MINISTRY OF WATER RESOURCES
FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

BASIC DESIGN STUDY REPORT ON WATER SUPPLY PROJECT FOR URBAN CENTERS IN FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

JULY 1997

JAPAN INTERNATIONAL COOPERATION AGENCY
SANYU CONSULTANTS INC.
KYOWA ENGINEERING CONSULTANTS CO.,LTD.

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PREFACE

In response to a request from the Government of Federal Democratic Republic of Ethiopia, the Government of Japan decided to conduct a basic design study on Water Supply Project for Urban Centers and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Ethiopia a study team from February 1 to March 8,1997.

The team held discussions with the officials concerned of the Government of Ethiopia, and conducted a field study at the study area. After the team returned to Japan, further studies were made, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Federal Democratic Republic of Ethiopia for their close cooperation extended to the teams.

July 1997

Kimio Fujita
President
Japan International Cooperation Agency

July 1997

Letter of Transmittal

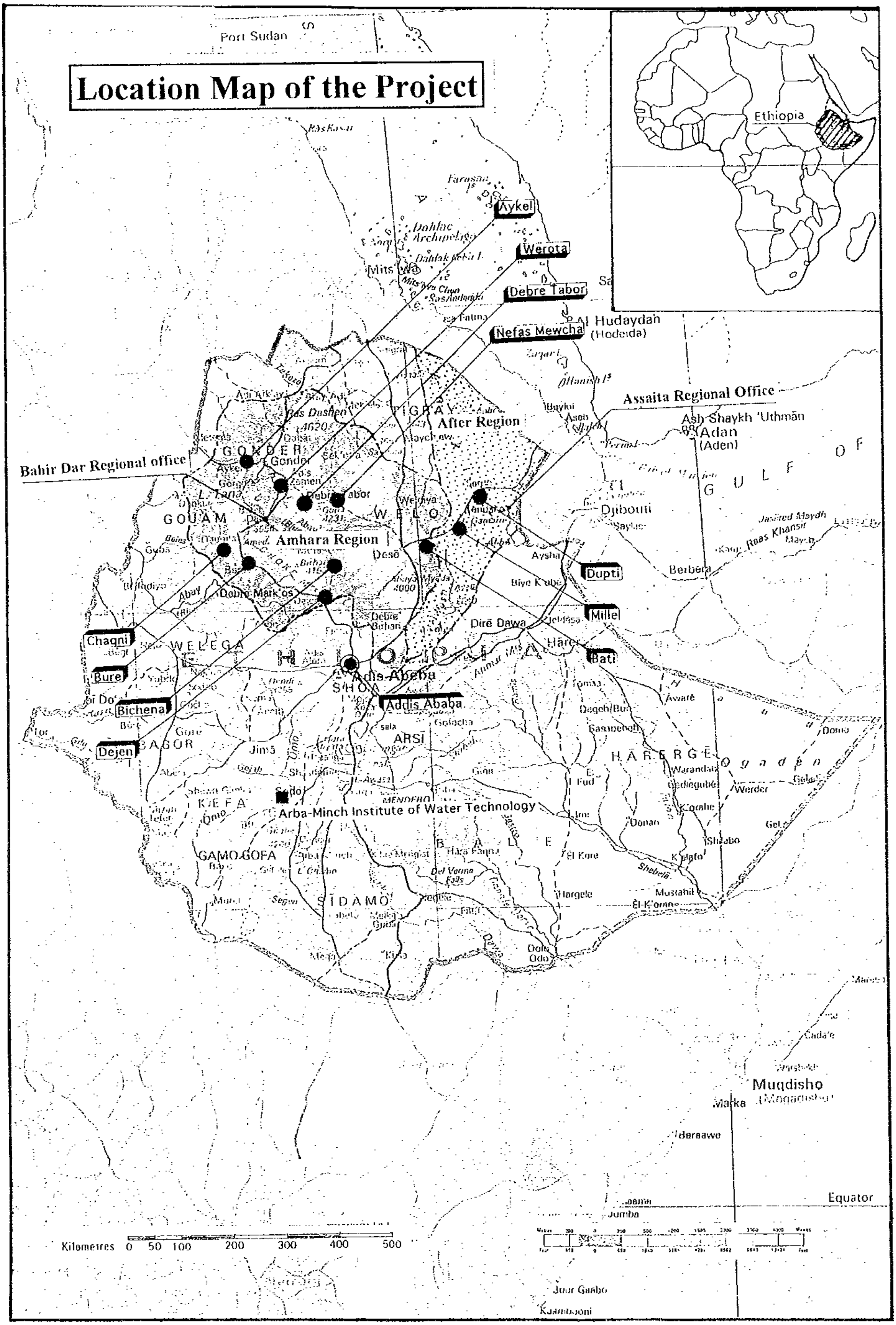
We are pleased to submit to you the basic design study report on Water Supply Project for Urban Centers in Federal Democratic Republic of Ethiopia.

This study was conducted by Sanyu Consultants Inc. in association with Kyowa Engineering Consultants Co. Ltd., under a contract to JICA, during the period from January 1 to August 15, 1997. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Ethiopia and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Kazunori Tamaki
Project manager,
Basic design study team on
Water Supply Project for Urban Centers
Sanyu Consultants Inc.
in association with
Kyowa Engineering Consultants Co., Ltd.


Location Map of the Project
Port Sudan
Ethiopia
Aykel
Werota
Debre Tabor
Nefas Mewcha
Al Hudaydah
(Hodeida)
Assaita Regional Office
After Region
TIGRAY
Ash Shaykh 'Uthmān
Adan
(Aden)
GULF OF
Bahir Dar Regional office
GONDER
Gonder
GOUAM
WELO
Amhara Region
Djibouti
Dupti
Mille
Bati
Debre Mark'os
Chagni
Bure
Bichena
Dejen
WELEGA
Adis Abeba
Addis Ababa
Dire Dawa
Harer
ARSI
HARERGE
Ogaden
Arba-Minch Institute of Water Technology
GAMO GOFA
SIDAMO
BALE
Muqdisho
Equator
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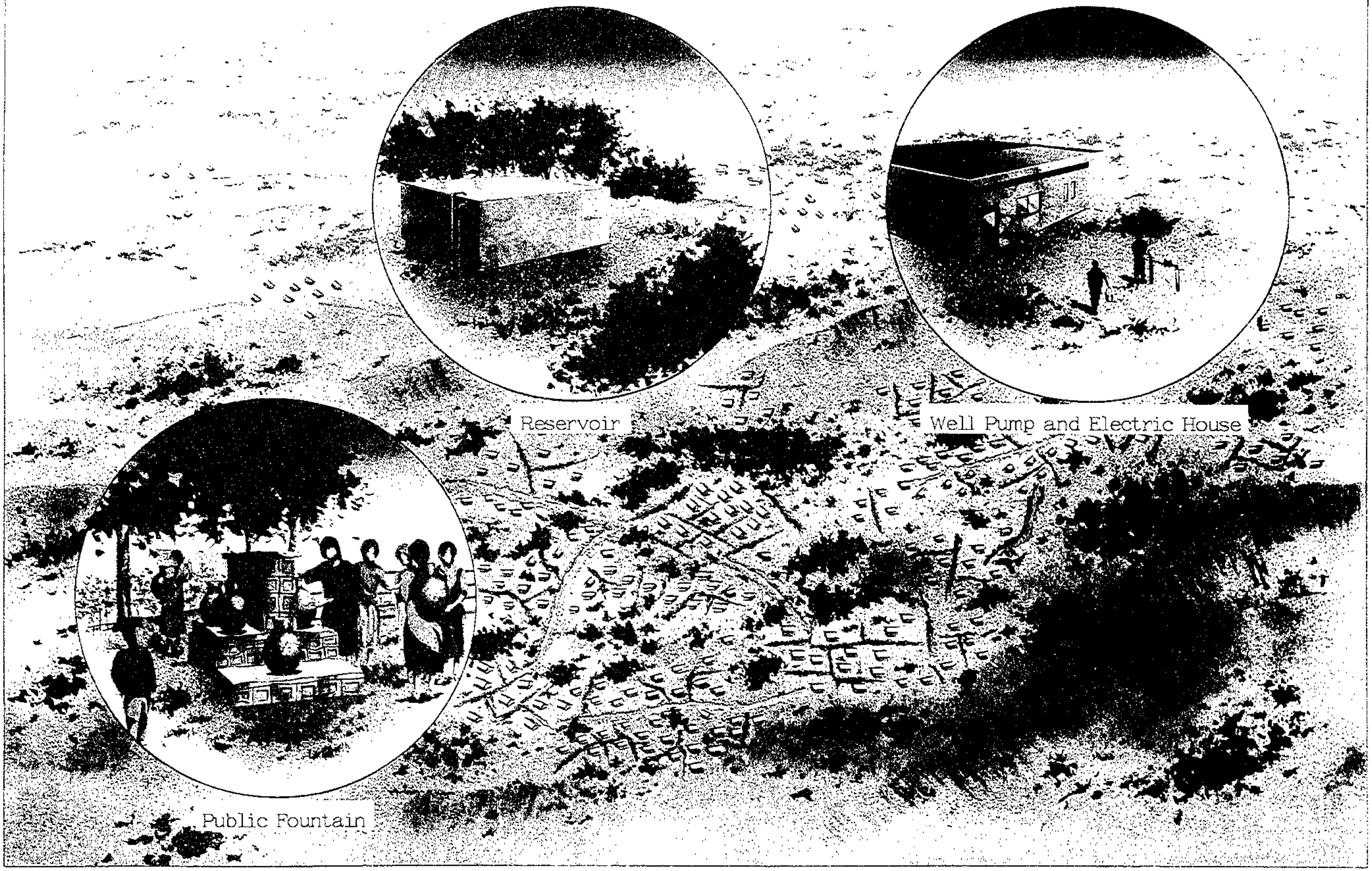
Water Supply Project for Urban Centers



ABBREVIATIONS

AfDB	African Development Bank
AfDF	African Development Fund
EELPA	Ethiopian Electric Light and Power Authority
ERRP	Emergency Recovery and Reconstruction Project
EWWCA	Ethiopian Water Works Construnciton Agency
GDP	Gross Domestic Product
GNP	Gross National Product
IBRD	International Bank for Reconstruction Development
ICS	Interconnected System
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
KFW	Kreditanstalt fur Wiederaufbau
MNRDEP	Ministry of Natural Resource Development and Environmental Protection
MWME	Ministry of Water, Mine and Energy
MWR	Ministry of Water Resources
ODA	Official Development Assistance
SCS	Self-Contained System
SRPF	Sector Review and Policy Framework
WSS	Water Supply Services
WSSA	Water Supply and Sewerage Agency
WSSD	Water Supply and Sanitation Department

CONTENTS

CHAPTER 1 BACKGROUND OF THE PROJECT

The Federal Democratic Republic of Ethiopia (hereinafter referred to as 'Ethiopia') is an inland nation in the north-eastern part of Africa continent surrounded by Eritrea, Sudan, Kenya, Somali and Djibouti in the north, west, south and east, respectively. Ethiopia has an area of 1,130,000 km^2, a population of 53,400,000 (in 1994) and a per-capita GDP of $100.

In the highland areas, the climate is relatively cool with an annual mean temperature between 10 to 20℃ and favorable annual rainfall of 1000mm and fertile soils for agriculture, while the graven belt and lowland areas with annual rainfall of 250mm are not favorable for agriculture but are favorable for grazing.

The economy and social infrastructure of Ethiopia had been totally annihilated during the civil strife. However, a provisional government of Ethiopia which was reorganized in 1991 drew up a new economic policy focusing the introduction of market economy and privatization of government-run corporations in September 1991, and programmed the restoration and promoted liberalized economy and concluded an agreement on the structural adjustment plan with International Bank for Reconstruction Development (IBRD) and International Monetary Fund (IMF) in September 1992.

The policy was later reviewed in 1995 and named as the 'Plan for Development, Peace and Democracy' (Five-year State Development Plan). In the plan, liberalized economy especially at both central and regional levels was programmed putting great emphasis on the expansion of agricultural productivity and the improvement of education and public sanitation.

Water supply systems in Ethiopia, except those in the capital Addis Ababa, are composed of local city system for local centers of population over 2,500 and rural systems for rural villages. In the course of decentralization of the authorities and commencement of federal regime of the government, Water Supply and Sanitation Department (WSSD) of Ministry of Water Resourses (MWR) at central government was responsible for technical cooperation to the regional government, and respective MWR in Afar regional government or Water Supply Department (WSD) of Ministry of Water, Mine and Energy (MWME) in Amhara regional government were assigned for operation and maintenance.

The status of water supply systems in Ethiopia is considerably poor and is said approximately 13,700,000 people (26% of the population) out of 53,400,000 can enjoy safe water. Only 4,000,000 people (10% of the population) who are living in the main cities are supplied with water. Meanwhile in the rural areas, only 9,700,000 people (18% of the population) are supplied with hygiene water, and thus, majority of the population use unsanitary or contaminated water. Consequently, 70% of disease cases in Ethiopia are infected by water-borne diseases.

Two regions in the northern Ethiopia, (Afar and Amhara Regions) suffered severe drought in 1984. Even in non-drought years they are constantly suffering water shortage especially in the dry seasons. In addition, due to frequent war operations in the regions the water supply systems are often destroyed and accordingly encountered problems such as low water productivity, insufficient delivery system, water leakage over 30%, etc.

Under this circumstance, the Government of Ethiopia requested the Government of Japan for cooperation in water supply planning of eleven centers in Afar and Amhara Regions (out of 230 centers nationwide) which suffer severe water shortage.

In response to the request, Japan Internatinal Cooperation Agency (JICA) conducted a feasibility study on Eleven Centers Water Supply and Sanitation (hereinafter referred to as 'the feasibility study') from December 1994 to March 1996, and formulated a plan to reach the project targets in 2005 and 2010. Based on the feasibility study, the government of Ethiopia has requested the government of Japan for a Grant-Aid Program for rehabilitation and improvement of water supply systems for the eleven centers in the target year of 2005. Contents of the request are as follows.

No. of centers involved:

Two (2) centers in Afar Region as Dupti and Mille and
nine (9) centers in Amhara Region as Bati, Werota, Aykel, Debre Tabor, Nefas Mewcha, Chagni, Bure, Bichena and Dejen

Descriptions of request:

Rehabilitation and improvement of water supply facilities in the captioned centers including installation of deep wells, pumps, construction of reservoirs, pipelines, public fountains, etc.

CHAPTER 2 CONTENTS OF THE PROJECT

2-1 Objectives of the Project

The water supply systems in Ethiopia is considerably poor. Out of the total population (53,400,000 people), approximately 26 % of the population (13,700,000 people) enjoy safe water. Only 18 % of the population (9,700,000 people), who are the majority of the population and living in the rural area, are secure with hygiene water.

Especially, the existing water supply facilities in Afar region and Amhara region have suffered damage and destroyed by the civil strife. Moreover, it is very difficult to supply sufficient water due to decline of water productivity and supply, water leakage of over 30 %, etc. Thus, the people suffer water shortage in the dry seasons even in non-drought years.

Under the said situation, the project is aimed to improve and expand the existing water supply facilities in eleven urban centers which suffered severe water shortage in Afar region and Amhara region and hence secure a stable water supply and to improve the hygienic environment of the inhabitants.

2-2 Basic Concept of the Project

This project aims to improve the present difficult water supply situation in the eleven urban centers in which the feasibility study was carried out, through construction of water supply facilities. The basic concepts on the project formulation to the target year 2005 are presented hereinafter.

2-2-1 Target Year of the Project

Generally water supply facilities are planned for demand in future, and the plan in the feasibility study was made as the target year 2005 and 2010. However, taking into consideration the present situation in town planning and urgent needs for the project, the project completion is set in the target year 2000 as presented below from viewpoint of significance of the Grant Aid program. The plan of the facilities unsuited for future expansion and implemented to the year 2005 by Ethiopia is set to the water demand in 2005 or 2010.

The target year of each facilities for the design and the construction is shown as follows.

Construction:

Target year 2010 : Transmission pipelines and main distribution pipelines
Target year 2000 : Intake facilities, transmission facilities , distribution facilities, water supply service facilities and electricity supply facilities except above mentioned facilities.

Design:

Target year 2010 : Transmission pipelines and main distribution pipelines
Target year 2005 : Intake facilities, transmission facilities , distribution facilities, water supply service facilities and electricity supply facilities except above mentioned facilities.

2-2-2 The Subject Centers

The urban centers are the same listed in the feasibility study.

Afar Region : Dupti and Mille
Amhara Region : Bati, Werota, Aykel, Debre Tabor, Nefas Mewcha, Chagni, Bure, Bichena and Dejen

2-2-3 Water Supply Area

Based on the recent field survey in the eleven urban centers, the residential areas in these centers had considerably progressed as compared with that of the field survey conducted in the feasibility study stage. The developed residential area covers the same area as that of the development plan by year 2000 at the feasibility study stage. Therefore, the planned water supply area will remain unchanged.

2-2-4 Design Criteria

The design criteria were based on in the Ethiopian standard titled "Guideline for Preparation of Project, WSSA", (hereinafter referred to as "design criteria") as were used in the feasibility study.

2-2-5 Water Supply under the Program

(1) Population and the proportion to be served

The population to be supplied with water is projected on the basis of the 1995 population of each center by taking into account past rates of population increase and the present economic situation. The proportion for water supply in each target year of the program is anticipated assuming that the present level of water supply will reach at 75% to 100% in 2010.

Below shows the projected population and proportional water supply levels in each urban center, and presented in the feasibility study.

Table 2-1 Projected Population in the Urban Centers

(Unit: person)

Name of Centers	1995	2000	2005	2010
Dupti	14,737	18,809	23,439	28,517
Mille	3,902	5,733	8,230	11,543
Bati	14,354	17,048	19,763	22,360
Werota	21,845	29,234	38,208	48,764
Aykel	11,718	15,315	19,546	24,258
Debre Tabor	25,575	31,871	38,776	46,054
Nefas Mewcha	13,726	19,251	26,376	35,297
Chagni	26,823	35,895	45,812	55,737
Bure	14,745	78,819	23,452	28,533
Bichena	14,629	19,120	24,403	30,411
Dejen	10,250	11,883	13,776	15,586
Total	172,304	222,978	281,781	347,060

Data from 1996 JICA Feasibility study Report, 'the Study on Eleven Centers Water Supply and Sanitation'.

Table 2-2 Planned Proportion of Water Supply

(Unit: %)

Name of Centers	1995	2000	2005	2010
Dupti	45	71	88	100
Mille	97	100	100	100
Bati	87	91	93	95
Werota	96	99	100	100
Aykel	71	77	82	85
Debre Tabor	34	53	66	75
Nefas Mewcha	93	97	99	100
Chagni	46	60	69	75
Bure	83	89	93	95
Bichena	67	75	81	85
Dejen	83	89	93	95

Data from 1996 JICA Feasibility study Report, 'the Study on Eleven Centers Water Supply and Sanitation'.

Table 2-3 Service Population Projected

(Unit: people)

Name of Centers	1995	2000	2005	2010
Dupti	6,614	13,386	20,716	28,517
Mille	3,795	5,733	8,230	11,543
Bati	12,494	15,463	18,413	21,242
Werota	21,014	28,819	38,208	48,764
Aykel	8,329	11,845	15,993	20,620
Debre Tabor	8,578	16,944	25,667	34,541
Nefas Mewcha	12,705	18,570	26,035	35,297
Chagni	12,375	21,620	31,709	41,803
Bure	12,226	16,736	21,729	27,108
Bichena	9,768	14,361	19,744	25,850
Dejen	8,507	10,550	12,757	14,807
Total	116,405	174,027	239,201	310,092

Data from 1996 JICA Feasibility study Report, 'the Study on Eleven Centers Water Supply and Sanitation'.

(2) Water Demand

1) Domestic water demand

Water is supplied through house connections, yard connections and public fountains, and the day demands for each are based on the following values. The values given below are selected by taking into consideration the fact that the regions covered by the project are in both lowland of harsh natural conditions and comparatively cooler highland, in accordance with design criteria.

Table 2-4 Domestic Demand by Connection Type

(Unit: liter/day/person)

Type	Day demand (Standard)	Highland day demand (Amhara Region)	Lowland day demand (Afar Region)
House connection	60	54	66
Yard connection	35	32	39
Public fountain	15	14	17

2) Non-domestic demand

Non-domestic uses include public facilities such as schools, hospitals and government offices; commercial facilities such as hotels, coffee shops and restaurants; and religious institutions such as mosques. The day demands by user are shown below, based on the design criteria.

Table 2-5 Non-domestic Demands

User	Day demand
School	5 l/student
Hospital, Health Center	20 l/ employee
Hotel, eatery, etc.	100 l/bed
Bar, Tea shop	200 l/ shop
Mosque	5 l/visitor
Office	5 l/ employee

3) Unaccounted losses

Taking account of the fact that facilities will be completed in 2000, unaccounted losses caused by water leakage, water stolen, etc. are put at 10%. By 2010, the amount of water loss will be 15%.

4) Average day demand,

The average amount of planned daily water supply is shown below.

Table 2-6 Average Day Demand in Target Years

Name of Centers	Average Day Demand in Target Years (Unit: m^3/day)		
	2000	2005	2010
Dupti	588	1,164	2,222
Mille	268	472	853
Bati	556	864	1,247
Werota	881	1,423	2,369
Aykel	290	505	893
Debre Tabor	831	1,384	2,293
Nefas Mewcha	583	973	1,652
Chagni	716	1,198	1,966
Bure	502	782	1,254
Bichena	420	767	1,427
Dejen	363	545	839

2-2-6 Project Facilities Plan

The following major water supply facilities are planned in the project.

Intake facilities	:	shallow wells, deep wells and well pumps
Transmission facilities	:	transmission (rising) pipes, rising pumps and collection chambers
Distribution facilities	:	reservoirs, distribution pipes, booster pumps and pressure reducing valves
Water supply service facilities	:	public fountains
Electricity supply facilities	:	panels and generators
Other work	:	electric houses and pipeline miscellaneous

Basic items of the major water supply facilities are given below.

(1) Intake facilities

An electric prospecting was carried out in the eleven urban centers under the feasibility study. The water sources will be decided with due attention to the results of the survey, and the problems emerged during the study are as follows.

i. The region, covering the area of Aykel, Debre Tabor, Nefas Mewcha, Bichena and Dejen, is located on a ridge of basalt lava strata and the area is surrounded by a sharp precipice. For this reason the watershed area is not large and water-bearing strata are not developed.

ii. The groundwater in Dupti and Bure is of poor quality, and there are needs to consider their water sources.

Dupti: The water contains much fluorine, and also has a high concentration of salt. A hot spring issues from a well in the cotton fields on the outskirts of the center, but the salt concentration is weaker near the Awash River.

Bure: There are springs of shallow-lying groundwater, but large amounts of colon bacillus are found. Subterranean water at deeper levels (confined groundwater) contains markedly large amounts of minerals, and is not fit for drinking water.

Groundwater is the cheapest source of water that can be put to use untreated as drinking water, and is an important source of water in Ethiopia. Water sources at

present used in the area covered by the project are groundwater and spring water, and for this project the basic source of water will be a deep-lying groundwater.
Taking the recharge volume in a drought year which will occur once in five years as the upper limit of groundwater development, effective locations for wells will be chosen plans for water pipes. However, in areas where the watershed area is small the results of the electric prospecting will be used to pick out locations where there are higher possibilities to draw out the planned volume of water. On the other hand, for Dupti where there are problems with water quality, there are plans to use shallow-lying groundwater of the Awash River, where the water quality seems to be relatively good. It is also planned to use shallow-lying groundwater for Bure, with chlorinating facilities to treat the colon bacillus contamination.

The chlorinating facilities planned in other centers except Dupti and Bure will be installed by the Ethiopian side.

Necessary wells shall be selected to meet the maximum daily demand in the target year.

1) Deep well

Where existing wells are to be used, they will be cleaned and submersible pumps will be renovated. Steel pipes and stainless steel pipes will be used for the casing and screen , respectively, for new wells.

2) Shallow well

Since contamination from domestic waste water in the surrounding area is possible, chlorinating facilities will be planned for newly-built shallow wells in Dupti and Bure.

3) Well pump

The same type of existing submersible pumps will be planned for the existing wells.

(2) Transmission facilities

Transmission facilities from well to reservoir will be those supplied by pump. Daily operation hours will be 20 hours by considering loss time for maintenance and change of diesel generator. No direct supply from rising pipe, in principle, will be allowed.

1) Rising pipes

Rising pipes shall all be newly installed with a diameter suited to the project target year 2010. The pipe material shall be ductile cast-iron pipe with proper sizes to meet economical flow velocities.

In principle, the Hazen-William equation shall be used for the design of the pipeline. The pipeline shall be laid under grounds with minimum earth cover of 80cm.

2) Rising pump

The rising pumps shall all be newly installed (three pumps including one stand-by unit) to pump enough the demand in the target year in 20 hrs daily.

The pumps shall be of volute-type with stop valve and non-return valve and be controlled manually (through switching ON/OFF), and shall stop automatically at emergency (e.g. pump operation below low water levels, motor driving while low voltage).

3) Collection chamber

A collection chamber shall be built when high pumping heads are required due to topographical conditions. The structure shall be of reinforced concrete and shall have a capacity of 30 minute intake volume of maximum daily demand in the target year, while the minimum capacity shall be 25 m^3.

(3) Distribution facilities

Distribution pipes (from reservoir to public fountain) will be of gravity flow by taking advantage of elevated water level of the reservoir; while some pressure reducing valves or booster pumping may be planned under some topographical conditions.

The existing facilities will not be used in any of the subject centers, since the records of their present location, alignment and diameter of the pipes are mostly missing, often damaged and leaking water due probably to insufficient earth cover.

1) Reservoir

The capacity of supply reservoirs shall be 8-hour volume of the maximum daily demand in the target year. The capacity of the reservoirs for construction shall selected from any one of the following standard volumes: 50m^3, 100m^3, 150m^3, 300m^3, 350m^3 and 500m^3. The structure shall be a reinforced concrete-made. In case of elevated tanks more than 7m-tall, a panel-type (FRP or steel plate) may be used. The reservoirs shall be equipped with water level gauges.

2) Distribution pipes

Similar to the rising pipes, the distribution pipes shall all be newly installed, and shall be of appropriate sizes in the target year 2005, while the area extension for laying will be limited within the present and programmed residential areas for town planning up to 2000.

Distribution pipes are classified into primary distribution pipes (ϕ 150 mm or more), secondary distribution pipes (ϕ 100 mm to ϕ 75 mm) and tertiary distribution pipes (ϕ 50 mm). The tertiary pipes will be procured in Japan, but installed by the Ethiopian side. However, tertiary pipes for new public fountains will be installed by the Japanese side.

The type of pipes used shall be either galvanized steel pipes (ϕ 75 mm or more) or PVC pipes (ϕ 50 mm) to allow flow velocity from 0.6 to 3.0m/sec. The water pressure will basically be kept from 0.5 to 6.0kg/ cm^2, and it is planned to avoid as far as possible the installation of pressure reducing valves and booster pumps. Pipelines shall be laid under roads, with a minimum top cover of 80 cm.

(4) Water supply service facilities

Water supply service facilities shall be installed through private connection and public fountain. Installation of these facilities from distribution pipe junctions to each private connection, such as house connection and yard connection, shall be undertaken by the Ethiopian side, while installation of new public fountains branching off from distribution pipes shall be carried out by the Japanese side. The number of public fountains to be newly installed will be referred from the feasibility study, and a public fountain will be equipped with five to six taps. Drainage facilities from the fountains will be laid to the nearest drains. The existing public fountains shall remain, and in case of repair it shall be carried out by the Ethiopian side. One public fountain shall be installed in every circumference of 200m to 300m radius. No fire-hydrant will be planned.

(5) Electricity supply facilities

Hydroelectric power and diesel generated power are sources of electricity in Ethiopia. The former is supplied to nearby cities by hydropower plants and the latter for supply to rural cities or water sources by mini-hydropower plants or a number of isolated diesel generating units. Table 2-7 indicates the current status of power supply to the project area.

The sources of power supply to the water sources are mostly different from those in the urban centers. Even hydroelectric power is supplied to the urban centers but due to long distance to the water sources and pumping station, isolated diesel generated power is frequently being applied. Efforts are being made to convert power from diesel to hydroelectric power in the urban centers. It is assumed that power for water intake and transmission facilities will be converted to hydroelectric power upon completion of the project completion. It is also assumed that those facilities in the urban centers programmed for conversion by 2000, such as Chagni will also be supplied with hydroelectric power by that time. Diesel generated power sources for four urban centers (Dupti, Mille, Aykel and Nefas Mewcha) will accordingly remain with two units including one stand-by unit for each center, while those for other seven urban centers are hydroelectric power equipped with an emergency generator unit at power failure.

Table 2-7 Source of Electricity Supply

Centers	In the Center	At Water Source	Hydroelectric Plan
Dupti	Diesel	Diesel	none
Mille	Diesel	Diesel	none
Bati	Hydroelectric	Hydroelectric	
Werota	Hydroelectric	Hydroelectric	
Aykel	Diesel	Diesel	none
Debre Tabor	Hydroelectric	Diesel	
Nefas Mewcha	Diesel	Diesel	none
Chagni	Diesel	Diesel	up to 2000
Bure	Hydroelectric	Diesel	
Bichena	Hydroelectric	Diesel	
Dejen	Hydroelectric	Diesel	

(6) Electric house

An electric house shall be built to each of pumping stations to accommodate control panels, power source units and operator room, etc. As expansion of operation room may be difficult after construction, the room space shall be enough to accommodate equipment for demand in the target year 2005. The house will be of brick-made.

(7) Valves

The following valves shall be installed in the rising and distribution pipes.

Stop valve: on the downstream and turning points of pipe junctions.

Air valve: on higher sections of pipe.

Drainage valve: on lower sections of pipe.

Pressure reducing valve : on higher pressure section of pipe.

Flow meters: at pump exits and public fountains.

(8) Use of existing facilities

The existing facilities suffer much from frequent failure of pumps and generators, water leak from supply reservoirs and rising and distribution pipes, and locations of pipes are often missing. The existing facilities will, therefore, be not used except the following;

- Existing well after dredging; new submersible pumps will be installed.
- Two reservoirs and a collection chamber built after the feasibility study.

Reservoirs	:	Aykel (50 m^3) and Debre Tabor (80m^3)
Collection chamber	:	Bati (50m^3)

- Existing public fountains required for repair

2-3 Basic Design

2-3-1 Design Concept

Design concepts in the formulation of project facilities and selection of equipment and materials, are based on the following policies;

(1) Natural conditions

- The project area covers two regions namely, (1) a cool highland region with yearly mean temperatures from 10℃ to 20℃ and more than 1,500 m in elevation, and (2) harsh lowland region (including a graven zone) with yearly mean temperatures ranging from 30℃ to 45℃. The diesel generator is inefficient in highland due to lack of air. In the lowland region, the severe natural environment is a factor for shortening the durability of tools and machinery into roughly half the lifetime. Thus technical specifications of generators shall consider carefully the elevation and natural condition.
- As boulders or exposed rocks are placed in the project sites, the pipe material and the pipe laying method shall be used to avoid the damage on pipes during the backfiring.

(2) Social conditions

- About 40 % of Ethiopian is Muslim, and it has a high ratio in Afar region. The religious practices and costumes, such as fasting, etc., shall be considered in the preparation of construction schedule during the implementation.

(3) Construction situation

- Since there is a scarcity of local private construction firms and skilled laborers in the regions covered by the project, some particularly specialized construction methods or engineering technologies requiring specific high skills, will be avoided as much as possible upon selection of construction methods.
- Ethiopia entirely relies on imports of construction materials and equipment, pipe and electrical materials and machinery. However, all construction materials and equipment available in the Ethiopian market will be locally procured.
- Considering the benefits for future maintenance, the materials and equipment to be procured will be selected with due attention onto the types of material and equipment already owned by the execution agencies.
- Ethiopian contractors can carry out civil works, building works, well drilling, etc., while procurement and installation of mechanical and electrical facilities are mostly undertaken by the foreign contractors. The technical engineers are dispatched during the installation of mechanical and electrical works.

(4) Employment of local contractors

- The scope of the project covers a large number of urban centers spread over a wide area, and there are much differences in the natural environment at each of the eleven urban centers with regard to topography, geology and climate. It is most suitable to employ Ethiopian contractors, who are familiar with the local conditions, during the construction stage.
- Major local contractors have a number of construction machinery and have experiences of water supply projects in the urban centers. Thus these contractors can be employed as sub-contractors.
- Local well drilling companies, though a few number in Ethiopia, can also be employed as sub-contractors.
- Major materials for the project are pipes (galvanized steel pipes, ductile cast iron pipes and PVC pipes), reinforcing bars, cement, sand, gravel and so on. Pipes are all imported and are marketed in Addis Ababa. Procuring pipes from the local market has many problems such as quality, delay in procurement and delivery. The pipes are supplied from Japan or the third country such as Europe. Minor materials for civil works other than the above are mostly available in the local market.

(5) Equipment and its grade of the facilities

- As the electricity was insufficiently supplied in the urban centers in the project, the mechanical system, such as start and stoppage of pumps, operation of valves, checking water level of reservoirs, etc., shall be adopted as much as possible.
- Existing facilities are mostly superannuated with much water leaks. The distribution pipes also have problems such that location of distribution pipelines are missing. Being such in this situation, use of existing facilities will be abandoned and new ones are to be planned.
- There is no agent to locally supply the equipment and materials for pumps and generators that the procurement will be made from Japan or the third countries particularly Europe.

(6) Operation and maintenance ability of WWS

- Water Supply Services (WWS) of the regional government, in charge of present operation and maintenance management, is not well functioning. Design of the facilities are therefore planned to minimized the maintenance cost.
- Design of facilities also are considered to the present methods and technical level for operation and maintenance.

(7) Construction schedule

- The eleven urban centers under the project are located in two regions. Taking into account the geographical conditions between the urban centers and the work volume to be done, the eleven urban centers will be divided into three to four groups in which works will be carried out in the span of about three years.

2-3-2 Design Condition

(1) Design water demand

1) Average daily demand

The average daily demands in the target years are shown below.

Table 2-8 Average Daily Demands

Name of Centers	Average daily demand (m^3/day)		
	2000	2005	2010
Dupti	588	1,164	2,222
Mille	268	472	853
Bati	556	864	1,247
Werota	881	1,423	2,369
Aykel	290	505	893
Debre Tabor	831	1,384	2,293
Nefas Mewcha	583	973	1,652
Chagni	716	1,198	1,966
Bure	502	782	1,254
Bichena	420	767	1,427
Dejen	363	545	839

2) Maximum daily demand

Taking seasonal fluctuations of maximum daily demand into account, the load factor 1.5 for the two urban centers in Afar Region and 1.2 for the nine urban centers in Amhara Region are employed based on the design criteria.

3) Peak hourly demand

The peak hourly demand is calculated by the following equation.

$$Qh=K \times Qd/24$$

Where, Qh is the peak hourly demand (m^3/hour)

K is the time coefficient, and

Qd is the maximum daily demand (m^3)

The time coefficient is 2.0 for Mille, which has the smallest population, and 1.6 for the other ten urban centers based on the design criteria.

Table 2-9 Design Water Demand

Name of centers	Maximum daily demand (m^3/d)			Peak hourly demand (m^3/d)		
	2000	2005	2010	2000	2005	2010
Dupti	882	1,746	3,333	58.8	116.4	222.2
Mille	402	708	1,280	33.5	59.0	106.6
Bati	667	1,037	1,496	44.5	69.1	99.8
Werota	1,057	1,708	2,843	70.5	113.8	189.5
Aykel	348	606	1,072	23.2	40.4	71.4
Debre Tabor	997	1,661	2,752	66.5	110.7	183.4
Nefas Mewcha	700	1,168	1,982	46.6	77.8	132.2
Chagni	859	1,438	2,359	57.3	95.8	157.3
Bure	602	938	1,505	40.2	62.6	100.3
Bichena	504	920	1,712	33.6	61.4	114.2
Dejen	436	654	1,007	29.0	43.6	67.1

(2) Intake facilities

According to the volume of water available from the planned wells under the feasibility study, the wells to secure enough volume for the maximum daily demand in the target year 2000 and 2005, are carried out.

Table 2-10 shows the maximum daily demand and the estimated water volumes in each urban centers adopted in the plan.

Among them, a portion of the wells enough for meeting the daily maximum demand in 2000 will firstly be installed by the Japanese side while the remaining will be done by the Ethiopian side.

Table 2-10 Water Source

Unit: m^3/d

Water source		Dupti	Mille	Bati	Werota	Aykel	D-Tabor	N-Mewcha	Chagni	Bure	Bichena	Dejen
Well	1	*212	191	123	*124	278			91	127		124
	2	*145	*145	*42		418		303	*182	*138	133	270
	3	218	*230	185	539		121	314	454	301	412	*267
	4	382	327	79			214		273			162
	5			273			218		*315		*514	
	6	*549			539		254	*291				
	7			*303	*539		291	*291				
	8							212				
	9	328							144			
	10											
	11											
	12						*303					
	13						*303					
Spring	1									*164		
	2									173		
2000	designed volume	928	518	660	1,078	696	1,096	829	962	601	545	556
	Max. day demand	882	402	667	1,057	348	997	700	859	602	504	436
2005	designed volume	1,834	893	1,005	1,741	696	1,702	1,411	1,459	903	1,059	823
	Max. day demand	1,746	708	1,037	1,708	606	1,661	1,168	1,438	938	920	654

- The number of well shows the drawings of proposed water source attached in 2-3-3, (2).
- The figures marked '*' show the water source covered in the target year 2005.
- Figures upper the underline (.....) show the existing water source while the lower shows proposed one.

(3) Transmission facilities

1) Rising pipe

The rising pipes shall be of sizes suited to meet the maximum daily demand in the target year 2010. Hazen-William formula shall be used for the design of the pipelines.

$$H=10.666 \cdot C^{-1.85} \cdot D^{-4.87} \cdot Q^{1.85} \cdot L$$

Where, H is the loss head (m),

C is the velocity coefficient (C=110),

D is the inner pipe diameter (m),

Q is the discharge (m^3/s), and

L is the pipe length (m)

2) Rising pump

The rising pumps shall be installed in the rising pipes in case the water source is far from the urban center or the range of elevations are high. Seven urban centers which require rising pumps and where the range of elevations between water source and supply reservoir is over 100 m are selected.

Table 2-11 Rising Pump

Name of Centers	Range of elevation	No. of rising pump
Dupti	13～30 m	-
Mille	61～84 m	-
Bati	94～138 m	1
Werota	104～135 m	2
Aykel	367 m	3
D-Tabor	89～226 m	2
N-Mewcha	72～128 m	1
Chagni	0～48 m	-
Bure	68～137 m	2
Bichena	104～172 m	2
Dejen	57～94 m	-

* Number of rising pump in Bichena includes 1 set of pump settled in 2005.

The rising pumps shall all be installed to pump enough the demand in the target year in 20 hrs daily. As the target supply in 2000 being almost a half that of 2005, two units including a stand-by unit will be installed first for the 2000 demand, while additional one unit will be installed by the Ethiopian side to meet the 2005 demand.

The required shaft power of pumps is calculated by the following equation;

$$P=0.163\ \gamma Q H\ (1+\alpha)/\eta$$

where,

P: shaft power of pump (kw)

γ : unit weight of water (kg/l)

Q: discharge (m^3/min)

H: total head (m)

α : allowance (15%)

η : pump efficiency (40%)

For calculation of total heads, 2.0m shall be added to the actual head as loss heads by valves and other fittings connected.

3) Collection chamber

The collection chamber serves as the pit for the rising pump and shall have a capacity to store 30-minute volume at the designed capacity of the water source in the project target year 2000 and 2005. A collection chamber with a capacity of 50 m^3 is existing in Bati and will be used.

Table 2-12 Designed Capacity of Collection Chamber

Name of centers		2000			2005		
		Capacity of Water Source (m^3/d)	30 min. worth (m^3)	Designed Capacity (m^3)	Capacity of Water Source (m^3/d)	30 min. worth (m^3)	Designed Capacity (m^3)
Bati	(P_1)	667	16.7	-	1,037	25.9	-
Werota	(P_1)	1,078	27.0	30	1,741	43.5	45
Aykel	(P_1)	418	10.5	25	418	10.5	25
	(P_2)	696	17.4	25	696	17.4	25
	(P_3)	696	17.4	25	696	17.4	25
D-Tabor	(P_2)	805	20.1	25	1,411	35.3	35
	(P_3)	339	8.5	25	945	23.6	25
N-Mewcha	(P_2)	829	20.7	25	829	20.7	25
Bure	(P_1)	602	15.1	25	938	23.5	25
Bichena	(P_1)	-	-	-	514	12.9	25
	(P_2)	545	13.6	25	545	13.6	25

(4) Distribution facilities

1) Reservoir

As reservoir can be built more in future, the reservoir capacity for the project construction will be an 8-hour demand in 2000 while the remaining required capacity will be additionally constructed by the Ethiopian side by 2005.

The capacities in the target 2000 against those in 2005 are presented the Table 2-13 in terms of hour-capacity.

Table 2-13 Design Capacity of Reservoirs

Name of Centers	Year 2005			Year 2000			Flow-hr capacity in 2000 vs 2005
	8-hr Capacity	Existing Capacity	Design Capacity	8-hr Capacity	Existing Capacity	Design Capacity	
	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(hr)
Dupti	582.0		300×2	294.0		300	4.1
Mille	236.0		300 (150×2)	134.0		200 (100 x 2)	6.8
Bati	345.7		350	222.4		300	6.9
Werota	398.5 170.8		500 300	242.6 107.3		300 100	4.9 4.9
Aykel	202.0	50	150	116.0	50	100	5.9
Debre Tabor	553.7	80	500	332.4	80	300	5.5
Nefas Mewcha	389.3		500	233.2		300	6.2
Chagni	479.3		500	286.4		300	5.0
Bure	250.2 62.5		300 100	161.8 56.0		300 100	 7.7
Bichena	306.7		300	168.0		300	7.8
Dejen	218.0		300	145.2		150	5.5

2) Distribution pipe

Pipeline network of the distribution pipes shall be designed by using Hardy-Cross formula, and the diameters of distribution pipes and water levels in the reservoirs shall be installed to maintain the terminal pressures within 0.5 to 6.0 kg/cm^2

(5) Public fountain

Public fountains shall be designed based on the feasibility study.

(6) Electric supply facilities

The present conditions of the electric supply facilities in eleven urban centers are shown in Table 2-7, and the electric supply sources of the project are as follows;

Hydroelectric power : Bati, Werota, Debre Tabor, Chagni, Bure, Bichena & Dejen

Diesel generated power : Dupti, Mille, Aykel & Nefas Mewcha

One unit each of stand-by diesel generator shall be installed in all pumping sites. From the viewpoint of efficiency, a minimum number of diesel generation shall preferably be installed. To avoid high O&M cost for transmission network, only one generators will be used within a distance of 500m or less.

The pump facilities in the following urban centers shall be equipped with diesel generators either individually or combined (refer to footnotes below).

Name of centers	Individual and combined Pump Facilities
Dupti	*W1・*W2・W3・W4・*W6・W9
Mille	W1・*W2・*W3・W4
Bati	W1・*W2・W3・W4・W5・*W7・P1
Werota	*W1・W3・W6・*W7・P1・P2
Aykel	W1・W2・P1・P2・P3
D-Tabor	W3・W4・W5・W6・W7・*W12・*W13・P2・P3
N-Mewcha	W2・W3・*W6・*W7・W8・P2
Chagni	W1・*W2・W3・W4・*W5・W9
Bure	W1・*W2・W3・P1・P2・S1・S2
Bichena	W2・W3・*W5・*P1・P2
Dejen	W1・W2・*W3・W4

Note: - Underlined (or combined) pump facilities in a particular urban center which has a distance of less than 500m require only one generator, while those without underline which has a distance of more than 500m, require individual generator for each pump facility.
- W, S and P presents deep well pump, shallow well pump and rising pump respectively.
- (*) shows the facilities set in 2005.

(7) Electric house

The electric house shall be planned into the following four types to meet the number of units of pumps and diesel generators.

Table 2-14 Types of Electric House

Type	Dimension	No. of Pumps	No. of Generator	Remarks
Type A	8.0 m×4.5 m	-	2 units	for water source
Type B	5.0 m×4.5 m	-	1 unit	ditto
Type C	12.0 m×8.0 m	2 units	2 units	for rising pump
Type D	12.0 m×6.0 m	2 units	1 unit	ditto

2-3-3 Basic Design

(1) Overall design

The water supply facilities to be constructed in the urban centers covered by the project are composed of intake facilities, transmission facilities, distribution facilities, water supply service facilities, electricity supply facilities, electric house and other related facilities. The lists of major facilities and their specifications for each urban center are as presented in Table 2-15 (1) and 2-15 (3) for construction target year of 2000 and in

Table 2-15 (2) and 2-15 (4) for construction target year of 2005 in the succeeding pages.

(2) Basic design drawings

The basic design drawings for construction of water supply facilities are as follows.

- Supplied Area in 2000 (Eleven centers)
- Plan of Proposed Water Sources (Eleven centers)
- Plan of Wells and Transmission Facility (Eleven centers)
- Type of Distribution Pipelines (Eleven centers)
- Distribution Pipeline Network (Eleven centers)
- Layout of Proposed Deep Well
- Layout of Proposed Shallow Well
- Layout of Proposed Electric House
- Layout of Proposed Collection Chamber
- Layout of Proposed Reservoir
- Layout of Proposed Public Fountain

Table 2-15(1) Intake Facilities and Transmission Facilities (Construction Target year 2,000)

		Dupti	Mille	Bati	Werota	Aykel	D-Tabor	N-Mewcha	Chagni	Bure	Bichena	Dejen	Total
Transmission Line (Design Target year 2,010)	φ250								1,680				1,680
	φ200			900	2,650	4,900	2,580	3,720			300		15,050
	φ150	5,200	1,150	830	1,350	2,500	3,800	440	2,890	5,380	4,070	3,730	31,340
	φ100		3,630		1,120		1,500	1,100	730	1,300	3,880		13,260
	φ75		980	840	350		2,770	250		2,420		820	8,430
	φ50								300		620		820
	Total	5,200	5,760	2,570	5,470	7,400	10,650	5,510	5,500	9,100	8,870	4,550	70,580
Well Facilities (Design Target year 2,005)		W 3 Q=0.182m3/min. H=67.7m 5.8kW	W 1 Q=0.159m3/min. H=95.6m 7.2kW	W 1 Q=0.103m3/min. H=30.7m 1.5kW	W 3 Q=0.449m3/min. H=36.1m 7.6kW	W 1 Q=0.232m3/min. H=30.8m 3.3kW	W 3 Q=0.101m3/min. H=43.4m 2.1kW	W 2 Q=0.253m3/min. H=43.9m 5.2kW	W 1 Q=0.076m3/min. H=61.5m 2.2kW	W 1 Q=0.106m3/min. H-36.7m 1.8kW	W 2 Q=0.111m3/min. H=112.9m 5.9kW	W 1 Q=0.103m3/min. H=69.6m 3.4kW	
		W 4 Q=0.318m3/min. H=65.7m 9.8kW	W 4 Q=0.273m3/min. H=68.1m 8.7kW	W 3 Q=0.154m3/min. H=21.9m 1.6kW	W 6 Q=0.449m3/min. H=25.9m 5.5kW	W 2 Q=0.348m3/min. H=64.9m 10.6kW	W 4 Q=0.177m3/min. H=76.3m 6.3kW	W 3 Q=0.262m3/min. H=41.9m 5.2kW	W 3 Q=0.378m3/min. H=46.4m 8.2kW	W 3 Q=0.251m3/min. H=21.8m 2.6kW	W 3 Q=0.343m3/min. H=83.7m 13.5kW	W 2 Q=0.225m3/min. H=84.1m 8.9kW	
		W 9 Q=0.273m3/min. H=61.3m 7.8kW		W 4 Q=0.066m3/min. H=29.4m 0.9kW			W 5 Q=0.182m3/min. H=20.1m 1.7kW	W 8 Q=0.177m3/min. H=30.1m 2.5kW	W 4 Q=0.228m3/min. H=54.6m 5.8kW			W 4 Q=0.135m3/min. H=84.2m 5.3kW	
				W 5 Q=0.228m3/min. H=56.7m 6.1kW			W 6 Q=0.212m3/min. H=67.4m 6.7kW		W 9 Q=0.120m3/min. H=56.9m 3.2kW	S 2 Q=0.144 m3/min.			
							W 7 Q=0.243m3/min. H=136.1m 15.5kW						
Pumps (Design Target year 2,005)				Q=0.420m3/min. H=84.8m 16.7 kW x2units	Q=0.145m3/min. H=105.1m 7.1 kW x2units	Q=0.348m3/min. H=85.0m 13.9 kW x2units				Q=0.302m3/min. H=112.3m 15.9kW x2units			
					Q=0.580m3/min. H=63.7m 17.3 kW x2units	Q=0.580m3/min. H=146.3m 39.8 kW x2units	Q=0.589m3/min. H=72.6m 20.0 kW x2units	Q=0.346m3/min. H=50.9m 8.3 kW x2units		Q=0.113m3/min. H=92.7m 4.9 kW x2units	Q=0.227m3/min. H=67.7m 7.2 kW x2units		
						Q=0.580m3/min. H=107.7m 29.3 kW x2units	Q=0.395m3/min. H=103.1m 19.1 kW x2units						

Table 2-15(2) Intake Facilities and Transmission Facilities (Construction Target year 2,005)

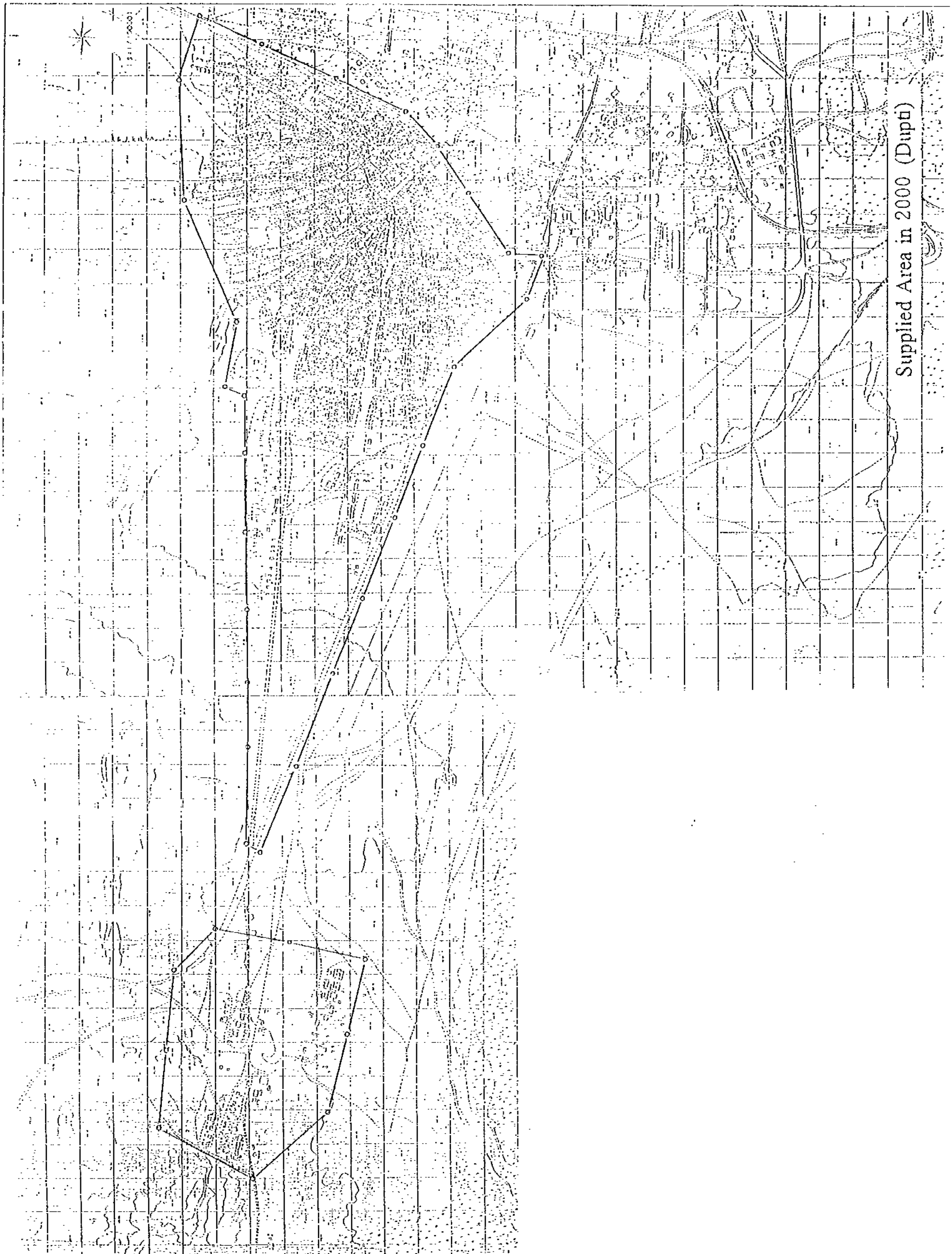
		Dupti	Mille	Bati	Werota	Aykel	D-Tabor	N-Mewcha	Chagni	Bure	Bichena	Dejen	Total
Transmission Line (Design Target year 2,010)	φ250	2,100											2,100
	φ200										2,400		2,400
	φ150			1,300			1,430	900	1,200		1,840		6,670
	φ100	500	1,370				1,100	1,400	1,360				5,730
	φ75						700	130	460	2,100			3,390
	Total	2,600	1,370	1,300			3,230	2,430	3,020	2,100	4,240		20,290
Well Facilities (Design Target year 2,005)		W1 Q=0.177m3/min. H=61.3m 5.1kW	W2 Q=0.121m3/min. H=76.9m 4.4kW	W2 Q=0.035m3/min. H=40.7m 0.7kW	W1 Q=0.103m3/min. H=25.4m 1.2kW		W12 Q=0.253m3/min. H=69.5m 8.2kW	W6 Q=0.243m3/min. H=76.0m 8.7kW	W2 Q=0.152m3/min. H=58.7m 4.2kW	W2 Q=0.115m3/min. H=55.9m 3.0kW	W5 Q=0.428m3/min. H=124.0m 24.9kW	W3 Q=0.223m3/min. H=78.7m 8.2kW	
		W2 Q=0.121m3/min. H=62.3m 3.5kW	W3 Q=0.192m3/min. H=79.7m 7.2kW	W7 Q=0.253m3/min. H=72.2m 8.6kW	W7 Q=0.449m3/min. H=14.9m 3.1kW		W13 Q=0.253m3/min. H=71.6m 8.5kW	W7 Q=0.243m3/min. H=51.6m 5.9kW	W5 Q=0.263m3/min. H=47.8m 5.9kW				
		W6 Q=0.458m3/min. H=54.2m 11.6kW								S1 Q=0.137 m3/min.			
Pumps (Design Target year 2,005)											Q=0.214m3/min. H=22.7m 2.3 kW x2units		

Table 2-15(3) Distribution and Facilities and Others (Construction Target year 2,000)

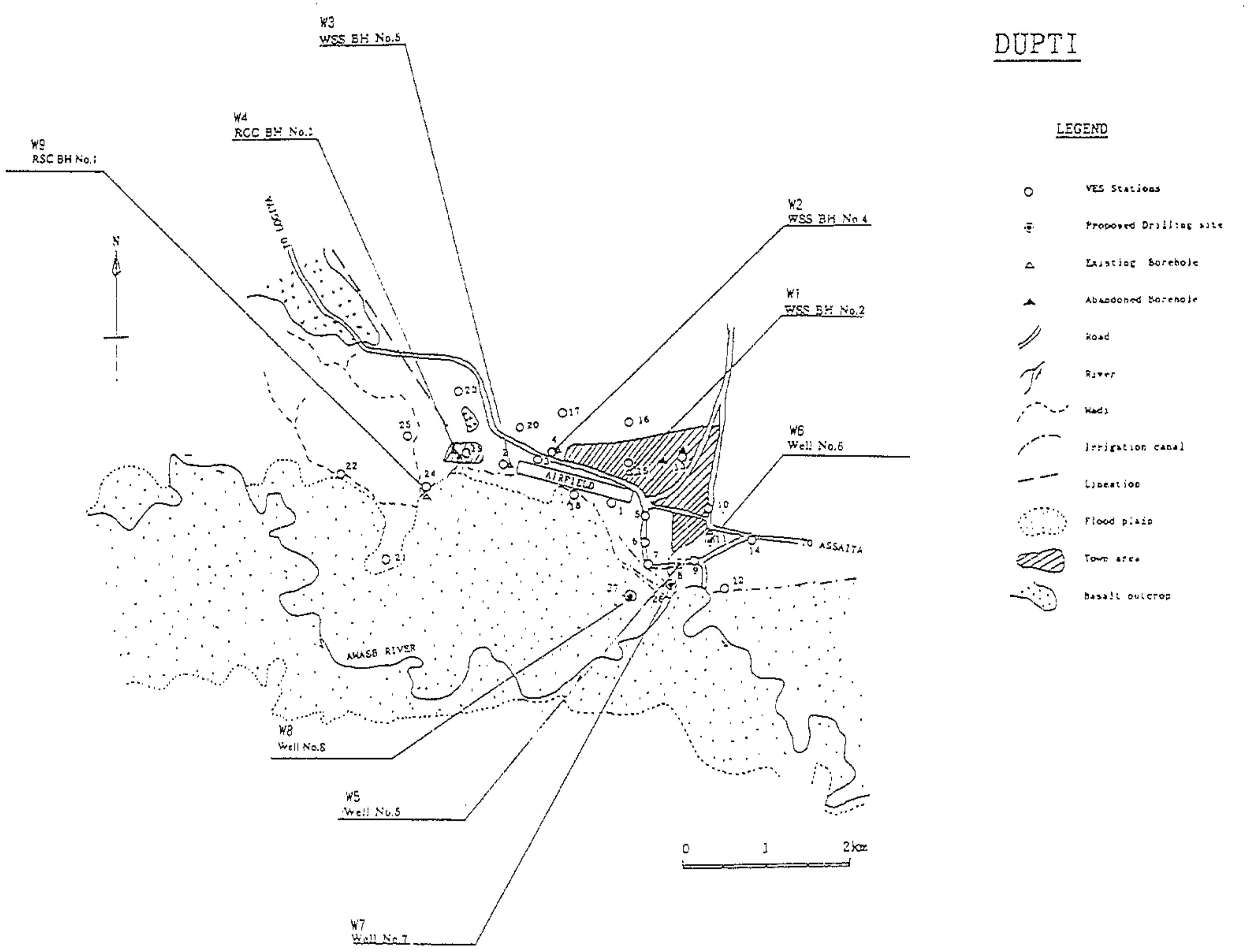
	Dupti	Mille	Bati	Werota	Aykel	D-Tabor	N-Mewcha	Chagni	Bure	Bichena	Dejen	Total(m)
Distribution Pipe (Design Target year) 2,010 φ300	40					315						355
Distribution Pipe (Design Target year) 2,010 φ250	470						330	760				1,560
Distribution Pipe (Design Target year) 2,010 φ200			285	355	285				620	320		1,865
Distribution Pipe (Design Target year) 2,010 φ150		360									2,745	3,105
Distribution Pipe (Design Target year) 2,000 φ250						210						210
Distribution Pipe (Design Target year) 2,000 φ200						590	540					1,130
Distribution Pipe (Design Target year) 2,000 φ150	1,810	2,120	1,305	330	1,485	3,305	795	1,535	630	1,735		15,050
Distribution Pipe (Design Target year) 2,000 φ100	650			1,230					1,760			3,640
Distribution Pipe (Design Target year) 2,000 φ75	4,545	770	4,880	6,035	3,585	11,395	3,825	8,580	5,210	7,165	2,775	58,765
Distribution Pipe (Design Target year) 2,000 φ50	900	600	200	500	600	800	200	600	300	1,100	600	6,400
Distribution Pipe (Design Target year) 2,000 φ50(Supplied)	10,135	675	5,660	7,510	8,050	13,090	7,460	7,110	6,740	9,820	10,465	86,715
Total (m)	18,550	4,525	12,330	15,960	14,005	29,705	13,150	18,585	15,260	20,140	16,585	178,795
Collection Chamber				30 m3 1set	25 m3 3sets	25 m3 2sets	25 m3 1set		25 m3 1set	25 m3 1set		9 sets
Reservoir	Head 0.0m 300m3 1set	Head 7.5m 100m3 1set Head 0.0m 100m3 1set	Head 0.0m 300m3 1set	Head 10.0m 100m3 1set Head 0.0m 300m3 1set	Head 5.0m 100m3 1set	Head 7.0m 300m3 1set	Head 0.0m 300m3 1set	Head 5.0m 300m3 1set	Head 0.0m 300m3 1set Head 0.0m 100m3 1set	Head 8.0m 200 300m3 1set	Head 7.0m 150 150m3 1set	14 sets
Electric House	Type A 3Nos	Type A 2Nos	Type B 2Nos Type D 1No	Type B 2Nos Type D 1No	Type A 1No Type C 3Nos	Type B 5Nos Type D 2Nos	Type A 1No Type C 1No	Type B 4Nos	Type B 3Nos Type D 1No	Type B 2Nos Type D 1No	Type B 3Nos	38 Nos
Reducing Valve			Dia. 150mm Reduce 40m 1unit			Dia. 250mm Reduce 20m 1unit	Dia. 75mm Reduce 26m 1unit					14 units
			Dia. 75mm Reduce 40m 1unit			Dia. 150mm Reduce 20m 1unit						
						Dia. 150mm Reduce 13m 2units						
						Dia. 75mm Reduce 13m 2units						
						Dia. 75mm Reduce 20m 2units						
						Dia. 75mm Reduce 10m 2units						
						Dia. 75mm Reduce 20m 1unit						
Diesel Generator	13KVA-1 2units 20KVA-1 4units 6 units	24KVA-1 2units 20KVA-3 2units 4 units	5KVA-1 1unit 20KVA-1 1unit 100KVA-3 1unit 3 units	24KVA-1 2units 195KVA-3 1unit 3 units	5KVA-1 2units 70KVA-3 4units 155KVA-3 2units 8 units	8KVA-1 2units 33KVA-1 2units 55KVA-3 1unit 100KVA-3 2units 7 units	50KVA-1 2units 70KVA-3 2units 4 units	13KVA-1 3units 24KVA-1 1unit 4 units	8KVA-1 1unit 13KVA-1 1unit 20KVA-1 1unit 100KVA-3 1unit 4 units	33KVA-1 1unit 55KVA-3 2units 3 units	20KVA-1 1unit 24KVA-1 1unit 37KVA-3 1unit 3 units	49 units
Public Fountains	9 units	6 units	2 units	5 units	6 units	8 units	2 units	6 units	3 units	11 units	6 units	64 units

Table 2-15(4) Distribution and Facilities and Others (Construction Target year 2,005)

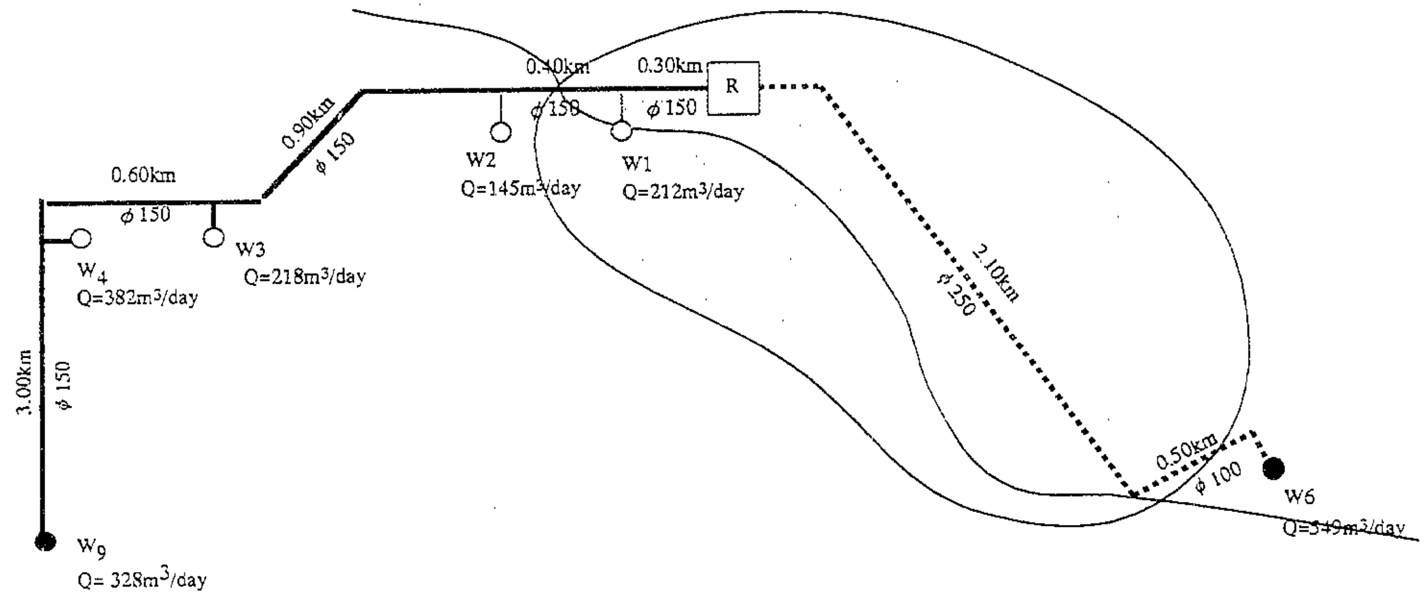
	Dupti	Mille	Bati	Werota	Aykel	D-Tabor	N-Mewcha	Chagni	Bure	Bichena	Dejen	Total
Collection Chamber				25 m3 1set		25 m3 1set				25 m3 1set		3 sets
Reservoir	300m3 1set	50m3 2sts	50m3 1set	100m3 2sets	100m3 1set	300m3 1set	100m3 1set	300m3 1set			100m3 1set	11 sets
Electric House	Type A 1No Type C 1No	Type A 2Nos	Type B 2Nos	Type B 2Nos		Type B 2Nos	Type A 2Nos	Type B 2Nos	Type B 2Nos	Type B 1No Type D 1No	Type B 1No	19 Nos
Reducing Valve			Dia. 150mm Reduce 36m 1unit			Dia. 250mm Reduce 19m 1unit	Dia. 75mm Reduce 24m 1unit					14 units
			Dia. 75mm Reduce 36m 1unit			Dia. 150mm Reduce 19m 1unit						
						Dia. 150mm Reduce 11m 2units						
						Dia. 75mm Reduce 11m 2units						
						Dia. 75mm Reduce 19m 2units						
						Dia 75mm Reduce 9m 2units						
						Dia. 75mm Reduce 19m 1unit						
Diesel Generator	20KVA-1 4units 4 units	13KVA-1 2units 24KVA-1 2units 4 units	5KVA-1 1unit 37KVA-3 1unit 2 units	5KVA-1 1unit 13KVA-1 1unit 2 units		33KVA-1 1unit 37KVA-3 1unit 2 units	33KVA-1 2units 37KVA-3 2units 4 units	20KVA-1 1unit 24KVA-1 1unit 2 units	13KVA-1 1unit 20KVA-1 1unit 2 units	20KVA-1 1unit 100KVA-3 1unit 2 units	37KVA-3 1unit 1 unit	25 units



Supplied Area in 2000 (Dupti)



Plan of Proposed Water Sources (Dupti)



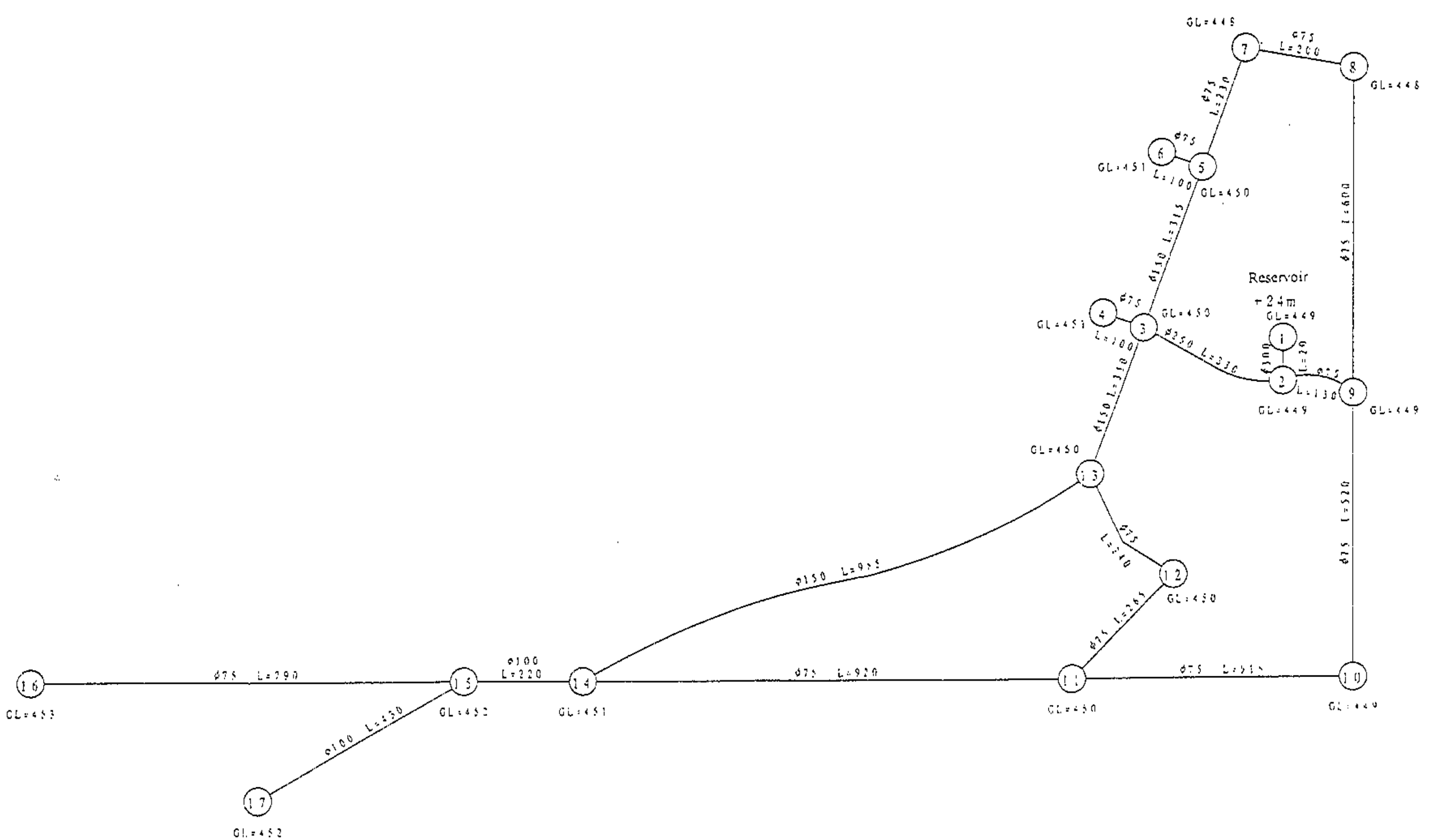
Legend

- : Water Supply Area
- : Existing Well
- : Proposed Well or Spring
- R : Proposed Reservoir
- P : Boosting Pump Station
- CC : Collecting Chamber
- Q : Planned production rate (m^3/day)
- 0.6km ϕ150 : Dia. & Length of Pipeline
- 0.6km ϕ150 : Dia. & Length of Pipeline to be constructed by the year of 2005

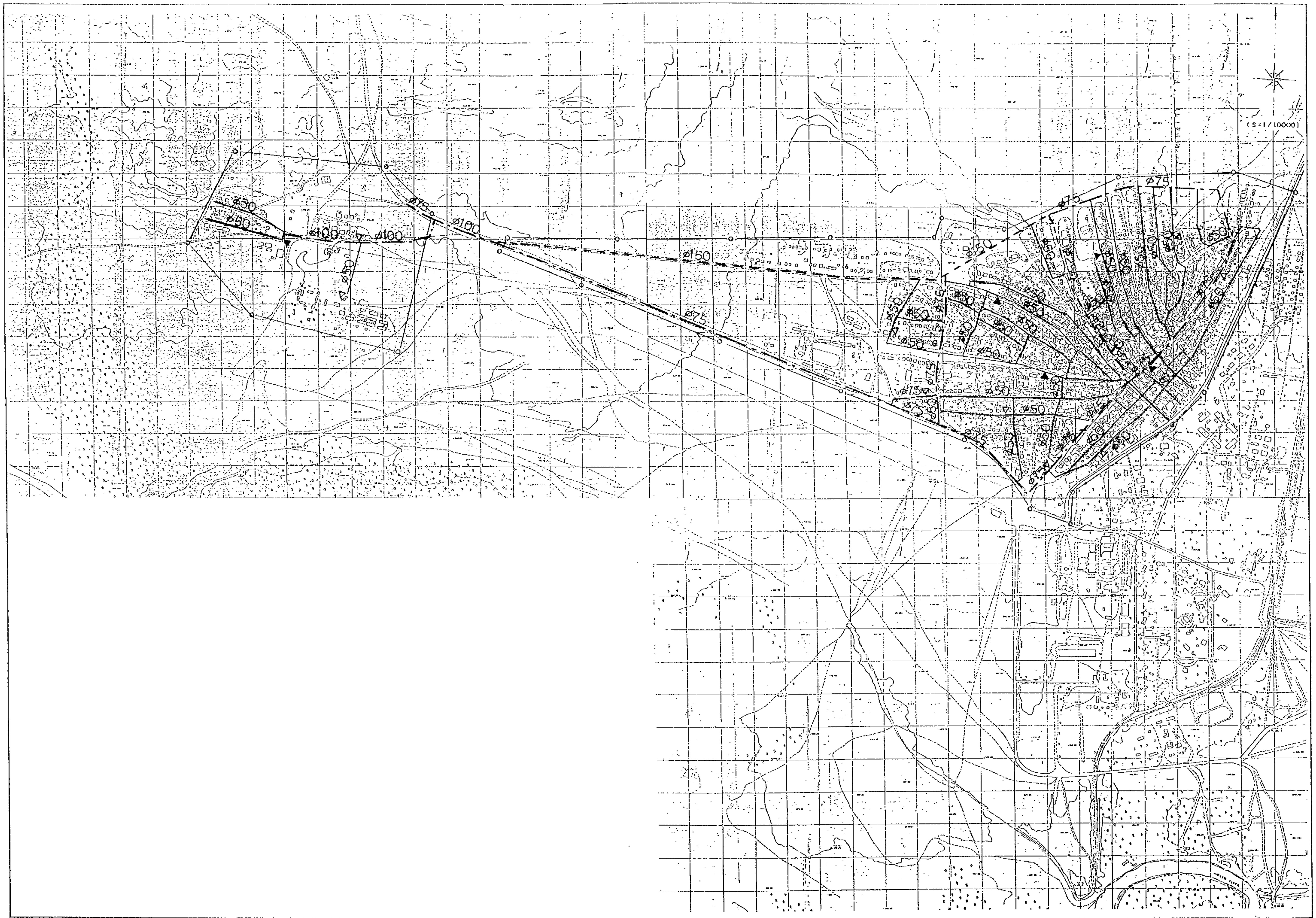
Well Development Plan

Target Year	Well No.	Production (m^3/day)	Max. Day Demand (m^3/day)
2000	W3+W4+W9	928	882
2005	W3+W4+W9+W1+W2+W6	1,834	1,746

Plan of Wells and Transmission Facility (Dupti)



Type of Distribution Pipeline (Dupti)


(S=1/10000)
ø50
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ø150
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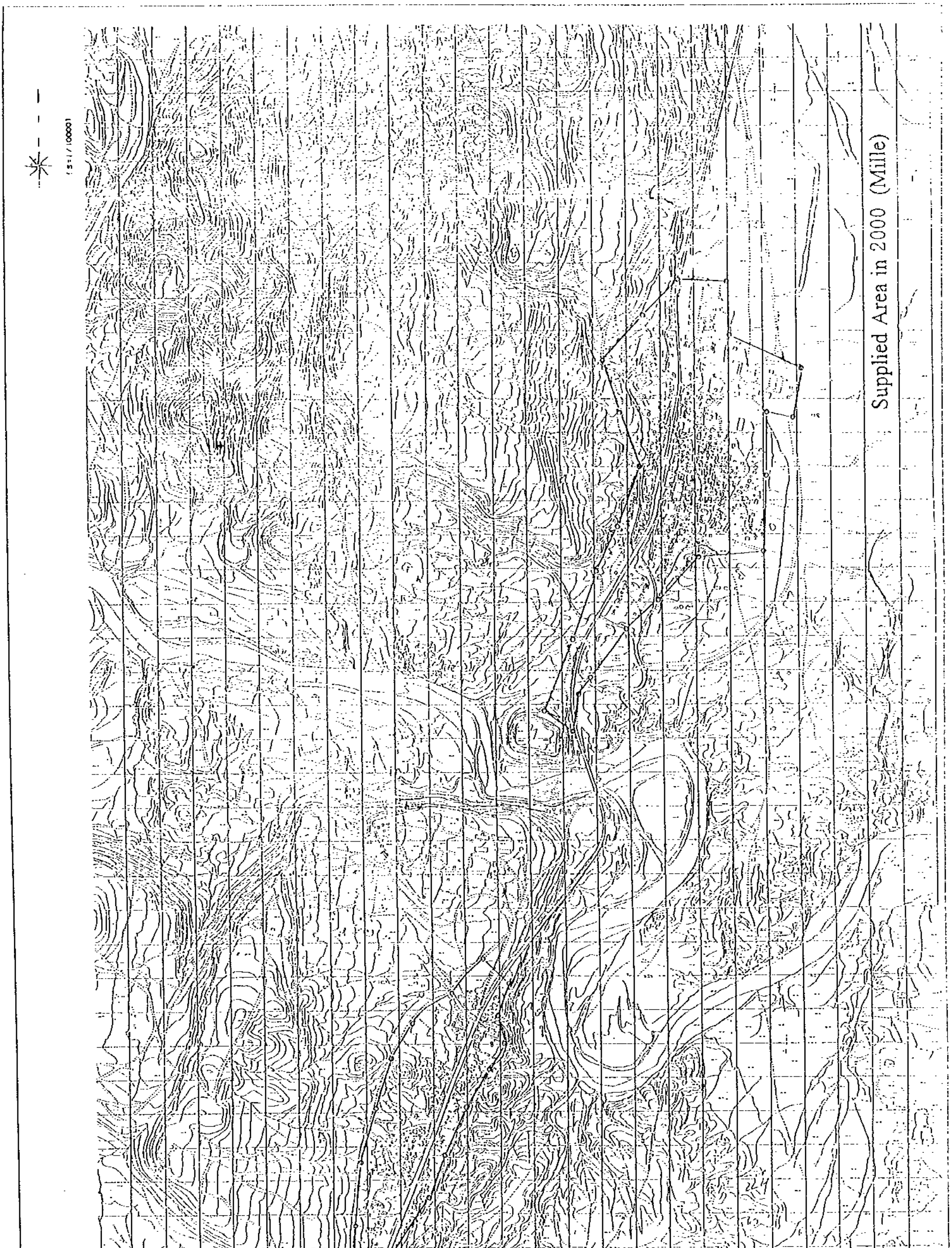
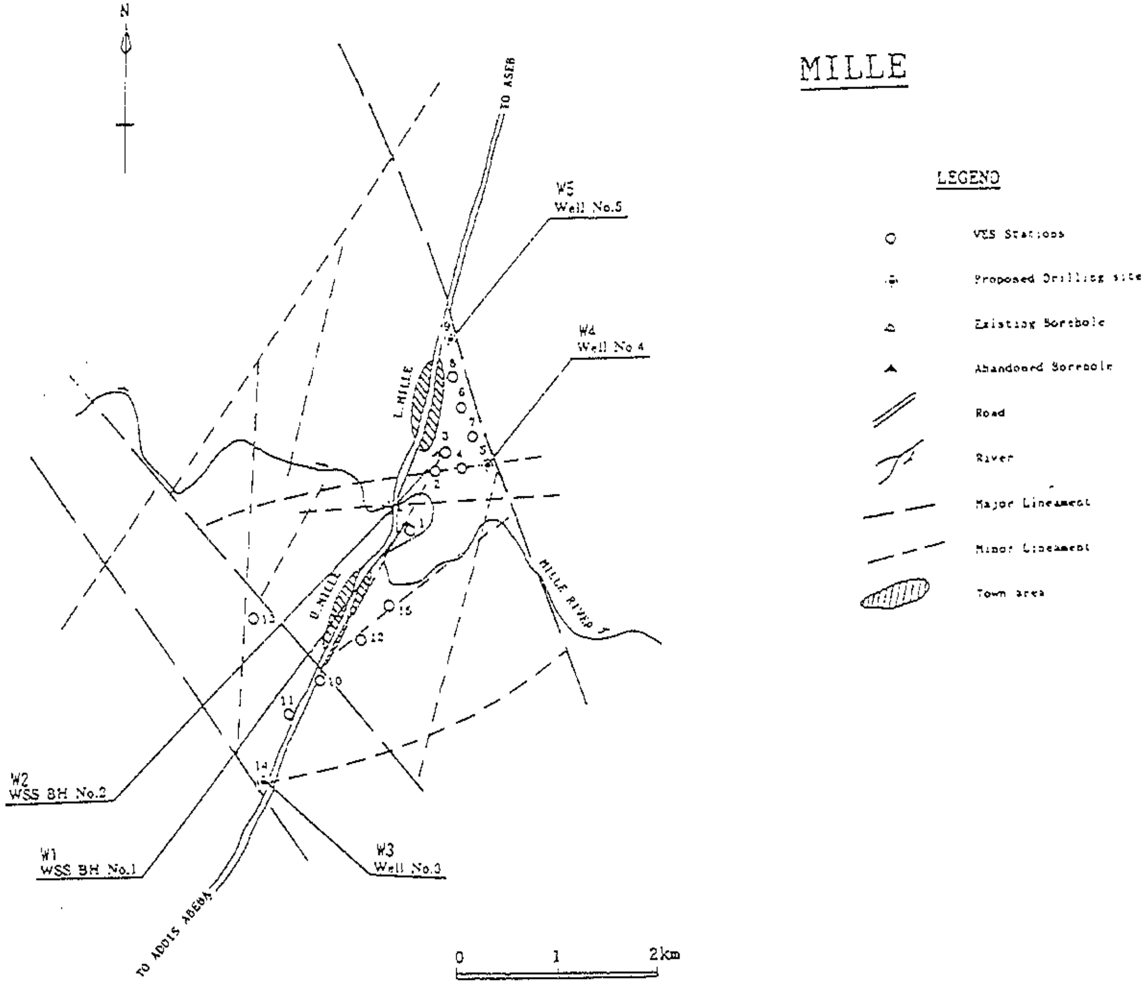
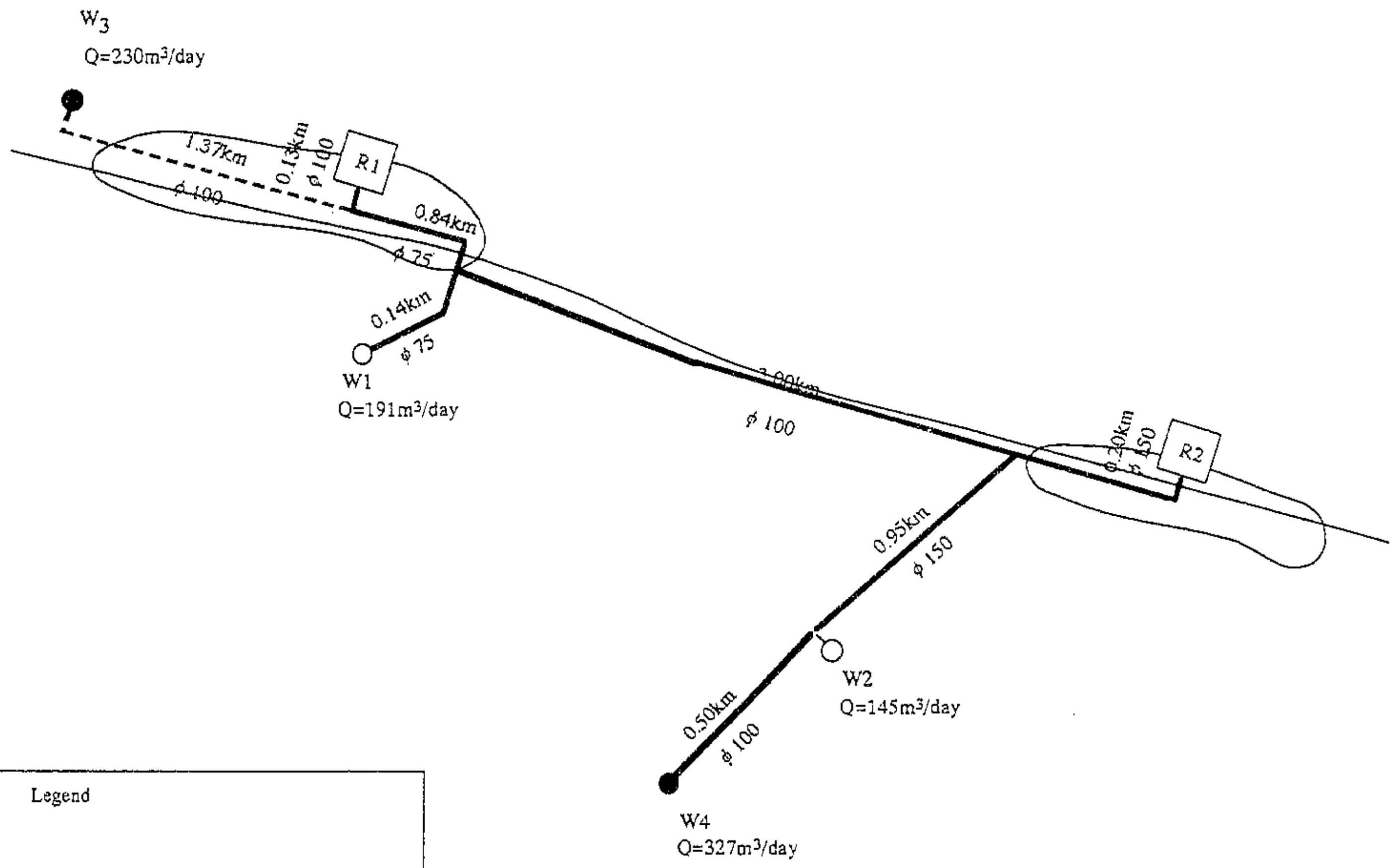
ø50


Supplied Area in 2000 (Mille)



Plan of Proposed Water Sources (Mille)



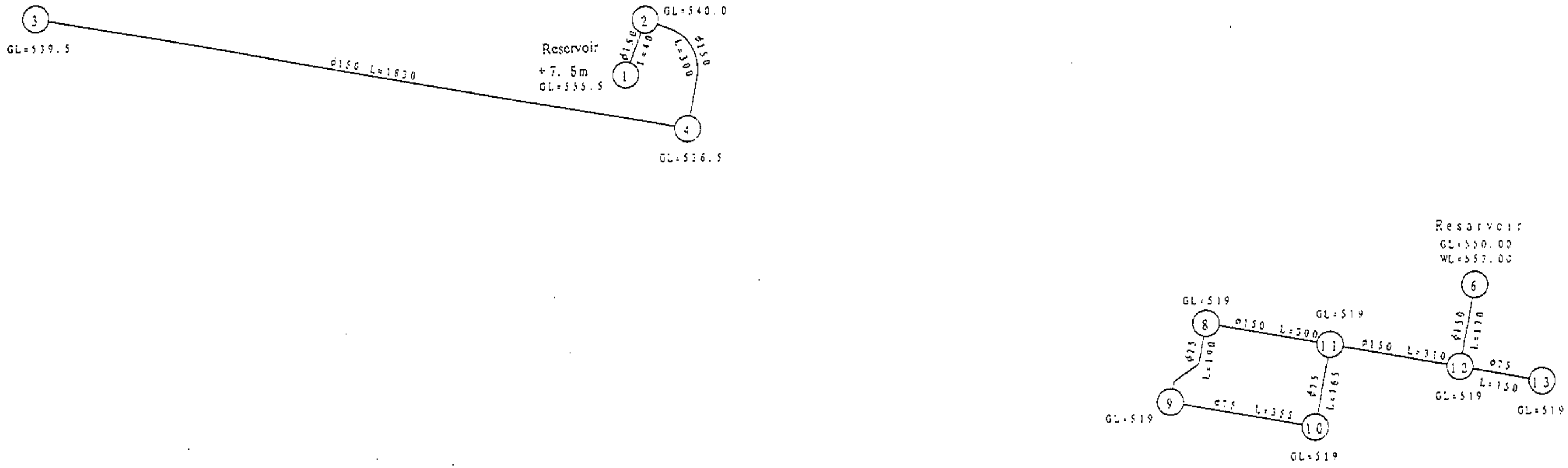
Legend

- : Water Supply Area
- : Existing Well
- : Proposed Well or Spring
- R : Proposed Reservoir
- P : Boosting Pump Station
- CC : Collecting Chamber
- Q : Planned production rate (m^3/day)
- 0.6km / ϕ150 : Dia. & Length of Pipeline
- 0.6km / ϕ150 : Dia. & Length of Pipeline to be constructed by the year of 2005

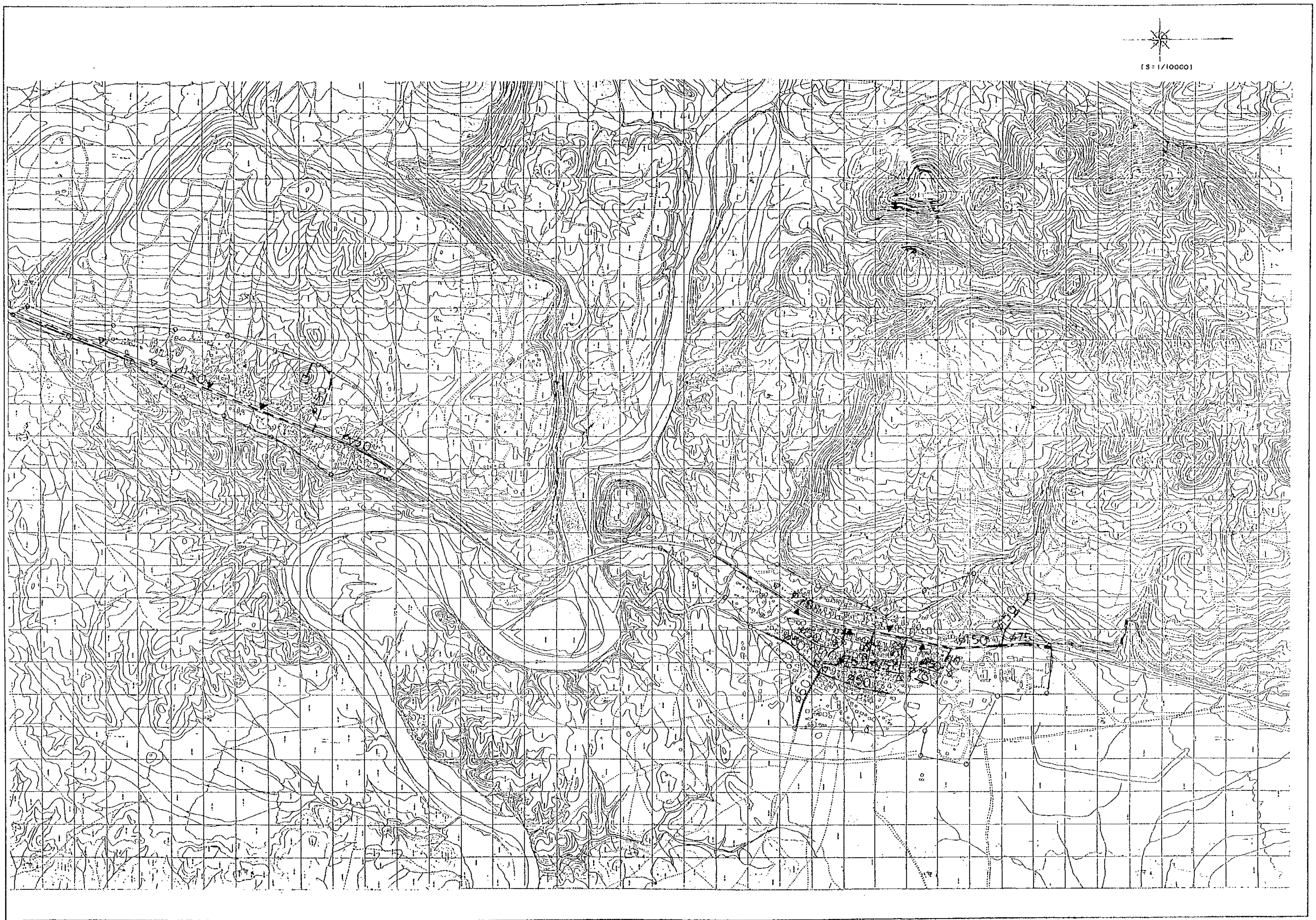
Well Development Plan

Target Year	Well No.	Production (m^3/day)	Max. Day Demand (m^3/day)
2000	W1+W4	518	402
2005	W1+W4+W2+W3	893	708

Plan of Wells and Transmission Facility (Mille)



Type of Distribution Pipeline (Mille)



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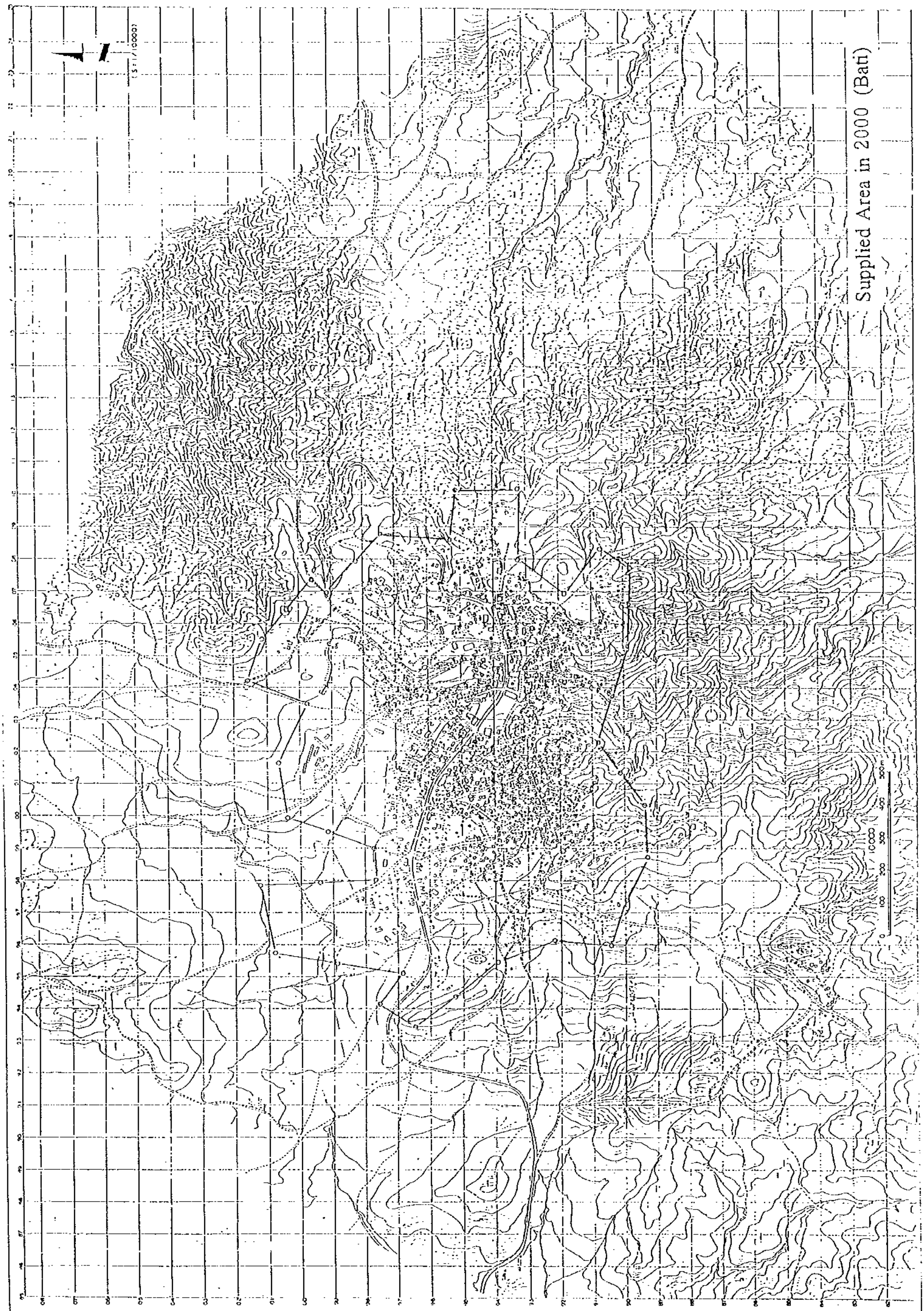
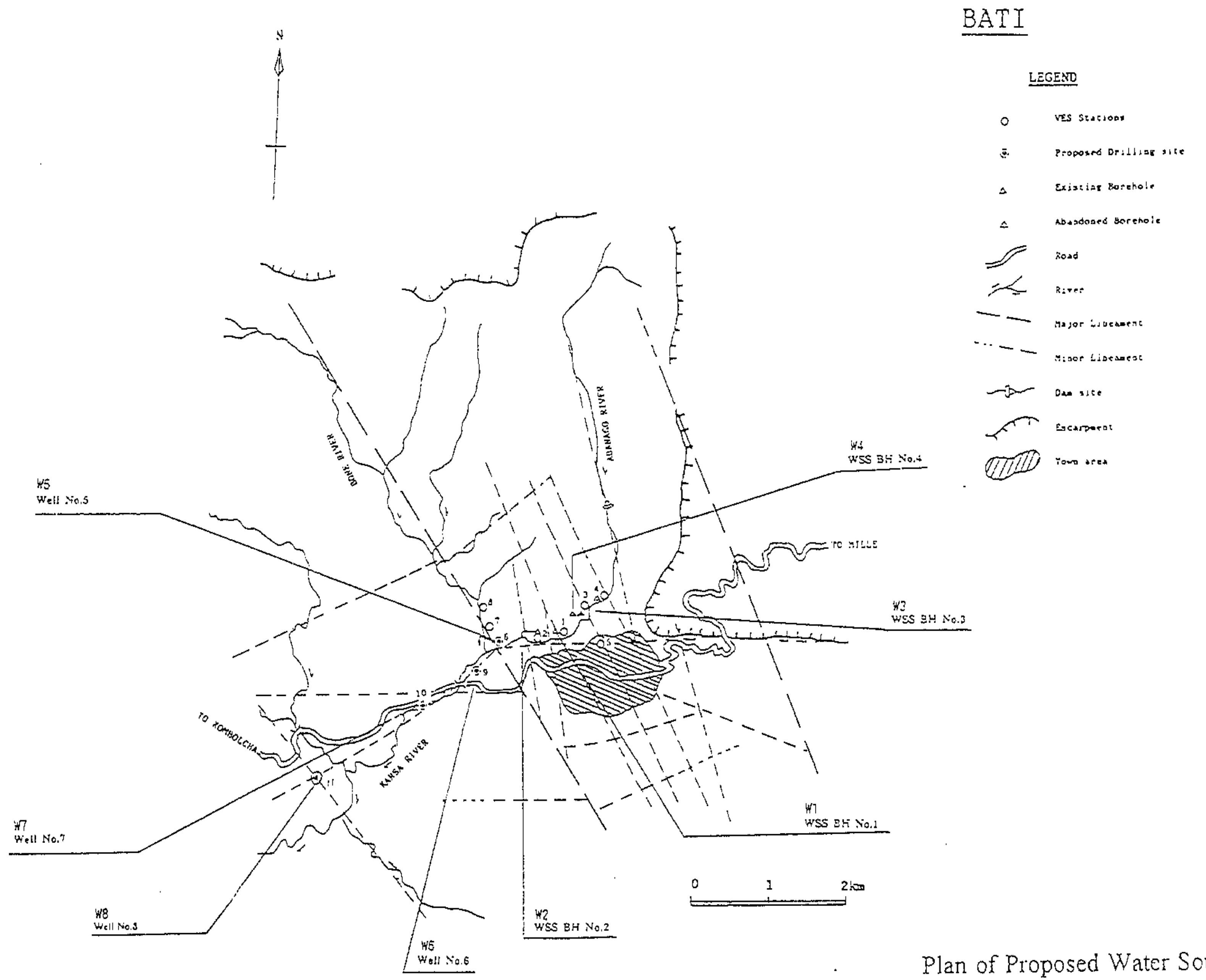
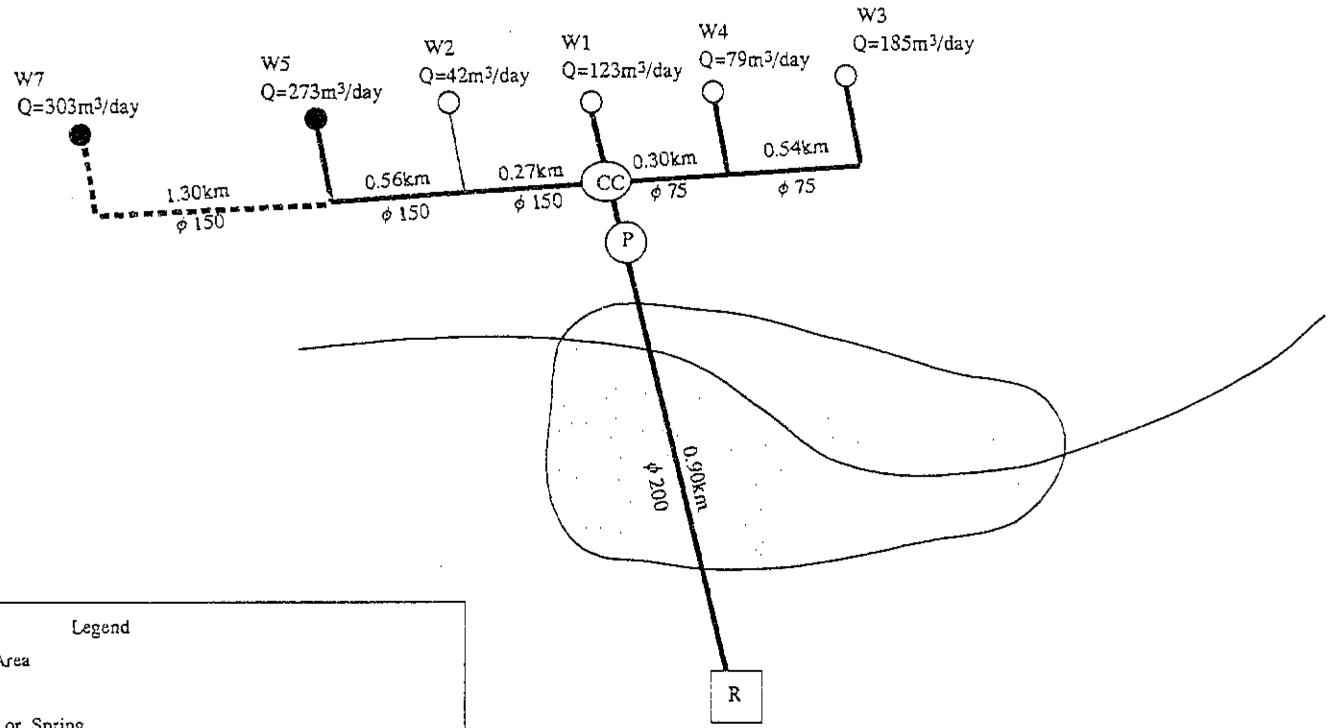

Supplied Area in 2000 (Bati)



Plan of Proposed Water Sources (Bati)



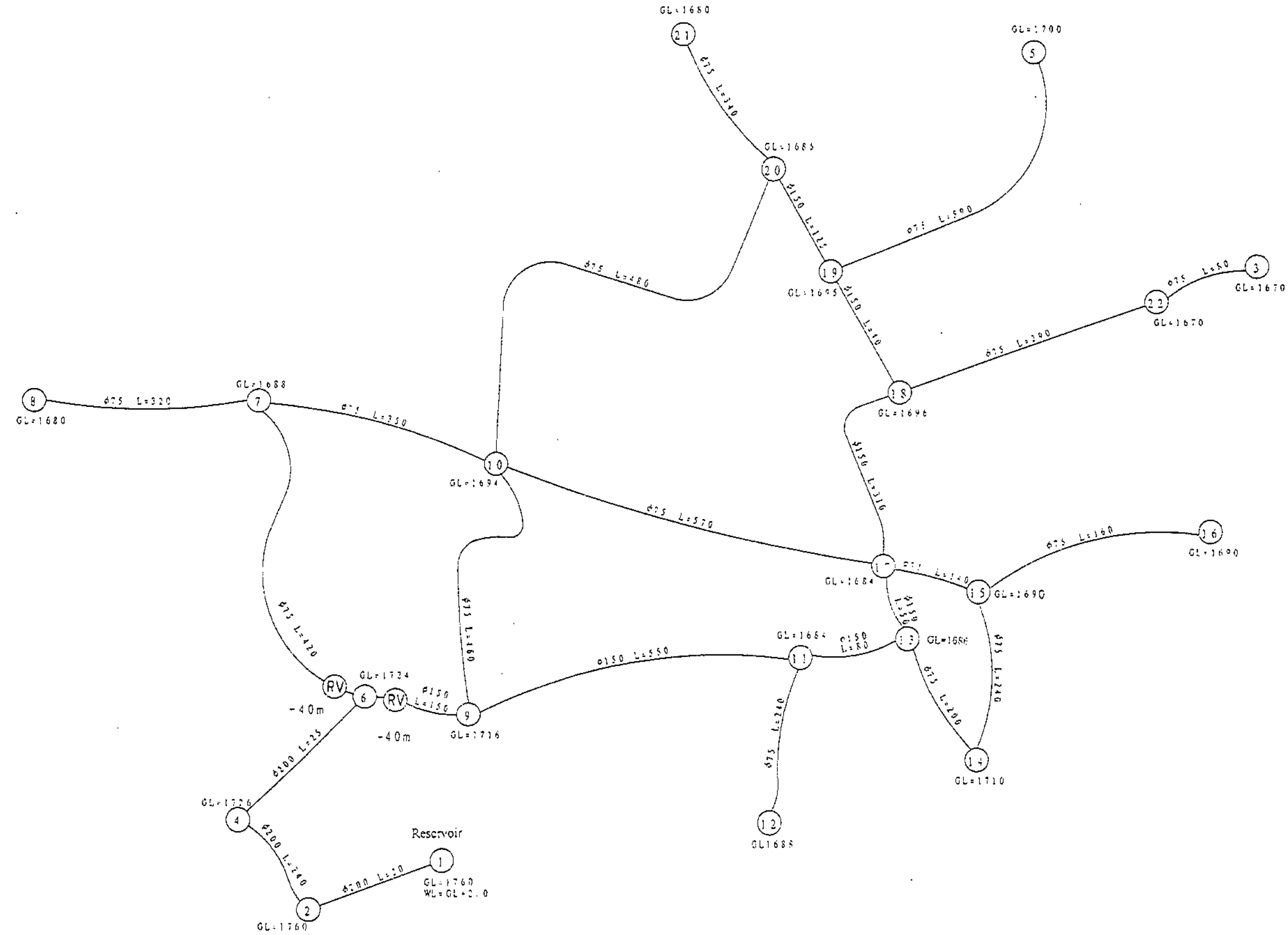
Legend

- : Water Supply Area
- : Existing Well
- : Proposed Well or Spring
- R : Proposed Reservoir
- P : Boosting Pump Station
- CC : Collecting Chamber
- Q : Planned production rate (m^3/day)
- 0.6km / Ø150 : Dia. & Length of Pipeline
- 0.6km / Ø150 (dashed) : Dia. & Length of Pipeline to be constructed by the year of 2005

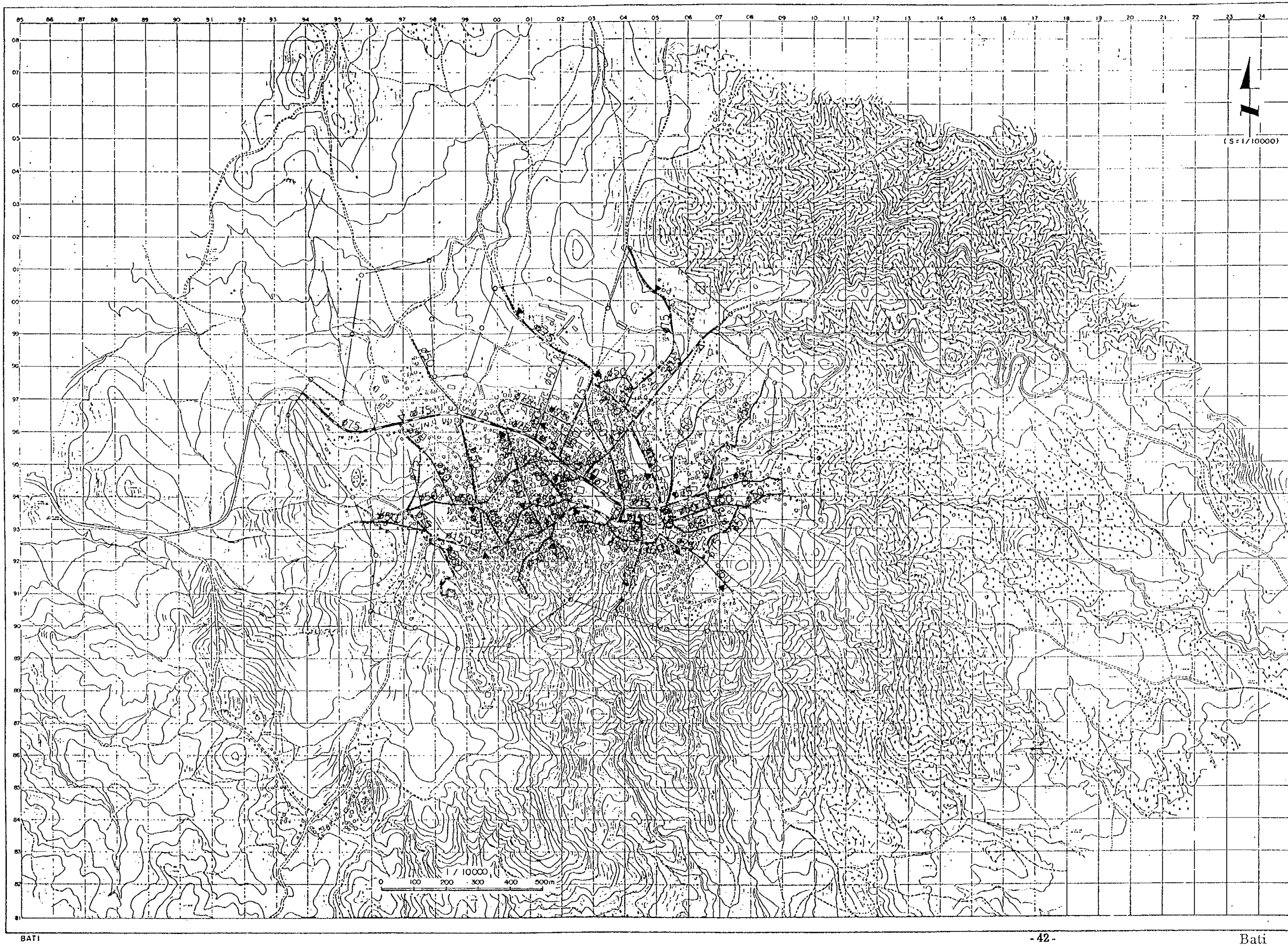
Well Development Plan

Target Year	Well No.	Production (m^3/day)	Max. Day Demand (m^3/day)
2000	W1+W3+W4+W5	660	667
2005	W1+W3+W4+W5+W2+W7	1,005	1,037

Plan of Wells and Transmission Facility (Bati)



Type of Distribution Pipeline (Bati)


(S=1/10000)
1 / 10000
0 100 200 300 400 500m
BATI