causing failures are internal condensation of the meter reading glass or ultra violet radiation which causes the plastic face to deteriorate thus making the meter un-readable.

The table below shows the failure rate and estimated losses :

Total number of Meter Connections	Total number of Meter Failures	Percentage Failure Rate of Meters	Estimated Losses Per Quarter
230,724	11284,	36.45%	9.054 MCM

5.3.2 Results of 7 point test

Two Doris meters were subjected to a 7 point test at a meter testing facility in England during April 1996 the result of which suggest, that the meter performed very well at Q Max and Qn but at Q Min it failed by as much as 22.7%.

One of the meters tested was a new meter and the other one was an old meter that had been repaired at the DAWSSA meter repair shop. There was little difference in either result. A seven point test is where a meter is subjected to a series of tests over a wide flow range starting at (Qt) which is the transitional flow rate, and 2 x Qt rising to (Qn) @1.5m^3 to 0.5 Qn to 0.25 Qn which is the nominal flow rate at which the meter is at its most effective, rising to (Q max) which is the highest flow rate at which the meter is required to operate in a satisfactory manner for a short period of time without deteriorating and finally at (Q min) which is the minimum flow rate at which the meter is expected to work accurately.

Details of the results of the seven point test as shown Data Book 5c

5.3.3 Estimation of Meter Malfunction

Meter malfunction represents 14.4% of the unaccounted for water figure. In 1995 the total numbers of meters with a consumption of less than 5 m^3/quarter was in excess of 84,000 meters and the average loss in water was equal to 31.4 MCM.

5.4 Water Leakage

Water leakage in the system is an unknown factor because none of the system is measured and at best can only be estimated at this time. Some of the major contributory factors for leakage in Damascus are the informal areas where there are great losses and system losses from old cast iron mains, some of which date back to the early part of this century. Most of these old water mains have lead run joints which all to frequently leak and are in urgent need of replacement.

The leak detection teams has recently been expanded from one team to three teams and are finding about 4 or 5 leaks a day, most of the leaks being on service pipe connections. DAWSSA estimate that 80% of all leaks are from service pipes and connections such as stop-taps and ferrules, and that the remainder of leaks are from sluice valves, fire hydrants and water mains.

Leakage from the network is a long term problem for which there is no quick or easy solution. As an interim measure, the Damascus City Water Supply & Sewerage Authority (DAWSSA) has initiated a program for reducing unaccounted for water. An active program for leak detection and repair has commenced and a program to replace water mains with a bad history of leaks is planned for the future. Historically, little attention has been paid to private leaks which represents a substantial portion of leakage.

Whilst there is a procedure for dealing with private leaks, there appears to be very little activity in following through the inspection procedures required for eliminating these leaks. In some cases, DAWSSA staff are discouraged from entering private dwellings which has meant that the numbers of private leaks are not represented properly in any report and therefore, it is likely that the numbers of private leaks are quite substantial. With over 1,000 km of water mains falling within the jurisdiction of DAWSSA , and no real measurements to rely on for identifying accurate losses, the whole process of searching for leaks is difficult. However a number of solutions have been identified which should enable accurate leakage information to be obtained in the future and should also help in directing the leakage teams to areas of high leakage.

Leakage happens for a number of reasons, the most common which are listed below :

- The age of the Distribution system
- Hilly terrain which causes high supply pressures in some areas
- The aggressive nature of the soil which may cause external corrosion
- The way in which pipes are laid and the pipe materials used.

Reducing leakage is desirable for a whole range of reasons which benefit the Customer, the Environment and the DAWSSA . These are as follows :

- To lessen the impact of shortages created by low rainfall
- To postpone or eliminate the need for the development of new water resources
- To reduce production and pumping cost in the distribution system

Currently DAWSSA operate a system of checking for leaks by deploying three leakage teams who are systematically working their way through the distribution system to look for leaks and having those leaks that are self evident repaired.

Each team has to work in a geographical areas and is equipped with various items of electronic equipment which will help them find leaks. Please see complete list in data book.

In anticipation that a strategy of district metering will be adopted, a computer spreadsheet has been designed and is ready for use when district metering becomes a reality. A specimen copy is also shown in Table F-5.2

5.5 Water Balance of DAWSSA in 1995

In order to assess unaccounted for water, the following figures were used whereby figures for billed water and allowances for un-billed water were deducted from the total water production and the balance is assumed to be unaccounted for water. The figures are presented in the table below :

Economic	Number	Description	MCM/Year	Percentage	Revenue	Technical
Billed	1	Domestic Use	46.1	21.1%	Meter	Delivered
	2	Government	13.6	6.2%		
	3	Commercial	2.8	1.3%		
	4	Industrial Use	0.5	0.2%		
	5	Water rights	14.9	6.8%		
Un - Billed	6	Religious & Public Use	3.8	1.7%	Un metered	
	7	Meter Malfunction	31.4	14.4%	Under estimation	
	8	Informal Use	29.7	13.6%	not metered	
	1 to 8	Sub Total	142.8			
	9=10-sub total	System Losses	75.5	34.7%		Losses
Production water	10	Total Production	218.3	100%		

6. STRATEGIC PLAN OF REDUCTION OF UFW

6.1 . Target of Reduction of UFW

In order to reduce the unaccounted for water figure, various countermeasures have been proposed and are explained later in this report.

All of these countermeasures are technically and economically possible. They would also provide for better management of the system and information about the system which is not available at this moment.. A reasonable target of 25% has been suggested for the year 2015 which should be achievable. If one compares this figure to typical English targets, then they are very similar and in Jakarta a target figure of 25% has also been set.

These targets are seen as realistic targets and ones that can be achieved It is therefore important that this goal is maintained by DAWSSA otherwise, there would be serious shortfalls in the supply of water to the detriment of both the customer and DAWSSA.

The table below shows the target reduction and timetable of events.

Items	Present (1995)	2,000	2,005	2,010	2,015
Informal Use	13.6%	4%	1%	0%	0%
Meter malfunction	14.4%	3%	0%	0%	0%
System Leakage	34.7%	32%	30%	28%	25%
Total Unaccounted for water	62.7%	39%	31%	28%	25%

6.2 Informal Use

There are 14 informal sites scattered in and around Damascus. A 10 year program to transfer all informal sites to formal status has been prepared and considerable savings from leakage can be achieved. Work has commenced at 3 of the sites and it is likely that they will probably be completed towards the end of 1997.

The table below shows each informal area, population and total consumption m^3/day.

Name of Area	Population	Consumption m^3/day
Esh Al Warwar	15,180	2,932
Kassioun Mountain Foot	33,977	6,562
Tishreen	15,448	2,983
Jobar Surroundings	25,704	4,964
East - West Tabbaleh	12,669	2,447
Mokhayam Al Yarmouk	86,068	16,621
Naher Eshah	15,180	7,146
Al Qazzaz	33,977	2,065
Mezze - Razy	46,786	9,036
Mezze # 86	46,390	8,959
Somareya	4,590	886
Dummar	14,841	2,866
Takadom	36,750	7,097
Kudsaya	20,800	4,017
Totals	406,900	78,580

Estimated losses for the informal areas is equal to 28.68 MCM and remedial work which has started is mainly confined to installing new pipelines, pump installations and some civil work. Once all of the informal sites have been transferred, there will be a considerable revenue increase as all the properties which are currently connected informally and who are not paying any water charges at this moment will, in the future be connected with a proper metered supply.

The table below gives details of the sites and projected transfer of status.

Name of Informal Site	Population	Date of transfer to formal status
Esh Al Warwar	15,180	1997/98 (work started)
Kassioun Mountain Foot	33,997	2001 (planned)
Tishreen	15,448	2003 (planned)
Jobar Surroundings	25,704	2002 (planned)
Tabbaleh	12,669	2005 (planned)
Yarmouk	86,068	1998 (planned)
Kadam	37,005	1998 (planned)
Shaghour Bassateen	10,692	2006 (planned)
Mezze Razy	46,786	2000 (planned)
Mezze # 86	46,390	1998 (work on-going)
Somareya	4,590	2006 (planned)
Dummar	14,841	2004 (planned)
Takadom	36,750	1997 (25% Started)
Kudsaya	20,800	2006 (planned)
Total Population	406,900	

6.3 Countermeasures for Reducing UFW

A number of countermeasures to reduce leakage levels have been proposed and are listed below :

6.3.1 Replacement of Old Water Mains with History of Leakage

A program to replace old water mains with a history of leakage has been prepared. Many of the pipes are old cast iron mains with lead run joints which frequently leak and by replacing these pipes the frequency of leakage will be reduced. The oldest pipes to be replaced date back to the early part of this century from 1906 dating to the late 60s and are cast iron pipes. Each year, there are many instances where these pipes leak and rapid attention is called for. In addition to the leaking lead joints, other fittings such as sluice valves and air valves are constantly leaking. Each time a leak develops, there is quite a substantial loss of water. The repair of such leaks can be expensive , as roads have to be excavated and the mains have to be emptied of water so that repairs can be carried out.

In total there are over 1,000 km of water mains which are the responsibility of DAWSSA and the table below shows each classification and the total number of mains to be replaced is over 97 km.

Under normal conditions it would be possible to replace the 97 km of mains within a six year period, which would mean on average that 16 km of mains would have to be installed. This is a realistic time scale to replace the critical pipes and would mean an average of 50 meters of pipe would have to be laid each working day.

Pipe Diameter	Ductile Iron	Cast Iron	Steel	Length	Length to be replaced
25 - 60mm	8,031	0	26,638	34,669	0
80 - 150mm	695,801	40,053	5,134	740,988	28,550
200 - 350mm	108,269	54,478	1,700	164,447	43,540
400 - 600mm	72,482	29,853	149	102,484	25,485
700 - 1200mm	13,373	0	1,582	14,955	0
Total Length	897,956	124,384	35,203	1,057,543	97,575

The implementation schedule for replacing these water mains is spread over 6 years from 1998 to 2003 (see Table F- 6.1). A detailed map of the mains to be replaced is shown in Figure F- 6.1

The strategy for implementation is based on a number of factors which were discussed with DAWSSA and are as follows :

From DAWSSA's experience, there are quite a number of mains which frequently leak and they cause problems each year. Some sections of pipe have had countless repairs carried out on them and still they will develop further leaks. All this leaves DAWSSA in a very vulnerable position and supplies are always threatened. Some of these pipes are inter connected with other pipes and when they are isolated during repairs, DAWSSA have tremendous problems maintaining supplies to other parts of the system. Other factors which cause the water mains to leak is the age of the pipe and high pressures in the system. One particular main is a steel main which is perforated and frequently leaks.

The mains replacement program is scheduled to commence from 1998 and should be completed by the year 2003. Realistically, this is achievable for DAWSSA. Those mains which are considered a high priority are featured in 1998 and the total length of mains to be replaced during that year is 16.6 km. In particular, the area surrounding Omawyeen square, Malki street and Mahadi Bin Barakeh have been real problem areas where the pipes have a history of continuous leaks and therefore this is considered as a priority. Most of the mains are connecting mains so it is important that they are dealt with first.

Projects scheduled for 1999 total 18 km, but most of these are small in size. The general area is near to the old city and is very critical with existing high leakage rates.
Some of the pipeline are connecting pipe to reservoirs and are very critical.

Projects for the year 2000 and 2001 include many small projects and a number of the mains to be replaced are linking the old part of Damascus to the newer areas. The project in the year 2003 (which is the final year) is confined mainly in the newer expansion areas of Mezze and is required for security of supplies.

6.3.2 District Meter Areas (DMAs)

The second countermeasure is to measure the system using a universally accepted principle that where leakage figures are unknown, then the only way forward is to measure the system. The measurement of the system would be through a policy of creating District Meter areas (DMAs) which is explained below.

(1) General principles of District Meter Areas

In an attempt to measure leakage more directly rather than estimating it from a mass balance approach, the distribution network in Damascus could be divided into approximately 65 to 70 district meter area's. The size of each of these areas would be determined by a number of factors, such as the size of the pipe supplying the zone, or its geographical boundaries.

As a rough guide, a district meter area should comprise of no more than 6,000 properties and no less than 2,000 properties. This figure is not absolute, and variations will arise from area to area, but these figures are normally considered to be manageable.

Consumption into these area's should be measured at night when leakage is assumed to be a major element because of low domestic and industrial use. After allowances have been made for these uses (normally 1.9 Liters/Property/Hour) the difference is assumed to be leakage. However, in Damascus, consideration will have to be given to the fact that is some areas, there is a possibility that overhead storage tanks might be filling during the night, therefore allowances will have to be made, such information will only become known once measurements have been carried out.

The advantage of this technique is that it can be used to target leak detection efforts more efficiently (since leakage levels will vary from area to area) and the leakage teams will be directed to those areas with high leakage levels.

A necessary condition in the setting up of district meter areas, is that sluice valves will have to be renewed or installed where none exist at present. Thereafter, certain valves in the system will have to be closed so that all water is directed only through the meter thus allowing measurement of the area to be made.

Each DMA will also require a meter chamber and a meter that could either be a fixed meter or a meter that can be transferred from site to site. It is also important that these meters can be used with data loggers for the storage of hard data.

It has been found that estimation of leakage from daily quantities is unlikely to give sufficiently accurate results. Therefore, it is recommended that leakage figures from the distribution system be obtained by measurements of night time flows and night consumption. This method can be used to obtain a measure of the absolute level of leakage, but to do so, it would be necessary to make a deduction for un-metered night time consumption.

The choice of a leakage control method appropriate to a given system should be made with due regard to economic and engineering factors, although financial or political constraints may also need to be considered.

The major elements to be considered are as follows :

- The magnitude of leakage from the system
- The benefits of reducing leakage
- The cost of implementation of a DMA program

By implementing a program of District Metering, it will be possible to arrive at accurate leakage levels for the City of Damascus. However, there will be a requirement to carry out a short feasibility study to confirm the viability of an extended DMA program.

It is therefore proposed to set up a number of small pilot areas, details of the feasibility study are outlined below.

(2) Required study for establishing District Meter Areas

The aim of the study is to identify area's where a reduction of leakage can be achieved by the setting up of District Meter Areas and where continuous monitoring can be accomplished. It is expected that a number of pilot study area's be selected and if the results of the feasibility study are favorable, then a program for extending DMAs to the whole of Damascus will be considered. The setting up of District Meters Areas is a prerequisite for any future Feasibility Study for a Pressure regulating program.

In order to effectively manage leakage it is essential that data quality is improved and maintained, therefore the following program should include :

i) DMA definition, sizing and integrity
ii) DMA data on property counts & mains lengths
iii) Industrial night use allowance
iv) Revenue meter audit
v) Service reservoir check (overflow & leakage) where applicable
vi) Critical monitoring point audit
vii) Fire main and operational use
viii) Identification of Hospital & Sensitive consumers
ix) Flow and Pressure profiles of proposed DMA
x) Preparations of plans & drawings
xi) Carry out initial flow /pressure measurement of DMA
xii) Carry out analysis of probable cost savings
xiii) Prepare detailed recommendations for DAWSSA

The water supply situation in Damascus is, that there is not an all year round supply, and during the months of July through to September, supplies are regulated during the night and there is every possibility that night time monitoring might be curtailed.

(3) Required equipment for the study and implementation schedule

Equipment for the study should comprise the following :

2 x Ultra Sonic Flow Meters with Accessories
2 x Electromagnetic type meters (i.e. Kent 3000) Optional
2 x Pressure Recorders
1 Portable Laptop Computer & Printer
2 x Data Loggers & Computer Software

The implementation schedule of the study, detailed design and installation are shown in Table 6.2

6.3.3 Increased Leak Detection Activity

At the beginning of 1996, there was only one leakage team for the whole of DAWSSA s distribution system. Clearly, this was insufficient and following recommendations in June, the section was increased to three teams. Each of the teams has been provided with a variety of electronic leak detectors and pipe locators and are now working in three geographical areas (see Figure F- 6.2). Each day a number of leaks are located and the leaks are also being repaired within a short period of time. The information regarding leaks is now being stored in a computer database and it is expected that the DAWSSA staff will be able to produce monthly reports for higher management and it will then be possible to identify trends and problem areas.

As the information is stored, then over a period of time, an historical information database will be possible, and information regarding failure rates, types of leaks and numbers of leaks over a period of time will be available.

With such information available, management at DAWSSA will have a valuable tool at there disposal which will enable them to make sound decisions based on factual information in the future.

6.3.4 Reduction of Leakage by Pressure Control.

Reduction of leakage by pressure control is considered supplementary to the DMA approach and is the next logical step in leakage control and that is to reduce pressures in those parts of the distribution system where pressures maybe considered high. This will have the effect of reducing the level of leakage, the rate at which leaks happen and further reduce the actual loss when a leak does develop. Advantage should be taken , where appropriate, to use the latest available pressure control valves that automatically adjust to varying demand patterns.

Reducing the pressure will not only reduce the level of leakage, but will also reduce the quantity of water used in what can be described as open tap use (widespread in Damascus) and it will also reduce the frequency of pressure burst. The only constraints for DAWSSA will be that most of the properties in Damascus are multi story flats and pressure reduction might only be possible in the high pressure zones.

Therefore any pressure reduction program will be have to be carefully designed so that customers will not suffer. The situation at DAWSSA will have to be looked at very carefully before any decision to embark on a pressure reduction program is made. It is very likely that any pressure reduction program will have to be limited, Nonetheless, the benefits of pressure reduction (where applicable) should be considered as savings can be achieved.

6.3.5 Meters

The position at DAWSSA is that there is a huge backlog of 65,000 + meters awaiting repair and a substantial number of meters are not being read, resulting in a substantial revenue loss. The reason for this huge backlog appears to be that DAWSSA have limited meter testing and repair facilities. There is only one elderly gentleman in the repair facility who has been kept out of retirement for the time being and he is currently repairing/renovating between 10 and 15 meters each day. However, this is not enough to make any impression on the backlog.

DAWSSA are currently trying to rectify some of the situation by embarking on a program of replacing defective meters with new meters. They recently engaged the services of a local contractor to replace 1,000 meters in a 45 day period. Subject to the contractors performance, further contracts to replace defective meters will be granted.

The meter used by DAWSSA is a locally made Syria meter which is based on an earlier French design and is a Doris meter of the Multi Jet Variety. It has a number of drawbacks, in that, being a Multi Jet Meter, it has to be fitted in the horizontal plane and any deviation from this will lead to distorted consumption figures. this also restricts the meter installation to horizontal positioning leaving little room for maneuver.

There are likely to be problems in the future if these meters are not replaced as explained previously, they under register and unless improvements are made to its performance, DAWSSA will continue to have a high proportion of meter malfunctions and the revenue received will be reduced. In order to rectify the current position , a replace meter as they fail option, or a preventative approach of phasing out Doris meters completely is a matter for consideration.

6.3.6 Improvements in Meter Testing and Repair Facilities.

Currently, DAWSSA have limited meter testing and repair facilities. Meter testing and repair facilities are currently confined to a one man operation where work is carried out at in the basement of DAWSSA head office.

Space is limited and the equipment is old but is still used every day. The meter repair man has occasional assistance from outside , but he is basically the only trained operator in DAWSSA and has been doing the same job for 40 years. He should have retired, but was asked to stay on and it would seem that there is no likely replacement for him. The experience he has in meter repairs and testing is not being passed on to the next generation and DAWSSA may have a problem in the future if no replacement is found.

The equipment consist of an American meter test bench which is over 30 years old and can accommodate testing of up to 30 meters at any one time. The test bench seems to be in fairly good condition and is used every day and appears adequate for existing operations.

The numbers of meters repaired each month is approximately 288 on average, all of which will have been tested and repaired and sent to the main store at Kadam for disbursement. There seems to be no problem in obtaining spare parts as the Syrian factory which manufacture the meter is located within a short distance from Damascus.

Most of the meters which are returned to DAWSSA have either been vandalized by persons unknown, or are leaking because of wear on the seals of the meter body or glass. In the repair of meters, the main body of the meter may be used time and time again and it is only the nylon cogs or seals that normally need to be replaced.

The installation of an additional meter test rig/workbench will have to be considered as well as looking for improved facilities and space. In addition, more staff will have to be trained in the repair and testing of meters and the renovation of existing meters with existing facilities and the repair/renovation of imported meters as and when they develop problems. The alternative would be to out source the repair/renovation of meters to an outside contractor.

Members of DAWSSA have recently joined a working group to consider whether the meter specification for the Doris meter might be improved (although this might not be possible).

In consideration that the problems with meter malfunction might continue and the likelihood of replacing the existing Doris meter with a replacement Doris meter would only increase the backlog of meters. It would therefore seem that DAWSSA would (at some future date) be in exactly the same position as they are now.

Because the Doris meter has two major drawbacks (fitting restricted to horizontal siting and the problems at Qmin) and because of the current situation regarding the huge backlog of defective meters, it is recommended that the Doris meter be eventually phased out in preference to imported domestic meters which generally have a higher degree of accuracy and are less likely to malfunction.

7. ALTERNATIVE PLAN OF IMPROVEMENT OF DISTRIBUTION SYSTEM

7.1 Informal Areas :

The alternative plan for the informal areas is to transfer all these sites from informal status to formal status. The reasons for this is to save water from leakage and to encourage the residents to pay their due water rates for water consumed. By transferring all these connections, the ration of un-billed customers should be reduced to zero by the year 2006 and the high leakage rates that exist at present at these informal housing areas will eventually be eliminated.(see Table F- 7.1).

7.2 Leakage Control

The alternative plan for leakage control falls into 4 main groups. They are as follows :

i) A program of mains renewal to reduce the level of leaking lead joints on cast iron mains and reinforce the existing distribution system thus safeguarding supplies (see Table F- 7.2).

ii) A program for setting up approximately 67 district meter areas which will enable DAWSSA to monitor the distribution system and identify areas of high leakage.

iii) A program of setting up pressure regulated zones which will reduce the levels of leakage in high pressure zones (see Table F- 7.3).

iv) Increased leak detection surveys to locate and report leakage from the distribution system (see Table F- 7.4).

7.3 Meter Replacement Scheme

The alternative plan for meter replacement is presented as two options which are listed below :

Option 1
Retention of existing Doris meters and increase efforts in annual repair program

Advantages:

Doris Meters are relatively inexpensive : Unit Cost $ 18.00 Approximately
Reasonable degree of accuracy
There is generally no waiting time for local delivery

DAWSSA have a substantial stock of spare parts and spares are easily available
DAWSSA meter readers have no difficulty in reading these meters (an Arabic dial).
Meters fairly inexpensive to maintain
DAWSSA have meter test bench facilities and associated equipment

Disadvantages:

Problems at Q Min, probable under recording leading to lost revenue
Meters have to be fitted in horizontal plane, if not fitted properly, meter error will occur
Expected life cycle 5 years according to DAWSSA's experience.
High number of meter readers required to read meters (38)
Access sometimes difficult leading to non reading of meter
High Failure Rate (30% +)
Meters subject to tampering & vandalism

Option 2
Rotary disk meters and gradually replace Doris meters

Advantages:
High degree of accuracy + or - 2%
Meter very durable
Meters can be fitted in the horizontal or vertical plane without affecting performance

Disadvantages:

Meters are more expensive , approximately 1.5 to 3.0 more expensive than Doris meter
Spare parts will be required in addition to Doris meter spare parts
Training will have to be provided to meter repair shop person
Make up pieces may be required at installation as foreign meters may be smaller length
Non English speakers may have to be trained to read meters (back to front in their eyes) a risk of incorrect readings possible
Labor intensive & considered inefficient
Access sometimes difficult leading to non reading

7.3.1 Expected Life Cycle of Water Meter .

The life of a water meter will depend on a number of factors such as water quality, pressure and installation . However, according to engineers at DAWSSA, the Doris meter probably has a life expectancy of 5 Years. Based on observation in England, the average life cycle of a meter is between 5 to 7 years, but this must only be regarded as a guide, as conditions in England differ from those in Syria.

The table below shows main features and options available :

Terms	Option 1	Option 2
Type of meter	Syrian made Multi Jet	Rotary disk meter
Accuracy Range	Q max +/- 2% Q min 22.7% Failure	Q max +/- 2% Q min +/- 5%
Durable	Reasonable	High
Read Style	Easy in Arabic	Some Difficulties in English
Installation	Reasonable	Possible make up pieces
Failure Rate	High 30% local	Low
Life expectancy	5 years unless failed	5 to 7 years average
Cost	$18.00 each	$22.00 to $27.00

The study and provisional conclusions of the meter replacement program is that the rotary disk meters would be advantageous to DAWSSA and would reduce the exceptionally high proportion of unaccounted for water caused by meter error & malfunction. The proposed program for meter replacement is shown in Table F- 7.5.

It is therefore recommended that option 2 be adopted on the grounds that it would reduce the unaccounted for water figure and that it would make economic sense.

7.4 Implementation Schedule

The implementation schedule of overall measures which are aimed at reducing unaccounted for water are summarized in the table below :

Name of Project	Start Date	Finish Date
Mains Renewal Program	1998	2003
District Meter Program	1998	2003
Meter Replacement Program	1997	2003
Pressure Control program	2000	2006
Improved Leak detection	1996	ongoing
Transfer Informal Sites to Formal Status	1997	2005

7.5 Ancillary measures to reduce UFW

Whilst, there is no doubt that DAWSSA have immense leakage losses in the distribution system, there must also be a question mark over the amount of water that is misused or wasted.

If one considers that the existing Doris meter fails to register at low flows, and that there are many faulty taps and toilets, and that the general public seem nonchalant in their attitude towards saving water, imagine what water might be lost or indeed what water might be saved. One major stumbling block which needs to be addressed is the lack of understanding by consumers on conserving water supplies. All too often, people waste water and don't seem concerned as to how they can help reduce wastage.

Many consumers leave taps open, leave hose pipes running unattended and generally are not concerned if they see water running down the road. This is particularly obvious in the high income areas.

Even in the DAWSSA headquarters, there is evidence that the water employees seem unconcerned and are willing to see water wasting on a daily basis. If any benefit is to be gained, it is important that all members of DAWSSA be more vigilant and responsive in their attitude towards wastage of water and try and educate those around them about misuse of water.

There is every possibility that other governmental institutions, (of which there are many) are as wasteful as the staff at DAWSSA headquarters and indeed may need to be educated in the idea of good water savings and practices.

DAWSSA have, in the past carried out public awareness campaigns by using local media and posters to try and persuade people to be more vigilant but with little success it seems. Nonetheless, the publicity should continue and wherever possible be extended.

One obvious solution would be to target schools and mosques with regular publicity campaigns. By reaching the younger generation, they are more likely to respond to such campaigns and there would be a successful outcome.

TABLES

Table F--4.1 Per Capita Consumption Meter Survey 1996

Area : Ruku Aldyn : Middle Income Bracket	6 Month Period	
Total Numbers of Domestic Meters	172	
Meters Broken or with Zero Readings	54	
Properties Unable to Gain Acces to read Meter	6	
Meters < 500 Litres/Property/Day – Not Included	30	
Domestic Properties with Actual Consumption	82	
Total Consumption (6 Month Period) m3	15,106.30	
Average Daily Domestic Consumption/Property	1023.46	Litres
Assuming 6 Persons/Property – Per Capita Consumption =	170.57701	Litres
Meter Failure Rate = 31.39%		

Area : Dar Al Moalimat : High Income Bracket	6 Month Period	
Total Numbers of Domestic Meters	106	
Meters Broken or with Zero Readings	28	
Properties Unable to Gain Acces to read Meter	15	
Meters < 500 Litres/Property/Day – Not Included	10	
Domestic Properties with Actual Consumption	53	
Total Consumption (6 Month Period) m3	14,394.00	
Average Daily Domestic Consumption/Property	1,436.96	Litres
Assuming 6 Persons/Property – Per Capita Consumption =	239.49	Litres
Meter Failure Rate = 26.41%		

Average Per Capita for Two Zones = 205.03 Litres/Capita/Day

Note : 6 Month Period – Covering February to August

Table F – 5.1 Meter Survey At Mosques

Meter Survey : Damascus City – Mosque's					Period : June – July 1996		
Date	Address	Sample Period	1st Reading	Date	2nd Reading	Daily Consumption	Comments
10–Jun	Mydan –Rifay Mosque	30 Day	133.10	10–Jul	276.30	4.773	
10–Jun	Zien Al Abadin Mosque	30 Day	192.80	10–Jul	271.70	2.630	
10–Jun	El Tanabia Mosque	30 Day	64.70	10–Jul	157.40	3.090	
10–Jun	El Zay Tuna Mosque	30 Day	35.00	10–Jul	71.60	1.220	
10–Jun	Al Manjak Mosque	30 Day	164.50	10–Jul	289.50	4.167	
10–Jun	Al Dakkak Mosque	30 Day	25.00	10–Jul	163.20	4.607	
10–Jun	Mazzi Mosque	30 Day	241.20	10–Jul	524.20	9.433	
10–Jun	Al Mansoor Mosque	30 Day	111.30	10–Jul	206.40	3.170	
10–Jun	Al Hassan Mosque	30 Day	316.80	10–Jul	631.40	10.487	
10–Jun	Doker Mosque	30 Day	42.80	10–Jul	70.90	0.937	
10–Jun	Yakoub Mosque	30 Day	46.10	10–Jul	79.00	1.097	
10–Jun	Ennabia Mosque	30 Day	130.50	10–Jul	242.20	3.723	
10–Jun	Saeed Ebin Zaid Mosque	30 Day	59.60	10–Jul	118.30	1.957	
10–Jun	Saha Mosque	30 Day	58.40	10–Jul	248.10	6.323	
10–Jun	Asfoor Mosque	30 Day	58.40	10–Jul	83.30	0.830	
10–Jun	Abad Arahman Mosque	30 Day	20.80	10–Jul	42.70	0.730	
10–Jun	Gaswat–Bader Mosque	30 Day	151.30	10–Jul	351.30	6.667	
10–Jun	Al Ashmar Mosque	30 Day	210.80	10–Jul	431.40	7.353	

Meters Surveyed	18
Meters broken/zero reading	0
Meters with Actual Consumption	18
Failure Rate of Meters =	0

Average Consumption = 4.066 Litres/day

Table F – 5.2 Typical Net Night Flow Analysis

SPECIMEN COPY ONLY

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Zone No	DMA No	Site Location Of Meter	Total Number Properties	M.N.F. m3 Hour	M.N.F.C. m3 Hour	Domestic Night Allow m3/Hour	Therefore N.N.F m3/Hour	Leakage Litres Prop/Hour	Target Night Flow m3/Hour	Target Litres Prop/Hour	Difference Actual/Target m3/Hour	Assumed Service Leaks	Cost of Leakage Per Year
1	3	Akrad B2	1,350	97.54	1.34	2.31	93.89	69.55	24.71	18.30	69.18	88	£48,987
2	8	Mezze #86	3,476	82.18	3.41	5.94	72.83	20.95	10.16	2.92	62.67	79	£44,374
3	5	Naher Eshah	2,778	82.63	0.00	4.75	77.88	28.03	16.92	6.09	60.96	77	£43,166
4	5	Kassioun #1	5,342	74.51	0.00	9.13	65.38	12.24	20.15	3.77	45.23	57	£32,024
5	7	Kafarsouseh	934	45.19	2.25	1.60	41.34	44.26	3.82	4.09	37.52	47	£26,570
6	1	East Tabbaleh	4,524	56.45	26.20	7.74	22.51	4.98	6.83	1.51	15.68	20	£11,106
7	6	Somareya	1,411	31.56	3.81	2.41	25.34	17.96	12.55	8.89	12.79	16	£9,055
8	2	Shagoor Basateen	3,871	37.60	2.12	6.62	28.86	7.46	18.60	4.80	10.26	13	£7,266
9	4	Jober #1	2,895	29.98	0.00	4.95	25.03	8.65	16.52	5.71	8.51	11	£6,026
10	7	Tishreen #1	3,620	27.45	0.00	6.19	21.26	5.87	19.60	5.41	1.66	2	£1,175
Zonal Statistics			Total 30201	Ave 56.51	Ave 3.91	Ave 5.16	Ave 47.43	Ave 21.99	Ave 14.99	Ave 6.15	Ave 32.45	Ave 41.07	Total £229,747

1) Zone Number
2) District Meter Area Number (DMA)
3) Site Location Of Meter
4) Total Numbers of Properties in DMA
5) Minimum Night Flow m3/Hour
6) Minimum Night Flow (Commercial) m3/Hour
7) Domestic Night Time Allowance m3/Hour
(based on 1.71 Lts/Prop/Hour)

Target Losses	149.86 m3/d
Actual Losses Per/Day	474.32 m3/d

Typical wage bill for year for 4 Men
@ £16,800/Month = £201,600

Total Projected Savings = £28,147

8) Net Night Flow m3/Hour
9) Leakage/Property/Hour
10) Target Night Flow m3/Hour
11) Target Litres/Property/Hour
12) Difference/Target/Actual
13) Assumed Leaking service pipes
14) Annual Cost Of Water Losses
(based on S£ 1.94 per m3)

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Table F-6.1 Program for Replacement of Mains

Diameter mm	1998	1999	2000	2001	2002	2003	Total Length Kilometres
600	6,100	960	1,250	4,800	1,000		14,110
500		1,700	2,200				3,900
400	1,975		1,900		1,000	2,600	7,475
300							0
250	6,950	7,670	2,400	4,150	3,420	2,400	26,990
200		5,050	2,700	4,800	3,000	1,000	16,550
150	700	2,000	1,900		3,600	3,500	11,700
125		250					250
100	940	400	3,800	1,560	3,600	5,700	16,000
80				600			600
	16,665	18,030	16,150	15,910	15,620	15,200	97,575

Table F-6.2 Proposed District Meter Program

	Area	Properties Covered	1997	1998	1999	2000	2001	2002	2003	2004	2005
Feasibility Study			>>>>>>								
Design/Drawings Preparation Intallation of Meter/Valves Check Area for Integrity First Run Leak Location Survey Monitor Each Month	Mouhajreen Ruku Aldyn	12,910 27,795									
Design/Drawings Preparation Intallation of Meter/Valves Check Area for Integrity First Run Leak Location Survey Monitor Each Month	Barze Jober	12,650 17,351									
Design/Drawings Preparation Intallation of Meter/Valves Check Area for Integrity First Run Leak Location Survey Monitor Each Month	Sarouja Old City	19,603 3,082									
Design/Drawings Preparation Intallation of Meter/Valves Check Area for Integrity First Run Leak Location Survey Monitor Each Month	Kanawat Kadem Shagour	11,127 10,696									
Design/Drawings Preparation Intallation of Meter/Valves Check Area for Integrity First Run Leak Location Survey Monitor Each Month	Shagour Midan	10,938 23,930									
Design/Drawings Preparation Intallation of Meter/Valves Check Area for Integrity First Run Leak Location Survey Monitor Each Month	Mezze Kaboon	18,334 8,599									
Design/Drawings Preparation Intallation of Meter/Valves Check Area for Integrity First Run Leak Location Survey Monitor Each Month	Kafar Souseh Yarmouk Part 1	16,004 17,890									
Design/Drawings Preparation Intallation of Meter/Valves Check Area for Integrity First Run Leak Location Survey Monitor Each Month	Yarmouk Part 2 Dummar	 17,890 8,235									
Total Numbers of Properties covered by DMAs =		237,034	**** Provisional Programme ; Possible Ammendments								

Table F-7.1 Program for Converting Informal Sites to Formal Status

Existing Situation

No	Informal Area	Estimated Population	Estimated Connections	Daily Area Demand m3	Estimated Area Lpcd
1	Esh Al Warwar	15,180	2,530	3,036	193,000
2	Kassioun	33,977	5,663	6,795	193,000
3	Tichreen	15,448	2,575	3,090	193,000
4	Jobar	25,704	4,284	5,141	193,000
5	Tabbaleh	12,669	2,112	2,534	193,000
6	Yarmouk	86,068	14,345	17,214	193,000
7	Kadam	37,005	6,168	7,401	193,000
8	Kafar Souseh – Lawan		0	0	193,000
9	Shaghour Bassateen	10,692	1,782	2,138	193,000
10	Mezze Razy	46,786	7,798	9,357	193,000
11	Mezze #86	46,390	7,732	9,278	193,000
12	Somareya	4,590	765	918	193,000
13	Dummar	14,841	2,474	2,968	193,000
14	Takadom	36,750	6,125	7,350	193,000
15	Kudsaya	20,800	3,467	4,160	193,000
	Total =	406,900	64,350	81,380	
	Year Total MCM =			29.70	

Future Situation

No	Informal Area	1997 Transfered to Formal Status	1997 Anticipated Savings m3/day	1998 Transfered to Formal Status	1998 Anticipated Savings m3/day	1999 Transfered to Formal Status	1999 Anticipated Savings m3/day	2000 Transfered to Formal Status	2000 Anticipated Savings m3/day	2001 Transfered to Formal Status	2001 Anticipated Savings m3/day	2002 Transfered to Formal Status	2002 Anticipated Savings m3/day	2003 Transfered to Formal Status	2003 Anticipated Savings m3/day	2004 Transfered to Formal Status	2004 Anticipated Savings m3/day	2005 Transfered to Formal Status	2005 Anticipated Savings m3/day
1	Esh Al Warwar	Stage 2	3,036																
2	Kassioun														6,795				
3	Tichreen												3,090						
4	Jobar										5,141								
5	Tabbaleh																2,534		
6	Yarmouk												17,214						
7	Kadam	Stage 1		Stage 2		Stage 3	7,401												
8	Kafar Souseh – Lawan																		
9	Shaghour Bassateen										2,138								
10	Mezze Razy								9,357										
11	Mezze #86	Stage 2	9,278																
12	Somareya																918		
13	Dummar						2,968												
14	Takadom	Stage 1	7,350	Stage 2															
15	Kudsaya																		4,160
	Daily Savings m3 =		19,664		0		10,369		9,357		7,279		20,304		6,795		3,452		4,160
	Annual Savings MCM =		7.18		0.00		3.78		3.42		2.66		7.41		2.48		1.26		1.52
	Population Transferred to Formal Status		61,570		36,750		51,846		46,786		36,396		101,516		33,977		17,529		20,800

Total MCM Savings 1997–2000 = 10.96

Population Transferred = 150,166

Percentage of Population 36.90%

Total MCM Savings 2000 –2005 = 18.74

Population Transferred = 257,004

Percentage of Population 63.10%

Table F-7.2 (1/6) Details of Mains Renewal Program

Site Identity	Pipe Dia	For Planning 1996 Location of Proposed works	Pipe Length Metres	Age of Pipe	Material	Joint	Leak Factor	Comments
B	600	From Arnaus Square till Amawyeen Square (Al Assad Library)	2,000	1945/50	Cast Iron	Lead Joint	High	
		From Amawyeen Square till River at North						
D	600	To the North of the river towards Malki > Wali Reservoir	1,500	1950/55	Cast Iron	Lead Joint	High	
	250	Kudsaya till the Entrance of Defence Fac tory	250	1915	Cast Iron	Lead Joint	High	
Y	250	Amawyeen Square towards Malki Street	800	1950/55	Cast Iron	Lead Joint	Low	
F	100	Nazen Basha Line To the Left	940	1940/45	Cast Iron	Lead Joint	High	
		From Maysat Square to Ibn Al Amid						
H	600	The Extra Bakehouse (With Tunnel)	2,600	1960	Cast Iron	Lead Joint	High	
L	400	From Tora River towards Malki Square & the Presidents House	725	1950/55	Cast Iron	Lead Joint	High	In Use
O	400	From Wali Reservoir till Fawakheer (Third Ally – Ibn – Ajad)	1,250	1940/45	Steel	Flanged	High	Perforated
	250	Khonchid towards Malki Street	1,600	1960/65	Cast Iron	Lead Joint	Low	
Z	250	Abee Al'aa Square – Al Jessr al Abyad – Al Afif	1,600	1950/55	Cast Iron	Lead Joint	Low	
5C	250	British Embassy Street to Arabic Language Centre to Malki	600	1960/65	Cast Iron	Lead Joint	Low	
6C	150	Beruit Street/Rabwa Crossing to Shiek Al Sa'aeed	700	1950/55	Cast Iron	Lead Joint	Medium	
4E	250	Haroon Rachid Street – Tora Street Jeser Abyad	2,100	1960/65	Cast Iron	Lead Joint	Medium	
		Total Length of Main to be Replaced during 1996 (Metres)	16,665					

Table F-7.2 (2/6) Details of Mains Renewal Program

Site Identity	Pipe Dia	For Planning 1999 Location of Proposed works	Pipe Length Metres	Age of Pipe	Material	Joint	Leak Factor	Comments
A1	250	The Front Of Damascus International Fair from the Meridian Hotel – Beruit Road till Assad Library	1,100	1950/55	Cast Iron	Lead Joint	Medium	
E	600	From Al Thawra Crossing to Saba Bahrat to Armus Square	960	1950/55	Cast Iron	Lead Joint	High	
A2	250	From Al Diafeh Palace – Al Tagheez Fardous Street To Salhieh Bawabeh	750	1940/45	Cast Iron	Lead Joint	Medium	
A13	250	From Hijaz till MuJtahed, Passing Khalid Ibn Walid St	1,120	1955/60	Cast Iron	Lead Joint	low	
A3	250	From Al Talaec (Mezze) till Al Kadamet Triangle (Fire Extinguishing Team) – towards Mwassa Hospital	2,800	1955/60	Cast Iron	Lead Joint	High	
6D	200	Sabea Bakrat to Dar Alsalam Square/Al Najma Square	1,200	1955/60	Cast Iron	Lead Joint	Low	
7D	200	Salihyya	250	1950/55	Cast Iron	Lead Joint	Low	
1E	200	29th May Street	400	1950/55	Cast Iron	Lead Joint	Medium	
1E	100	29th May Street	400	1950/55	Cast Iron	Lead Joint	Medium	
2E	250	Al Najma Square to Al Cham Hotel, Brazil Street	1,100	1940/45	Cast Iron	Lead Joint	Medium	
3E	250	Al Amawyyen Square/Beruit Street – Al Deyafa Kaser	800	1950/55	Cast Iron	Lead Joint	Medium	
A4	500	From the Justice Palace to Al Nasre Street Khalid Ibn Walid till Al Mujtahed	1,700	1965/70	Cast Iron	Lead Joint	Medium	
	200	Al Naser Street – Fire Extinguishing Station – Bab Siregha	600	1955/60	Cast Iron	Lead Joint	low	
A14	200	Mustahed towards Al Ashmar Square, Baranbeh DAWSSA Stores	2,600	1950/55	Cast Iron	Lead Joint	Medium	
A15	150	From Hijaz till Justice Palace passing Ibn Walid Street Towards Damascus University	1,000	1950/55	Cast Iron	Lead Joint	High	Pipe Very Corroded
B4	125	Zid Bin Thabit Mosque to North to Bin Al Walid	250	1940/45	Cast Iron	Lead Joint	High	
B5	150	Fahhama – Abbass Street From the Customs to Baramka Sana Agency	1,000	1940/45	Cast Iron	Lead Joint	Medium	
		Total Length of Main to be Replaced during 1999 (Metres)	18,030					

Table F-7.2 (3/6) Details of Mains Renewal Program

Site Identity	Pipe Dia	For Planning 2000 Location of Proposed works	Pipe Length Metres	Age of Pipe	Material	Joint	Leak Factor	Comments
P	500	From Airport Circle up to Sheik Raslan	1,500	1975/80	Cast Iron	Lead Joint	High	
R	200	Medhat Basha , Bab Al Jabieh till Bab SHarki	1,600	1920	Cast Iron	Lead Joint	High	Rusty
S	200	From Bab Al Jabieh Snanieh Al Badawi Street Up Till Al Ameen Street	1,100	1920	Cast Iron	Lead Joint	High	Pipe Very Rusty
T	250	From Airport Circle till Mechanical Engineering Facaulty (Complicated System – Gardens & Roads)	1,450	1960/65	Cast Iron	Lead Joint	High	
O	600	From Airport Circle up to Bab Mussala	1,250	1965–70	Cast Iron	Lead Joint	High	
A6	250	From Ameen Street till Bab Musalla	950	1955/60	Cast Iron	Lead Joint	High	
A12	400	Ibn Asakey Street from Bab Mousalla to Airport Circle	1,900	1950/55	Cast Iron	Lead Joint	High	
B8	80/100	Bab Toma Ozeri'aa	3,000	1930	Cast Iron	Lead Joint	High	NetworkCorroded
2C	150	Al Ameen Street – Madhat Basha Vegetable Market	400	1940/45	Cast Iron	Lead Joint	High	
X	500	Al Ameen Street till Medhat Basha Street, Nakkshat	700	1960/65	Cast Iron	Lead Joint	Medium	
B1	150	Bab Mousala Square to Sweqqa	500	1940/45	Cast Iron	Lead Joint	High	
B2	150	Bab Mousala Square to Sweqqa To Bab Jahhia	1,000	1940/45	Cast Iron	Lead Joint	High	
B3	100	Hamidyya Market	800	1950/55	Cast Iron	Lead Joint	Low	
		Total Length of Main to be Replaced during 2000 (Metres)	16,150					

Table F-7.2 (4/6) Details of Mains Renewal Program

Site Identity	Pipe Dia	For Planning 2001 Location of Proposed works	Pipe Length Metres	Age of Pipe	Material	Joint	Leak Factor	Comments
	200	Amara –Malek Faisel Street till Al Roos Tower	1,100	1950/55	Cast Iron	Lead Joint	Low	
U	100	Amara –Malek Faisel Street till Al Thawra Street	1,560	1950/55	Cast Iron	Lead Joint	Low	
V	80	Amara towards Al Thawra Street	600	1950/55	Cast Iron	Lead Joint	Low	
I	600	Berze towards Kaboon Square > Abbasyin Square	4,000	1960/65	Cast Iron	Lead Joint	High	
J	600	Abbasyin Square till Zablatani	800	1955/60	Cast Iron	Lead Joint	High	
	250	Garages Square till Abbasiyin towards Joher	1,500	1955/60	Cast Iron	Lead Joint	High	
A10	250	Abbasiyin Street towards Zahlatani Street	950	1955/60	Cast Iron	Lead Joint	Medium	
3C	250	Berze Housing Str to Police School To Balancing Res.Kaboon	1,700	1960/65	Cast Iron	Lead Joint	Low	
4C	200	Berze Housing to University City to North of Agriculture College	700	1960/65	Cast Iron	Lead Joint	Medium	
7E	200	Dooma Old Street – Garages Square	3000	1950/55	Cast Iron	Lead Joint	High	
		Total Length of Main to be Replaced during 2001 (Metres)	15,910					

Table F-7.2 (5/6) Details of Mains Renewal Program

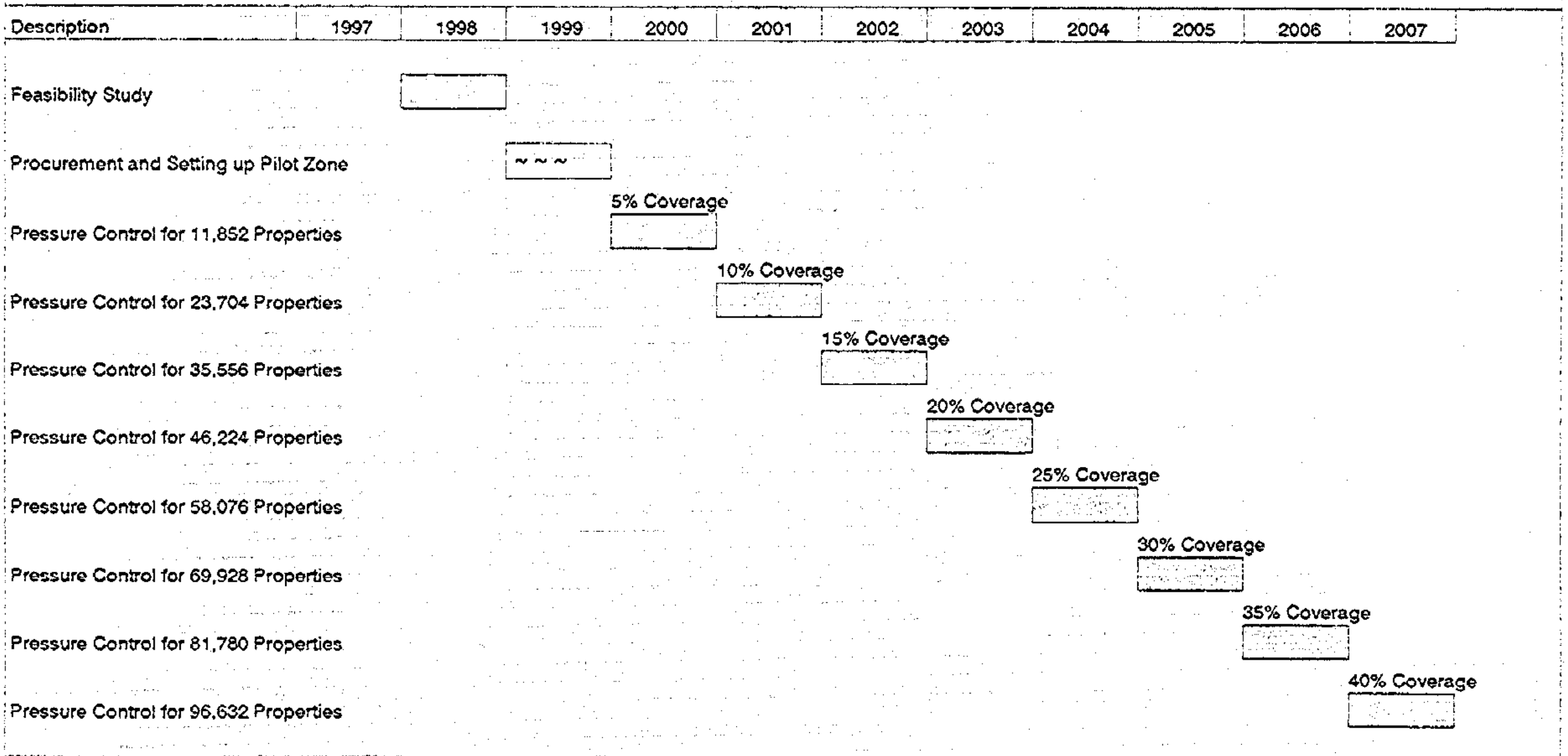
Site Identity	Pipe Dia	For Planning 2002 Location of Proposed works	Pipe Length Metres	Age of Pipe	Material	Joint	Leak Factor	Comments
W	600	Old Zahera till Al Ka'aa (Midan) From the High Road Bridge to the end of Masaken Zahera	1,000	1960/65	Cast Iron	Lead Joint	High	
	200	New Zahera	1,500	1960/65	Cast Iron	Lead Joint	Low	
B11	200	Old Zahera	1,500	1960/65	Cast Iron	Lead Joint	Low	
	150	Bab Mousala Square – Medan Street	1,000	1935	Cast Iron	Lead Joint	High	
1C	150	Bab Mousala Square – Moujtahed Al Ashmar Square	2,600	1940	Cast Iron	Lead Joint	High	
B12	100	Medan Street	3,600	1936	Cast Iron	Lead Joint	High	
G	250	Kafar Sousse Towards Dariya Road Southern High Road up to Dayas Domitary	2,500	1940/45	Cast Iron	Lead Joint	High	
A7	400	Moukhaygam Palastine Street, From Al Basheer Mosque till Vegetable Market	1,000	1950/55	Cast Iron	Lead Joint	High	
A8	250	From the Vegetable Market till Moukhaygam Palastine (the Bus Circle)	920	1950/55	Cast Iron	Lead Joint	High	
		Total Length of Main to be Replaced during 2002 (Metres)	15,620					

Table F-7.2 (6/6) Details of Mains Renewal Program

Site Identity	Pipe Dia	For Planning 2003 Location of Proposed works	Pipe Length Metres	Age of Pipe	Material	Joint	Leak Factor	Comments
A11	250	Halbouni – Al Jinaily	1,500	1950/55	Cast Iron	Lead Joint	High	
B7	200	Ali Bin Taleb Street to Alamaweyyin Market to College of Science	1,000	1960/65	Cast Iron	Lead Joint	Low	
B6	100	Customs House to Kafar Souseh Square	1,300	1950/55	Cast Iron	Lead Joint	High	
5D	250	Kafar Souseh Square to Abban Street (Boukhtyar)	600	1950/55	Cast Iron	Lead Joint	Low	
A5	400	Amawyeen Square till the Custom Square	200	1955/60	Cast Iron	Lead Joint	Low	
A9	400	Mawassat – Mezzo, Sheik S'aad till Al Talaee Garden Till Al Wurood Reservoir	2,400	1960/65	Cast Iron	Lead Joint	High	
1D	250	Mezze High Road Education Ministry	300	1960/65	Cast Iron	Lead Joint	High	
2D	150	Behind Teachers Union – Razi Hospital	1,500	1960/65	Cast Iron	Lead Joint	High	
3D	100	Dar Al Moualimat – Al Akram Mosque	600	1960/65	Cast Iron	Lead Joint	Medium	
4D	100	Customs Square to UNiversity	1,000	1950/55	Cast Iron	Lead Joint	High	
7C	150	Mezze – Talaeea Garden	800	1960/66	Cast Iron	Lead Joint	Low	
8E	100	West of Communications Company – Azadi Hospital	1500	1970/75	Cast Iron	Lead Joint	High	
9E	150	Mezze – Western Building Serving Triangle to Talacea Garden	1,200	1960/65	Cast Iron	Lead Joint	High	
10E	100	Mezze – Omar Khyyam Street	1300	1960/65	Cast Iron	Lead Joint	High	

Total Length of Main to be Replaced during 2003 (Metres) 15,200

Table F-7.3 Proposed Program for Pressure Reduction



** Properties covered is a provisional figure only

Pressure Control to Follow District Meter Installations

Table F-7.4 Implementation Program for Annual Leakage Survey

	Number of House Connections Sounded Each Year																			
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007	2009	2010	2011	2012	2013	2014	2015
Leak team 1	20,072	82,239	60,017	61,474	62,967	64,497	66,064	67,669	69,313	70,997	71,100	71,599	72,000	72,500	73,000	73,500	74,000	74,500	75,000	75,500

	Number of House Connections Sounded Each Year																			
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007	2009	2010	2011	2012	2013	2014	2015
Leak team 2	22,389	68,799	60,017	61,474	62,967	64,497	66,064	67,669	69,313	70,997	71,100	71,599	72,000	72,500	73,000	73,500	74,000	74,500	75,000	75,500

	Number of House Connections Sounded Each Year																			
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007	2009	2010	2011	2012	2013	2014	2015
Leak team 3	27,115	83,333	60,017	61,474	62,967	64,497	66,064	67,669	69,313	70,997	71,100	71,599	72,000	72,500	73,000	73,500	74,000	74,500	75,000	75,500

	Number of House Connections Sounded Each Year																			
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007	2009	2010	2011	2012	2013	2014	2015
Leak team 4			60,017	61,474	62,967	64,497	66,064	67,669	69,313	70,997	71,100	71,599	72,000	72,500	73,000	73,500	74,000	74,500	75,000	75,500

	Number of House Connections Sounded Each Year																			
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2007	2009	2010	2011	2012	2013	2014	2015
Leak team 5											71,100	71,599	72,000	72,500	73,000	73,500	74,000	74,500	75,000	75,500

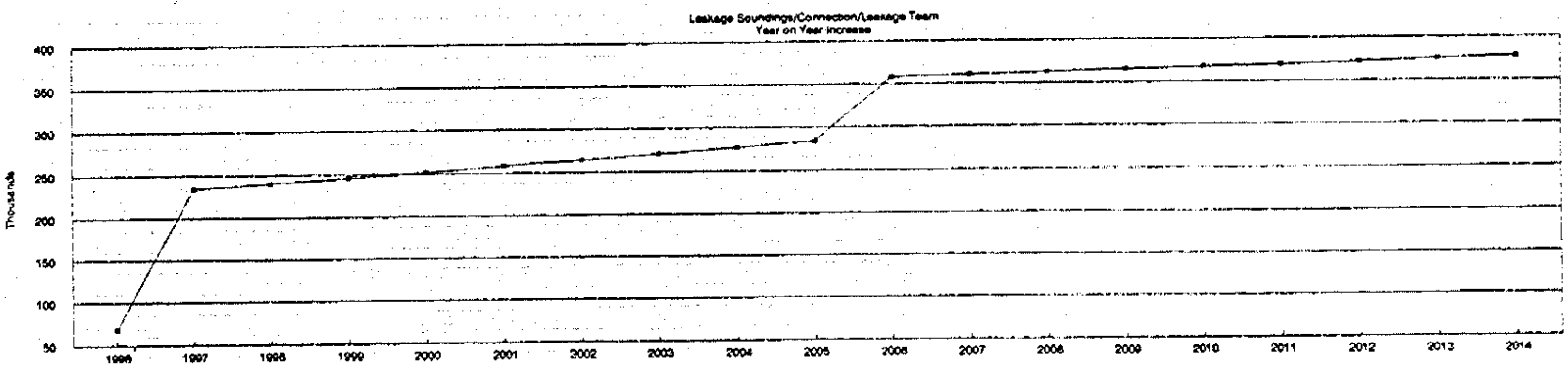
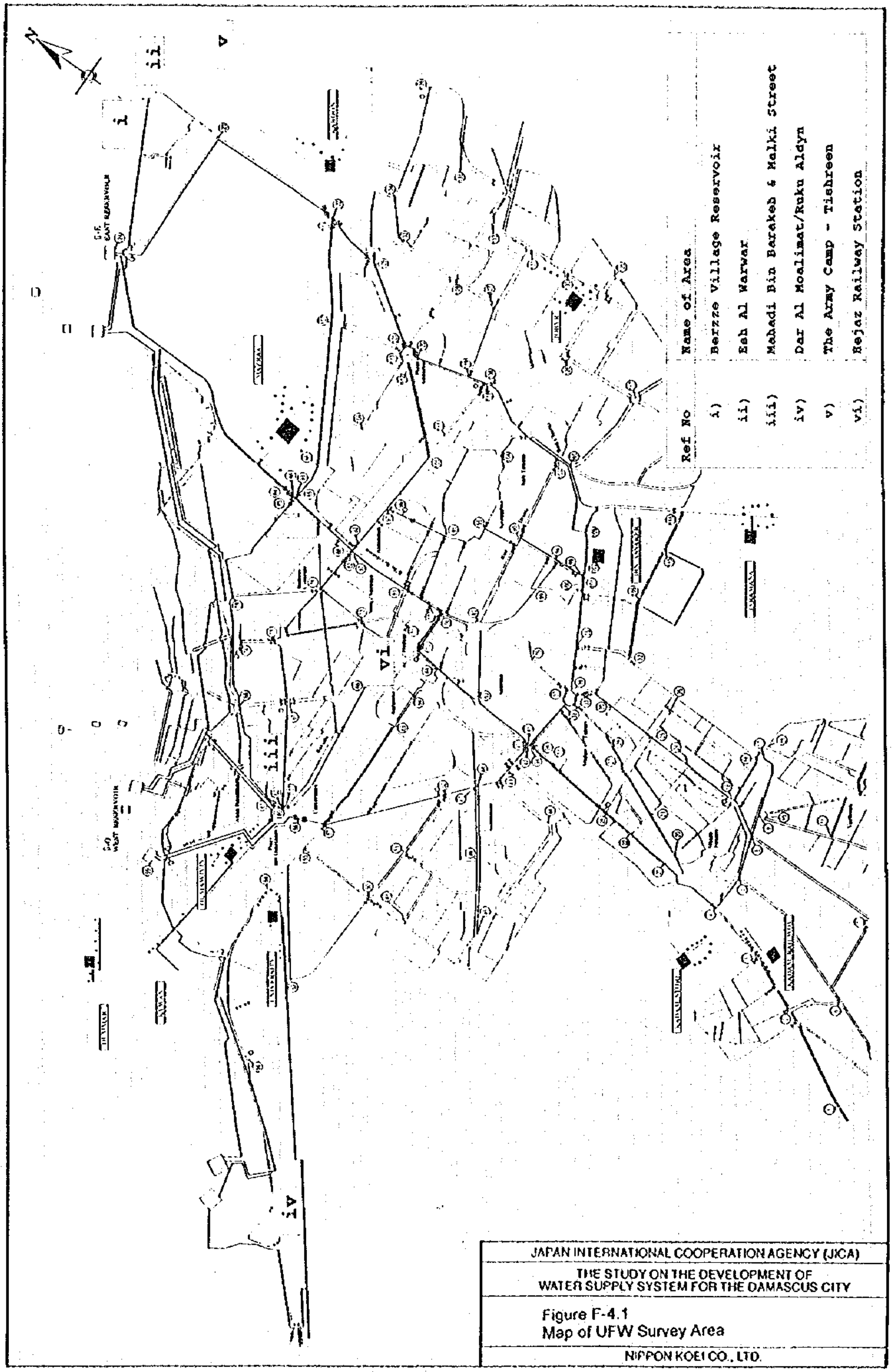


Table F-7.5 Meter Replacement Program

Meter Sizes	Status @ 1995 ave	1997 Replaced	Backlog End 1997	1998 Replaced	Backlog End 1998	1999 Replaced	Backlog End 1999
Domestic Meters 15mm	39,687	5,979	35,268	7,000	29,828	7,000	24,388
Water Rights 15mm	27,448	8,000	21,008	7,000	15,568	7,000	10,128
Commercial 15mm	15,000	0	15,000	2,000	13,000	2,000	11,000
Commercial 20mm	2,585	0	2,585	0	2,585	0	2,585
Industrial 20mm	612	612	0	0	0	0	0
Industrial 32mm	300	300	0	0	0	0	0
Industrial 40mm	200	200	0	0	0	0	0
Governmental 20mm	609	609	0	0	0	0	0
Governmental 32mm	200	200	0	0	0	0	0
Governmental 40mm	100	100	0	0	0	0	0
Backlog of Meters=	86,741		73,861		60,981		48,101
Total Meters Replaced		16,000		16,000		16,000	

Meter Sizes	2000 Replaced	Backlog End 2000	2001 Replaced	Backlog End 2001	2002 Replaced	Backlog End 2002	2003 Replaced	Backlog End 2003
Domestic Meters 15mm	7,000	18,948	9,312	11,196	12,756	0	0	0
Water Rights 15mm	7,000	4,688	4,688	1,560	1,560	0	0	0
Commercial 15mm	2,000	9,000	2,000	7,000	1,684	5,316	7,901	0
Commercial 20mm	0	2,585	0	2,585	0	2,585	2,585	0
Industrial 20mm	0	0	0	0	0	0	0	0
Industrial 32mm	0	0	0	0	0	0	0	0
Industrial 40mm	0	0	0	0	0	0	0	0
Governmental 20mm	0	0	0	0	0	0	0	0
Governmental 32mm	0	0	0	0	0	0	0	0
Governmental 40mm	0	0	0	0	0	0	0	0
		35,221		22,341		7,901		0
Total Meters Replaced	16,000		16,000		16,000		10,486	

FIGURES



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

Figure F-4.1
Map of UFW Survey Area

NIPPON KOEI CO., LTD.

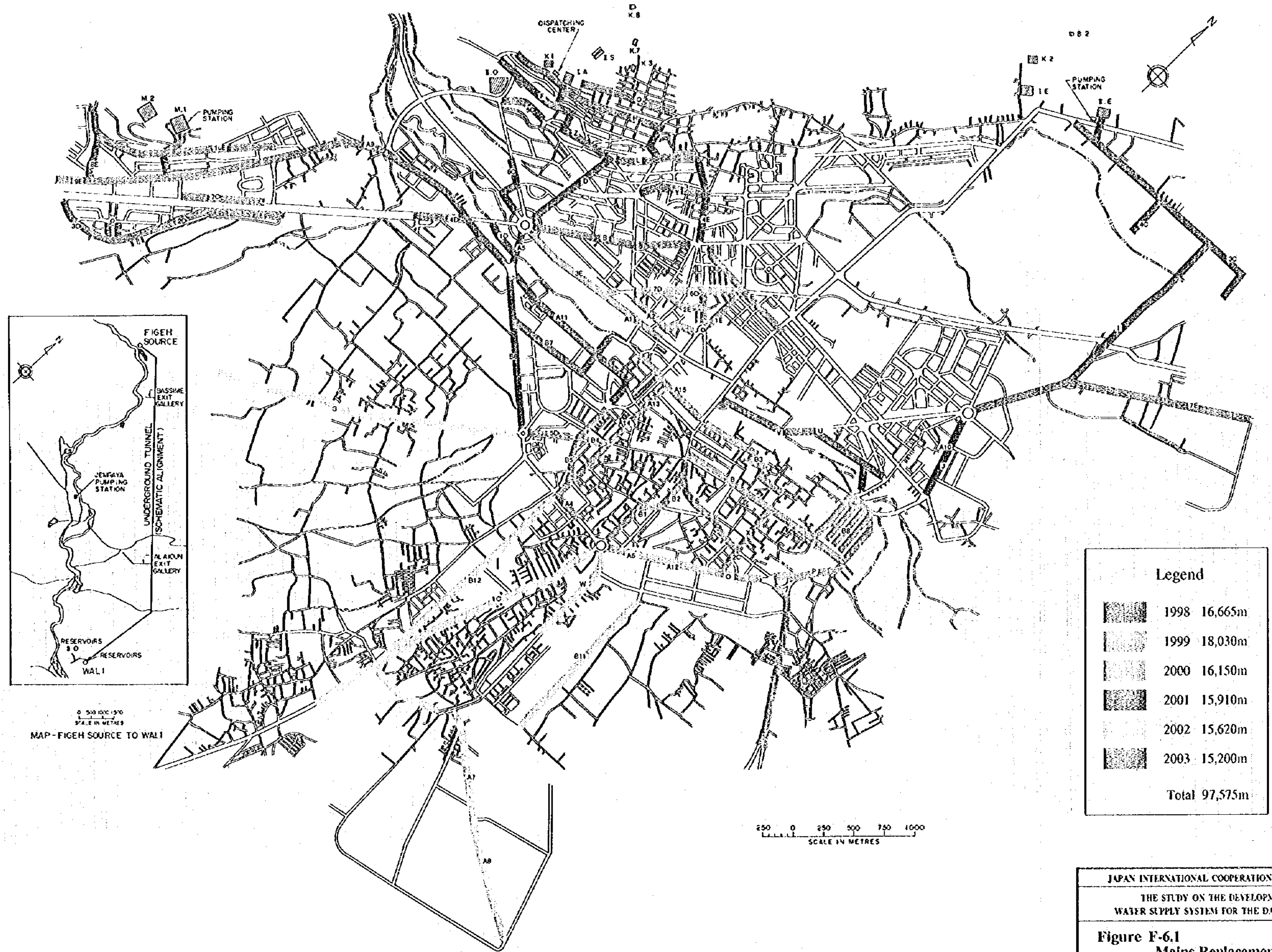

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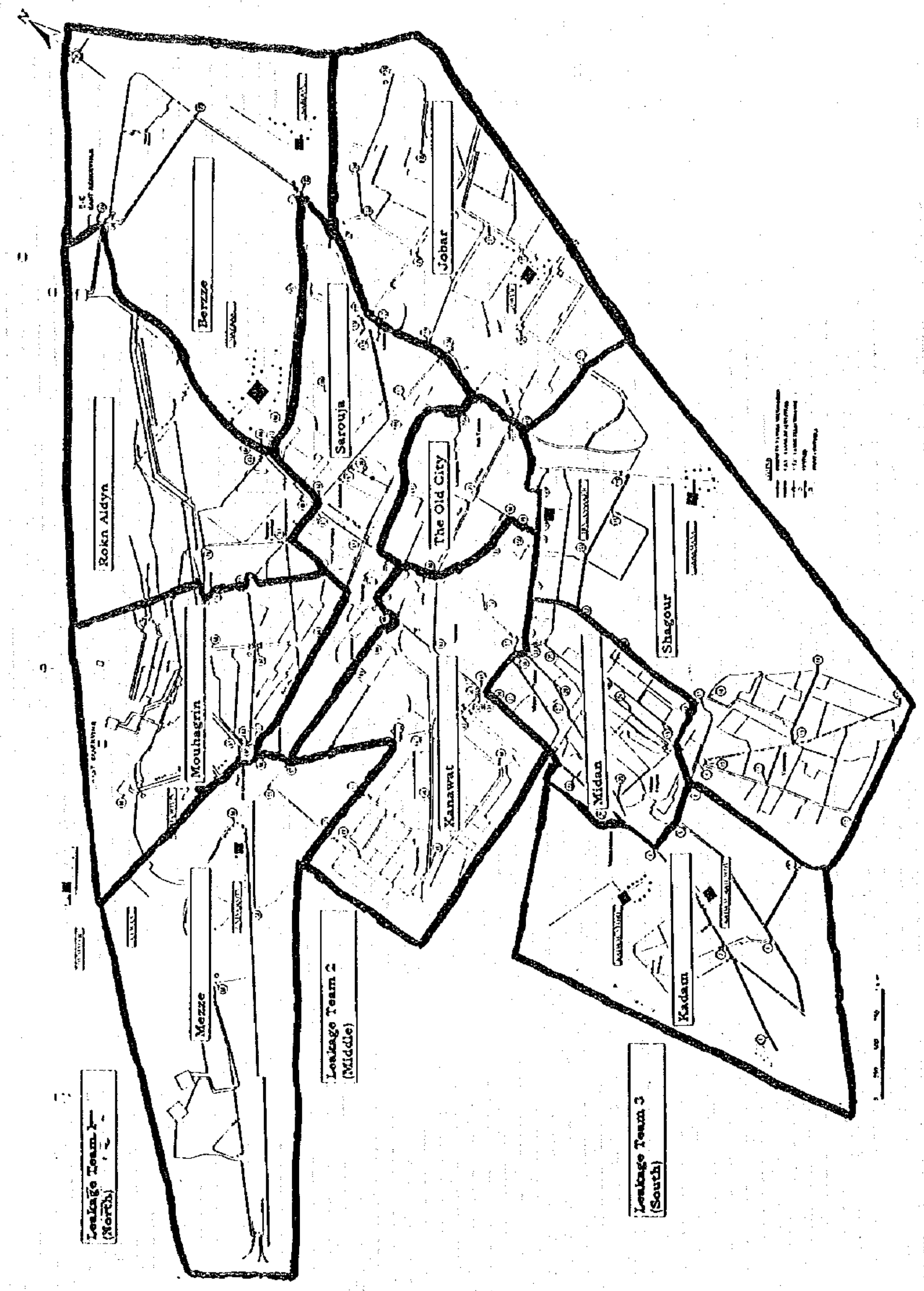
Figure F-6.1 Mains Replacement Program

NIPPON KOEI CO., LTD.



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

Figure F-6.2
Map of Allocated Zones for Leakage Teams

NIPPON KOEI CO., LTD.