2.2.5 Fauna and Flora

Mongolia, by its ecological division, comes under the Arctic and Central Asian sub-region. The existence of several geographical zones, such as highland, steppe, taiga, and desert predetermine the diversity of fauna and flora species (refer to Fig. 2.2.13).

(1) Fauna

Fauna are numbered 640 species of Vertebrate as follows.

68 species of fish,
8 species of amphibians,
20 species of reptiles,
410 species of birds
134 species of mammals.

Besides these, there are more than 20,000 species of Invertebrate in Mongolia.
Most of endemics are encountered in the deserts and steppes in Mongolia.

Mongolia is classified into 6 zone of fauna as follows:
- alpine zone, taiga zone, forest-steppe zone, steppe zone, govi zone, and desert zone.

Fauna in the alpine zone is characterized by reindeer, vole, alpine pica, mountain hare, ermine, and birds of snipe, dunnock and so on. Many species of birds and mammals of alpine zone migrate to the forest zone in summer.

Fauna in the taiga and forest zones have a great varieties of species that make up the taiga complex.

Fauna in the steppe zones is rich in various species of rodents such as marmot, gopher, hare, vole and so on. Other animals are as follows: dog fox, wild cat, antelope, crane, falcon, eagle, lark and so on.

Fauna in the desert zone is extremely diverse characterized by rodents, gazelle, camel, ass and birds. Many animals of Govi desert are rare and disappearing species, which have been included in the Mongolian and International Red Data Books.

The Study Area spreads for the Forest-steppe zone with Steppe zone in the south.

(2) Flora

The vegetation in the northern region is similar to the south Siberian vegetation as a natural continuation. The vegetation of central and southern region, which are classified as the steppe and desert, is considerably poorer, but distinctive by its composition. It is presented by the Central Asian proper floristic complex.

The vegetation consists of 2443 species of vascular plants, united in 625 genera and 122 families. Among them 95.57 % are flowering plants.

Mongolia is classified into 6 zones of vegetation as follows :

-high mountain, mountain taiga, mountain-steppe and forest-steppe, steppe, desert-steppe, and desert.

High mountain zone is characterized by the distribution of low-growing alpines and alpine-sedge meadows.

Mountain taiga zone covers limited areas of the Hentii and Hovsgol mountains. Ceder and ceder-larch tree forests are the main formation.

Flora in the mountain-steppe and forest-steppe zone is the transition zone from mountain to steppe flora and or from forest to steppe flora.

Flora in the steppe zone is characterized by the all kinds of feather-grass.

The main life-forms in the desert-steppe zone are low cespitose feather-grass with a considerable share of semi-shrubs.

The species and life-forms in the Govi are extremely poor and unique.

The Study Area spreads for the mountain-steppe and forest-steppe zone with steppe zone in the south.

Table 2.2.1 The Results of the Test Well Drilling

Well No.	Location	Elevation	Coordinate X	Coordinate Y	Drilled Depth	Screen Depth from	Screen Depth to	Pumping Rate	Pumping Rate	S.W.L	P.W.L	Draw-down	Specific Capacity	Trans-missivity	Permeability Coefficient	Producing Layer	Depth to Bedrock	Remarks
		(m)	(Long.E)	(Lat.N)	Gl-(m)	Gl-(m)	Gl-(m)	(l/sec)	(m^3/day)	Gl-(m)	Gl-(m)	(m)	(m^3/day/m)	(m^2/day)	(cm/sec)		Gl-(m)	
A-1	Uliastai River	1442.50	107-03'22"	48-00'25"	183.5	84.0	177.5	10.5	903	12.4	58.75	46.35	19	23	(4.10×10^{-4})	Bedrock		
A-2	Selbe River	1431.50	106-54'20"	48-03'23"	201.8	102.8	196.3	0.6	52	11.8	82.05	70.25	1	<1	(4.61×10^{-6})	Bedrock		
A-3	Bayan Goliin	1374.60	106-42'48"	47-58'28"	200.3	95.5	123.0	25.0	2164	5.61	53.42	47.81	45	40	(6.52×10^{-4})	Bedrock	0	
						134.0	178.0											
						183.5	194.5											
A-4	Selbe River	1425.20	106-54'03"	48-03'02"	134.0	49.5	134.0	16.7	1441	3.48	52.22	48.74	30	31	(7.97×10^{-4})	Bedrock	18	
	Sub Total				719.6													
B-1	Buheg River	1305.50	106-45'00"	47-38'18"	50.0	22.5	39.0	3.9	337	(2.0)	11.53	13.53	25	35	2.46×10^{-3}	Alluvium	>50	Flowing well
B-2	Buheg River	1297.00	106-42'56"	47-39'45"	50.0	16.0	21.5	6.3	540	0.45	5.65	5.2	104	122	8.56×10^{-3}	of	>50	
						38.0	49.0									Buheg		
B-3	Buheg River	1230.50	106-35'02"	47-43'52"	65.0	22.0	33.0	22.0	1901	2.7	10.04	7.34	259	354	1.86×10^{-2}	River	>65	
						43.0	54.0											
	Sub Total				165.0													
C-1	Lower Area	1392.30	107-21'59"	47-48'52"	30.5	10.0	21.0	10.8	935	0.75	8.69	7.94	118	142	1.49×10^{-2}	Lower	21	
C-2	of Upper	1386.60	107-19'51"	47-49'10"	24.0	11.0	22.0	5.6	485	1.71	8.53	6.82	71	59	6.21×10^{-3}	Layer	20	
C-3	Water	1370.70	107-15'10"	47-50'52"	31.0	24.5	30.0	2.9	253	2.47	16.9	14.43	18	13	2.74×10^{-3}	of Alluvium	28	
C-4	Source	1331.70	107-09'55"	47-55'12"	22.3	9.1	14.6	4.4	382	1.08	7.23	6.15	62	91	1.91×10^{-2}	Tuul River	14	
C-5	Buheg	1226.60	106-35'20"	47-46'17"	30.0	13.5	24.5	8.5	734	5.47	26	20.53	36	37	3.89×10^{-3}		>30	
C-6	Lower Part	1204.50	106-30'36"	47-45'52"	32.0	13.5	30.0	25.0	2160	1.93	3.69	1.76	1227	873	6.12×10^{-2}	Alluvium of	>31	
C-7	of Power	1174.20	106-17'20"	47-43'35"	30.0	13.5	24.5	36.7	3168	1.8	3.37	1.57	2018	2410	2.54×10^{-1}	Tuul River	>30	
C-8	Plant	1173.00	106-18'10"	47-42'50"	30.0	16.0	27.0	4.4	382	1.2	8.06	6.86	56	50	5.26×10^{-3}		>30	
	Sub Total				229.8													
	Grand Total				1114.0													

S.W.L ; Static Water Level
P.W.L ; Pumping Water Level

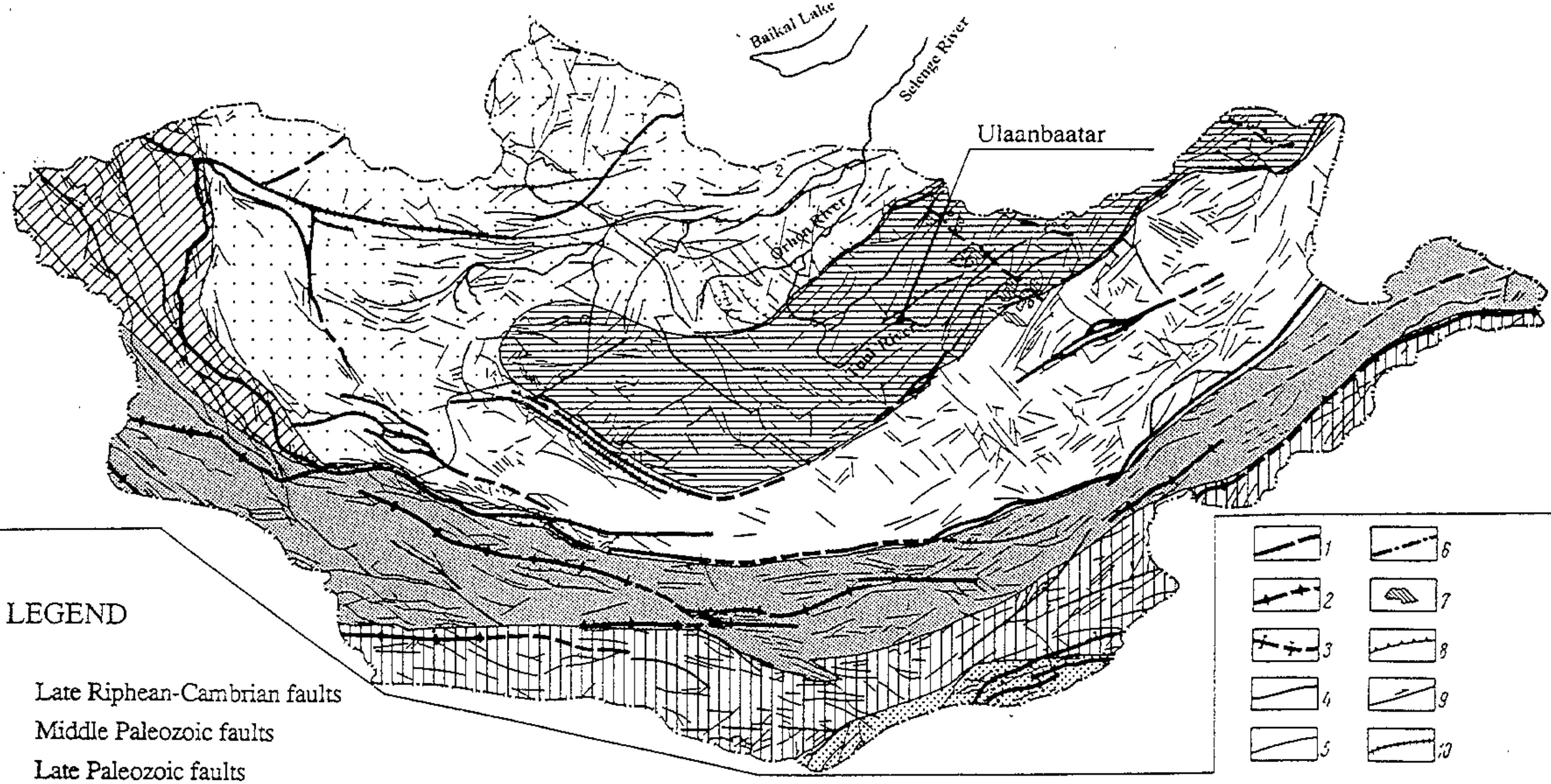
Table 2.2.2 Summary of Climatic Condition of Selected Stations

1. Station: Ulaanbaatar												
Parameter	Month											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Temperature												
Mean	-24.2	-19.6	-9.6	0.6	9.1	14.7	16.7	14.8	7.8	-1.0	-13.4	-21.7
Maximum	-6.5	-1.0	9.7	18.8	28.2	30.5	30.8	29.7	25.1	18.7	5.6	-3.3
Minimum	-37.8	-35.7	-28.1	-17.4	-8.8	-1.5	2.9	0.2	-8.5	-17.9	-29.1	-36.2
Humidity	81	78	67	54	50	59	68	70	68	69	78	83
Precipitation	1.4	1.9	2.4	7.7	14.4	48.8	69.5	57.0	27.6	6.5	3.8	2.1

2. Station: Terelj												
Parameter	Month											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Temperature												
Mean	-24.1	-15.9	-11.8	-1.6	6.5	10.9	13.1	11.4	4.9	-2.8	-14.8	-20.8
Maximum	-6.8	-0.8	7.0	16.2	24.8	27.8	27.8	27.1	21.4	17.4	5.5	0.9
Minimum	-39.2	-37.1	-31.8	-20.9	-10.8	-6.5	-1.9	-0.2	-12.2	-20.0	-32.1	-37.1
Humidity	91	83	81	68	64	71	80	76	79	78	85	91
Precipitation	1.1	2.8	3.9	11.6	17.6	70.8	122.2	106.5	46.3	9.7	6.9	3.2

3. Station: Tahilt												
Parameter	Month											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Temperature												
Mean	-21.5	-17.3	-7.7	0.9	10.0	14.7	17.0	15.1	8.3	0.6	-11.3	-18.7
Maximum	-7.2	-1.5	9.7	19.2	27.9	30.2	30.8	29.2	24.2	19.2	5.6	-4.2
Minimum	-33.4	-30.1	-23.6	-14.4	-6.0	0.8	5.6	3.3	-6.2	-13.9	-24.7	-31.5
Humidity	79	74	63	52	48	57	63	67	63	63	73	79
Precipitation	2.1	2.0	3.7	7.6	12.5	53.3	66.6	81.9	27.5	8.9	4.7	3.0

4. Station: Ih Surguuli												
Parameter	Month											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Temperature												
Mean	-20.9	-17.4	-8.8	0.8	10.1	14.1	16.3	14.7	7.9	0.6	-11.2	-18.3
Maximum	-6.8	-1.3	8.8	18.5	26.2	30.3	30.7	29.0	23.9	19.6	5.7	-3.4
Minimum	-31.9	-29.9	-23.9	-14.8	-5.8	-0.8	3.9	3.1	-5.9	-13.1	-25.2	-31.6
Humidity	79	74	62	52	48	59	67	71	66	65	73	79
Precipitation	1.8	2.1	2.6	8.1	10.3	54.5	79.8	83.9	35.4	10.7	4.4	1.9



LEGEND

1. Late Riphean-Cambrian faults
2. Middle Paleozoic faults
3. Late Paleozoic faults
4. Regional faults
5. Other faults
6. Faults accompanied by stems of Mesozoic intrusions
7. Mesozoic granitoids within "intrusive rocks"
8. Thrust faults
9. Lateral faults
10. Faults accompanied by recent seismic activity

I. Mongolian Altai Folded Zone
II. North Mongolian Folded Zone
III. Mongol Pre-baigalian Folded Zone
IV. Central Mongolian Folded Zone
V. South Mongolian Folded Zone
VI. South Gobian Folded Zone
VII. Inner Mongolian Folded Zone

Fig. 2.2.1 Geological Structure of Mongolia

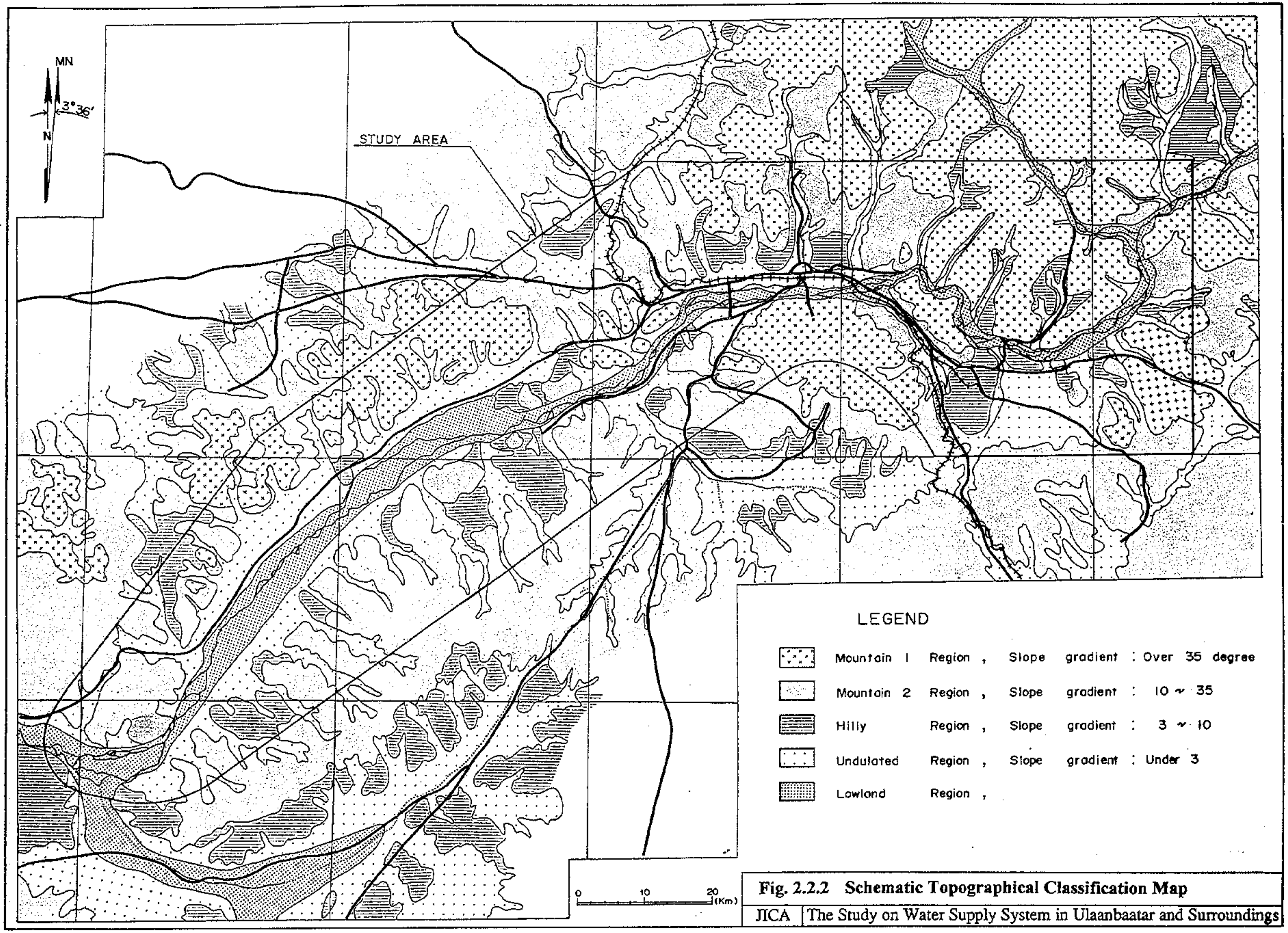


Fig. 2.2.2 Schematic Topographical Classification Map

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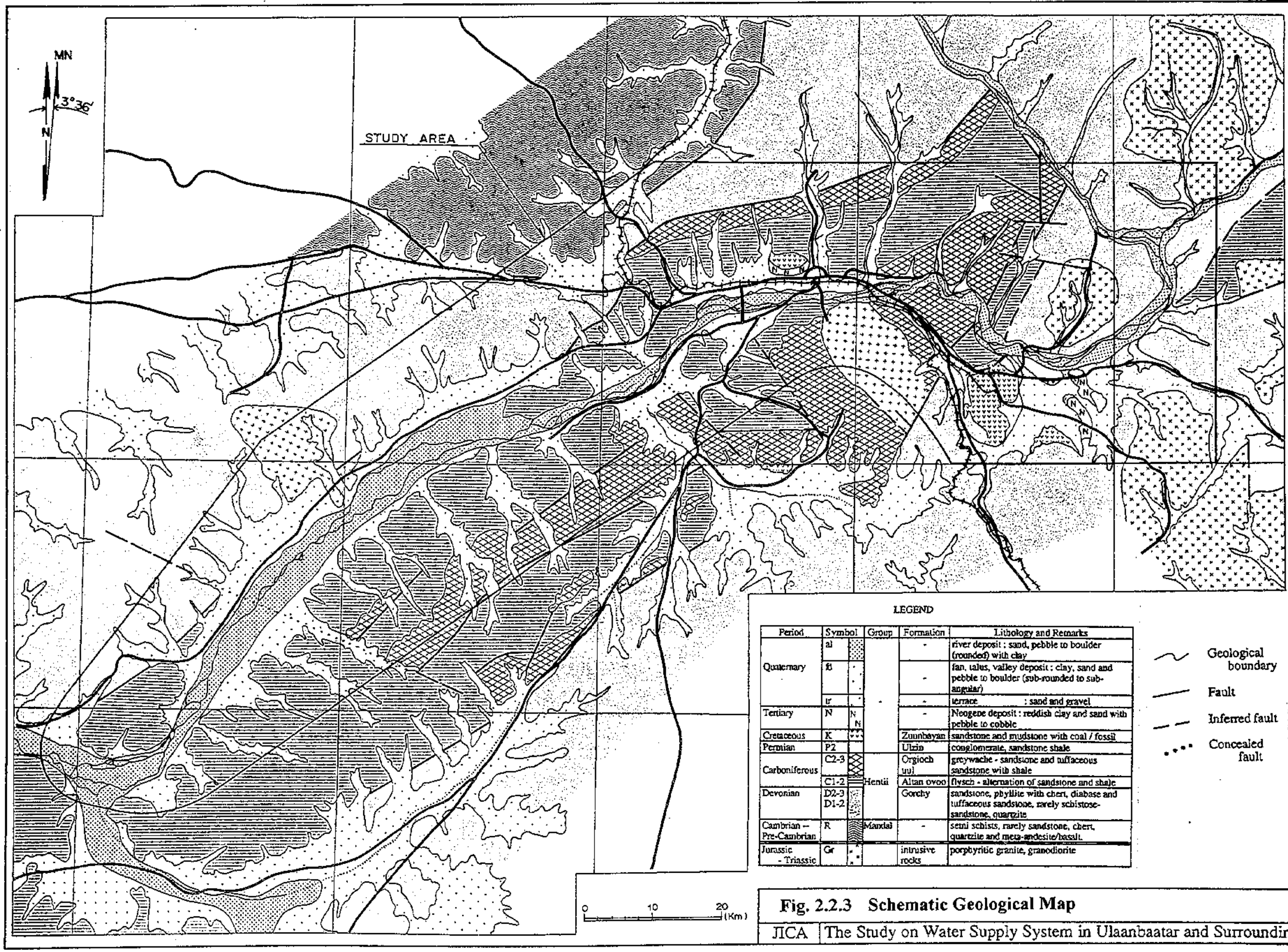

LEGEND

Period	Symbol	Group	Formation	Lithology and Remarks
Quaternary	al	-	-	river deposit : sand, pebble to boulder (rounded) with clay
	fl		-	fan, talus, valley deposit : clay, sand and pebble to boulder (sub-rounded to sub-angular)
	tr		-	terrace : sand and gravel
Tertiary	N		-	Neogene deposit : reddish clay and sand with pebble to cobble
Cretaceous	K		Zuunbayan	sandstone and mudstone with coal / fossil
Permian	P2		Ulzin	conglomerate, sandstone shale
Carboniferous	C2-3	Hentii	Orgioch uul	greywache - sandstone and tuffaceous sandstone with shale
	C1-2		Altan ovoo	flysch - alternation of sandstone and shale
Devonian	D2-3 D1-2		Gorchy	sandstone, phyllite with chert, diabase and tuffaceous sandstone, rarely schistose-sandstone, quartzite
Cambrian – Pre-Cambrian	R	Mandal	-	semi schists, rarely sandstone, chert, quartzite and meta-andesite/basalt.
Jurassic - Triassic	Gr		intrusive rocks	porphyritic granite, granodiorite

Fig. 2.2.3 Schematic Geological Map

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Fig. 2.2.4 Basement Depth Map

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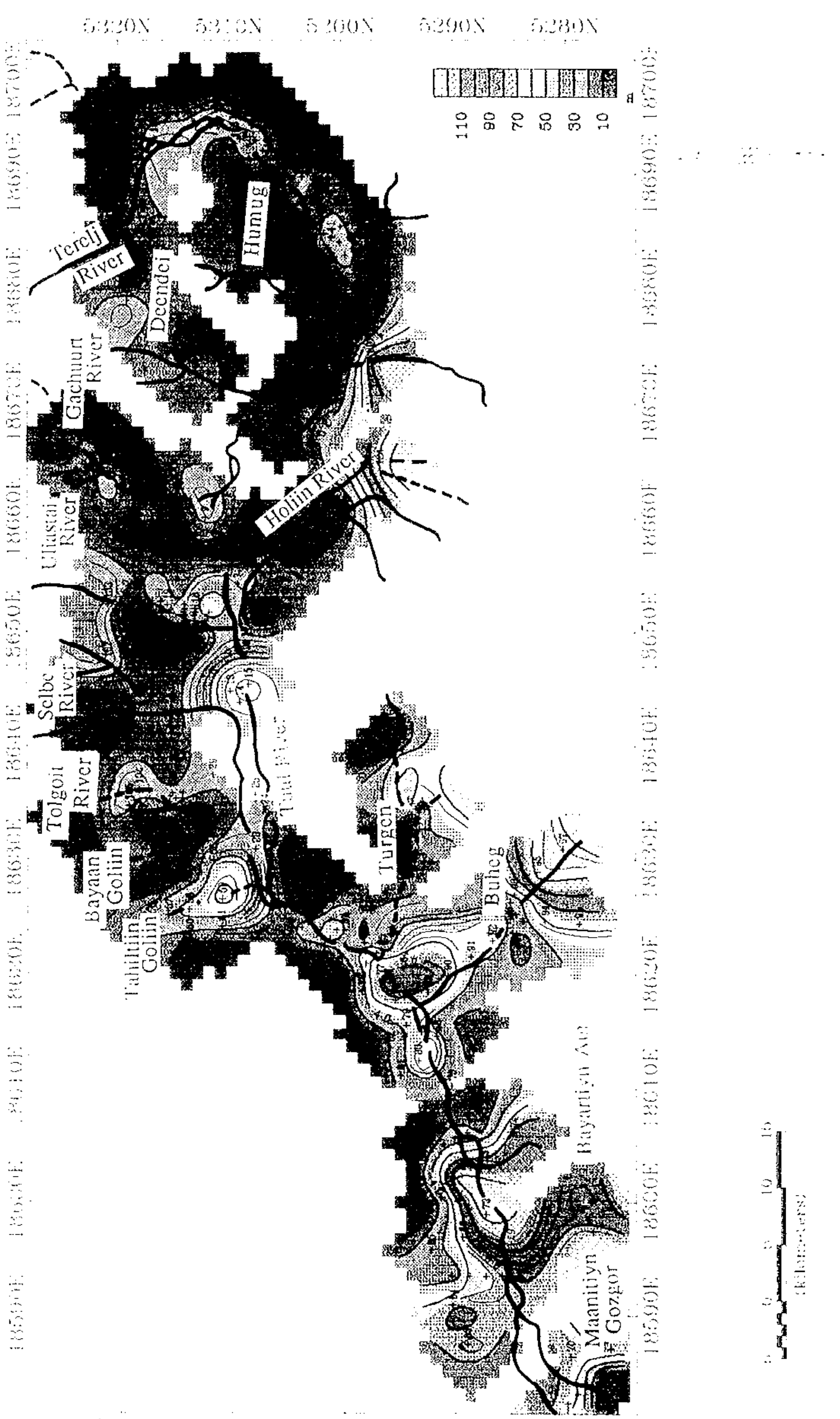

Fig. 2.2.4 Basement Depth Map

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

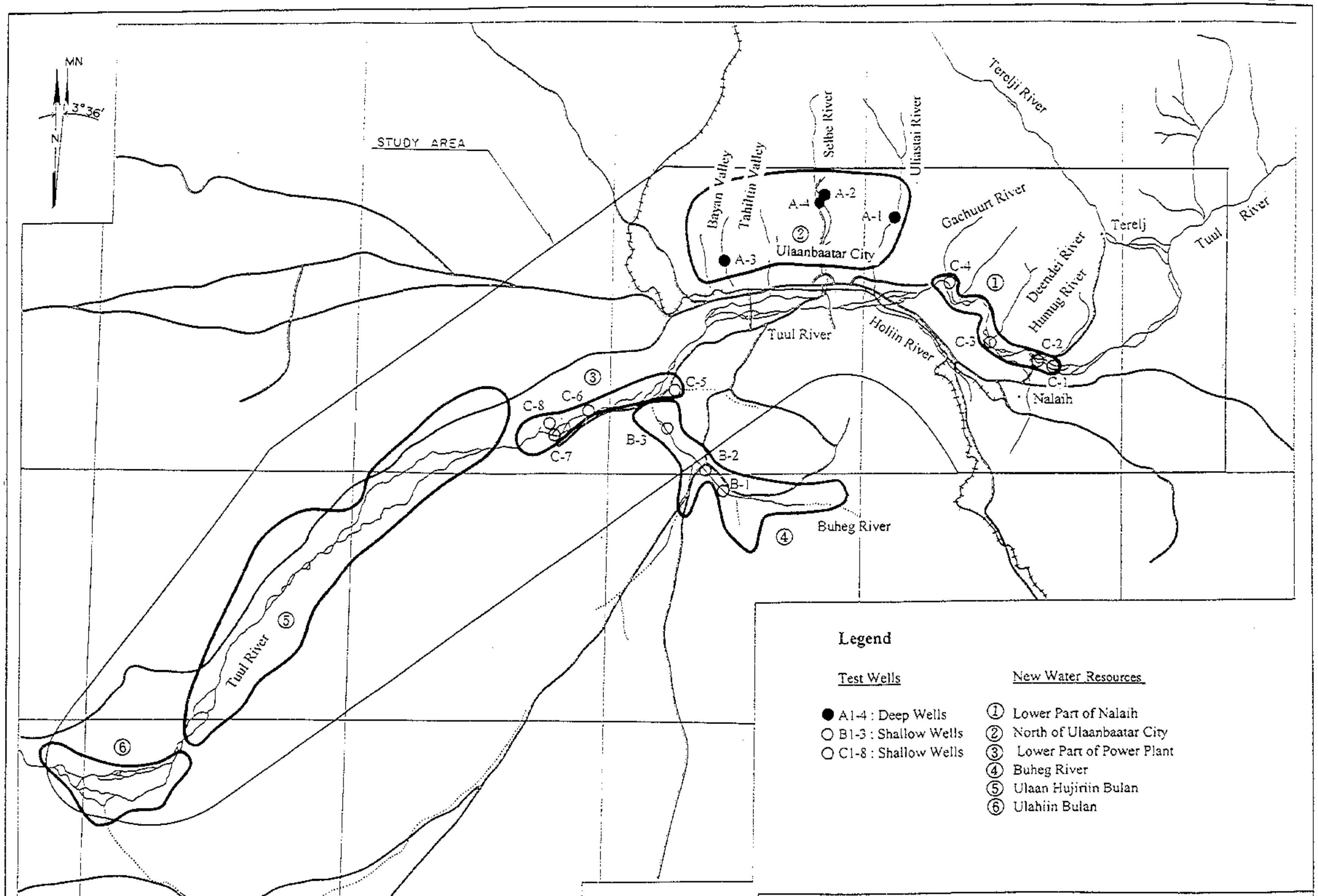

Fig. 2.2.5 Location of Test Wells and New Water Resources

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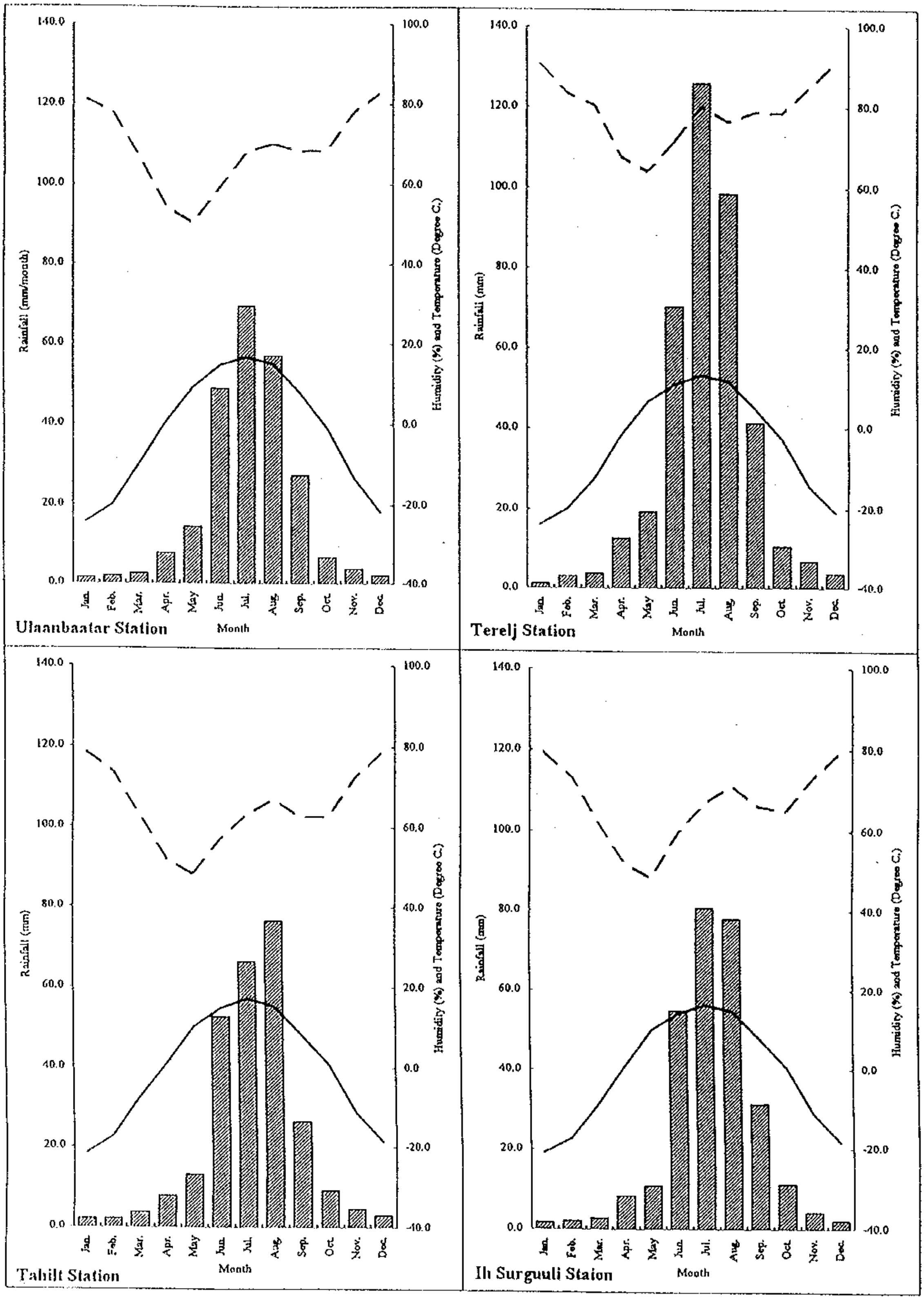

Fig. 2.2.6 Climate in Ulaanbaatar, Tahilt, Ih Surguuli and Terelj

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

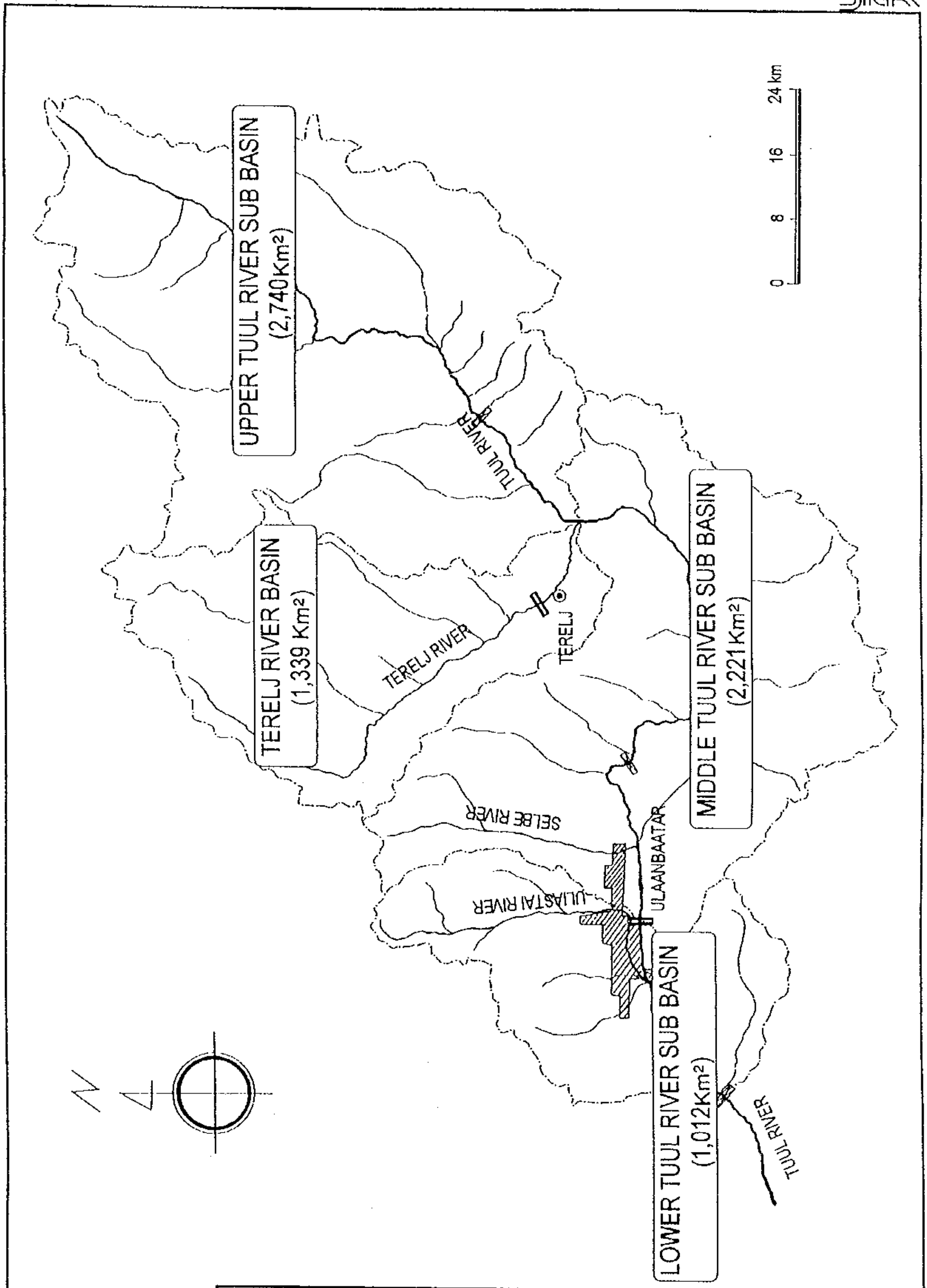

Fig. 2.2.7 Upper Tuul River Basin

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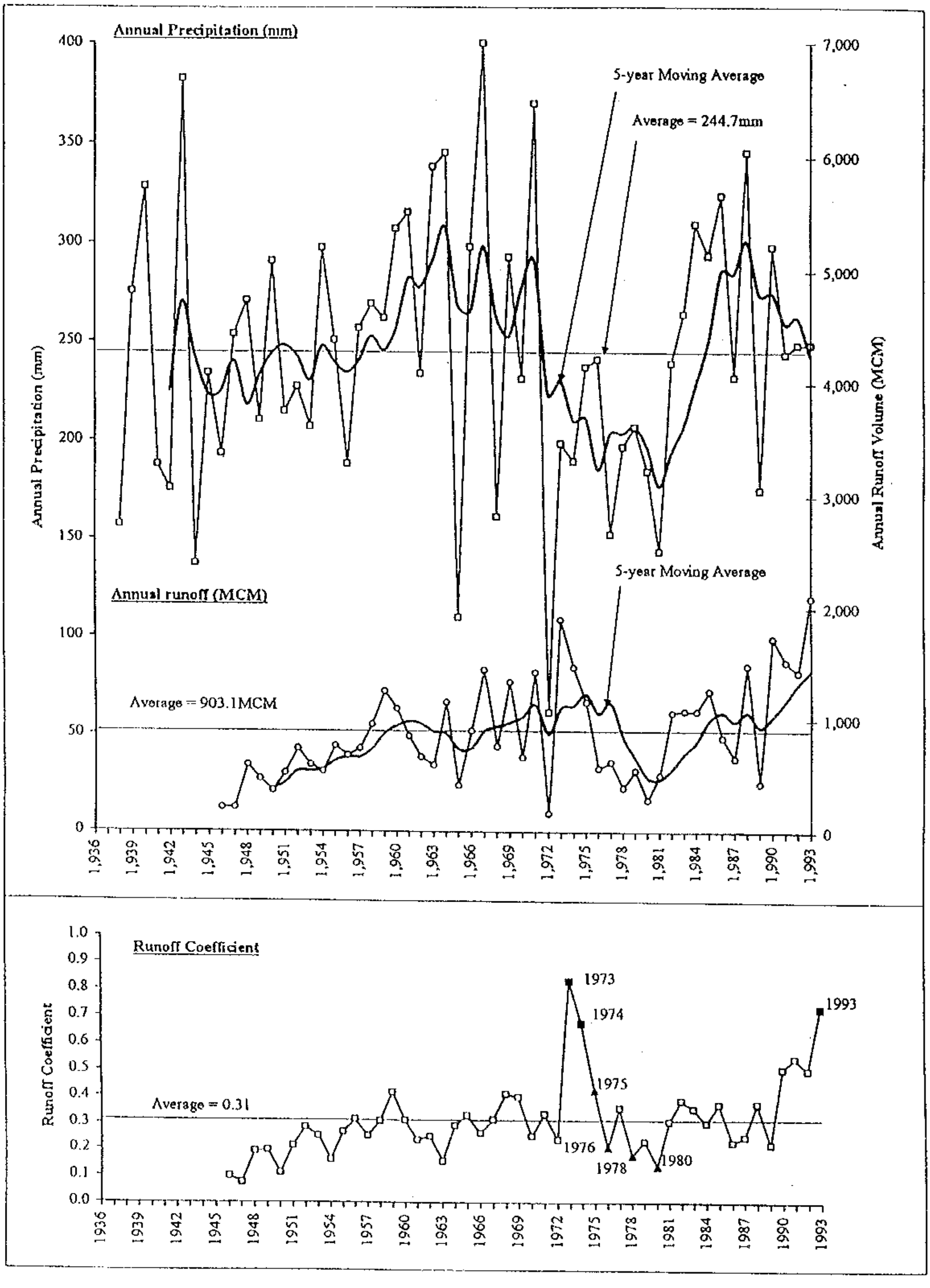

Fig. 2.2.8	**Long Term Trend of Precipitation and Surface Runoff in Ulaanbaatar Station**
JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

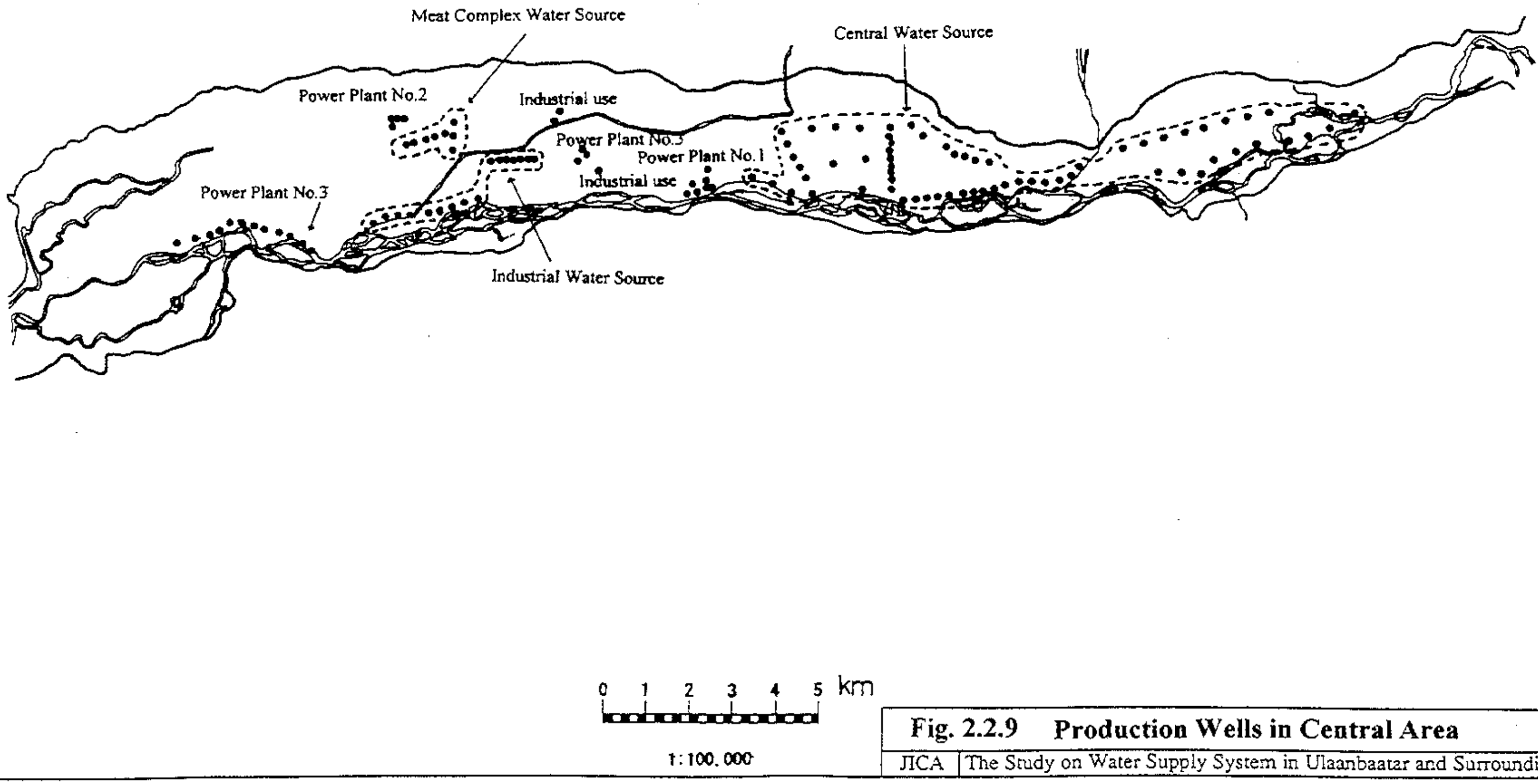

Fig. 2.2.9 Production Wells in Central Area

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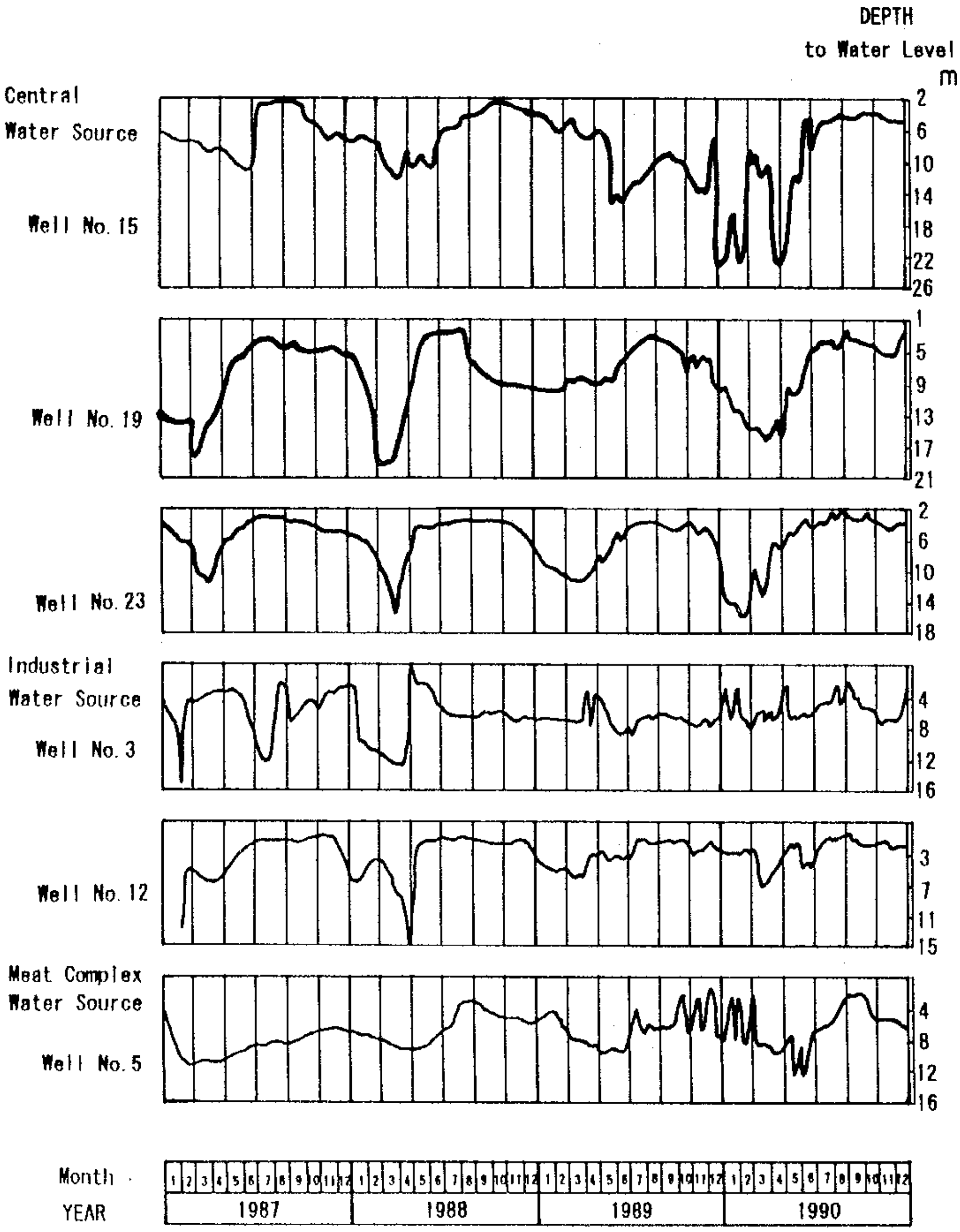

Fig. 2.2.10 Groundwater Level Fluctuations (1987 to 1990)

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

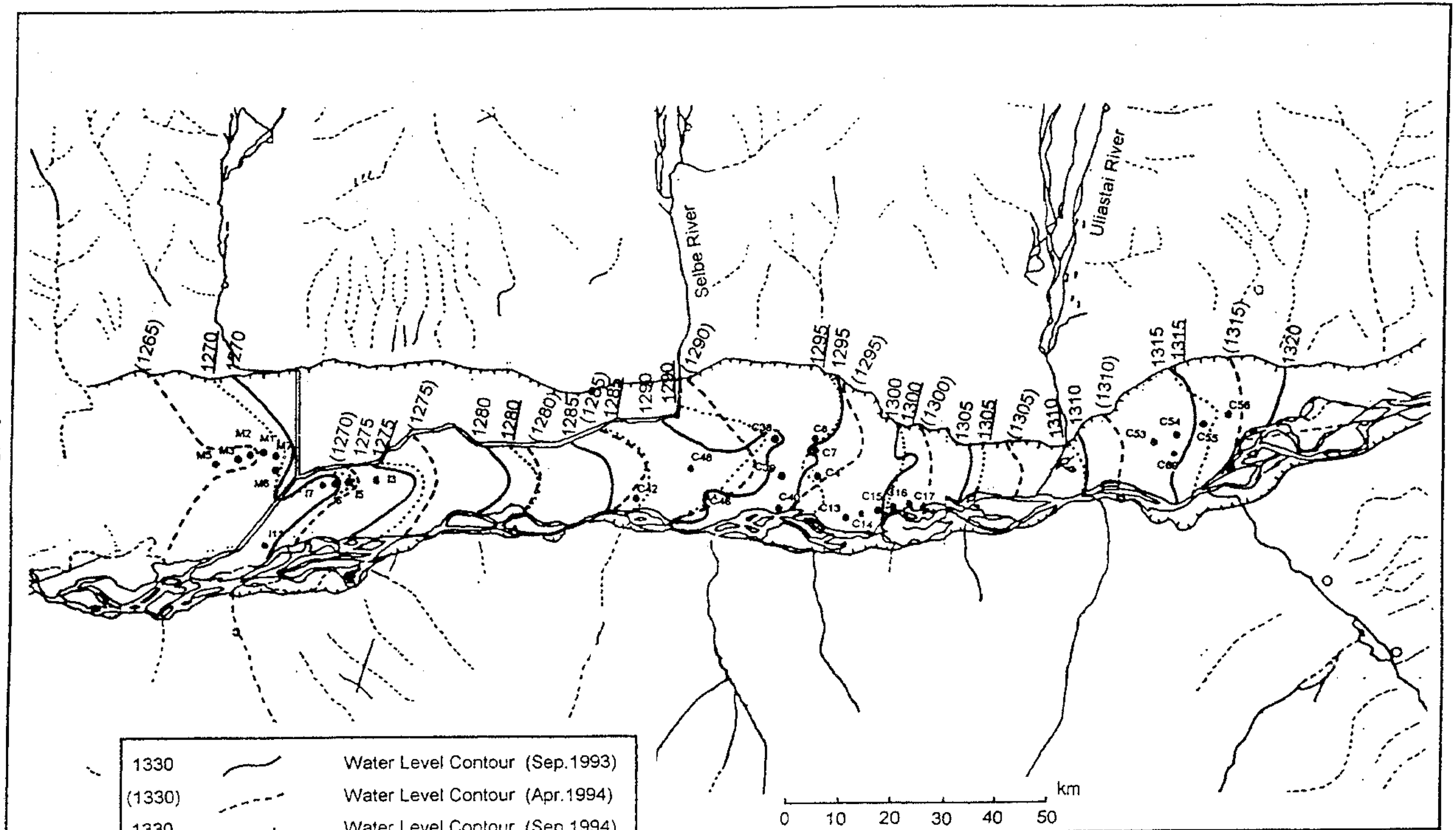

Fig. 2.2.11 Groundwater Table in Ulaanbaatar City Area

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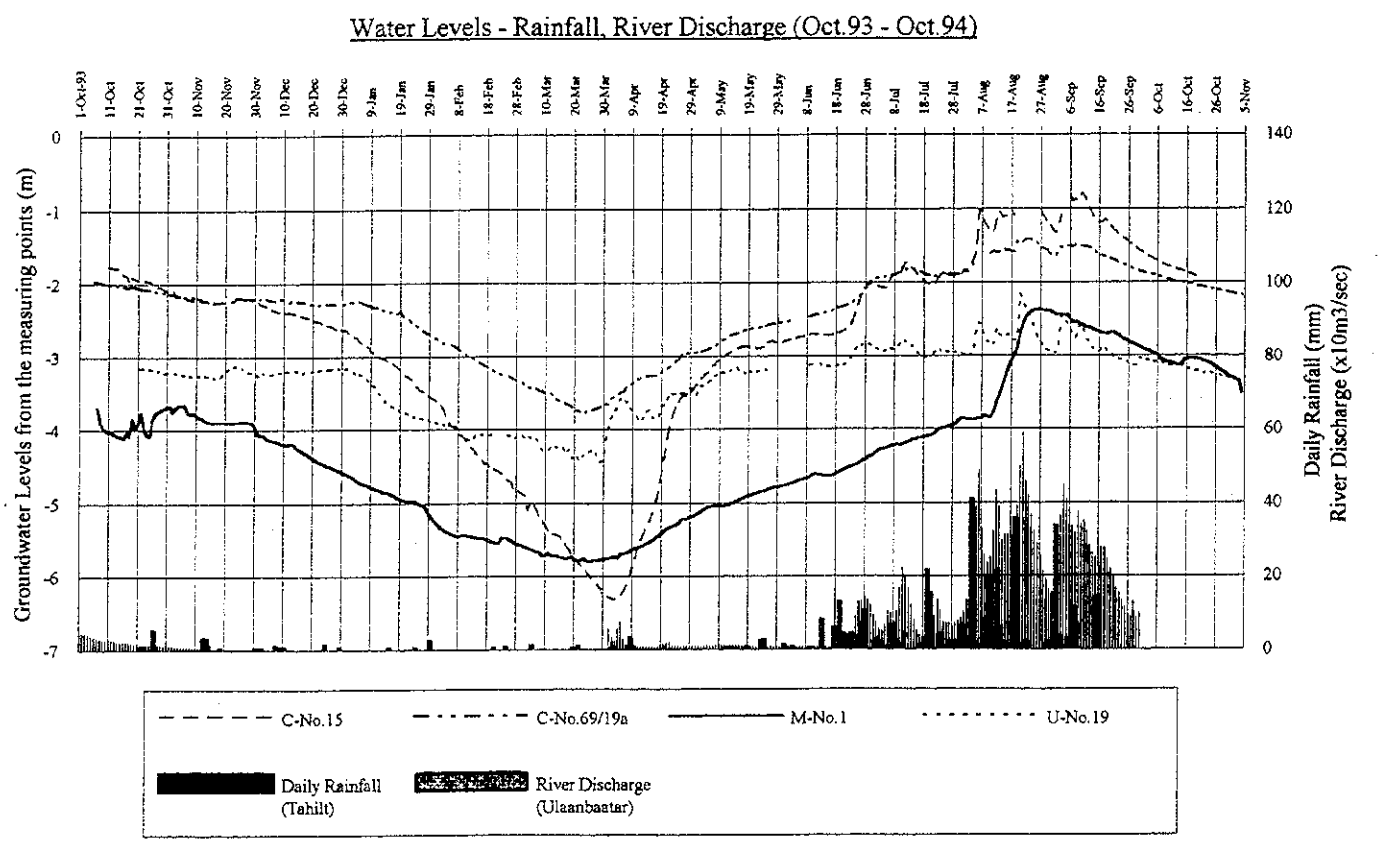

(Rainfall and river discharge data from 1Oct. 94 were not available.)

Fig. 2.2.12 Continuous Record of Water Levels

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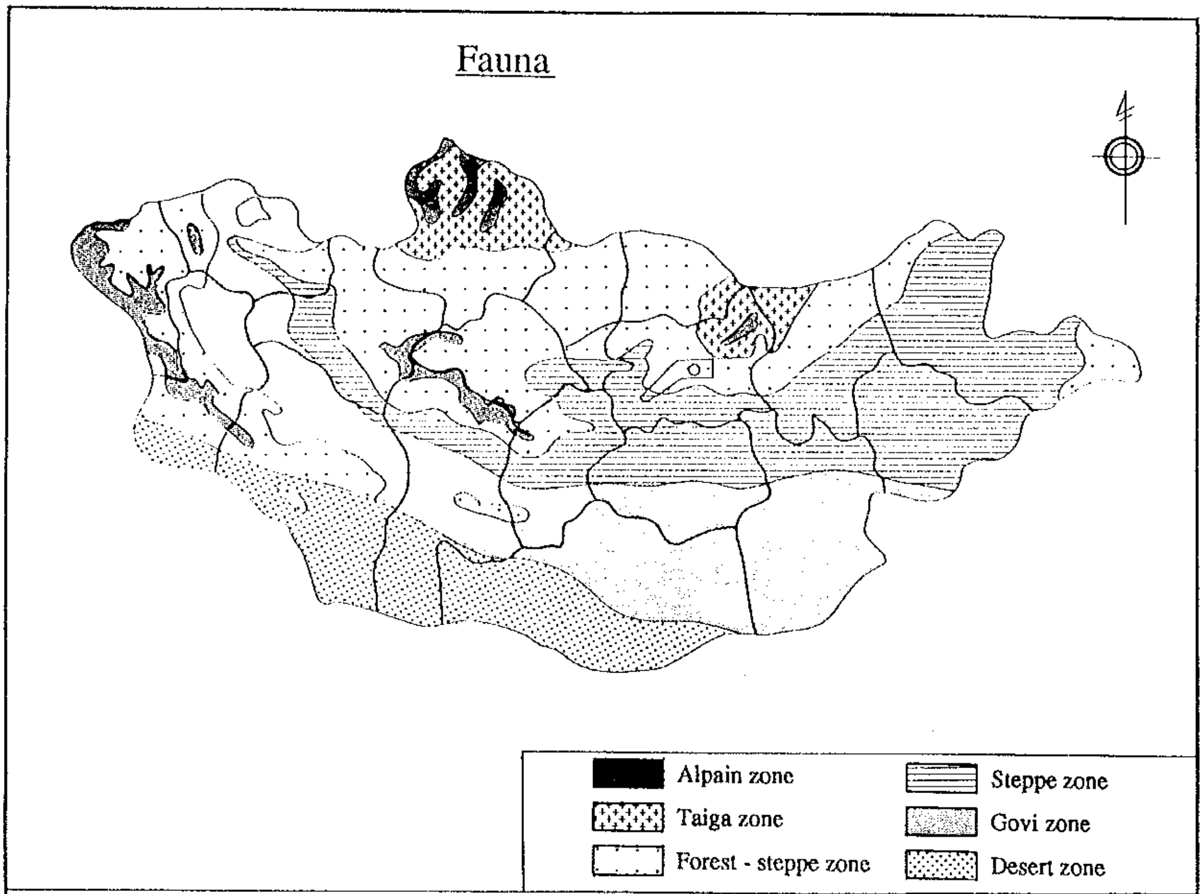
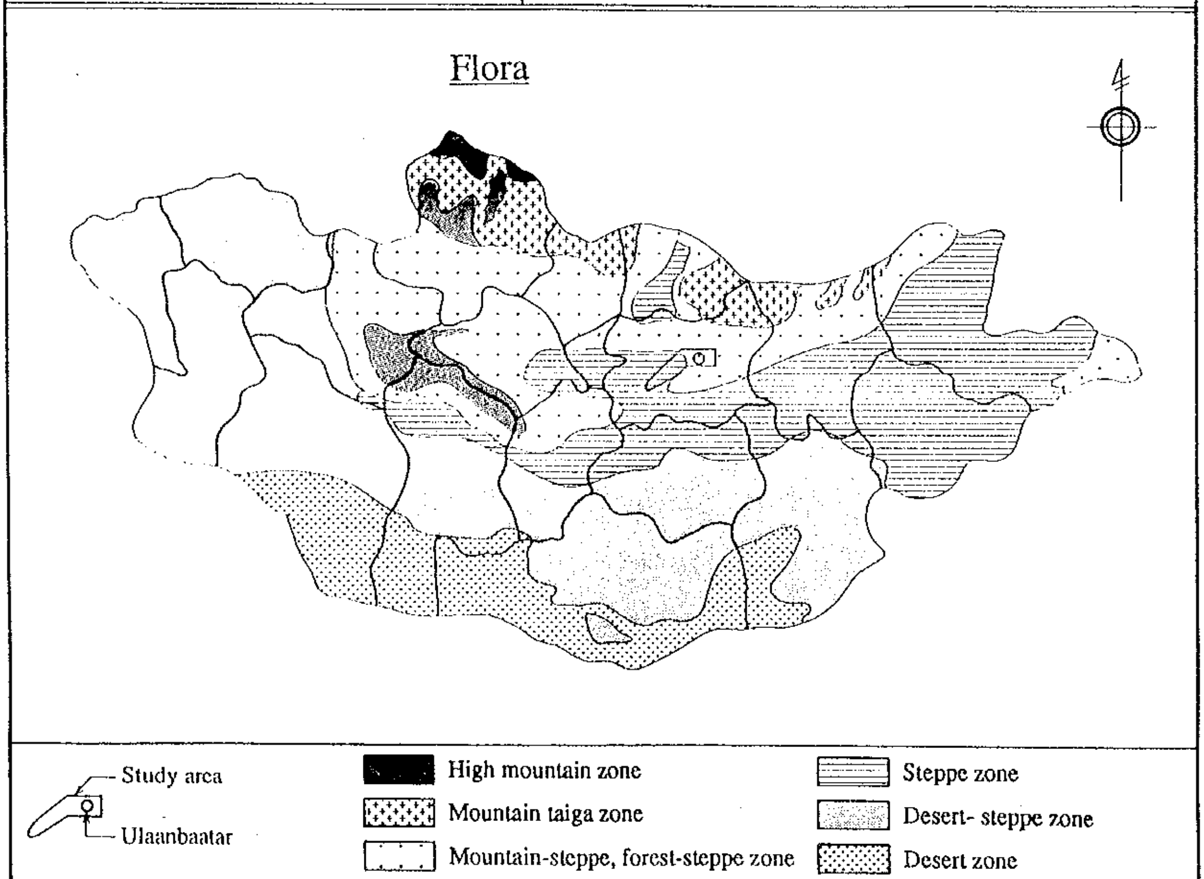




Scale 1:15,000,000	**Fig. 2.2.13 Classification Maps of Fauna and Flora in Mongolia**
	JICA — The Study on Water Supply System in Ulaanbaatar and Surroundings

2.3 Water Supply System

2.3 WATER SUPPLY SYSTEM

2.3.1 Water Supply System

The people of Ulaanbaatar City live either in apartment buildings located in the central area of the City and on low hills, or in Ger dwellings (traditional Ger tents or wooden houses) scattered mainly on northern hills of the City.

Population in the city was 569,405 in the year of 1994; they are evenly distributed among the apartment buildings and Ger Areas, as given below:

- Total population in Ulaanbaatar City = 569,405 (1994)
- Population in apartment buildings = 318,428 (55.9%)
- Population in Ger Areas = 250,977 (44.1%)

The public system (central water supply system) supplies potable water to citizens including Ger dwellers. The served area by the public water supply system is shown in Fig. 2.3.1.

(1) Outline of the System

The central water supply system is operated and managed by USAG (Water Facilities Exploitation Department of Ulaanbaatar Municipality) which withdraws the raw groundwater and supplies to consumers after chlorinating. The USAG is responsible for the supplying of water up to the community heating center (hereinafter called "CTP") which is managed by the community company. There are 51 CTP in the City.

The water is supplied through pressured pipelines to apartment buildings with individual house connections and by way of water tank lorries to people in Ger Area at water vending centers (kiosk).

The apartment buildings are supplied with both cold and hot water in all season through CTP. The USAG is responsible for supplying water up to the entrance of CTP; and tertiary distribution pipelines thereafter and other water facilities like a tap in the apartment buildings are the responsibility of the CTP. The CTP distributes both cold and hot water by their own booster pumps.

Water meters have neither been installed in individual houses nor in apartment buildings. All the CTP were once equipped with water meters at the time of their commissioning. However, at present, all of them are out of the service due to the mechanical failures.

In Ger Areas, there are 280 kiosks for vending the drinking water to the dwellers. The USAG maintains water service stations (7 stations in the city) and tank lorries with a capacity of about 5m^3 that transport it to the kiosks.

Groundwater is transmitted to the storage reservoirs located in the premises of distribution pumping stations. Chlorination is done in the storage reservoirs in principle.

A schematic flow chart of the public water supply system for Ulaanbaatar City is shown in Fig. 2.3.2.

(2) Supply Capacity

The actual water supply capacity of existing four(4) water sources of the present water supply system is given in the following table. An average of supply capacity for the past one (1) year was 165,304m^3/day.

[Unit m^3/day]

Year	Month	Existing Water Source				Total
		Central	Industrial	Meat	Upper	
1993	10	70,455	43,200	15,120	24,000	152,775
	11	69,891	43,200	15,120	24,000	152,211
	12	78,052	43,200	12,000	24,000	157,252
1994	1	79,373	43,200	12,000	24,000	158,573
	2	94,286	43,200	12,000	24,000	173,486
	3	96,000	43,200	15,120	24,000	178,320
	4	96,000	43,200	12,000	23,933	175,133
	5	90,000	42,648	12,000	23,742	168,390
	6	91,600	43,200	12,000	26,000	172,800
	7	96,731	30,240	12,000	24,000	162,971
	8	95,143	30,240	12,000	24,000	161,383
	9	92,327	39,840	14,184	24,000	170,351
	Average	87,488	40,714	12,962	24,140	165,304
Design Capacity		97,000	43,000	15,000	72,000	227,000

Data Source : Above water supply capacity was calculated on the operation records of distribution pumps of water source respectively, it has recorded by USAG

(3) Water Source

The central water supply system operated by USAG fully depends on the groundwater. The water sources of USAG are located in four (4) places along the Tuul River. The groundwater is withdrawn by the tube wells with submersible pumps. The water sources are outlined in the following table.

Water Source of Ulaanbaatar City

No.	Name of Water Source	Years of Development	Number of Existing Well	Depth of Well in Average	Capacity of Pump in Average
1)	Central Water Source	1950s-	70	30m	53m³/hour
2)	Industrial Water Source	1960s-	16	33m	130m³/hour
3)	Meat Complex Water Source	1960s-	8	31m	119m³/hour
4)	Upper Water Source	1990	39	32m	127m³/hour
	Total/Average		133	32m	87m³/hour

Schematic layout of existing water sources are illustrated in Fig. 2.3.3 ~ 6.

(4) Intake Facilities

Intake facilities consist of intake wells, intake pumps and collection pipelines.

Groundwater is withdrawn by the submersible pumps in the intake wells and transmitted to the storage reservoirs through collection pipelines (Steel pipe; Diameter: 100-700mm). These facilities are described below.

1) Intake Wells

Intake wells had been constructed at four water sources along Tuul River and count 133 numbers in 1993. First in 1957, Central Water Source (70 wells presently) was developed under the aid of former Soviet Union; since then, Meat Complex Water Source (8 wells presently) was developed in 1962, and Industrial Water Source in 1963. The groundwater of alluvium is suitable for the portable water in view of quantity and quality.

Recently, in order to supplement the above water sources, Upper Water Source consisting of 39 wells was developed by former Soviet Union in 1990.

The wells in Central Water Source are comparatively shallow with a depth of 29.6 m in average. The ground level is at an average of +1,286.2 m above the sea level. The height difference between the highest well and the lowest one is about 30 m. Static water level of the wells, is at an average of 2.47 m below the ground level, is almost similar and corresponds with the water level of Tuul River. Borehole diameter of the wells is 400-600 mm in general, and casing steel pipe diameter is 300-400 mm. Screens made of steel pipe, have 15.9 m average length and openings of 10-20 mm in diameter and 700-1,000 numbers per meter length.

An average depth of wells is 31.3 m in Meat Complex Water Source. The average ground level is +1,269.1 m and difference of the ground levels is about 3.0 m. Static water level is 2.36 m below the ground level; considered to be infiltrated water from the River. Borehole is 350-600 mm in diameter and casing pipe is 200-400 mm in diameter. Average screen length is 17.6 m.

An average depth of wells in Industrial Water Source is 32.8 m. The average ground level is +1,272.9 m and difference of the ground levels is about 10 m. Average static water level is 2.40 m ; and this is considered to be infiltrated water from the River as well as the water sources of upper stream. Borehole is 500-600 mm in diameter and casing pipe diameter is 400 mm in general. Screen length is 20.0 m in average.

An average depth of wells is 31.7 m in Upper Water Source. The average ground level is +1,423.7 m above sea level. These wells are located at the highest places among the four(4) existing water sources. Difference of the ground levels is 42.0 m. Static water level is 1.9 m below the ground level, similar to Tuul River water level. Borehole is 530-630 mm and casing is 325 mm in diameter. Screens have 14.7 m length in average and openings are 10-20 mm in diameter and 860-980 in number per meter length. This water source was developed recently and data for the intake well construction have been well maintained.

Actual conditions of the wells were surveyed from September to November in 1993. All the wells together with intake pumps were installed in brick-made and single / double locked pump houses; and they were well protected. About 102 wells in total were surveyed, excepting some of Upper Water Source wells which were not accessible because of river.

Technical data of the intake wells of all the water sources are given in Appendix III.1.6 of Supporting Report III.

2) Intake Pumps

The intake pumps which are installed in entire well, convey to the storage reservoir through the collection pipeline at each water source. Accessories of the intake pumps have been installed as a rule in all pump houses, under a certain design criteria. Except in Upper Water Source, all the pressure gauges and the water meters had already been damaged and are out of service. Accordingly, actual pressure and water flow-rate can not be measured, and also pumps are operated without proper engineering support.

The pumps used are submersible pumps and vertical turbine pumps driven by electric motors. At the time of development of Central Water Source, the type of the pump was the vertical turbine pump only; and after their deterioration, they had been replaced with submersible pumps. Presently all of the intake pumps in Central Water Source had been replaced with submersible pumps. The vertical turbine pumps are still used in Meat Complex Water Source (1 unit) and Industrial Water Source (5 units). At present, such kinds of pumps are not manufactured because of big size and low efficiency, and their spare parts are no longer available. Therefore, these pumps may be out of service at any time in near future.

Except the pumps in Upper Water Source, almost all of the pumps have been once damaged and repaired since their installation. Most of the damaged parts were electric motors. When the spare parts were not available, they were taken from old pumps.

The USAG keeps a workshop for the repairing and a warehouse for the spare parts. However, no new spare parts are available and damaged pump parts are piled in the yard. All the existing pumps were made in former Soviet Union, and procurement of the spare parts is currently very difficult, after the collapse of above country.

Lists of the existing intake pumps are given in Appendix III.1.7 of Supporting Report III and drawings of typical pump house including pipe arrangement are shown in Appendix III.1.8 of Supporting Report III.

3) Electric Facilities

The electric power for the operation of intake facilities is supplied by the public power plants. Electric cables (3 phases) and electric poles have been constructed exclusively for the intake facilities. The power (6000 volts / 50Hz / 3 phases) which comes into the substations is to be transformed to 380 volts to operate the intake pumps, a transformer panel, control panel, remote operation panel, and room heater in each intake pump house.

Electric facilities in Central Water Source were installed in 1961-1984. Most of the facilities are become superannuated and some of them have already been replaced; although they are not in serious trouble for just pump operation. The control equipment and remote operation system had been damaged. They are now completely out of service. Also in Meat Complex Water Source and Industrial Water Source, present conditions of electric facilities are almost similar to those of Central Water Source.

Upper Water Source was developed in 1990, and facilities are generally new and have no remarkable technical problems. However, the remote operation system has been damaged, and operation and maintenance for the intake pumps has faced much difficulty, because of bad access.

4) Collection Pipelines

The pipelines have been laid underground with earth covering depth of 2.5-3.0m in general. These pipelines were constructed at the time of water source development. The details are shown below.

List of Raw Water Transmission Pipelines (October 1993)

Pipe Diameter	Pipe Material	Total Length	Year of Construction
700mm	Steel	20,813m	1972, 1983, 1990
600mm	"	10,271m	1958-1984
500mm	"	8,600m	1966-1972
400mm	"	23,873m	1966-1972
300mm	"	13,970m	1959-1980
250mm	"	5,392m	1959-1968
200mm	"	11,430m	1959-1972
150mm	"	2,946m	1980
100mm	"	45m	1980
Total Length		97,340m	

The collection pipelines are considered to have no serious technical problems in general.

(5) Distribution Facilities

Distribution facilities consist of the storage reservoirs and distribution pumps. Each water source has its own storage reservoir and distribution pump.

1) Storage Reservoirs

Groundwater is collected and stored in storage reservoirs located adjacent to the distribution pump house in the premises of distribution pumping station in the water source field.

Reservoirs, made out of reinforced concrete, are constructed at the ground level and covered with earth (about 1.0 meter on the roof slab). Their shapes are either rectangular or circle, and the water depth is 4.80m as a rule.

Chlorine gas is injected with a dosage rate of 0.8 - 1.2 mg/ℓ, for the purpose of disinfection at the reservoir. Chlorination equipment is installed in the pumping stations of Central, Industrial and Meat Complex Water Sources.

Presently, the storage reservoirs have no serious technical problems in general.

List of Storage Reservoirs

Name of Reservoir	Upper Source	Central Source	Industrial Source	Meat Complex Source
Capacity	1,000m^3 x 2Nos. = 2,000m^3	6,000m^3 x 1 3,000m^3 x 1 500m^3 x 2 Total= 10,000m^3	2,000m^3 x 2 = 4,000m^3	2,000m^3 x 2 = 4,000m^3
Dimensions (Size)	14m x 15m x 4.8m x 2Nos.	36m x 36m x 4.8m x 1 25m (Dia) x 4.8m x 1 10.5m (Dia) x 4.8m x 2	18m x 24m x 4.8m x 2	18m x 24m x 4.8m x 2
Year of Construction	1991	1959 (10.5m Dia. x 2), 1972	1963	1966
Water Level above Sea Level	HWL = +1,430.0m LWL = +1,425.2m	HWL = +1,299.95m LWL = +1,295.15m	HWL = +1,283.8m LWL = +1,279.0m	HWL = +1,271.88m LWL = +1,267.08m
From Where Water Coming	From 39 wells in Upper Water Source	From 70 wells in Central Water Source	From 16 wells in Industrial Water Source	From 8 wells in Meat Complex Water Source
To Where Water Going	To communities	To communities and Tasgan Reservoir	To industrial factories and communities	To meat factories and communities, and to NorthWest Reservoir in 1994

Total Capacity of Storage Reservoir = 2,000 + 10,000 + 4,000 + 4,000 = 20,000m^3

2) Distribution Pumps

Distribution pumps supply chlorinated groundwater from the storage reservoirs to consumers through distribution pipelines. Some water is supplied directly to consumers by these pumps, and the other through supply reservoirs located on the northern hills of the city.

There are five (5) distribution pumping stations. Four (4) water sources have their own distribution pumping stations. In addition, there is a boosting pumping station in Tasgan. The number and specification of pumps are summarized in the following table.

List of Distribution Pumping Station

Pumping Station	No.	Specification						Installation Year*
		Diameter (mm)	Flow Rate (m^3/hr)	Head (m)	Volt (V x Hz)	Motor Power (kw)	Revolution (rpm)	
Central	1	300 x 250	630	90	380 x 50	250	1,470	1959, 1990
	2	300 x 250	540	94	380 x 50	200	1,475	1959, 1969
	3	300 x 250	630	90	380 x 50	200	1,475	1959, 1987
	4	300 x 250	540	94	380 x 50	200	1,475	1959, 1962
	5	500 x 300	2,000	100	6000 x 50	800	1,000	1972, 1985
	6	500 x 300	1,750	88	6000 x 50	630	1,000	1972
	7	500 x 300	2,000	100	6000 x 50	800	1,000	1972, 1985
Tasgan	1	300 x 250	630	90	380/660x50	160	1,475	1984
	2	300 x 250	630	90	380/660x50	160	1,475	1984
	3	300 x 250	630	90	380/660x50	160	1,475	1984
	4	300 x 250	630	90	380/660x50	160	1,475	1984
Industrial	1	400 x 300	900	60	380/660x50	200	1,470	1973
	2	300 x 250	630	90	380/660x50	250	1,475	1987
	3	300 x 250	630	60	380/660x50	200	1,470	1987
	4	400 x 300	900	60	380/660x50	200	1,475	1962
Meat Complex	1	300 x 250	630	90	380/660x50	250	1,475	1988, 1992
	2	300 x 250	630	90	380/660x50	250	1,475	1990, 1992
	3	300 x 250	500	65	380/660x50	160	1,475	1988, 1992
	4	300 x 250	500	65	380/660x50	160	1,475	1985, 1992
Upper Water	1	400 x 300	1,000	180	6000 x 50	630	1,500	P1989, M1988
	2	400 x 300	1,000	180	6000 x 50	500	1,500	P1987, M1987
	3	400 x 300	1,000	180	6000 x 50	500	1,500	P1987, M1987
	4	400 x 300	1,000	180	6000 x 50	500	1,500	P1987, M1987
	5	400 x 300	1,000	180	6000 x 50	500	1,500	P1982, M1987
	6	400 x 300	1,000	180	6000 x 50	630	1,500	P1989, M1988
Total	25							

(Note) * P : pump, M : motor.

More detailed lists of these pumps are given in Table III.1.10 to 14 in Supporting Report III and layout of the pumping stations is shown in Appendix III.1.9 of Supporting Report III.

In general, distribution pumps and their accessories have become superannuated and been heavily damaged, and about one-third units of the pumps shall be replaced with new pumps.

(6) Service Facilities

The service facilities consist of supply reservoirs, distribution pipelines and some service facilities for Ger Area.

1) Supply Reservoirs

There are four (4) supply reservoirs located on the northern hills in the City and one (1) reservoir located at east side of the City. Presently, two (2) reservoirs of the

Tasgan Reservoir and the 3/4 District Reservoir are working. They are shown below .

List of Supply Reservoirs

Name of Reservoir	North-East Reservoir	Tasgan Reservoir	3/4 Districts Reservoir	North-West Reservoir	Zavsariin Reservoir
Capacity	6,000m^3 x 2Nos. = 12,000m^3	6,000m^3 x 3Nos. = 18,000m^3	3,000m^3 x 2Nos. = 6,000m^3	3,000m^3 x 2Nos. = 6,000m^3	3,000m^2 x 2 Nos = 6,000 m^3
Dimensions (Size)	36m x 36m x 4.8m x 2Nos.	36m x 36m x4.8mx3Nos.	24m x 27m x 4.8m x 2Nos.	24m x 27m x 4.8m x 2Nos.	24m x 27m x 4.8m x 2 Nos
Year of Construction	1985	1972-2 Nos. 1986-1 No.		Under Construction	Leave off Construction
Water Level above Sea Level	HWL = +1,386.86m LWL = +1,382.06m	HWL = +1,334.8m LWL = +1,330.0m	HWL = +1,374.8m LWL = +1,370.0m	HWL = +1,346.8m LWL = +1,342.0m	HWL = +1429.8 m LWL = +1425.0 m
From Where Water Coming	From Upper Source Distribution Pumps	From Central Source Distribution Pumps	From Tasgan Reservoir Distribution Pumps	From Meat Complex Source Distribution Pumps	From Upper Source Distribution Pumps
To Where Water Going	To communities by gravity	To communities by gravity, and to 3/4 Districts Reservoir by pumps	To communities by gravity	To communities by gravity	To communities by gravity
Remarks	Not being used because of no need currently			May be completed in 1994	Not completed

Total Capacity of Supply Reservoir =12,000 + 18,000 + 6,000 + 6,000 = 42,000m^3
(Except the Zavsariin reservoir)

The supply reservoirs, as well as the storage reservoirs, made of reinforced concrete, are constructed at the ground level and covered with earth (about 1.0m on the roof slab). Their shapes are rectangular and water depth is 4.80m as a rule.

Water from distribution pumps flows into distribution pipelines and first goes to CTP in principle; and if water is in excess of CTP's demand, the excessive water flows into supply reservoirs for storage. Accordingly, the water is stored during night time in particular.

Presently, the supply reservoirs except Zavsariin reservoir have no serious technical problems in general, as well as the storage reservoirs.

The construction works for Zavsariin Reservoir started in the end of 1980s together with the Distribution Pipeline. And the concrete basins and pipeline from the distribution main to the basins were constructed.
However, the construction works stopped due to the lack of the budget in 1990, before installation of the equipment required for the operation such as water level meter, telecommunication system, etc.
Therefore the Zavsariin Reservoir is out of use at present.

If the necessary equipment is installed, the Zavsariin Reservoir can be operated and the water supply capacity from the Upper Water Source will be increased.

2) Distribution Pipelines

Distribution pipelines constructed in Ulaanbaatar City are as follows.

List of Distribution Pipelines (October 1993)

Pipe Diameter	Pipe Length (m)		Total	Year of
	Steel	Cast Iron	Length	Construction
800mm	18,846	0	18,846	1985-1990
700mm	29,103	1,200	30,303	1972, 1983, 1990
600mm	23,381	4,480	27,861	1958-1984
500mm	21,780	1,430	23,210	1966-1972
400mm	20,200	7,650	27,850	1966-1972
300mm	0	21,340	21,340	1959-1980
250mm	0	29,600	29,600	1959-1968
200mm	0	5,510	5,510	1959-1972
150mm	0	14,140	14,140	1959
100mm	0	1,680	1,680	1959
Total	113,310	87,030	200,340	

The pipelines are laid underground with the earth covering depth of 2.0 to 3.0m in general. The pipelines networks had been designed to keep water pressure of 26m on main corners of the streets in the city.

Some pipes might be suffering from leakage because of the superannuated condition, although visual leakage on the ground surface from the pipelines is not so remarkable. Accordingly, old pipelines shall be carefully surveyed for the purpose of leakage detection for the repair and replacement of pipelines. This work would take longer period, and should be solved by daily routine work of the USAG.

3) Service Facilities for Ger Area

To Ger Areas where nearly a half of Ulaanbaatar population live, USAG supplies water for their domestic use not through pipelines, but by the transportation of water by tank lorries.

The tank lorries take water from the water service stations (7 stations in the city) located on the distribution mains, and transport it to kiosks (280 kiosks in the city) scattered in Ger Areas, where people buy a drinking water with their own containers.

The USAG maintains the following facilities for water supply to Ger Areas.

Water service stations	:	7 buildings
Water vending centers (kiosk)	:	280 buildings
Tank lorries	:	55 numbers

Among the above, most serious issue is the shortage of tank lorries. Most of them are quite old and superannuated.

2.3.2 Water Quality

(1) Groundwater Quality

Water Quality Analyses were conducted, using the analysis kit, for wells of USAG, private wells in Ger Area, and newly constructed test wells.

As for groundwater quality, no existing datum is available, because water quality analysis has not been conducted by USAG and others.

Number of wells for which the analyses were conducted, are shown below.

Number of Wells for Analysis

Water Source	Number of Existing Wells	Phase I Number of Wells analyzed	Phase II Number of Wells analyzed	Location map of Sampling
Upper Water Source	39	6	8	Fig. 2.3.7
Central Water Source	70	23	24	
Industrial Water Source	16	1	1	
Meat Complex Water Source	8	5	5	
Private Wells		-	4	
Test Wells	15	-	15	Fig. 2.3.8
(Total)	148	35	57	

Note Period of Phase I : August to November in 1993.
Period of Phase II : May to November in 1994.

1) Existing Wells of USAG

- Table 2.3.1 shows the summary of the results obtained from water quality analysis of groundwater for the samples taken from the four (4) water sources. The original data of water quality analyses are shown in Appendix IV.1.1 of Supporting Report.

- Almost all items clear the standard limits for drinking water in Mongolia, except Mn at some wells in Central Water Source, Industrial Water Source and Meat Complex Water Source and Coliform at No.3 well in Meat Complex Water Source.

- Water temperature in all water sources showed below 10°C in average. It ranges from 3 to 6 °C in winter (December to April) and 5 to 11°C in June to September.

- For every item except water temperature, seasonal changes could not be recognized in each water source.

- Water samples from Industrial Water Source and Meat Complex Water Source showed higher values of Conductivity, SO4 and TDS compared with those from Upper Water Source and Central Water Source. Besides Meat Complex Water Source showed higher values of Alkalinity also. However these higher values still clear the standard limits for drinking water. Contamination from the town area and industrial area to the Industrial Water Source and Meat Complex Water Source, might be have occurred.

- Water quality of these groundwater is so called a soft water containing little salts of cation. It could be used as a boiler feed water. In fact, well water is used as the boiler feed water without demineralization (softening) in the existing Power Plants in Ulaanbaatar.

2) Private Wells in Ger Area

In September 1994, samplings could be done at four (4) locations as shown in the following table and Fig 2.3.7.

Well number	Location	Sampling
G-1	Amagalan	1
G-2	Damba	1
G-3	Chingeltei	1
G-4	Tolgoit	1
Total		4

- The water quality for all wells does not clear the standard limits for drinking water in Mongolia. The results of water quality analysis is shown in Table 2.3.2.

- According to the residents using the well water, they do not use the water for drinking but for washing, bathing and watering of plantation, etc.
  Anyway it should be noted that these water can not be utilized for drinking water.

- The followings can be considered to be the sources of contamination.

  (i) Excrements of livestocks
  (ii) Fertilizer
  (iii) Seepage from solid waste disposal

3) Test Wells

Samples were taken from the Test Wells when the pumping tests were conducted. The locations of Test Well are shown in Fig. 2.3.8. Table 2.3.3 indicates the results of analyses for the Test Well water.

Category	Well number	Location	Sampling
Type A (Deep well)	A-1	Uliastai	1
	A-2	Selbe	1
	A-3	Bayan Goliin	1
	A-4	Selbe	1
Type B (shallow well)	B-1	Buheg	1
	B-2	Buheg	1
	B-3	Buheg	1
Type C (shallow well)	C-1	Lower Part of Nalaih	1
	C-2	Lower Part of Nalaih	1
	C-3	Lower Part of Nalaih	1
	C-4	Lower Part of Nalaih	1
	C-5	Lower Part of Power Plant	1
	C-6	Lower Part of Power Plant	1
	C-7	Lower Part of Power Plant	1
	C-8	Lower Part of Power Plant	1
Total			15

- Almost all item clear the standard limits for drinking water in Mongolia, except Mn at A-2, B-1 and B-3 and Fe at A-2 site.
  Little higher values of Mn and Fe are considered to be caused by the geological conditions of materials contacting with the groundwater.

- In conclusion, water quality of the Test Wells is fairly good and appropriate for drinking water, although the further investigation will be required especially for Mn and Fe at the site "A" (north of Ulaanbaatar) and "B" site (Buheg).

- Water quality of sample from "C" sites (Lower part of Nalaih and Lower part of Power Plant) showed good result. All item clear the standard limits for drinking water in Mongolia. Especially Conductivity and TDS in C-1 to C-4 sites (Lower part of Nalaih) showed lower value than other sites.

(2) River Water Quality

Water quality of Tuul River was investigated through data collection and water quality analysis.

1) Review of Existing Data

The Central Environment Research Laboratory, the Ministry of Environment , has conducted the water quality analysis of Tuul River at the following three points.

Sampling point	Remarks
Terelj	-
Ulaanbaatar	in Central Water Source
Altanbulag	in Lower Part of Power Plant

Sampling points are shown in Fig. 2.3.8. Analyses have been conducted once in a month for each sampling point.

Table 2.3.4 shows the annual average value of each item at three points from 1986 to 1992. The original data are shown in Appendix IV.2.1 of Supporting Report

(i) General

There is not so much difference in the analysis value in each item among three points. However, NH4 and TDS in the lower stream are higher than in the upper stream. This might have been caused by some contamination from the town area and industrial area.

(ii) Water quality change in seasons

Table 2.3.5 and Fig 2.3.9. show the seasonal change of water quality (Cl, SO4, P, NH4). Every item showed highest value in the winter season (from January to March) and lowest in the summer season (from July to September). This might have been caused by the river discharge of Tuul river.

2) Water Quality Analysis

Water quality analyses were also conducted by JICA Study Team, taking samples from three points on September in 1993 and March, May, August, and September in 1994.

Sampling location is shown in Fig. 2.3.8. Water quality is shown in Table. 2.3.6

Sample no.	Sampling point	Location
R-1	Terelj Bridge	Upper Water Source
R-2	Zaisan Bridge	Central Water Source
R-3	Chicken Factory Bridge	Lower Part of Power Plant

The Original data are shown in Appendix IV.2.2 of Supporting Report

- There is not much difference from the results obtained by the Central Environment Research Laboratory in each location, although the river water discharge was much more than that of the other years.
- The tendency that the water quality in the lower stream is worse than that of upper stream (NH4, SO4, Fe, Cl, Zn, Cu, COD) is also the same as the results by the Central Environment Research Laboratory.
- Mn exceeded occasionally the standard limit for drinking water at every location.

- Cr and Fe which exceeded the standard limit at R-3 are considered to be influenced by the waste from industrial area.

- pH in R-2 and R-3 and Coliform in R-1, R-2, and R-3 exceeded the Standard limit for drinking water in Mongolia. It shows that the surface water cannot be utilized directly as a drinking water.

- R-3 showed higher value of Conductivity, Turbidity, SO4, and TDS, which might have been influenced by the waste from city and industrial area.

(3) Comparison of Water Quality of Groundwater and River Water

Water quality of groundwater and river water has been compared for each Water Sources as mentioned below.

Groundwater	River Water
Upper Water Source	R-1
Central Water Source	R-2
Industrial Water Source	R-3
Meat Complex Water Source	R-3

Table 2.3.7 shows Comparison of Water Quality of Groundwater and River Water in the existing Water Sources area.

1) In all Water Sources, Bacteria and Coliform value of River Water are higher than Groundwater.

2) In the Upper Water Source, seasonal change of Cl^- between dry season (from Dec.to Apr.) and wet season (from May to Nov.) for the River Water (R-1) is remarkable.

3) In the Central Water Source, $Cl^-$and Fe value of River Water (R-2) are higher than Groundwater. And pH and Cl^- value of both Groundwater and River Water in the wet season is higher than dry season.

4) As the location of R-3 is far from the Industrial and Meat Complex Water Sources, there might not be relation between river water and the water sources.
However, Turbidity of R-3 is higher than the water sources and TDS of the water sources is higher than R-3.

(4) Drinking Water

1) Reservoir

Drinking water quality was investigated through the collection and review of existing data and water quality analysis.

(i) Review of Existing Data

Water quality of reservoirs which are located at pumping station in existing four (4) water source, has been analyzed by USAG. Sampling points are located at the following four (4) storage reservoirs.

i) Storage reservoir of Upper Water Source
ii) Storage reservoir of Central Water Source
iii) Storage reservoir of Industrial Water Source
iv) Storage reservoir of Meat Complex Water Source

Water quality analysis has been conducted for four (4) times in a year. Table. 2.3.8 shows the water quality of reservoirs of four (4) pumping stations during three (3) years from 1991 to 1993.

The original data are shown in Appendix IV.3.1 of Supporting Report

Sampling locations are shown in Fig 2.3.10.

- Water quality standard for drinking water in Mongolia is shown in Table IV.3.2.9 and WHO Guideline Values in Table 2.3.10

- Almost all values clear the standard limits of drinking water in Mongolia. However, NO_3 in Meat complex and Mn in Central pumping station exceed slightly the standard limits. Regarding to the above item, it should be conformed continuously in future.

- Water quality of four (4) items of NO_3, TDS, SO4, and DO in Industrial pumping station and Meat complex pumping station is inferior than that of other two pumping stations.

(ii) Water Quality Analysis

Sampling points are the following seven (7) reservoirs including the same point being investigated by USAG.

i) Storage reservoir of Upper Water Source
ii) Storage reservoir of Central Water Source
iii) Storage reservoir of Industrial Water Source
iv) Storage reservoir of Meat Factory Water Source
v) Supply reservoir (North-East Reservoir)
vi) Supply reservoir (Tasgan Reservoir)
vii) Supply reservoir (North-West Reservoir)

Fig 2.3.10 shows location of the sampling points. Table 2.3.11 shows the analysis results. The original date is shown in Appendix IV.3.2 of Supporting Report.

- Analysis results showed Mn, Cr, Fe and F exceeded slightly the standard limit for drinking water in several reservoirs.

- Discussions were held with persons in charge at Water Supply Department, regarding these items and values which exceeded the standard limits. Discussion results are as follows.

i) These components are considered from the raw water, that is well water, taking the analysis results for well water into consideration.

ii) High value of Fe (0.58 mg/l) might be from rust of pipeline.

iii) According to the experience from the routine analysis in USAG, F in the well water at the Industrial Water Source showed higher value sometimes.

iv) Slightly higher value of Cr could not be explained clearly. Some sedimentation in the reservoirs might be the reason.

2) Water Taps, Water Service Station, Water Vending Center

Analysis results of tap water for apartment dwellers and some office, service station water and vending center water for Ger dwellers are described in Table 2.3.12 and Fig. 2.3.10. Original data are shown in Appendix IV.3.3 of Supporting Report.

(i) Data for these water showed a good results. All items clear the standard limits.

(ii) Although continuous survey will be required, but present survey indicates that a clean and safe water has been supplied to the citizen from the central water supply system by USAG.

(iii) Routine analysis for the items in Table 2.3.12 will be required

2.3.3 Population Served and Water Consumption

(1) Population Served and Service Area

1) Ulaanbaatar City was divided into 12 districts until the end of 1994, among which six (6) districts (No.1-No.6) were located in the central area of the city and the other six (6) districts (No.7-No12) were the suburbs area of the city.

The six (6) districts (No.1 ~ No.6) were further divided into subdistricts. Present number of population in each subdistrict was divided into two (2) categories, that is, those in the area covered by the central water supply system of USAG and those which were not covered by the central system. The latter dwellers use private wells or water supply system of one's own.

Moreover, in each category, the population number was divided into Apartment dwellers and Ger dwellers. The total population was confirmed to be 569,405. The population being served and not served by the central water supply system were 506,674 (89%) and 62,731 (11%) respectively.

The summary of the population served and not served by the central water supply system is shown below.

Population Served (in October 1994)

(Unit : Person)

	No	Districts	Covered by central water supply system of USAG		Not covered by central water supply system of USAG		Total
			Apartments	Ger	Apartments	Ger	
Central area of the city	1	Han-Uul	19,429	29,631	2,341	0	51,401
	2	Bayanzurh	50,529	39,863	1,891	0	92,283
	3	Suhbaatar	45,397	23,987	0	0	69,384
	4	Chingeltei	28,282	55,539	0	0	83,821
	5	Bayangol	90,737	16,741	0	0	107,478
	6	Songinohairhan	56,235	50,304	0	0	106,539
		Sub-total	290,609	216,065	4,232	0	510,906
The Suburbs area of the city	7	Baganuur	0	0	13,007	3,268	16,275
	8	Bagahangai	0	0	3,422	2,282	5,704
	9	Nalaikh	0	0	5,890	17,514	23,404
	10	Gachuurt	0	0	0	3,450	3,450
	11	Jargalant	0	0	720	5,697	6,417
	12	Tuul	0	0	548	2,701	3,249
		Sub-total	0	0	23,587	34,912	58,499
		Total	290,609	216,065	27,819	34,912	569,405
			51%	38%	5%	6%	
			506,674	(89%)	62,731	(11%)	

Population number of Districts No.1- 6 : October, 1994
Population number of Districts No.7-12 : December,1993
Source: Town Planning Department

USAG's service area is shown in Fig. 2.3.1.

2) At the end of 1994, rearrangement of the districts was carried out. The name of new districts and the population are shown below.

New Districts and the Population

No.	Name of District	Population (person)	Remarks
1.	Han-Uul	53,288	the old Tuul District is included
2.	Bayanzurh	99,950	the old Gachuurt District is included
3.	Chingeltei	88,987	
4.	Sukhbaatar	78,843	
5.	Bayangol	110,807	
6.	Songinohairhan	120,500	the old Jargalant District is included
7.	Bagahangai	5,600	
8.	Baganuur	16,595	
9.	Nalaih	21,430	
	Total	596,000	

(2) Water Consumption

The actual supply capacity of the present water supply system is shown in the following table.

Present Water Consumption

No	Item	Capacity (Average)	
		(m^3/day)	(%)
1	Apartment dwellers (q1)	122,056	73.8
2	Ger dwellers (q2)	1,600	1.0
3	Industrial factories (q3) *-1	11,452	6.9
4	Other consumers (q4) *-2	8,100	4.9
5	Loss (q5)*-3	22,096	13.4
	Total Actual Supply Capacity (Q)	165,304	100.0

Note *-1 Recorded by water meters
*-2 Including the supply water to un-recorded consumers
*-3 $q5 = Q - (q_1 + q_2 + q_3 + q_4)$
* More detailed present water balance is described in 1.1.2 of Supporting Report III.
* q1 Unit water demand x population.
* q2 Unit water demand x population.

2.3.4 Institutional and Financial Aspects

(1) Short History of the Organization

Municipal water supply system in Ulaanbaatar began at the time when ten (10) wells, having the capacity of 4,500m^3/day, were constructed inside the present Central Water Source area, by the aid of former Soviet Union, in 1955.

An organization for municipal water supply under the administration of Municipality was established in 1959.

Sewerage system for the town area under control of the same organization was constructed in 1963.

Since 1959 the organization had been belonging to the Municipality until 1972.

In 1972, a new ministry under the Government of Mongolia was established, combining the communal services, as the Ministry of Communal Services.

And the organization belonged to the Ministry of Communal Services from 1972 until 1990, when the major change occurred.

In 1990, the organization started as USAG under the administration of Municipality.

(2) Organization and Management of USAG

- USAG is one of the Departments under the administration of the Municipality. However, it is an independent enterprise economically.
- USAG covers the water supply facilities, including the water sources, pumping stations, reservoirs, piping in the centralized system up to CTP and Water Service and Supply Stations, and sewerage facilities (piping and sewage treatment plant) in the Municipality.
- Planning and budgeting, operation and maintenance of the above facilities are the main tasks of USAG.
- The number of employee of USAG is 1,185 at present including the chairman.
- Detailed organization of USAG is shown in Fig. 2.3.11.

(3) Financial Statements of the USAG

1) Profit and loss statement (P/L)

Table 2.3.13 shows the P/L statement of USAG for four consecutive years starting from 1990. The fiscal year coincides with the calendar year. Upper source pumping station was commissioned in 1991.

1992

Profit before tax is 17.3 % of the total income, of which 75 % went to tax. It did not pay any interest in the same year as is the case with enterprises in the socialist countries. Profit tax which is equivalent to 13 % to the total income, can be regarded as interest. Depreciation cost was set to 5 % of the value of basic fund at the year end.

With around 1200 staff, the average monthly salary (including social insurance) was about 2,000Tg.

Due to the fact that the tertiary distribution pipeline networks have been maintained by CTP, no cost was incurred to that end.

1993

Profit before tax is 8.4 % of the total operating revenue. Thirty five (35) % of the total profit with non-operating revenue went to tax. It did not pay any interest in the same year on the one hand; 10 % of total profit before tax with non-operating revenue was used as management expenditure, on the other hand. Depreciation cost is set to 9 % of the value of basic fund at the year end.

With 1,185 staff, the average monthly salary (including social insurance) was 7,365 (US$ 21: Tg 350/$; Sep.'93), 3.7 times more of the average salary of previous year in nominal terms.

2) Balance sheet (B/S)

1992

The B/S shows a healthy financial status of the organization. Though the year saw a big rise in outstanding of payment from the communal service companies, the amount was contained within 2.8 % of the total sale*.

* Total sale = total income + change in outstanding

The net profit gained in this fiscal year went into the economic and social development fund, therefore it can be regarded as accumulated profit.

Production unit is a unique system of raising cattle for supplementing employees' income; but in this fiscal year, cost of raising cattle is not included within the operational cost of the enterprise. This may mean that it was shared by the interested party.

1993

The value of the basic fund (building, machinery) was raised about 100 % of the previous year in nominal term by valuation more or less consistent to the real value of the currency.

The amount of outstanding increased by the fact that the water rate was revised. The amount, though, was contained within 2.4 % of the total sale, which was less than the previous year.

(4) Water Tariff

The present water tariff (including waste water charge) which has been effective since June 1, 1993 is shown below. Domestic users from pipeline system pay the tariff at the fixed rate of 150 l/person/day which is not based on the actual usage capacity.

Water Tariff (June 1, 1993)

(Unit : Tg/m^3)

Type of User	Water Supply	Wastewater	Total
PIPELINE SYSTEM:			
Industry & Enterprises	39	39	78
State Organization	39	39	78
Domestic	8	6.7	14.7
VIA SERVICE STATION:			
(1) OWN TRANSPORT			
Industry & Enterprises	100	50	150
Domestic	400	-	400
(2) WATER CART SUPPLY AREA AND WATER VENDING CENTER			
Industry & Enterprises	600	-	600
State Organization	600	-	600
Summer Housing Area	600	-	600
Domestic	600	-	600

(5) Marginal Unit Cost

1) Physical Efficiency

Physical efficiency of the USAG's operation was estimated at 51.3 % in 1993. According to the information provided by the USAG this year, the volume of actual billed water supply in 1993 was 30,795,400m^3 and that of treated waste water was 29,245,000m^3.

2) Financial Efficiency

Financial efficiency of the USAG's operation was estimated at 97.6 % in 1993. The value is calculated from P/L and B/S of the USAG by the following formula: total income/(total income + change in outstanding).

3) Marginal Unit Cost (MUC)

The MUC of water production in 1993 is estimated at 17.1 Tg/m^3 (0.049US$: 350 Tg./$, Sep. 1993) by using the following values and formula.

Fixed Assets (net) (A)(*1)	:	763,678,992 Tg. x 65.87% = 503,035,352Tg.
Depreciation Rate (D)	:	3.0 %
Interest Rate (I) (*2)	:	3.0 %

Production (P) : 60,040,400 m^3/year

Physical Efficiency (PE) : 51.3 %

Financial Efficiency (FE) : 97.6 %

Operation Cost (OC) (*3) : 733,469,500 Tg. x 65.87% = 483,136,360Tg.

MUC=(Ax(D+I)+OC)/(PxPExFE)

*1 We use the ratio of recurrent expenditure for water supply to the total expenditure of the USAG in 1993 as an estimate of the ratio of assets for water supply to the total assets of the USAG.

*2 The rate that may be applicable to the long-term loan for public utilities projects.

*3 Total expenditure -Depreciation costs (see Table V.1:805,437.8-69,752.5-2,215.8)

The MUC in 1993 was around twice as much as domestic unit water rate.

2.3.5 Operation and Maintenance

(1) Purpose of Operation and Maintenance (hereinafter called O&M)

Operation

The purpose of operation for the water supply facilities is to operate the facilities properly as planned at the designing stage so that the water can be supplied safely and steadily to the consumers.

Therefore an operation manual for daily use and education of the operators is considered to be indispensable.

On the other hand, it would be important to operate the facilities economically depending on the circumstances; for instance, to change the numbers of operating pumps in accordance with the supply capacity of water.

Maintenance

Maintenance of the water supply facilities shall be conducted periodically so as to keep the facilities safely as long as possible. At the same time, daily inspection of the facilities is required.

A maintenance manual and education of the employee are also necessary.

Competitiveness of the enterprises, not only water supply enterprise but also other production companies, depends on the capability of the maintenance.

Preparation of spare parts and scheduling of the replacement of the equipment will also be required in the course of the maintenance.

(2) Facilities requiring O&M

Following facilities of USAG require O/M.

- Intake Facilities of four(4) Water Sources;
  Upper Source, Central, Industrial, Meat Complex

- Distribution Pumping Stations of four(4) Water Sources and one(1) Reservoir

  Upper Source, Central, Industrial, Meat Complex, and Tasgan
- Storage and Supply Reservoirs
- Transmission and Distribution Pipeline
- Service Facilities for Ger Area
- Workshop of USAG

(3) Organization

At present, the employees in charge of O&M for water supply facilities of USAG are as follows.

- Engineer : 12 persons
- Supply Stations (Intake Water Well , Pumping Stations and Reservoirs)
  - Laboratory : 5 persons
  - Upper Source : 57 persons (12 hr/day 2 shift/day x 4 group)
  - Central Source : 87 persons (12 hr/day 2 shift/day x 4 group)
  - Industrial Source : 73 persons (12 hr/day 2 shift/day x 4 group)
  - Meat Complex Source : 33 persons (12 hr/day 2 shift/day x 4 group)
- Pipeline : 41 persons
- Construction Machine : 40 persons
- Materials Supply Group : 28 persons
- Water Transportation Center : 500 persons

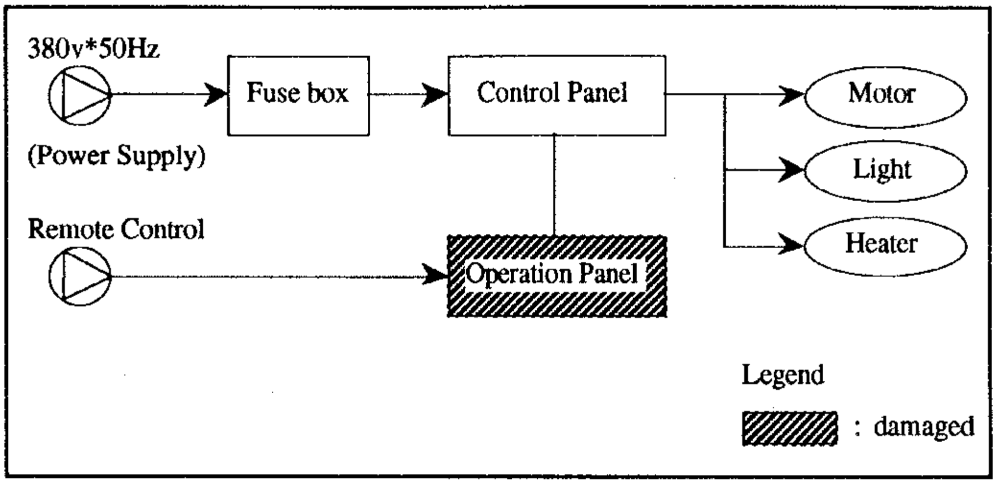
(4) Present Condition (May, 1994).

Present conditions of the water supply facilities; intake wells, intake pumps, distribution pumps and motor drive valves, are shown in the following tables. The power supply diagram for Intake wells is illustrated below.

Present Conditions of Intake Wells and Pumps

Conditions	Water Source				Total
	Upper	Central	Industrial	Meat Complex	
Existing Intake Wells	39	70	16	8	133
Workable Intake Wells	39	62	9	3	113
Workable Intake Pumps	34	49	8	3	94

The Power Supply Diagram for Intake Wells.



Present Conditions of Distribution Pumps

(Unit : Number)

Conditions	Pumping Station					Total
	Upper	Central	Industrial	Meat Complex	Tasgan	
Workable pumps	2	3	2	4	2	13
Damaged pumps	2	2	0	0	1	5
Under repair pumps	2	2	2	0	1	7
TOTAL	6	7	4	4	4	25

Present Conditions of Motor Drive Valves for Distribution Pumps

(Unit : Number)

Conditions	Pumping Station					Total
	Upper	Central	Industrial	Meat Complex	Tasgan	
Workable	14	0	0	0	3	17
Damaged	0	6	0	0	1	7
Under Repair	0	0	0	0	0	0
TOTAL	14	6	0	0	4	24

Transmission and Distribution Pipeline

Although some leakage from the existing pipeline occurred inside the Ulaanbaatar City, they have not caused fundamental problems. Because most of the materials of pipeline are steel and USAG could repair them easily by welding.

Service Facilities for Ger Area

i) Outline of Works

The water transportation facilities are managed by water transportation group of USAG. And, where pipeline system does not exist, they supply the potable water to Ger Area and so on by tank lorries. These facilities are as follows.

- Water Transportation Center

- Tank Lorries (55 numbers)
- Water Service Stations (7 places)
- Water Vending Center (280 places)

ii) Employee

Total number of employee in this sector are about 500 persons including administrators, tank lorry drivers , staffs of water service stations and water vending centers.

iii) Tank Lorries (made in Russia)

Present situation of Tank Lorries (May, 1994) is as follows.

Total number	:	55
Workable Number	:	33

* 22 tank lorries have already been damaged.

Service Distance

Actual (on Nov, 1993)	:	120 ~ 180 km/day/car.
Water Tank Volume	:	5 ~ 8 m^3 (almost 5 m^3)
Water Tank Structure	:	Double casing of aluminum and mild steel
Times of Delivery	:	Minimum 155 times/day
(on January, 1993)		Maximum 366 times/day
		Average 262 times/day

Work Shop of USAG

i) Location of Workshop

A workshop is adjacent to USAG office.

ii) Machine Handcraft

A small-scale repair (manufacture of small diameter shaft, cutting, and surface processing) can be conducted in this machine handcraft chamber.

The handcraft machine are lathes, ball board, cutter, and so on.

iii) Equipment of Shop Test

The equipment for shop test for intake pumps and other pumps repaired are installed.

iv) Electrical Equipment

A workshop does not have a function to repair an electrical equipment. It will be sent to a contractor if necessary.

Community Heating Centers (CTP). [Out of Scope of USAG Works]

i) Outline of Works

CTP has water supply facility that supplies hot and cold water to consumers of apartments and another buildings. As mentioned above, O&M are managed by Central Heating Company.

ii) Water Supply System

The typical water supply system of CTP is shown in Fig. 2.3.12.

iii) Tariff Collection

Each CTP collects the water tariff from the dwellers of the apartment buildings. USAG receives the water tariff from each CTP.

iv) Instrumentation Equipment

The instrumentation, such as flow meter, pressure gage, and so on, are not provided or already broken, if any.

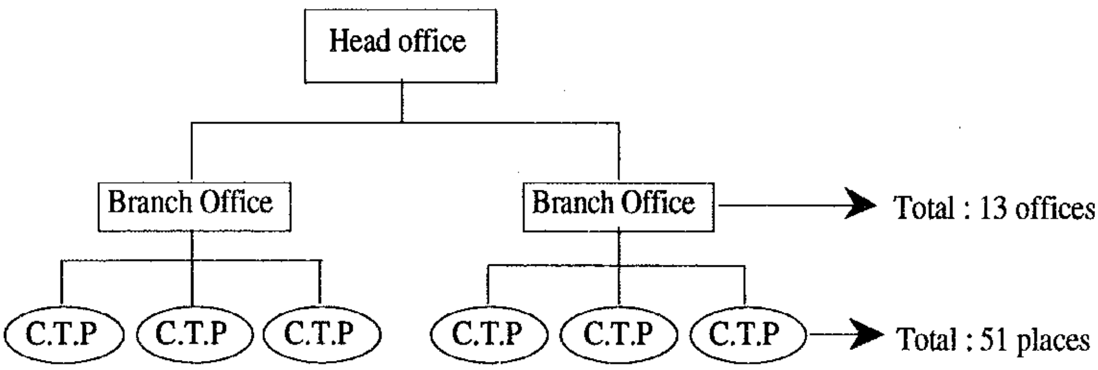
v) Freezing Countermeasure

The facilities of CTP are equipped wholly for freezing protection inside a building.

vi) Organization

An organization of CTP is shown below.

Organization of CTP



vii) Operation Method

An operation method of booster pumps is a manual operation at a control panel. An automatic system is not provided.

viii) Countermeasure for Power Failure

The countermeasure for power failure such as generator or two(2) lines power supply system is not provided. However, consumers have not faced a serious trouble in the past.

ix) Number of Workers

Number of workers per CTP is as follows.

Shift Worker (3 persons) : working time 24 hours/day x 1 shift /day

x) Scope of Works of Shift Workers.

The scope of works of shift workers is to operate and maintain the water supply facilities in the CTP and water taps in the apartments.

Water Supply Facilities in the Apartments

The results of water leakage survey from taps inside apartments are summarized below.

Present Condition of Water Taps

Survey Period and District	Phase 1 (1993)				Phase 2 (1994)		
					Hon-Uul	Sukhbaatar	Chingeltei
Building Age	Semi-old	Semi-old	old	old	21 Years-old	35 Years-old	35 Years-old
Building No.	No.3	No. 30	No. 13		No. 37	No.28	No.6
Number of Home Surveyed	12	9	12	7	28	35	15
Number of Existing Water Taps	36	36	70	25	84	105	45
Number of Leakage of Taps	12	6	46	16	12	30	13
Percentage of leakage of taps	33.3 %	16.7 %	65.7 %	64.0 %	14.2 %	28.6 %	28.9 %

As evident from the above survey results, 14.2 - 65.7 % of water taps are suffering from leakage problems.

(5) Recommendations and or Considerations for Operation and Maintenance

1) Intake Facilities

Replacement of the damaged intake pumps

To maintain water supply quantity to Ulaanbaatar City, the heavily damaged and the broken pumps should be replaced. Details are shown in "Emergency Rehabilitation Program" in Appendix at the end of this report.

Electrical Equipment

The fundamental function is not damaged. However, panels of intake facilities are old and unsafe except those in the Upper Water Source. Therefore the electrical panels for replaced pumps shall also be replaced.

Remote Control System

Adoption of remote control system for the intake facilities from the distribution pumping station will bring the great merits as shown below.

- Water quantity required can be controlled easily and quickly.

- Working frequency to use each equipment can be controlled and can be uniform.
- O&M management can be easy, since an operation condition of the facilities can be supervised at the pumping station.
- Economical operation can be conducted by controlling the numbers of operating pumps.

The remote control system should include at least the following items.

- Operation of intake pumps.
- Operation of a motor drive valve installed in the delivery side of intake pump.
- Indication of operation and damaged situations of intake pumps and motor drive valves.

Preparation of Spare Parts

The major spare parts of machine, electricity and instrumentation should be prepared.

2) Distribution Pumping Stations

Replacement of the Distribution Pumps

To maintain water supply quantity to Ulaanbaatar City, older and damaged pumps should be replaced. Details are shown in "Emergency Rehabilitation Program" in Appendix at the end of this report.

Electrical Equipment

Though the fundamental function is not damaged, the electrical equipment such as incoming panels, control panels, operation panels and so on are totally old and unsafe. Therefore the electrical panels for replacement pumps shall also be replaced.

Instrumentation Equipment.

A measuring device of flow rate and pressure of distribution pipeline should be installed.

Emergency Power Supply Facilities

At present, no countermeasure for power failure is prepared. Power failure will cause the suspension of water supply. However, the existing water supply system in Ulaanbaatar City has reservoirs and a long distance of distribution pipeline connected to the four(4) water sources.

Therefore a short time power failure will not cause the immediate suspension of water supply. The study of the countermeasures for emergency will be required.

3) Storage and Supply Reservoirs

- Almost all reservoirs are not equipped for an accurate water level gauge. Water level gauge for reservoirs should be installed for the protection of intake and distribution pumps, and for the proper operation of these pumps, .
- The operation of the North West Reservoir (under construction) and the North East Reservoir not used at present, will be considered.

4) Collection and Distribution Pipeline

The length of collection and distribution pipeline are about 100 km and 200 km respectively. Pipes are made of steel and cast iron. As mentioned above, the oldest pipe was installed in 1958. Therefore, the old existing pipeline must be replaced sequentially in near future. However, the reconstruction works will be possible if USAG get the materials.

Regarding the replacement of existing pipeline, USAG has no schedule of reconstruction at present.

5) Service Facilities for Ger Area

Supplement of the Tank Lorries

For continuous water supply service to Ger Area, seven (7) supplementary tank lorries are required as soon as possible.

Maintenance of the Tank Lorries

Although the workshop for tank lorries is already established, however maintenance of them is now facing difficulties due to the lack of spare parts.

Important parts of the Tank Lorries

Important spare parts for tank lorries are tires and batteries which are difficult to obtain in this country. Bad road condition increases the necessity of tires.

6) Community Heating Centers (CTP)

O & M of the Facilities

O&M inside the CTP seem to be not so difficult, because the equipment are only pumps, piping and heat exchangers. However, appropriate maintenance inside the apartment buildings requires more man powers for improving the water leakage from the taps. One shift system for workers should be improved.

Emergency Power Supply System

Emergency countermeasure for power failure inside the CTP is not provided yet. It should be considered in future.

Measurement of Water Supply Quantity from USAG

Almost all flow meters installed at the boundary between CTP and USAG are already broken. They should be installed if the water tariff is to be paid according to the actual flow rate.

7) Water Supply Facilities in the Apartment

At present, consumers pay the water tariff based on the constant calculation basis (8 Tg/m^3 x 150 l/day/person) which is having no relation with the actual consumption.

In future, a tariff system based on the actual consumption should be adopted, which will cause the decrease of water leakage from the taps, and lead to the water save consciousness of the consumers and finally result in efficient use of water sources.

8) O&M Manuals and Training of Employee

O&M manuals for mechanicals and electrical equipment should be prepared. Training of employee for O&M will also be required.

9) Preparation of Spare Parts

The major spare parts of machine, electricity, and instrumentation should be prepared. Especially the bearings of pump and motor are indispensable.

2.3.6 Technical Problems of the Existing Water Supply Facilities

The followings are major technical issues related to the existing water supply facilities, and found during the course of the present Study. Among them, countermeasure works for items 1) -6) are proposed to be implemented in the emergency rehabilitation program.

On the other hand, countermeasures for items 7) -12) are recommended to be executed in the daily routine work of the USAG based on their own long term schedule.

<u>Problems to be Taken up in the Emergency Rehabilitation Program</u>

1) Damage or deterioration of the existing intake pumps.
2) Breakdown (out of service) of the existing remote operation system for intake pumps.
3) Damage of the existing distribution pumps.
4) Shortage in number of tank lorries.
5) Deterioration of the existing intake tube wells.
6) Lack and damage of water flow-rate measuring devices at CTP

<u>Problems to be Solved by the USAG in the Long Term Plan</u>

7) Lack and damage of the water flow-rate measuring devices at Apartment Buildings
8) Damage of water faucets (water taps) of consumers.
9) Wastage of water by domestic consumers.
10) Deterioration of distribution pipelines.
11) Excessive energy consumption (high electric power cost) to supply water by pumps, throughout the supply system.
12) Lack of emergency power supply facilities, such as generators.

Table 2.3.1 Groundwater Quality of Existing Water Sources

Item	UNIT	Upper Water Source			Central Water Source			Industrial Water Source			Meat Complex Water Source			Standard
		Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	
Water temperature	℃ *1	9	7	7.8	13	5	9.3			12	9	7	8.2	
	*2	11	3	5.6	12	3	7	12	6	9.7	9	5	7.3	
pH		6.8	6.6	6.7	7.2	6.6	6.8			7.7	7.1	6.7	6.9	
		8.1	6.9	7.5	8.1	6.4	7.3	7.9	7.5	7.7	7.6	6.9	7.3	
Conductivitiy	μ S/cm	70	70	70	180	70	113			60	440	360	406	
		100	50	70	220	70	120	240	110	190	490	330	410	
Turbidity	NTU													
		0	0	0	0	0	0	1	0	0.5	0	0	0	
DO	mg/l	14.5	13.8	14.1	16.1	11.5	13.2			12.6	15	12.6	13.8	
		19.9	12.7	16	19.6	10.3	14.6	17.7	12	14.1	14.5	10.5	13	
Alkali	mg/l, CaCO3	38	24	34	59	29	43			159	133	42	101	
		39	26	32	77	28	42	40	37	39	144	52	75	
SO4--	mg/l	13	0	2.8	22	0	5.3			0	75	19	51.6	500
		1	0	1	28	0	8	50	18	38.3	75	44	64.5	
Cl-	mg/l	18	5	8.2	10	4	6.6			7	37	25	29.8	350
		13.5	4.4	6.6	32	0.9	7.9	25.5	7.5	16.5	32	21	26.5	
Ca++	mg/l	1.3	0.45	1.03	1.85	0.55	1.04			0.65	3.25	2	2.39	100
		0.95	0.37	0.74	1.65	0.55	0.89	1.62	0.82	1.33	3.25	2.02	2.4	
Mg++	mg/l	7.29	1.82	4.25	35.2	1.21	6.41			12.16	10.57	4.25	7.22	30
		7.05	0.6	3.79	26.7	0.24	5.42	13.74	2.43	7.73	19.4	1.45	8.46	
TDS	mg/l	125.5	70	87.7	142.5	48.5	86.2			251	293.5	200.5	260.1	1000
		115.5	24	58.5	172	42	75.6	262.5	81	168.5	368.5	240	287.5	
Mn	mg/l													
		0.1	0	0.04	0.4	0	0.06	0.5	0.1	0.2	0.4	0	0.1	0.1
Fe	mg/l													
		0.18	0.01	0.07	0.4	0	0.06	0.2	0.04	0.1	0.07	0	0.04	0.3
Bacteria	number/l													
		0	0	0	3	0	0.2	0	0	0	1	0	0.3	
Coliform	number/l													
		0	0	0	3	0	0.2	3	0	1	5	0	0.6	3

*1 Upper row: result of Phase 1
*2 Lower row: result of Phase 2

(shaded): Exceed the standard limit for drinking water

Table.2.3.2 Groundwater Quality of Private Wells in Ger Area

Sampling date		10,Sep.	07,Sep.	07,Sep.	10,Sep.	*
Item /Location	unit	G-1	G-2	G-3	G-4	Standard
Water temperature	℃	7	6	6	11	
pH		7.1	7.4	7.4	7.3	6.5-8.5
Conductivity	μS/cm	110	110	130	55	
Turbidity	NTU	5	7	4	3	
DO	mg/l	14.5	16	13.5	13.2	
Alkali	mg/lCaCO3	161	191	235	162	
SO4--	mg/l	75	75	75	62	500
Cl-	mg/l	280	200	55	165	350
Ca++	mg/l	7.07	3.52	4.12	3.3	100
Mg++	mg/l	9.12	6.05	12.28	4.94	30
TDS	mg/l	730.5	846	1439.5	348.5	1000
NO2-	mg/l	0.016	0.027	0.33	0.003	
NO3-	mg/l	16.3	11.6	15.1	3.4	10
NH4+	mg/l	0.21	0.15	0.17	0.09	
PO4	mg/l	0.07	0.2	0.05	0.23	3.5
Cr	mg/l	0.05	0.07	0.04	0.06	0.05
Mn	mg/l	0.5	0.1	0.3	0	0.1
Fe	mg/l	1.18	0.11	0.07	0	0.3
CN	mg/l	0.001	0	0.001	0	
F	mg/l	0.03	0.49	0.2	0.65	0.7-1.5
Cu	mg/l	0.42	0.07	1.16	0.01	1
Zn	mg/l	0.56	0.03	0.17	0.03	5
Cd	mg/l	0.001	0.004	0.003	0.002	0.01
Phenol	mg/l	0.0001	0	0.0002	0.0001	0.002
Hg	mg/l	0.004	0.005	0.003	0.002	
Bacteria	number/l	1	7	5	1	
Coliform	number/l	2	12	3	9	3

Sampling location(Ger area)
G-1:Amagalan
G-2:Damba
G-3:Chingelte
G-4:Tolgoit

[shaded box] :Exceed the standard limit for drinking water

* Standard limits of drinking water in Mongolia

Table. 2.3.3 Groundwater Quality of New Test Wells

Sampling Date		19,Sep. 1994	08,Aug. 1994	07,Jul. 1994	Oct. 1994	18,Aug. 1994	13,Aug. 1994	06,Aug. 1994	03,Jul. 1994	07,Jul. 1994	28,Jul. 1994	16,Jul. 1994	09,Aug. 1994	01,Aug. 1994	26,Jul. 1994	20,Jul. 1994	
Location		A-1	A-2	A-3	A-4	B-1	B-2	B-3	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	Standard
Item	Unit																
Temperature	℃	3	4	4	2	4	6	4	3	4	4	5	3	5	4	4	
pH		7.7	8.2	7.8	8.1	8	8.1	8	7.8	7.5	7.6	7.6	7.9	8	8.1	7.9	6.5-8.5
Conductivity	μS/cm	330	400	240	340	370	420	590	160	140	210	180	260	260	250	240	
Turbidity	NTU	0	35	0	0	0	0	0	0	0	0	0	0	0	0	0	
DO	mg/l	14	6.5	12.4	3.4	12.5	13.1	12.6	14.6	17.5	13.3	14.2	9.8	10.2	10.8	11.2	
Alkali	mg/lCaCO3	133	185	201	184	197	159	171	83	50	145	47	187	55	60	55	
SO4--	mg/l	26	75	30	10	26	28	27	1	1	15	1	20	22	20	21	500
Cl-	mg/l	13.5	9.5	19.5	9.0	12.5	20	14	20	19	15.5	12	9.5	36	23.5	23	350
Ca++	mg/l	2.05	0.50	1.25	2.40	1.95	2.43	1.55	1.45	0.5	2.65	0.95	2.22	1.5	1.3	1	100
Mg++	mg/l	20.67	14.59	24.32	16.41	18.24	15.56	26.14	3.28	3.04	8.51	2.67	11.9	9.12	3.64	1.21	30
TDS	mg/l	194.5	280.5	230	212.5	221.5	232.5	306	115	95	169	85.5	183.5	175	159	146.5	1000
NO2-	mg/l	0.001	0.096	0	0	0	0.001	0.006	0.005	0.002	0.004	0.01	0.003	0.001	0.001	0.011	
NO3-	mg/l	1.5	3.1	1	0.4	2	1.9	2.9	0.8	0.7	1.1	0.6	1.6	1.1	0.4	1	10
NH4+	mg/l	0.04	1	0.07	0.18	0.11	0.15	0.36	0.13	0.08	0.14	0.18	0.09	0.15	0.2	0.14	
PO4	mg/l	0.01	0.1	1.79	0.01	0.16	0.12	2.75	0.02	0.01	0.03	0.33	0.9	0.02	0.58	0.01	3.5
Cr	mg/l	0.04	0.02	0.01	0.03	0.01	0.02	0.03	0.02	0.01	0.02	0.03	0.03	0.02	0.03	0.02	0.05
Mn	mg/l	0.1	0.2	0	0.1	0.2	0.1	0.2	0	0	0.1	0.1	0.1	0.1	0	0	0.1
Fe	mg/l	0.04	0.54	0.03	0.1	0.1	0	0.09	0.13	0.1	0.06	0.04	0	0.01	0	0.01	0.3
CN	mg/l	0.001	0.004	0	0	0.009	0	0	0.001	0.001	0	0	0.001	0	0.001	0	
F	mg/l	0.42	0.34	0.82	0.21	1.02	0.31	0.68	0.75	0.53	0.52	0.82	0.11	0.1	0.01	0	0.7-1.5
Cu	mg/l	0.04	0.47	0	0	0	0	0.08	0	0	0.01	0	0	0.02	0.03	0.03	1
Zn	mg/l	0.18	1.09	0.08	0.14	0.33	0.09	0.08	0.06	0.06	0.07	0.03	0.02	0.09	0.18	0.05	5
COD	mg/l	96	20	21	69	77	85	90	16	20	93	22	85	86	111	113	
Pb	mg/l	0.022	0.008	0.012	0.020	0.009	0.014	0.013	0.016	0.012	0.009	0.009	0.02	0.012	0.01	0.008	0.03
Cd	mg/l	0.002	0	0.002	0.003	0.001	0	0.001	0.002	0.002	0.003	0.002	0.001	0.002	0.004	0.005	0.01
Phenol	mg/l	0.0001	0	0.0005	----	0.0001	0.0002	0	0.0006	0.001	0.0001	0.0004	0.0001	0.0001	0.0001	0.0001	0.002
Hg	mg/l	0	0	0.0017	----	0.0017	0.0017	0.0034	0.007	0.0017	0.0017	0.002	0.0034	0.0017	0.0034	0.0034	
Bacteria	number/l	0	0	0	0	0	4	0	0	2	2	0	0	0	3	1	
Coliform	number/l	0	0	0	0	0	0	0	0	1	2	0	2	0	0	0	3
As	mg/l	0.008	0.010	0.012	0.010	0.008	0.012	0.021	0.009	0.008	0.011	0.01	0.022	0.011	0.012	0.011	0.05

(shaded) : Exceed the standard limit for drinking water

Table 2.3.4 River Water Quality Investigated by Mongolian Side

Terelj — Annual average

Item/Year	unit	1986	1987	1988	1989	1990	1991	1992
pH	-	7.7	7.5	7.3	7.6	7.6	7.5	7.2
Ca	mg/l	5.2	10.2	9	13.8	9.1	11.5	9.6
Mg	mg/l	1.5	4.9	4.2	3.2	2.5	2.8	2.5
SO4	mg/l	9.9	14.5	8.2	10.3	5	4.3	4.1
Cl	mg/l	1.3	3.6	7.3	10.7	3.9	3.6	5.9
TDS	mg/l	60.8	92.2	67.1	108.4	63.8	64.9	55.3
NH4	mg/l	0.9	0.4	0.4	0.4	0.8	0.4	0.6
NO2	mg/l	0.043	0.006	0.007	0.008	0.006	0.005	0.004
NO3	mg/l	0.22	0.34	0.2	0.16	0.29	0.4	0.4
P	mg/l	0.006	0.009	0.01	0.022	0.034	0.018	0.01
Fe2+3	mg/l	0.11	0.06	0.12	0.05	0.04	0.06	0.14
Cu	mg/l	0.005	0.004	0.009	0.005	0.005	0.008	0.003
Mn	mg/l	0.1	0.06	0.11	0.08	0.06	0.06	0.18
F	mg/l	0.12	0.09	0.05	0.1	0.29	0.29	0.63
Mo	mg/l				0.007	0.118	0.073	0.191
Coliform	nos/l				26	20	22	

Ulaanbaatar — Annual average

Item/Year	unit	1986	1987	1988	1989	1990	1991	1992
pH	-	7.6	7.5	7.1	7.6	7.7	7.7	7.3
Ca	mg/l	7.6	12.7	10.7	10.9	9.6	12.4	8.7
Mg	mg/l	1.1	4.4	3	2.2	2.2	2.3	2
SO4	mg/l	9.9	20.5	3.2	2.9	4.5	6.1	1.7
Cl	mg/l	2.6	3.8	8.6	9.4	3.7	4.7	9.2
TDS	mg/l	80.7	93.2	68.3	74.2	57.1	81.9	64.2
NH4	mg/l	0.4	0.7	0.4	0.3	0.4	0.6	0.6
NO2	mg/l	0.007	0.005	0.007	0.005	0.003	0.017	0.011
NO3	mg/l	0.22	0.19	0.16	0.23	0.31	0.25	0.6
P	mg/l	0.007	0.038	0.008	0.025	0.012	0.018	0.059
Fe2+3	mg/l	0.23	0.07	0.12	0.05	0.04	0.05	0.17
Cu	mg/l	0.002	0.009	0.004	0.003	0.007	0.015	0.002
Mn	mg/l	0.11	0.07	0.07	0.06	0.31	0.28	0.37
F	mg/l	0.07	0.08	0.1	0.17	0.31	0.28	0.37
Mo	mg/l				0.006	0.04	0.092	0.14
Coliform	nos/l				12	12		

Altanbulag — Annual average

Item/Year	unit	1986	1987	1988	1989	1990	1991	1992
pH	-	7.7	7.6	7.3	7.6	7.7	7.6	7.2
Ca	mg/l	16.7	24.7	26.3	29.7	24.3	18	20.5
Mg	mg/l	3.4	5.3	7.2	6.1	5.5	3.6	4.5
SO4	mg/l	31	37.1	48.4	80.5	47	26.5	33.9
Cl	mg/l	41.1	24.2	37.4	55	41.1	36.6	29.1
TDS	mg/l	197.1	193	151.5	345.2	232.6	133.1	207.3
NH4	mg/l	2.7	2.5	3.5	4.8	7	6.8	6.3
NO2	mg/l	0.062	0.099	0.056	0.246	0.359	0.122	0.048
NO3	mg/l	0.22	0.59	0.29	0.76	1.61	0.81	1.86
P	mg/l	0.086	0.264	0.203	0.572	0.382	0.234	0.411
Fe2+3	mg/l	0.42	0.14	0.16	0.11	0.08	0.07	0.26
Cu	mg/l	0.009	0.011	0.011	0.002	0.004	0.025	0.006
Mn	mg/l	0.13	0.4	0.09	0.17	0.12	0.08	0.26
F	mg/l	0.15	0.13	0.24	0.21	0.28	0.35	0.34
Mo	mg/l				0.035	0.108	0.017	0.173
Coliform	nos/l				35	33	29	

Table 2.3.5 Seasonal Change of River Water Quality

Season		1	2	3	4	
Item	Location	Jan.-Mar.	Apr.-Jun.	Jul.-Sep.	Oct.-Dec.	Unit
Cl	Terelj	6	5.9	4.3	4.5	mg/l
	Ulaanbaatar		5.9	6.1	5.9	
	Altanbulag	120	23.4	8.4	40.5	
SO4	Terelj	18.8	8	6.1	3.1	mg/l
	Ulaanbaatar	13.6	8.9	5.5	3.9	
	Altanbulag	96.6	33.5	10.3	33.4	
P	Terelj	0.028	0.013	0.009	0.022	mg/l
	Ulaanbaatar	0.011	0.022	0.029	0.007	
	Altanbulag	0.759	0.165	0.033	0.4	
NH4	Terelj	0.41	2.2	0.71	0.39	mg/l
	Ulaanbaatar	0.45	0.56	0.5	0.19	
	Altanbulag	11.2	7.1	0.93	5.03	

Note : The values are an average of seven years.

Table 2.3.6 River Water Quality Analized by JICA Study Team

Location		R-1			R-2			R-3			
Item	Unit	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Standard
Water temperature	℃	15	7	11	22	3	12.6	22	7	14	
pH		8.3	7.1	7.8	8.7	7.3	8.1	9	7.8	8.3	6.5-8.5
Conductivity	µS/cm	80	50	68	100	80	88	220	120	154	
Turbidity	NTU	7	0	2	9	0	4	48	0.9	19	
DO	mg/l	16.1	12.7	14.2	17.3	10.6	14	14.8	10.6	12.4	
Alkali	mg/l$CaCO_3$	70	27	41	43	6	31	73	14	45	
SO_4^{--}	mg/l	3	0	1.2	7	1	4	75	7	45	500
Cl^-	mg/l	31.5	5	12.7	29	5	12.8	40	10	17.5	350
Ca^{++}	mg/l	0.95	0.47	0.62	0.95	0.5	0.72	2.12	0.9	1.4	100
Mg^{++}	mg/l	8.75	1.89	4.56	7.9	0.97	4.17	16.4	3.64	8.6	30
TDS	mg/l	75	47	61	87.5	52	70.1	144.5	96.3	117.3	1000
NO_2^-	mg/l	0.005	0.001	0	0.03	0.001	0.01	0.215	0.023	0.09	
NO_3^-	mg/l	1.1	0.5	0.8	1.6	0.7	1.1	7.6	1.1	4.3	10
NH_4^+	mg/l	0.17	0.01	0.1	0.2	0.05	0.13	2.75	0.27	1.01	
PO_4	mg/l	2.75	0.01	0.71	2.46	0	0.95	2.64	0.15	1.18	3.5
Cr	mg/l	0.02	0.01	0.01	0.05	0	0.03	0.06	0.04	0.05	0.05
Mn	mg/l	0.2	0	0.1	0.4	0	0.1	0.5	0.1	0.2	0.1
Fe	mg/l	0.12	0.02	0.06	0.25	0.03	0.11	0.55	0.05	0.19	0.3
F	mg/l	1.18	0.05	0.58	1.19	0.03	0.67	1.21	0.21	0.57	0.7-1.5
Cu	mg/l	0.04	0	0.02	0.07	0	0.02	0.15	0	0.05	1
Zn	mg/l	0.07	0.02	0.04	0.12	0.01	0.04	0.26	0	0.1	5
COD	mg/l	21	0	8	70	0	28	115	0	41	
Bacteria	number/l	4	0	2	9	0	3	26	1	10	
Coliform	number/l	4	0	1	22	0	5	26	1	9	3

Standard:Standard limits for drinking water in Mongolia

R-1:Terelj bridge

R-2:Zaisan bridge

R-3:Chicken factory bridge

(shaded) : Exceed the standard limits for drinking water

Table 2.3.7 (1) **River Water and Groundwater Qualities of Upper Water Source Area**

Item	River Water (R-1)			Groundwater		
	All season	Dry season	Wet season	All season	Dry season	Wet season
Water temperature	11	7	12	6.4	3.7	6.7
pH	7.8	7.1	7.9	7.2	7.1	6.7
Conductivity	68		6.8	70	73	66
Turbidity	2	0	3	0	0	0
DO	14.2	16.1	13.8	15.3	19.5	13.4
Alkali	41	27	45	32.5	33	30
SO4--	1.2	0	1.5	1.2	0	1
Cl-	12.7	5	14.6	7.1	5	7.2
Ca++	0.62	0.47	0.66	0.8	0.5	0.85
Mg++	4.56	3.64	4.79	4	4.29	3.67
TDS	61	75	57	68.8	91	61
Mn	0.1	0.2	0.1	0	0.1	0.1
Fe	0.06	0.07	0.06	0.1	0.06	0.03
Bacteria	2	0	2	0	0	0
Coliform	1	0	2	0	0	0

Table 2.3.7 (2) River Water and Groundwater Qulaities of Central Water Source Area

Item	River water (R-2)			Groundwater		
	All season	Dry season	Wet season	All season	Dry season	Wet season
Water temperature	12.6	3	15	7.6	5.6	8.4
pH	8.1	7.3	8.3	7.2	6.9	7.3
Conductivity	88		88	118.2	126	115
Turbidity	4	0	5	0	0	0
DO	14	17.3	13.2	14.3	16	13.6
Alkali	31		31	43	15	44
SO4--	4		3.5	7.7	5.5	6.7
Cl-	12.8	9	13.8	7.6	5.5	8.3
Ca++	0.72	0.95	0.66	0.93	0.79	0.97
Mg++	4.17	3.64	4.3	5.68	6.54	5.24
TDS	70.1	87.5	66	78.3	62	85
Mn	0.1	0.4	0.1	0.1	0.1	0.1
Fe	0.11	0.09	0.11	0.06	0.07	0.03
Bacteria	3	1	3	0.2	1	1
Coliform	5	1	7	0.2	1	1

Table 2.3.7 (3) **River Water and Groundwater Qualities of Meat Complex and Industrial Water Source Area**

Item	River Water (R-3)			Groundwater of Meat Complex Source			Groundwater of Industries source		
	All season	Dry season	Wet season	All season	Dry season	Wet season	All season	Dry season	Wet season
Water temperature	14	7	15.8	7.5	6	8.1	10.3	6	11.7
pH	8.3	7.8	8.4	7.2	7	7.2	7.7	7.5	7.7
Conductivity	154	140	158	411	402	414	163	240	137
Turbidity	19		19	0	0	0	0.5		0.3
DO	12.4	14.8	11.8	13.2	13.6	13.1	13.7	17.7	12.4
Alkali	45		45	82	62	89	44	39	45
SO4--	45	59	42	61	69	58	29	47	23
Cl-	17.5	40	11.9	27.4	25	28	14.1	16.5	13
Ca++	1.4	2.12	1.22	2.39	2.15	2.48	1.16	1.62	1.01
Mg++	8.6	16.4	6.66	8.13	3.57	9.76	8.84	7.01	9.44
TDS	117.3		117	280.5	247	292	189.1	262.5	164.7
Mn	0.2	0.1	0.2	0.1	0.1	0.1	0.2	0.5	0.1
Fe	0.19	0.07	0.23	0.04	0.02	0.03	0.1	0.2	0.03
Bacteria	10	1	12	0.3	1	1	0	0	0
Coliform	9	1	11	0.6	1	1	1	0	1

Note : All season : All average
Dry season : From Dec. to Apr.
Wet season : From May to Nov.
The Values of groundwater quality is an average of all wells in an each water source.

Table 2.3.8 Water Quality of Reservoir Water Analyzed by USAG

Location / Items	Unit	Upper Water Source	Central Water Source	Industries Water Source	Meat Comply Water Source	Standard
NH_4	mg/l	0.036	0.01	0.006	0.017	
NO_2	mg/l	0.002	0	0	0.001	
NO_3	mg/l	1.38	2.47	3.41	10.59	10
Fe	mg/l	0.098	0.045	0.028	0.091	0.3
Hardness	mg/l	0.73	0.96	2.65	3.16	
Ca	mg/l	0.52	0.78	2.26	2.49	100
Mg	mg/l	2.71	2.11	4.59	8.16	30
Cl	mg/l	6	6.9	26.5	29.8	350
TDS	mg/l	63.7	75.4	225.7	271.3	1000
SO_4	mg/l	11.3	8.7	62.5	57.2	500
DO	mg/l	2.24	2.16	0.8	0.8	
Residual Cl_2	mg/l		0.39	0.61	0.63	
Mn	mg/l	0	0.11	0.01	0.005	0.1
F	mg/l	0.11	0.16	0.8	0.2	0.7-1.5
pH	-	6.9	6.9	6.9	6.9	6.5-8.5

Standard : Standard for drinking water in Mongolia
Data Source : USAG
Investigation Data : During three (3) years from 1991 to 1993

Table 2.3.9 Standard of Water Quality for Drinking Water in Mongolia and *WHO

		Standard	
Item	unit	Mongolia	WHO
Color	TCU	20	15
Odour		2	-
Taste		2	-
Perspective	cm	>30	-
Ca^{++}	mg/l	100	-
Mg^{++}	mg/l	30	-
Hardness	mg/l	-	-
Cl^-	mg/l	350	250
NH_4	mg/l	-	1.5
NO_2	mg/l	-	3
NO_3	mg/l	10	50
pH		6.5 - 8.5	-
Fe	mg/l	0.3	0.3
SO_4	mg/l	500	250
TDS	mg/l	1,000	1,000
PO_4	mg/l	3.5	-
Mn	mg/l	0.1	0.1
Cu	mg/l	1.0	1.0
Pb	mg/l	0.03	0.01
F	mg/l	0.7 - 1.5	1.5
Mo	mg/l	0.25	0.07
Zn	mg/l	5.0	3.0
Residual Cl_2	mg/l	-	-
Coliform	Number/l	3	**
Be	mg/l	0.0002	-
Cd	mg/l	0.01	0.003
Ag	mg/l	0.05	-
Se	mg/l	0.001	0.01
St	mg/l	2.0	-
Cr	mg/l	0.05	0.05
Al	mg/l	0.5	0.2
As	mg/l	0.05	0.01
CN	mg/l	0.01	0.07
Phenol	mg/l	1.5	-
Turbidity	NTU	-	5

* Refer to Table 2.3.10

** Refer to Bacteriological Quality in Table 2.3.10

Table 2.3.10 WHO Guideline for Drinking Water

Item	Values
I. Bacteriological Quality [i]	
All water intended for drinking	
E. coli or thermotolerant coliform bacteria [ii, iii]	Must not be detectable in any 100-ml sample
Treated water entering the distribution system	
E. coli or thermotolerant coliform bacteria [ii]	Must not be detectable in any 100-ml sample
Total coliform bacteria	Must not be detectable in any 100-ml sample
Treated water in the distribution system	
E. coli or thermotolerant coliform bacteria [ii]	Must not be detectable in any 100-ml sample
Total coliform bacteria	Must not be detectable in any 100-ml sample. In the case of large supplies, where sufficient samples are examined, must not be present in 95% of samples taken throughout any 12-month period

(i) Immediate investigative action must be taken if either E. coli or total coliform bacteria are detected. The minimum action in the case of total coliform bacteria is repeat sampling; if these bacteria are detected in the repeat sample, the cause must be determined by immediate further investigation.

(ii) Although E. coli is the more precise indicator of faecal pollution, the count of thermotolerant coliform bacteria is an acceptable alternative. If necessary, proper confirmatory tests must be carried out. Total coliform bacteria are not acceptable indicators of the sanitary quality of rural water supplies, particularly in tropical areas where many bacteria of no sanitary significance occur in almost all untreated supplies.

(iii) It is recognized that, in the great majority of rural water supplies in developing countries, faecal contamination is widespread. Under these conditions, the national surveillance agency should set medium-term targets for the progressive improvement of water supplies, as recommended in Volume 3 of Guidelines for drinking-water quality.

Item	Values	Remarks
II. Inorganic Constituents of Health Significance	mg/l	
Arsenic	0.01 b(P)	For excess skin cancer risk of 6×10^{-4}
Cadmium	0.003	
Chromium	0.05(P)	
Cyanide	0.07	
Fluoride	1.5	Climatic conditions, volume of water consumed, and intake from other souses should be considered when setting national standards
Lead	0.01	It is recognized that not all water will meet the guideline value immediately; meanwhile, all other recommended measures to reduce the total exposure to lead should be implemented
Mercury	0.001	
Molybdenum	0.07	
Nitrate (as NO_3)	50	The sum of the ratio of the concentration of each to its respective guideline value should not exceed 1
Nitrate (as NO_2)	3	
Selenium	0.01	

Item	Values	Remarks and Reasons
III. Organic Constituents of Health Significance	μg/l	
Benzene	10 b	For excess risk of 10^{-5}
Chlorinated Alkanes and Alkenes		
Carbon Tetrachloride	2	
1, 2-Dichloroethane	30 b	For excess risk of 10^{-5}
1, 1-Dichloroethylene		NAD
Tetrachloroethylene	40	
Trichloroethylene	70(P)	
Chlorophenols		
Pentachlorophenol	9(P)	
2, 4, 6-Trichlorophenol	200 b	For excess risk of 10^{-5}
Polynuclear Aromatic Hydrocarbons		
Benzo (a) phrene	0.7 b	For excess risk of 10^{-5}
Trihalomethanes		
Chloroform	200 b	For excess risk of 10^{-5}
Pesticides		
Aldrin/Dieldrin	0.03	
Chlordane	0.2	
2,4 D	30	
DDT	2	
Heptachlor and Heptachlor Epoxide	0.03	
Hexachlorobenzene	1 b	For excess risk of 10^{-5}
lindane	2	
Methoxychlor	20	
IV. RADIOACTIVE MATERIALS	Bq/l	
Gross alpha activity	0.1	If a screening value is exceeded, more detailed radionuclide analysis is necessary.
Gross beta activity	1	Higher values do not necessarily imply that the water is unsuitable for human consumption
V. AESTHETIC QUALITY	mg/l	
Aluminum	0.2	Depositions, discoloration
Ammonia	1.5	Odour and taste
Chloride	250	Taste, corrosion
Copper	1.0	Staining of laundry and sanitary ware
Hardness	-	High hardness: scale deposition, scum formation Low hardness: possible corrosion
Iron	0.3	Staining of laundry and sanitary ware
Manganese	0.1	Staining of laundry and sanitary ware
Sodium	200	Taste
Sulphate	250	Taste, corrosion
Total Dissolved Solids	1000	Taste
Zinc	3	Appearance, teaste
Colour	15 TCU	Appearance
Taste and Odour	-	Should be acceptable
Turbidity	5 NTU	Appearance; foe effective terminal disinfection, median turbidity <= 1NTU, single sample <= 5NTU
pH	-	Low pH: Corrosion, High pH: Taste, soapy feel Preferably < 8.0 for effective disinfection with chlorine

(P) : Provisional guideline value.
b : For substances that are considered to be carcinogenic, the guideline value is the concentration in drinking-water associated with an excess lifetime cancer risk of 10^{-5} (one additional cancer per 100,000 of the population ingesting drinking-water containing the substance at the guideline value for 70 years).
NAD : No adequate data to permit recommendation of a health-based guideline value.
TCU : time colour unit
NTU : nephelometric turbidity unit

Table 2.3.11 Water Quality of Reservoir Water Analyzed by JICA Study Team

Location		Upper Water Source			Central Water Source			North-East			Tasgan			North-West			Industrial Water Source			Meat Complex Water Source		
Item	Unit	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.
Water temperture	℃	10	6	8.4	11	4	7.5	13	8	10.8	11	5	8.2	13	6	9.6	11	7	9.8	10	8	8.7
pH		7.8	6.5	7.3	7.6	6.3	7	7.7	7.1	7.4	7.8	7.1	7.3	7.5	6.7	7.2	7.8	6.7	7.3	7.5	6.8	7.1
Conductivity	μS/cm	90	60	72.5	130	100	114	110	80	100	110	100	103	140	110	125	290	230	258	440	380	410
Turbidity	NTU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DO	mg/l	17.5	12.4	14.7	16.8	12.6	14.8	15.9	11.2	13.6	16.7	11.9	14.2	16.7	11.2	13.4	15.4	11.7	13	17.1	11.8	13.7
Alkali	mg/lCaCO$_3$	54	0.28	35.5	68	15	44.6	45	39	42.6	44	32	37.6	46	30	40	67	14	50	90	23	74
SO_4^{--}	mg/l	45	0	18.2	16	3	10.3	10	0	5.8	27	0	13	17	0	12.6	61	20	43	70	49	64.7
Cl^-	mg/l	11	5	6.8	13	6.5	8.7	12.5	7	9.1	12	7	9.2	15.5	6.5	10.7	32	12	21.8	38	30	33.8
Ca^{++}	mg/l	1.57	0.5	0.82	0.95	0.75	0.86	0.92	0.4	0.7	1.05	0.77	0.9	1.35	0.6	0.87	1.6	1.32	1.48	2.62	1.3	2.19
Mg^{++}	mg/l	10.7	1.45	4.86	10.09	1.21	4.09	5.47	3.04	4.27	5.9	1.21	3.51	9.97	0.24	4.13	13	2.06	6.05	19.45	1.21	9.55
TDS	mg/l	67	47.5	54.5	90	50.5	72.4	65.5	52.4	59	72.2	51	58.8	89.5	58.5	69.4	292	86.7	193.7	328	89.4	258.3
NO_2^-	mg/l	0.005	0	0.002	0.004	0.001	0.003	0.009	0	0.003	0.008	0	0.003	0.005	0.001	0.002	0.005	0	0.002	0.01	0.001	0.004
NO_3^-	mg/l	1.8	0.4	0.8	1.9	0.5	1.1	1.3	0.4	0.8	2	0.4	1	3.1	0.2	1.2	1.8	0.3	1	9.1	1.4	3.2
NH_4^+	mg/l	0.15	0	0.08	0.18	0	0.1	0.16	0	0.09	0.16	0	0.08	0.2	0	0.11	0.17	0.03	0.1	0.19	0.05	0.12
PO_4	mg/l	2.75	0.02	1.14	2.75	0.01	1.04	1.8	0.02	0.41	2.75	0.05	0.74	1.92	0.03	0.78	2.4	0.01	0.84	1.33	0.03	0.41
Cr	mg/l	0.02	0	0.01	0.06	0	0.02	0.03	0	0.02	0.08	0	0.03	0.04	0	0.02	0.04	0.01	0.02	0.04	0	0.02
Mn	mg/l	0.2	0	0.04	0.2	0	0.07	0.6	0	0.18	0.3	0	0.14	0.4	0	0.16	0	0	0	0.2	0	0.13
Fe	mg/l	0.08	0	0.04	0.11	0	0.05	0.22	0.02	0.1	0.38	0.04	0.22	0.25	0.03	0.12	0.2	0.01	0.06	0.3	0.03	0.1
F	mg/l	1.7	0	0.8	1.84	0.1	0.8	1.23	0.14	0.65	1.5	0.12	0.83	1.14	0.5	0.83	1.83	0.46	1.09	1.13	0	0.61
Cu	mg/l	0.02	0	0.01	0.03	0	0.01	0.04	0	0.02	0.01	0	0.01	0.08	0	0.03	0.03	0	0.01	0.03	0	0.01
Zn	mg/l	0.07	0	0.03	0.25	0	0.06	0.04	0	0.02	0.07	0	0.03	0.02	0	0.01	0.2	0	0.08	0.29	0	0.07
COD	mg/l	19	0	8	17	0	10	21	0	10	22	0	10	16	0	9	20	0	13	99	0	34
Residual Cl_2	mg/l	0.8	0	0.2	0.05	0.01	0.03	2.2	0	0.53	1.94	0	0.55	1.77	0	0.41	0.2	0.01	0.06	0.2	0.02	0.06
Coliform	Number/l	0	0	0	1	0	1	3	0	1	1	0	1	0	0	0	0	0	0	11	0	2
Bacteria	Number/l	1	0	1	1	0	1	1	0	1	11	0	3	1	0	1	7	0	1	35	0	6

(shaded) Exceed the standard limit for drinking water

Table 2.3.12 Water Quality of Tap Water, Water Service Station and Water Vending Center

Location		Tap Water of Anal Hotel			Tap Water of TPD			Tap Water of USAG			Water Service Station			Water Vending Center		
Item	Unit	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.
Water temperture	℃	12	8	10.4	14	11	12.2	15	8	11.4	10	8	9.6	11	10	10.3
pH		7.5	7.2	7.3	7.7	7	7.3	7.5	6.5	7.1	7.4	6.5	6.9	7.5	6.6	7.1
Conductivity	μS/cm	110	100	105	120	100	108	140	100	113	260	100	145	100	100	100
Turbidity	NTU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DO	mg/l	18.7	10.9	13.9	17.1	10.4	13.4	16.4	10.3	13.2	17.8	11.9	14	13.3	11.1	12.4
Alkali	mg/l$CaCO_3$	37	5	23.4	92	15	45.4	44	7	28	48	10	28	44	12	27.3
SO_4--	mg/l	27	0	9	19	0	5.4	28	1	9.4	45	1	14.8	21	2	11.5
Cl^-	mg/l	10.5	0	6.5	11	0	6.2	9	0	4.3	12	1	6.8	11.5	1	6.3
Ca^{++}	mg/l	0.9	0.55	0.77	0.9	0.5	0.71	0.97	0.55	0.8	0.85	0.55	0.74	1	0.42	0.74
Mg^{++}	mg/l	7.9	1.24	3.94	4.25	0.6	2.2	3.04	0.6	1.82	3.04	1.05	2.22	3.4	0.97	2.19
TDS	mg/l	94	58.5	72.9	99.5	48.5	71.2	67.5	54.3	60.3	243.5	72	113.5	96	61.5	74.9
NO_2-	mg/l	0.003	0	0.001	0.003	0.002	0.002	0.008	0.001	0.003	0.003	0	0.001	0.002	0	0.001
NO_3-	mg/l	1.4	0.2	1	0.9	0.4	0.8	1.9	0.5	1	1.6	0.4	0.9	1.3	0.5	0.9
NH_4+	mg/l	0.13	0.01	0.07	0.11	0.01	0.07	0.12	0	0.06	0.12	0	0.06	0.1	0	0.05
PO_4	mg/l	0.19	0	0.07	0.09	0	0.04	0.55	0.01	0.16	1.58	0	0.4	2.56	0	0.77
Cr	mg/l	0.02	0.01	0.01	0.03	0	0.01	0.05	0.01	0.02	0.05	0.01	0.03	0.05	0.01	0.03
Mn	mg/l	0.5	0	0.1	0.1	0	0.02	0.1	0	0.04	0.1	0	0.02	0.1	0	0.03
Fe	mg/l	0.07	0	0.04	0.08	0.02	0.06	0.78	0.06	0.25	0.13	0.01	0.07	0.13	0.01	0.06
CN	mg/l	0	0	0	0.001	0	0	0.001	0	0	0.001	0	0	0.001	0.001	0.001
F	mg/l	1.33	0.1	0.49	1.5	0.1	0.6	1.22	0.01	0.46	0.74	0.17	0.34	0.32	0.06	0.21
Cu	mg/l	0.09	0.01	0.03	0.02	0	0.01	0.04	0	0.01	0.04	0	0.02	0.04	0	0.02
Zn	mg/l	0.14	0.01	0.06	0.27	0.01	0.09	0.14	0	0.05	0.15	0	0.04	0.09	0	0.05
Cd	mg/l	0.005	0.001	0.003	0.005	0.001	0.003	0.01	0.002	0.005	0.009	0.001	0.004	0.005	0.003	0.004
Phenol	mg/l	0.0001	0	0	0.002	0.0002	0.001	0.0001	0	0	0.0001	0	0	0.0001	0.0001	0
Hg	mg/l	0	0	0	0.0017	0	0.001	0.0017	0	0.001	0.0017	0.0017	0.002	0.0017	0	0.001
Residual Cl_2	mg/l	0.05	0	0.02	0.06	0	0.03	0.03	0.02	0.02	0.04	0.01	0.02	0.04	0.01	0.02
Coliform	number/l	11	0	2	15	0	3	3	0	1	3	0	1	2	0	1
Bacteria	number/l	3	0	1	29	0	6	2	0	1	1	0	1	1	0	1

Table 2.3.13 Profit and Loss Statement of USAG

(Unit :1,000Tg.) (Unit : %)

	1990	1991	1992	1993	1993	
Water Supply				479,890	55%	
Sewerage				399,835	45%	
Total Income	70,311	105,526	128,627	879,725	100%	
Water Supply				530,575		65.87%
Sewerage				274,863		34.13%
Total Expenditure	31,929	54,077	105,126	805,438	91.56%	100.00%
Salary	4,940	11,758	25,029	95,544		11.86%
Social Insurance	469	1,629	3,379	10,506		1.30%
Power	12,601	22,553	37,254	502,221		62.35%
Heating	488	599	1,900	6,718		0.83%
Oil & Coal	211	500	13,501	76,900		9.55%
Office Exp. & Tel.	38	42	201	1,738		0.22%
Assignment Exp.	0	0	0	1,055		0.13%
Labour Safety	49	159	0	0		0.00%
Material	668	417	1,785	3,138		0.39%
Spare Parts	0	0	0	17,682		2.20%
Low-Cost Items	0	0	0	4,774		0.59%
Operation Exp.	0	0	0	2,310		0.29%
Guards	1,274	1,100	2,200	3,718		0.46%
Others	389	270	1,222	7,165		0.89%
Production Unit	1,525	2,919	0	0		0.00%
Depreciation Cost	9,192	12,053	18,391	69,753		8.66%
Dep.Spare Parts	85	78	264	0		0.00%
Dep.Low-Cost Items	0	0	0	2,216		0.28%
Profit before Tax	38,382	51,449	23,501	74,287	8.44%	
Other Income(+)				486		100.00%
Management Exp.:(-)	348	581	0	7,666		10.32%
Transport. Tax:(-)	3,306	4,330	1,192	1,240		1.67%
Sales Tax:(-)	21,828	0	0	0		0.00%
Penalty:(-)	-1	0	959	0		0.00%
Profit Tax:(-)	10,929	37,270	16,706	26,347		35.47%
Net Profit	1,972	9,268	4,644	39,521		53.20%

Source : USAG 1993 & 1994

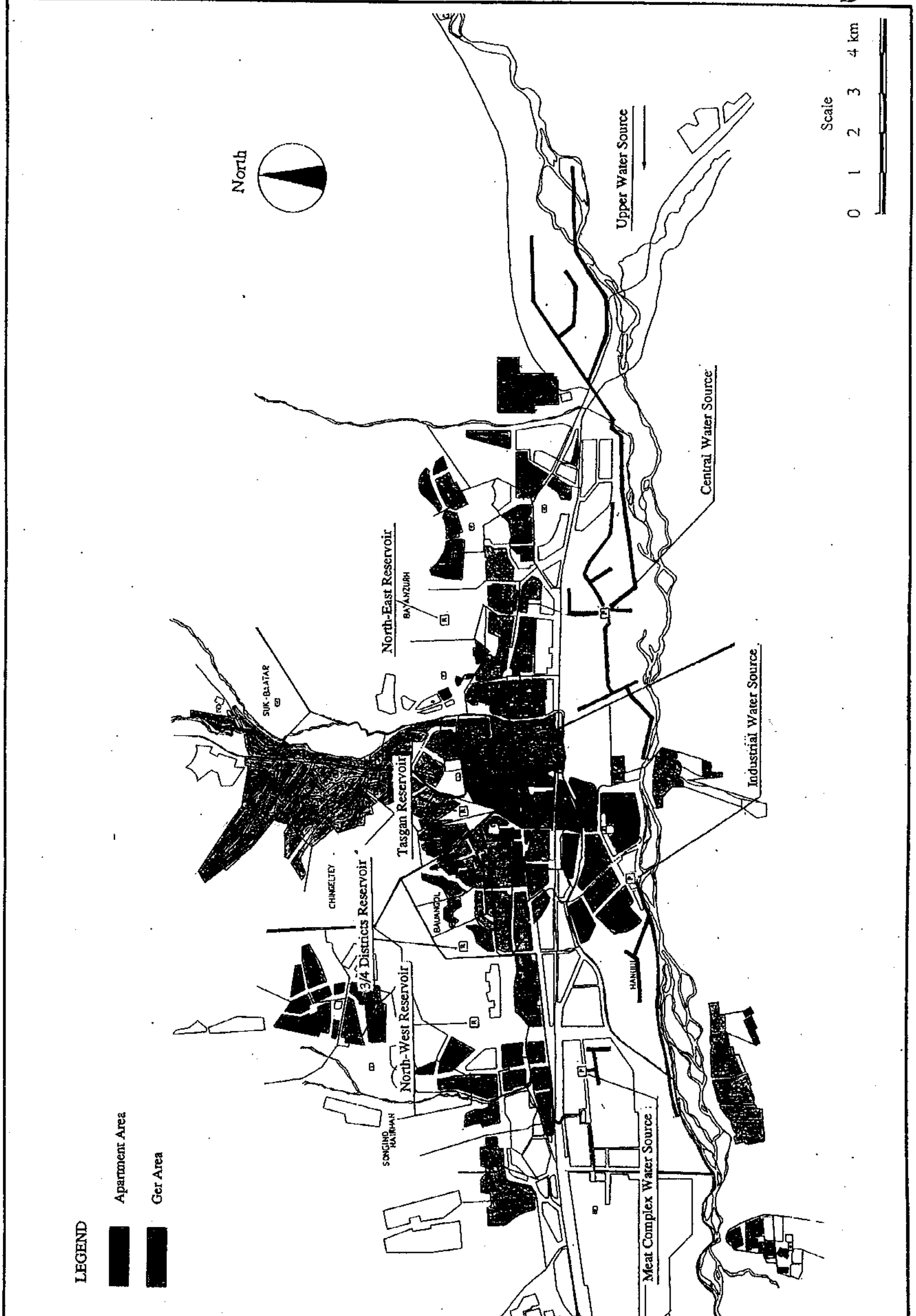
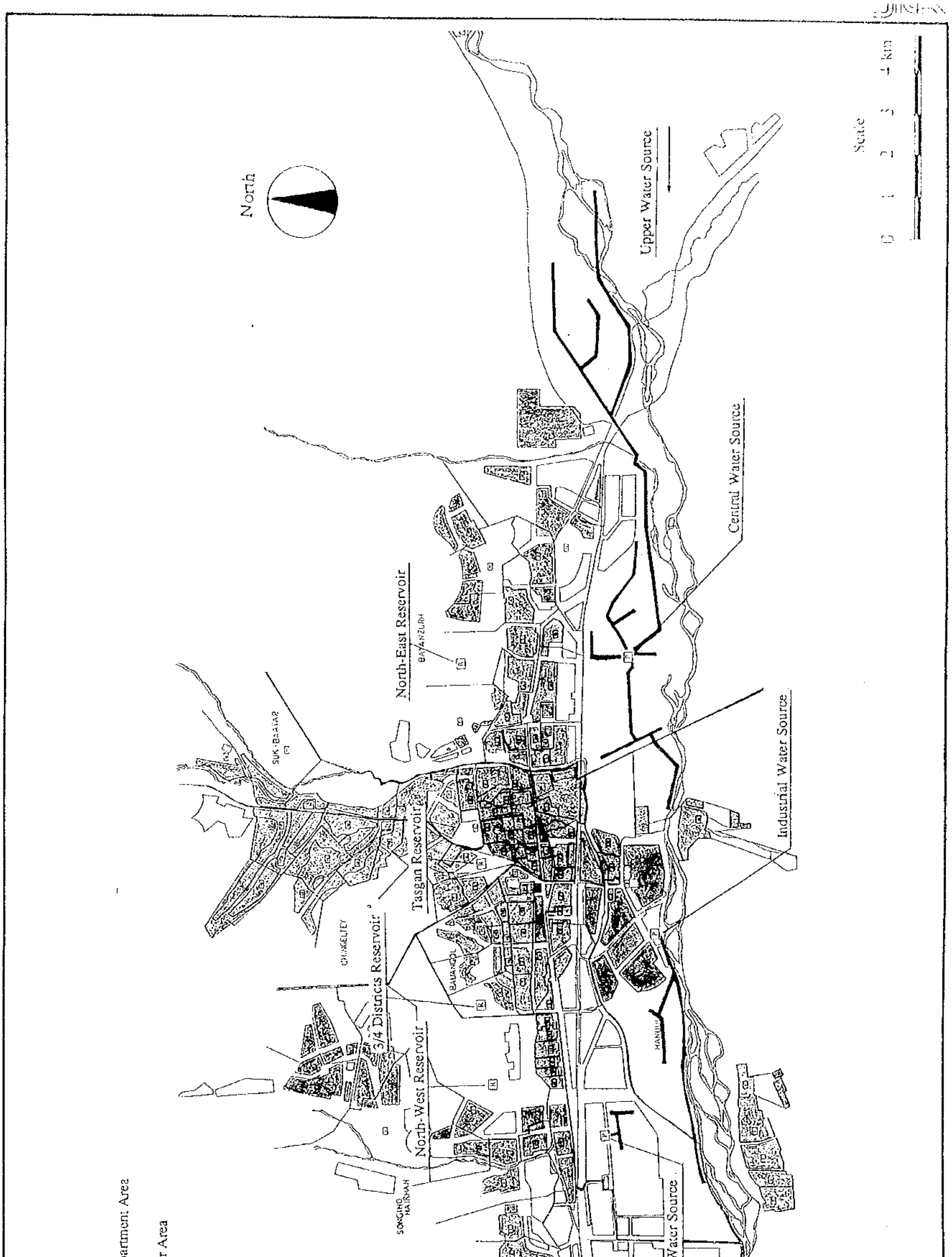


Fig. 2.3.1 Service Area by the USAG Water Supply System at Present (excluding the six districts outside of central city area)

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings



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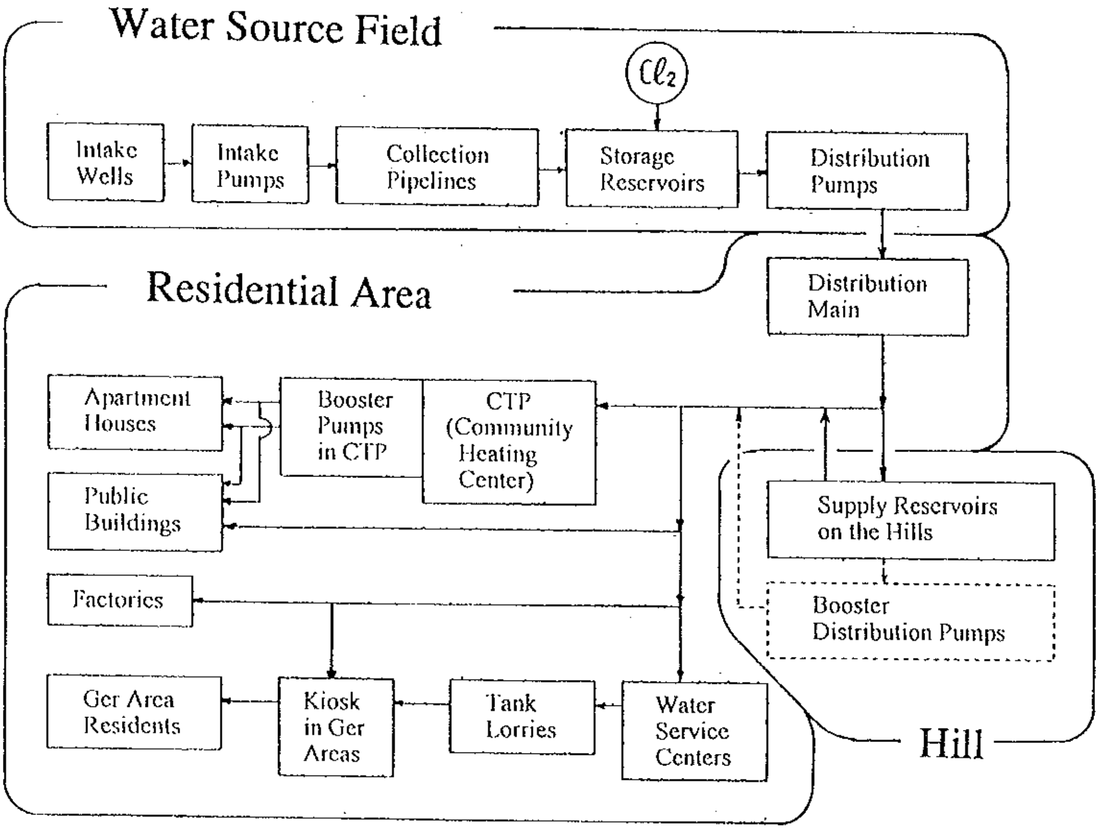

Fig. 2.3.2 Flow Chart of Water Supply System in Ulaanbaatar City

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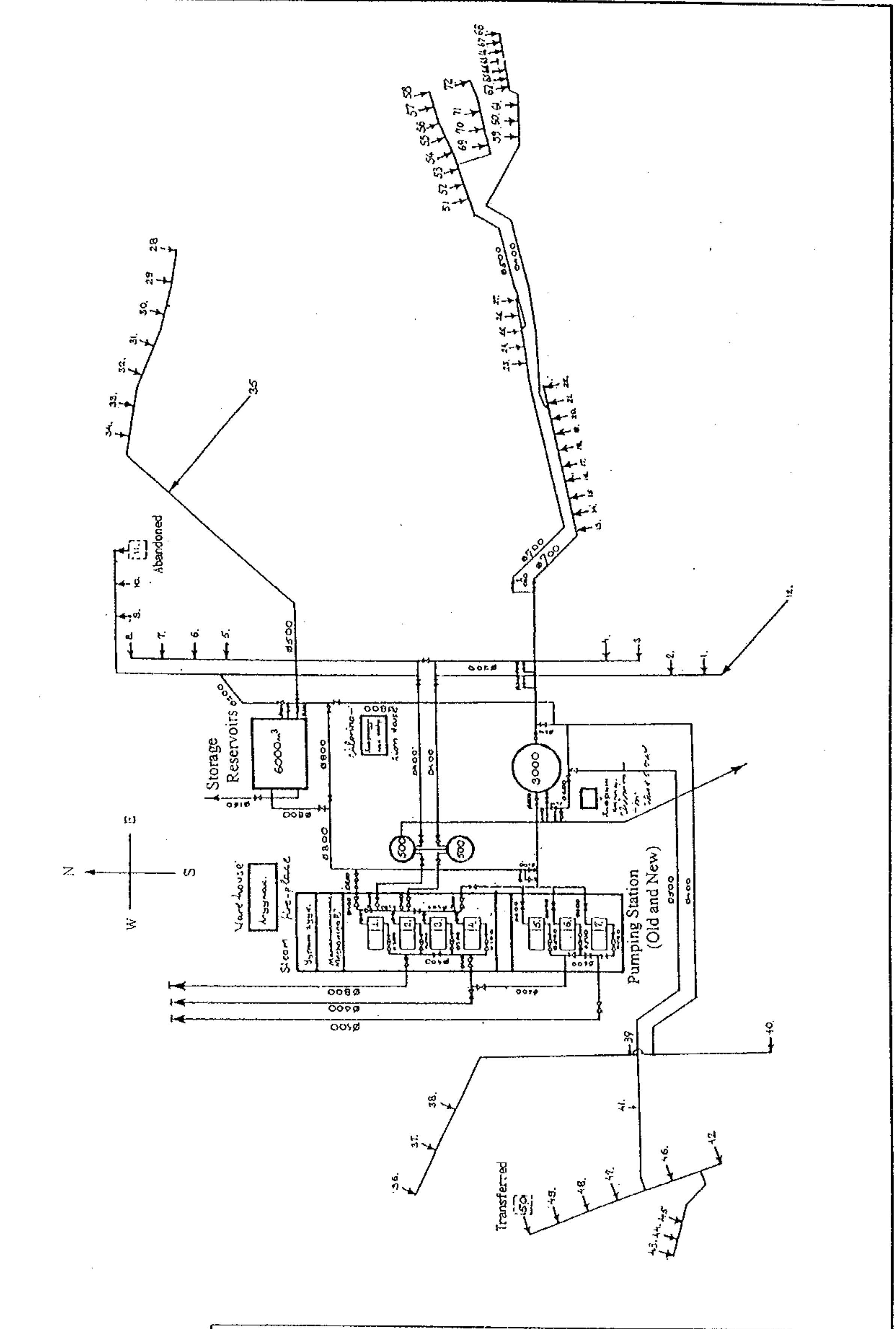

Fig. 2.3.3 Schematic Layout of Central Water Source

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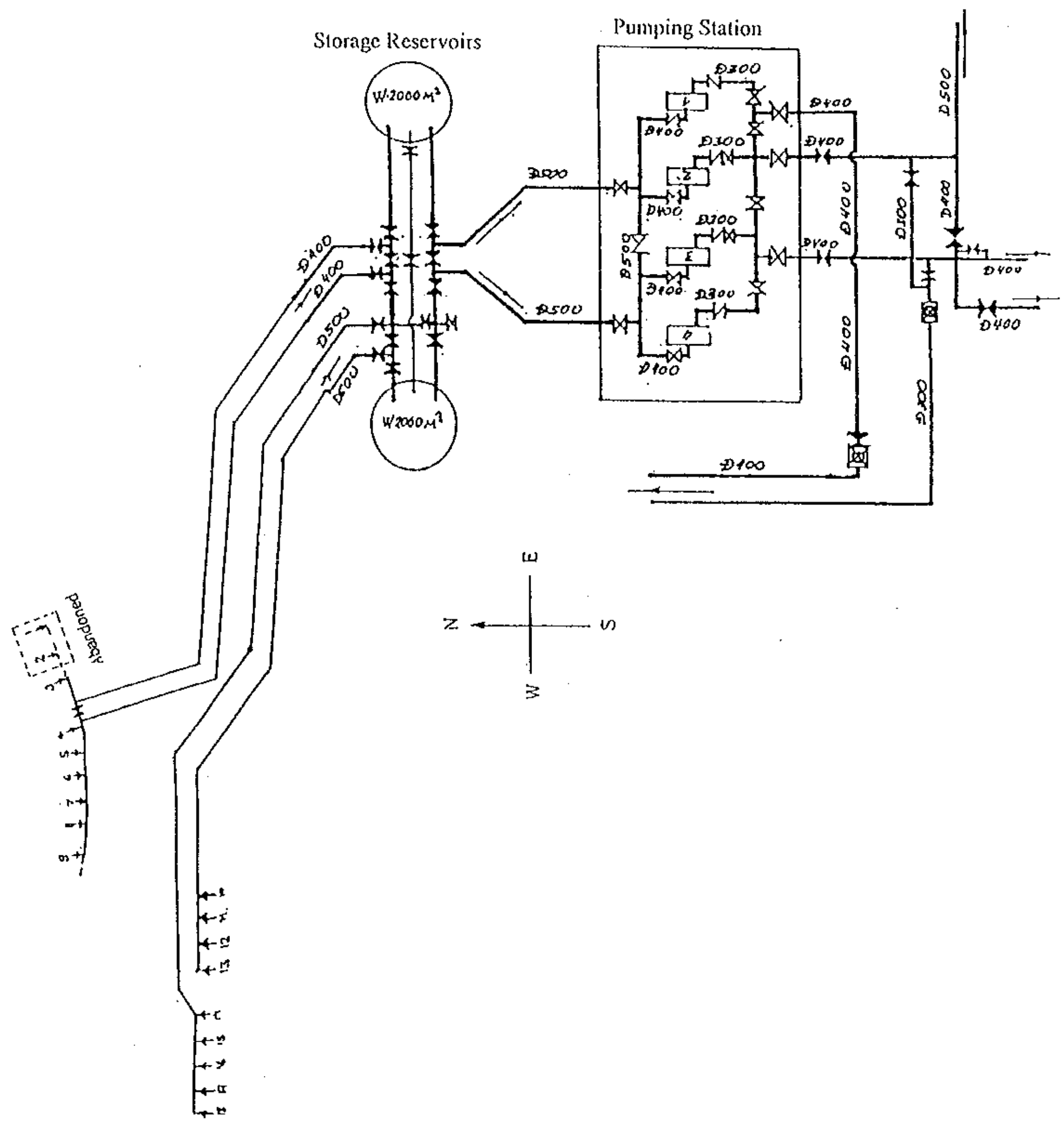

Fig. 2.3.4 Schematic Layout of Industrial Water Source

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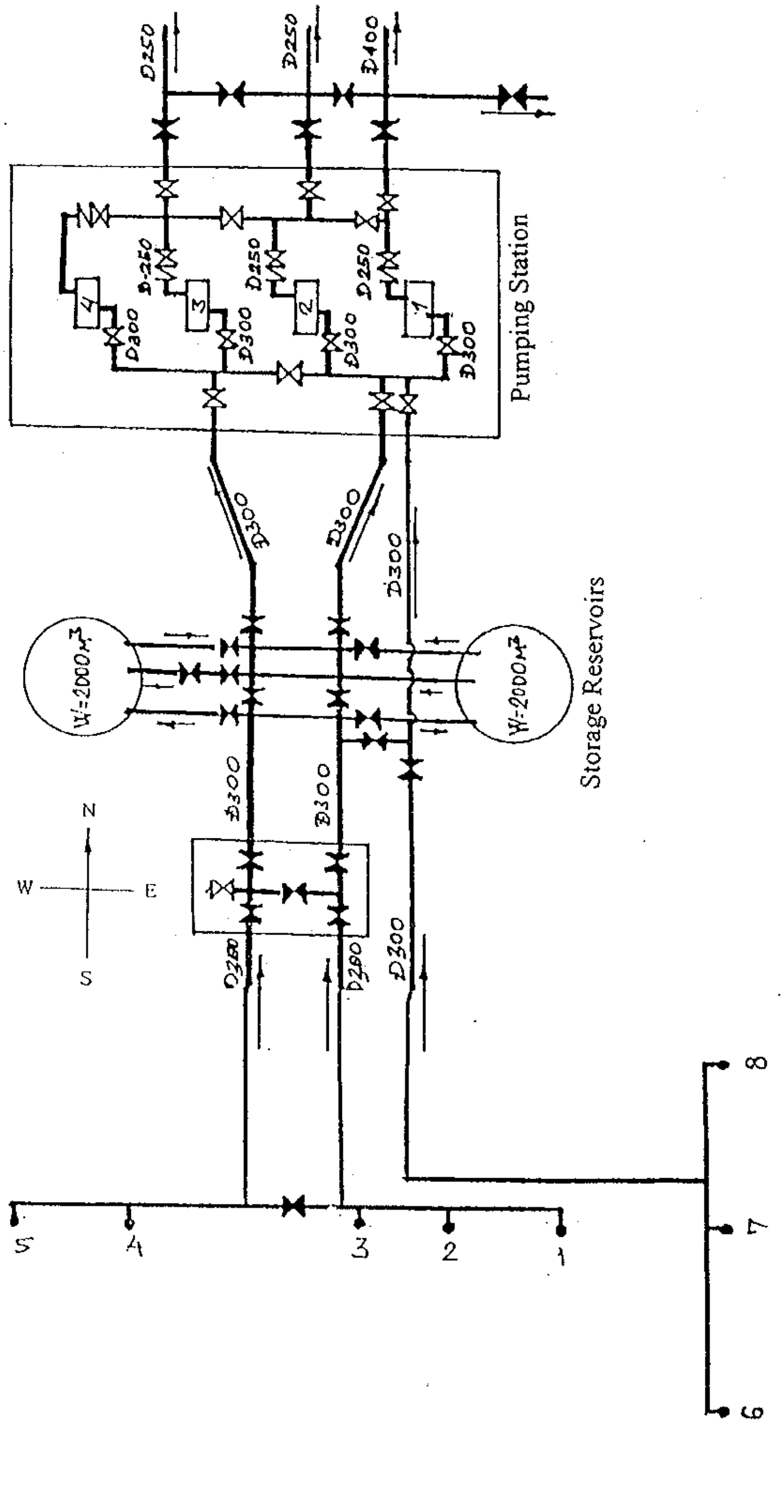

Fig. 2.3.5	**Schematic Layout of Meat Complex Water Source**
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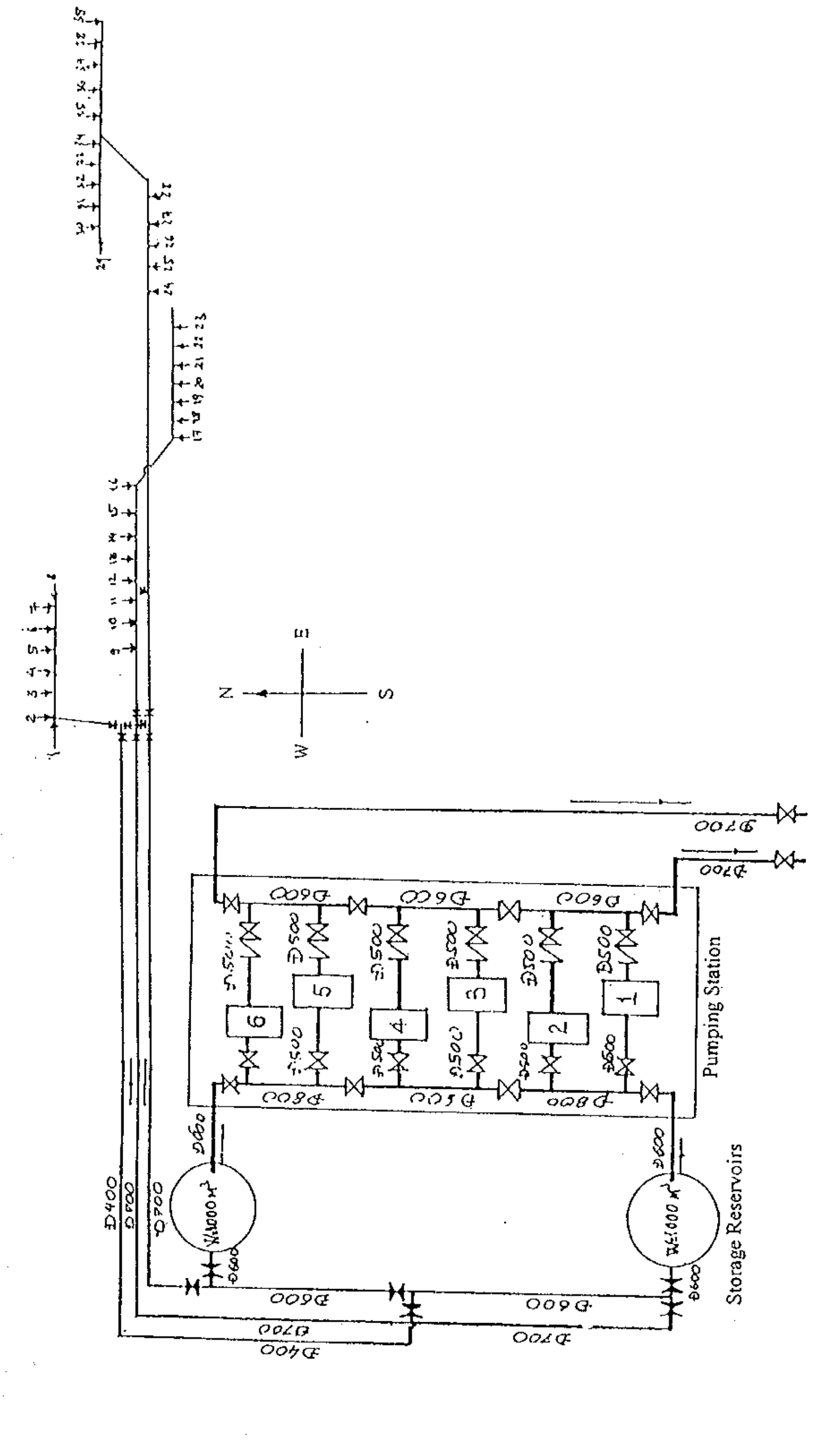

Fig. 2.3.6 Schematic Layout of Upper Water Source

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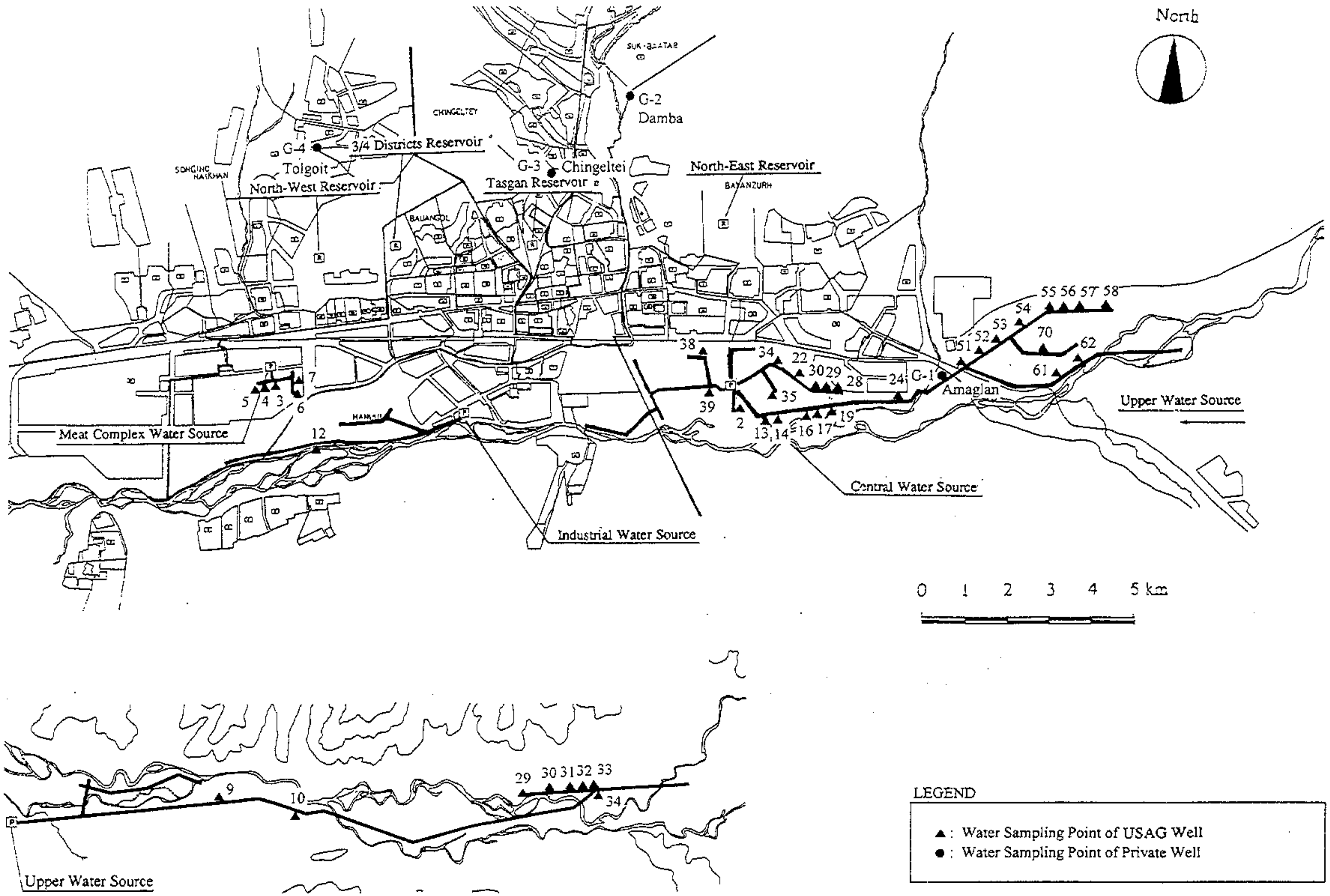

Fig. 2.3.7 Sampling Points of Groundwater (Wells of USAG and Private Wells)

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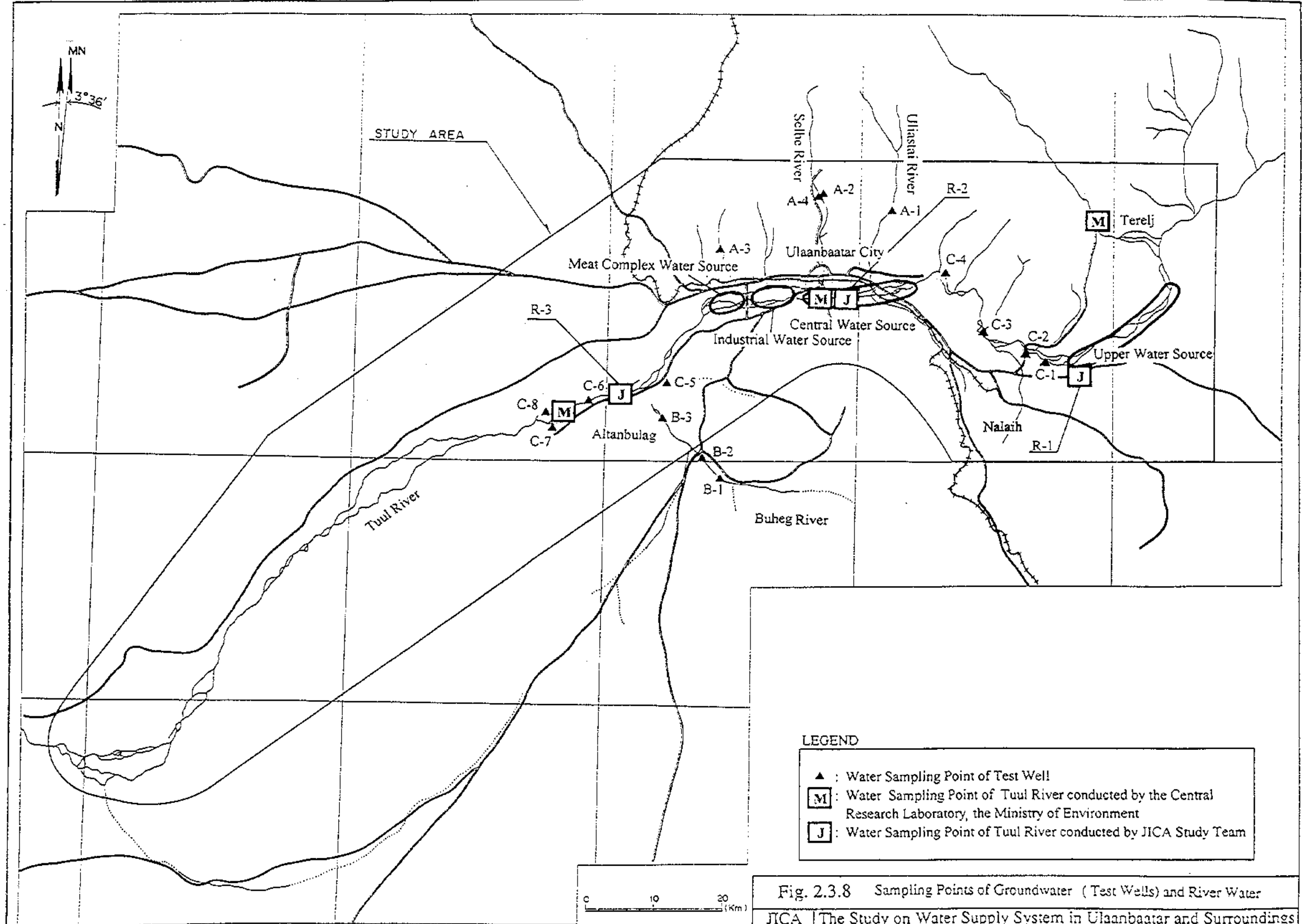

Fig. 2.3.8 Sampling Points of Groundwater (Test Wells) and River Water

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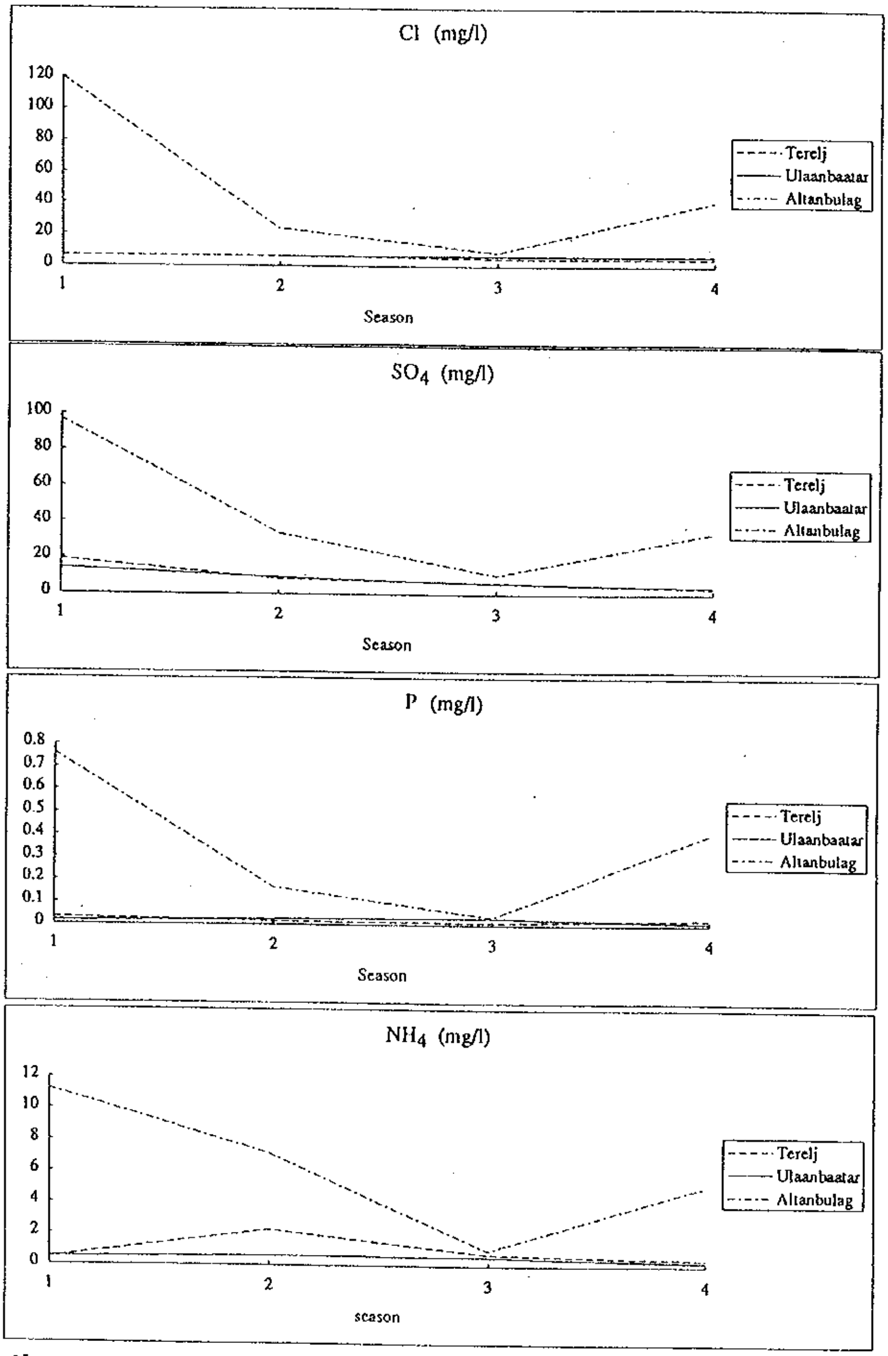

Note
1: Jun.- Mar., 2: Apr.- Jun., 3: Jul.- Sep., 4: Oct.- Dec.

Fig. 2.3.9	Seasonal Changes of River Water Quality
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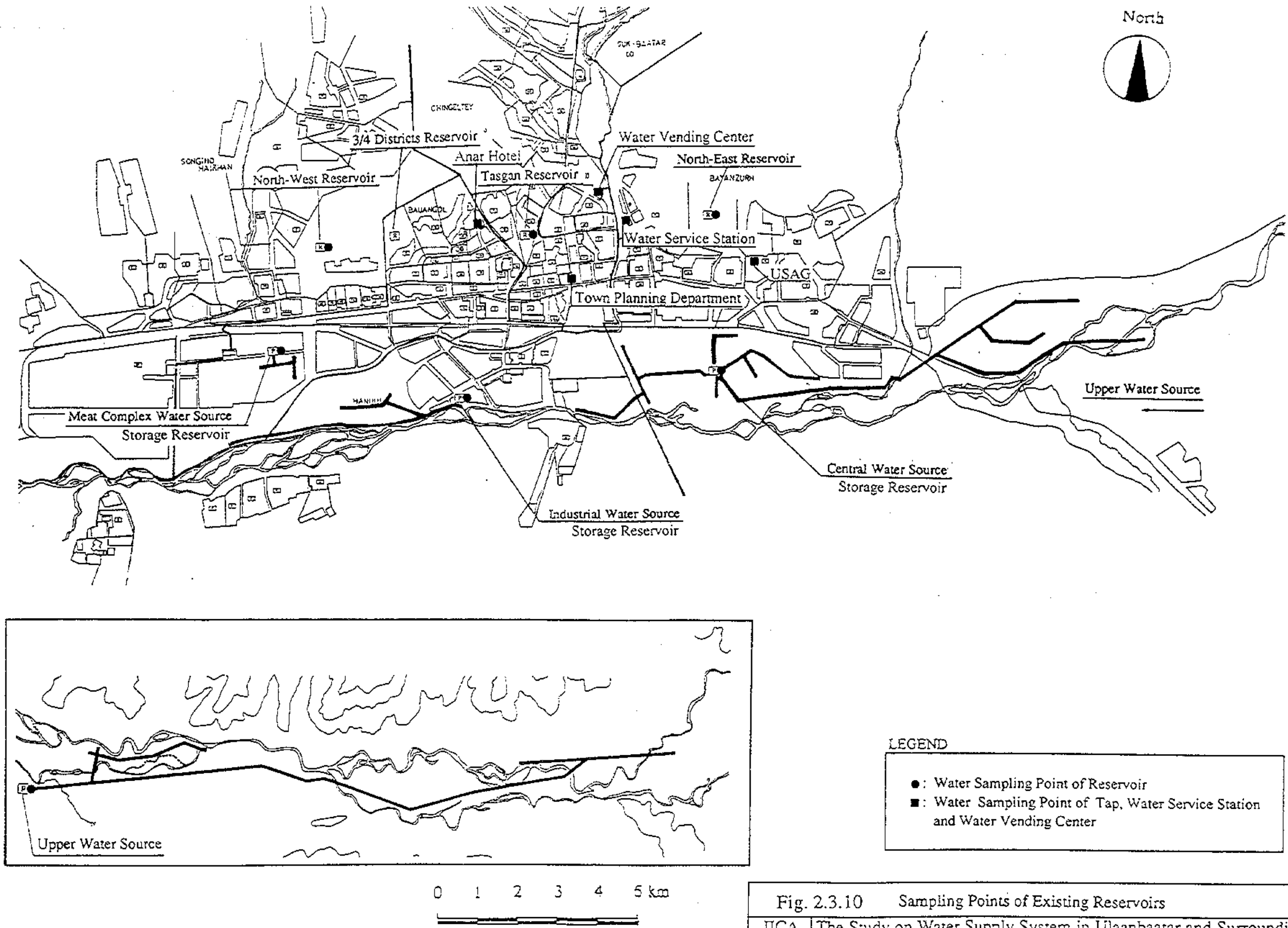

Fig. 2.3.10 Sampling Points of Existing Reservoirs

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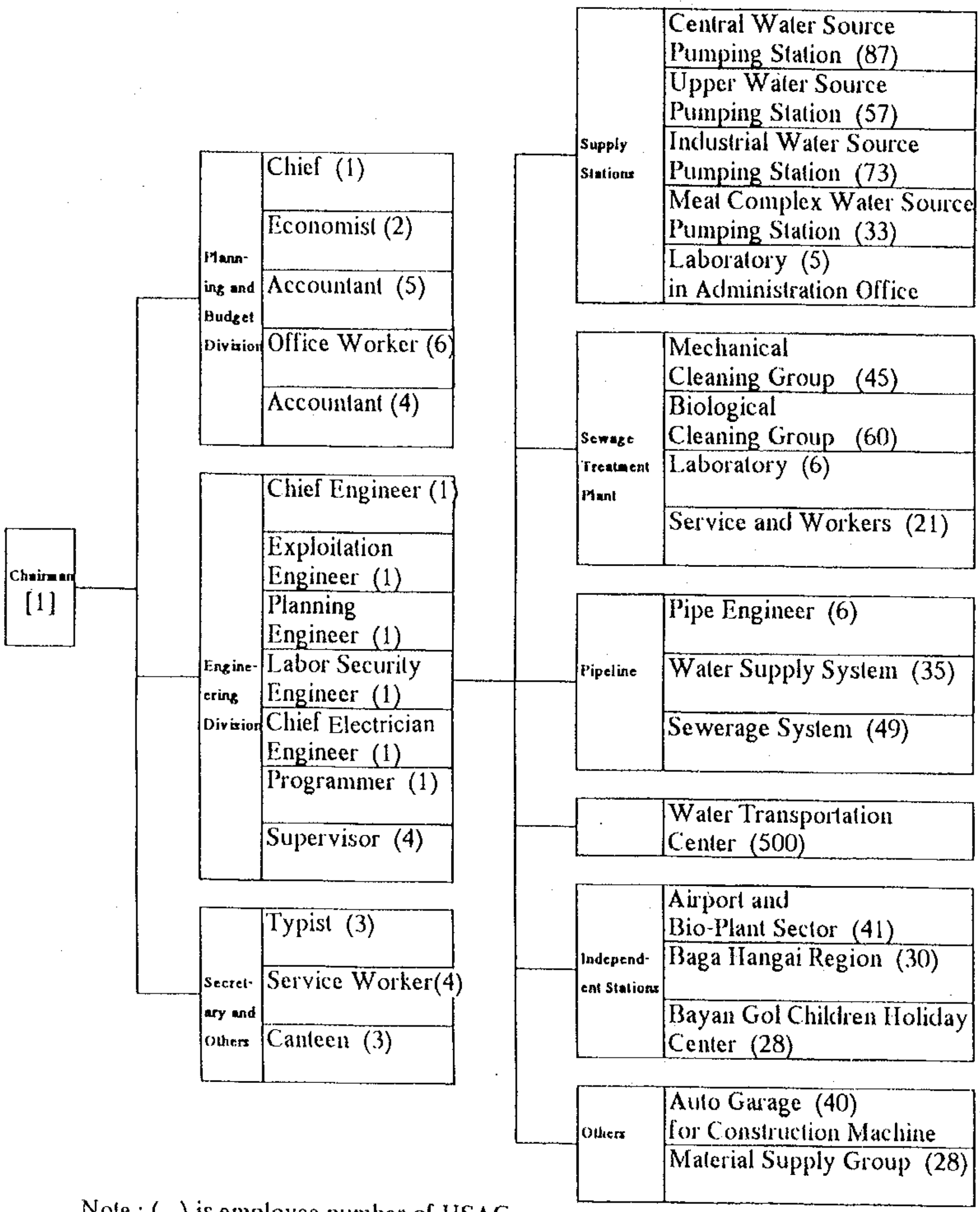

Note : ( ) is employee number of USAG.

Fig. 2.3.11 **Organization of USAG**	
JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

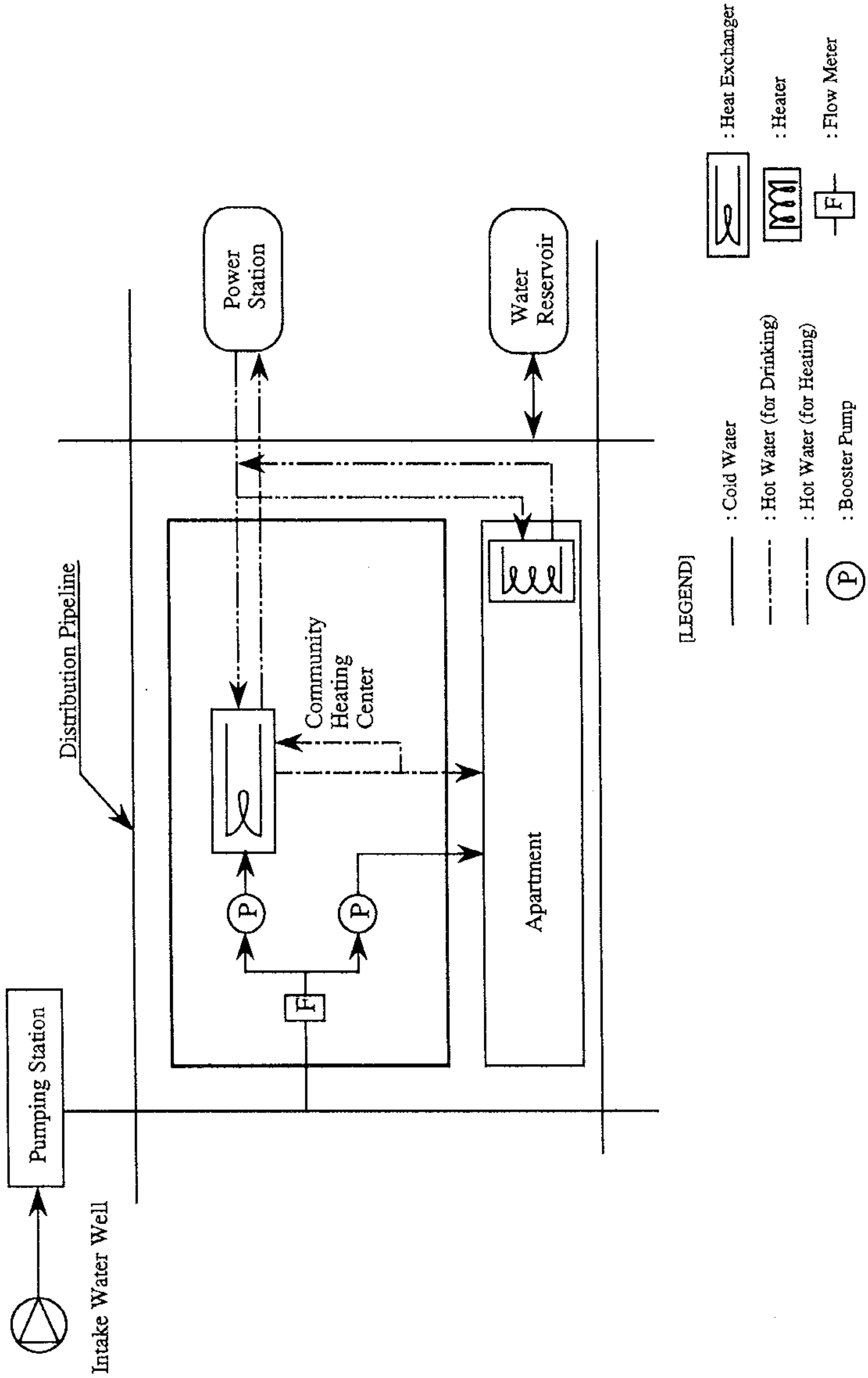

Fig. 2.3.12 **Typical Water Supply System of CTP**

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CHAPTER 3　MASTER PLAN

3.1 Groundwater Potential

CHAPTER 3. MASTER PLAN

3.1 GROUNDWATER POTENTIAL

3.1.1 Evaluation of Groundwater Resources

(1) Existing Water Sources

Central Water Source and Upper Water Source have some potential for the additional development on the basis of the existing data conducted by the former Soviet Union.

Potential of existing water source (unit : m^3/day)

Water source	Total potential	Developed volume	Undeveloped volume
Central Water Source	114,300	97,000	17,300
Upper Water Source	90,000	24,000	66,000

Groundwater simulation was conducted to reevaluate the Central Water Source which is the main and important water source for Ulaanbaatar City.

(2) New Groundwater Resources

Groundwater potential of the new groundwater resources is roughly estimated as follows.

Estimated volume of groundwater resources

	Lower Part of Nalaih	Buheg River	Lower Part of Power Plant	Downstream area *
Area (km^2)	42.5	237.5	>50	>1,000
Thickness of alluvium (m)	15-20	20-40	40-60	50-100
Water table (Gl-m)	2.5	5.5	2-3	2-3
Thickness of aquifer (m)	12.5-17.5	14.5-34.5	about 40-60	about 50-100
Specific Yield	0.15	0.1	0.15-0.2	0.15-0.2
Volume (10^6 m^3)	102	586	>300	>1000

* including Ulaan Hujiriin Bulan and Ulahiin Bulan

Groundwater potential of the alluvial aquifer in Lower Part of Nalaih is estimated about 102 million cubic meters. The average thickness of the saturated layer and the average specific yield of the alluvial aquifer were estimated from the results of the test wells by JICA and the previous studies. One meter thickness of saturated aquifer contains the volume of about 13 million cubic meters of water, which is equal to the amount of 86 thousand cubic meters multiplied by 150 days, an expected maximum period of no recharge from Tuul River. That is recoverable by recharge from Tuul River flow. Actually the water table in the area may decrease more than one meter with this amount of withdrawal, because of the limitations imposed by groundwater velocities, time, configuration of water movement, and withdrawal techniques.

Groundwater potential of the alluvial aquifer in Buheg River basin is estimated more than 500 million cubic meters. One(1) meter thickness of this saturated aquifer is estimated to contain the groundwater about 23.7 million cubic meters.

Groundwater potential of Lower Part of Power Plant and the downstream area of Ulaan Hujiriin Bulan and Ulahiin Bulan is expected to be many times , because these downstream area are larger and the aquifers are thicker comparing with the Lower Part of Nalaih.

The fissure aquifers in North of Ulaanbaatar City shall be developed for a local use. Test wells conducted by JICA yield 903 m^3/ day at Uliastai River, 2,164 m^3/ day at Bayan Goliin, 1,441 m^3/ day at Selbe River. The capacity of groundwater is sufficient for a supply to the all Ger areas in Ulaanbaatar. However, it is not available to develop on a large scale, because the potential is smaller than that of alluvial aquifer, and also it is difficult to determine the drilling sites without a detail geological investigation.

3.1.2 Selection of the Priority Development Area of Groundwater

(1) Necessary Conditions for Water Source

Priority groundwater development areas shall be selected from the hydrogeological and economical criteria as described below.

Hydrogeological condition

Aquifer has to satisfy the following elements.

Capacity	:	large groundwater basin---distribution of alluvial deposit and fractured zone
Essential element	:	high permeability, transmissivity, specific yield etc.
External element	:	large precipitation, large recharge volume, a few existing water utilization etc.

Economical condition

Low construction cost	:	sites shall be located near the beneficiary
Low running cost	:	avoiding the wastage of energy
Good water quality	:	avoiding the installation of costly purification facilities

(2) Possible Groundwater Resources

According to the results of geological survey, interpretation of satellite image/aerial photographs, and geophysical prospecting, possible groundwater resources are listed below.

Possible Groundwater Resources

Location	Aquifer type	Distance *1 (km)	Hydro-geological condition	Groundwarer potential	Construc-tion cost	Running cost	Priority
Lower part of Nalaih	alluvial	28-40	fairly good	medium	low	Low	1
Buheg River	alluvial	34-54	fairly good	big	high*2	medium	4
Lower part of Power Plant	alluvial	34-55	fairly good	big	medium	medium	2
Ulaan Hujiriin Bulan	alluvial	55-122	fairly good	big	high	high	6
Ulahiin Bulan	alluvial	122-147	fairly good	big	high	high	7
North of ULBT							3
Uliastai	fissure	10-15	good	sufficient as for the local water source	low	low	
Selbe	fissure	5-10	good		low	low	
Bayan goliin	fissure	18	good		low	low	
Tabiltiin goliin	fissure	16-22	good		medium	medium	
Holiin river	fissure	10-15	good	ditto	medium	medium	5

*1 :Distance from the center of ULBT.

*2 :Water quality is unsuitable for drinking water.

(3) Proposed Development Area of Groundwater

From the hydrogeological and economical criteria as mentioned above, the following areas are recommended for the priority groundwater development areas.

- The surrounding area of Upper Water Source, namely Lower Part of Nalaih
- Lower areas, which include Lower part of Power Plant, Ulaan Hujiriin Bulan.
- North of Ulaanbaatar City

1) Lower part of Nalaih
It shall be developed simultaneously with the undeveloped groundwater of Upper Source. Lower part of Nalaih and Upper Water Source are the continuos groundwater basin.

2) Lower areas
Lower Part of Power Plant and upper part of Ulaan Hujiriin Bulan are excellent places, having large alluvial aquifer with very high specific capacity as observed from the exploration boreholes of previous studies.

3) North of Ulaanbaatar City
Fissure aquifer is expected here. Uliastai River, Selbe River, Bayan goliin valley and Tahiltiin goliin valley may have a potential for the local water source. Test wells conducted by JICA for a fissure aquifer at these sites recorded the comparatively high yield.

These priority groundwater resources shall be selected in combination with the future water demand.

3.1.3 Groundwater Simulation in Central Water Source Area

(1) Selection of the Groundwater Simulation Area

Central Water Source is the most important water source for Ulaanbaatar City from the view point of its supply capacity and economy. It has supplied about 43% of potable water to the City and is located near the City. Recently, it has been difficult to withdraw the designed capacity of groundwater from the production wells in winter season due to the lowering of groundwater table. Consequently, it is necessary and important to reevaluate its groundwater potential for the estimation of water supply capacity and water source development in future.

(2) Construction of Simulation Model

It was considered indispensable to conduct the groundwater simulation effectively as precisely as possible applying the program that enables the multi-layers analysis, both on steady and unsteady conditions by quasi-three dimensional analysis covering Central Water Source Area.

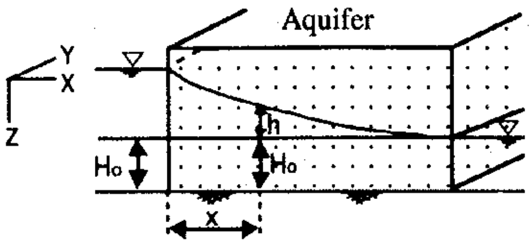
In this context, the computer program " UNISSF "; Unified Normal and Inverse Sub-Surface Flow analysis program was applied to simulate the groundwater potential and assess the impact of the additional groundwater development plan in Central Water Source. The UNISSF was developed by the Information -Technology Promotion Agency, Japan (IPA) and is applied to this study.

The computer program for groundwater simulation employed in this study is prepared based on the following dominant equation. The dominant equation, relating to infiltration handled here, is based on Dupuit's hypothesis that the head is equal on the perpendicular section of the aquifer.

Using Dupuit's hypothesis, the continuation formula relating to three-dimensional (x,y,z) flow is, from Vz = 0 is, as follows.

$$S\frac{\partial h}{\partial t}+\frac{\partial}{\partial x}\{(Ho+h)Vx\}+\frac{\partial}{\partial y}\{(Ho+h)Vy\}=q \quad \text{(i)}$$

S : coefficient of storage
$Vx,\ Vy,\ Vz$: apparent flow velocity in x, y, z directions
q : spring flow or discharge per unit time



Putting Darcy's formula of motion equation (ii) into equation (i) yields:

$$\left.\begin{aligned} Vx &= -Kx\frac{\partial h}{\partial x} \\ Vy &= -Ky\frac{\partial h}{\partial y} \\ Vz &= -Kz\frac{\partial h}{\partial z} \end{aligned}\right\} \quad \text{..................} \quad \text{(ii)}$$

$$S\frac{\partial h}{\partial t} = \frac{\partial}{\partial x}\left\{Kx(Ho+h)\frac{\partial h}{\partial x}\right\} + \frac{\partial}{\partial y}\left\{Ky(Ho+h)\frac{\partial h}{\partial y}\right\} + q$$

$$= \frac{\partial}{\partial x}\left(Tx(h)\frac{\partial h}{\partial x}\right) + \frac{\partial}{\partial y}\left(Ty(h)\frac{\partial h}{\partial y}\right) + q \quad \text{..................} \quad \text{(iii)}$$

(Where Tx, Ty : coefficients of transmissivity in x, y directions, being functions of head h)

This is the dominant equation relating to the infiltration using Dupuit's hypothesis. From equation (iii), after finite element formulation by using the weighted remainder method, the solution is obtained under proper initial conditions and environmental conditions.

The computer program prepared by the above mentioned method can easily be applied for not only aquifer formed of a single layer but also aquifer consisting of multiple layers. Further, it can perform quasi-three dimensional groundwater analysis in a well manner.

Parameters of Simulation Model

i) Calculation Mesh System
The simulation area occupies approximately 30.5 km^2 and its calculation mesh system consists of 512 nodes and 592 elements. The intervals of large mesh, medium and small one are 500m, 250m, and 125m respectively (refer to Fig.3.1.1).

ii) Distribution of Aquifer

Data on distribution of aquifers must be input for the simulation at all calculation nodes. Two aquifers; "upper aquifer" and "lower aquifer" are recognized from a hydrogeological point of view. A conceptual geological section for simulation is illustrated in Fig.3.1.2. The upper aquifer and the lower aquifer can be regarded as gravely faces and sandy faces respectively.

iii) Coefficient of Aquifer

Their aquifers are both regarded as unconfined. The coefficients of permeability and specific yields are assumed as follows.

- Permeability
  - Upper Aquifer : $K=1.79\times10^{-1}$ cm/sec
  - Lower Aquifer : $K=4.48\times10^{-2}$ cm/sec
- Specific yield
  - Upper Aquifer : Sy=0.20
  - Lower Aquifer : Sy=0.15

iv) Discharge and Recharge of Groundwater

Since discharge and recharge of groundwater with the exception of withdrawal and precipitation may be regarded as so called "Black Box", they had to be assumed as boundary conditions as mentioned below.

v) Boundary Conditions

The fundamental boundary conditions were established through calculations in steady state in October 1993 by the UNISSF. They were calculated in the simulation program automatically in the steady state by reproducing the present groundwater level in stead of inputting their values directly. In this case, it is better way in order to construct the simulation model.

On the other hand, the seasonal variations were accorded with the flow discharge fluctuation of Tuul River at Ulaanbaatar Observing Station in the same period.

vi) Initial Groundwater Table

Initial groundwater table is necessary for the construction of groundwater simulation model in the steady state calculation. It was input according to the static water table contour map in October 1993 (refer to Fig.3. 1.3 (1)).

(3) Applicability of Simulation Model

1) Establishment of Hydrological Year

The hydrological year: October 1993 to September 1994 was established as the simulation period which should be reproduced in terms of groundwater conditions by the simulation model. The above mentioned year is the latest and only year when a series of simulation parameters can be prepared mostly and continuous measurement of groundwater level has been conducted at NO.15 Well in Central Water Source Area. This is the reason of selecting it as hydrological year.

2) Reproduction of Present Groundwater Conditions

Applying the above-mentioned simulation parameters, the groundwater simulation model was established through two calculation procedures namely, Steady State calculation and Unsteady State calculation.

The former is for construction of fundamental simulation model and the latter is for reproduction of the groundwater conditions during the hydrological year.

3) Applicability of Simulation Model

- Steady State Calculation

  The result of steady state calculation is illustrated as the contour map of groundwater level in Fig.3.1.3 (2). The figure indicates that this simulation model could reproduce the groundwater conditions in October 1993, practically except for the limited parts of the simulation area.

- Unsteady State Calculation

  The unsteady state calculation was carried out to check the applicability of the model during the hydrological year. The applicability was confirmed by the recognition of the maximum drawdown in April 1994 and recovering it in the end of the hydrological year just like the monitoring result of groundwater level at NO.15 Well (refer to Fig.2.2.14).

(4) Reevaluation of Central Water Source

As mentioned above, the simulation results indicate that Central Water Source is sustainable water source at present and have a possibility of additional groundwater development. As described in Fig. 3.1.4 (2), the possibility of additional development is feasible, particularly in the eastern or the western part of the simulation area where the drawdown is less than one meter except for the area along Tuul river.

(5) Estimation of Safe Yield in Central Water Source Area

When an additional development plan of groundwater resource is projected, it is very important to maintain the groundwater source to be sustainable, in other words, to keep a safe yield of groundwater. However, it is difficult to determine the safe yield value. Because it is necessary to calculate numerous cases to get final answer. One of the case studies is shown in Fig.3.1.4 (2) that the additional developing groundwater volume is 17,300 m^3/day .

The simulated drawdown in April 1994 compared with October 1993 is illustrated in Fig.3.1.4 (1).

Although the affected area where the drawdown is more than one meter is enlarged considerably by the additional withdraw, it was confirmed that the area will be recovered at the end of the hydrological year. This suggests that the proposed development capacity is acceptable.

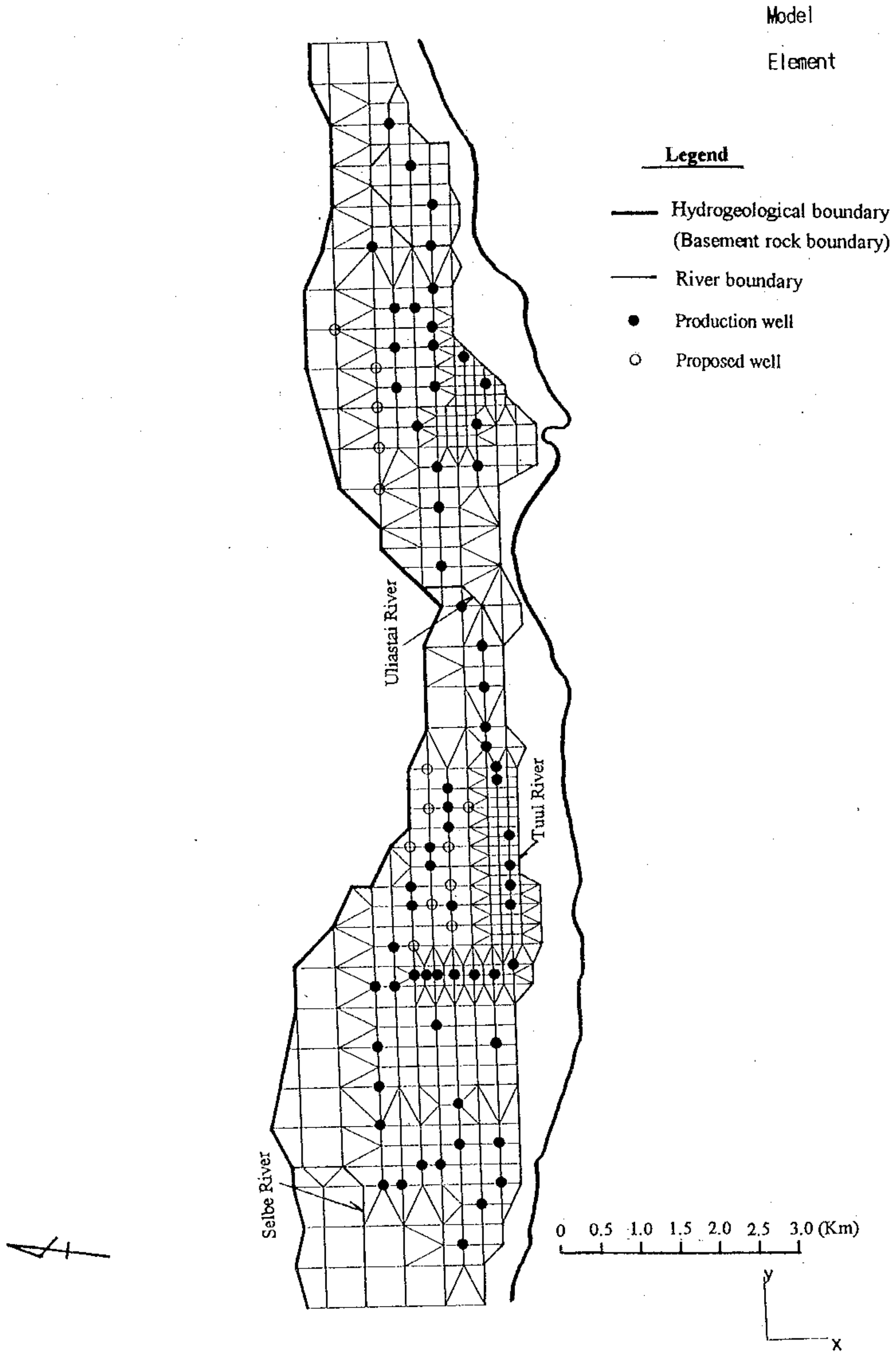


Fig. 3.1.1	Calculation Mesh System and Distribution of Present Production Wells and Proposed Wells for Groundwater Simulation
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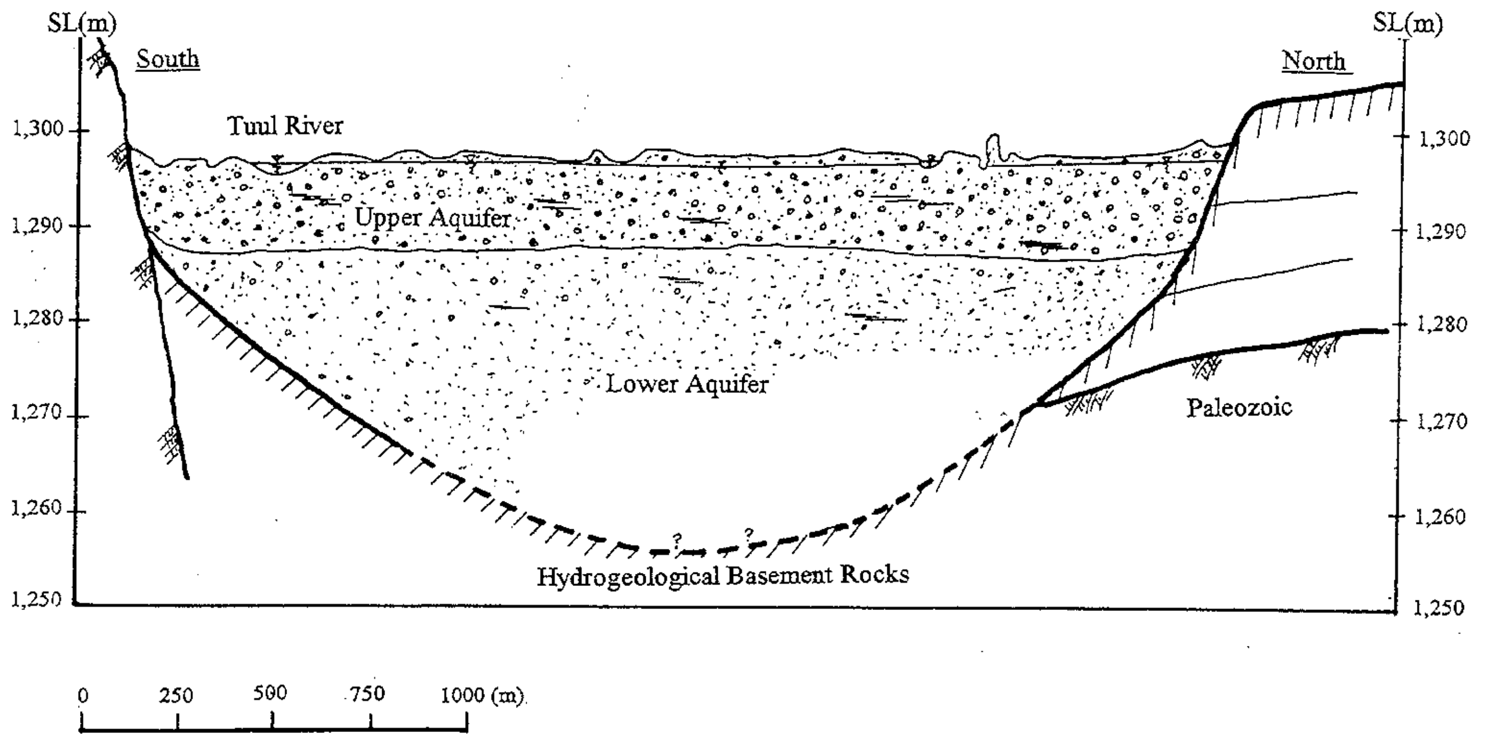

Fig. 3.1.2 Conceptual Hydrogeological Section for Groundwater Simulation in Central Water Source	
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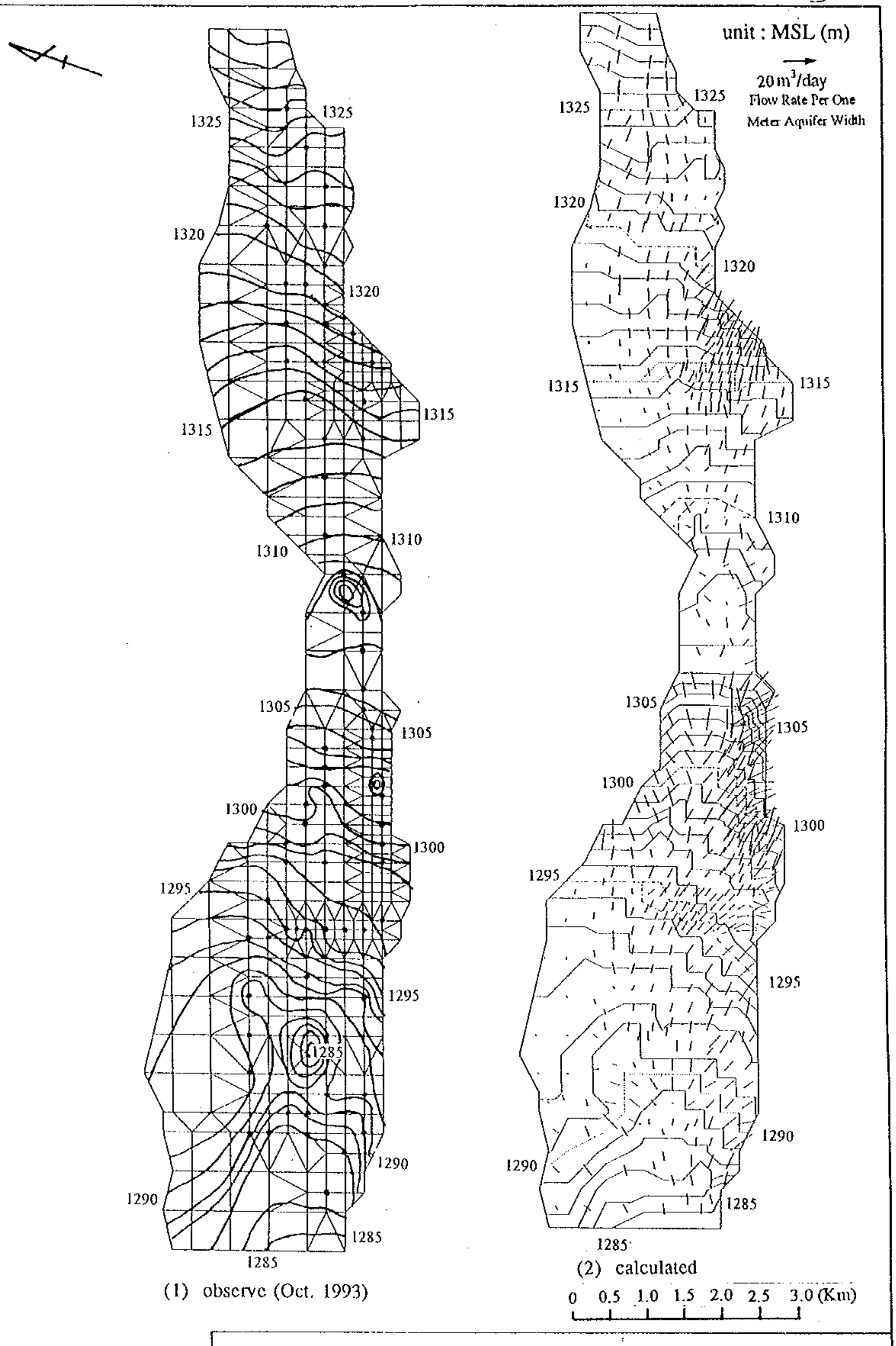

Fig. 3.1.3 Comparison between Observed and Calculated Groundwater Level

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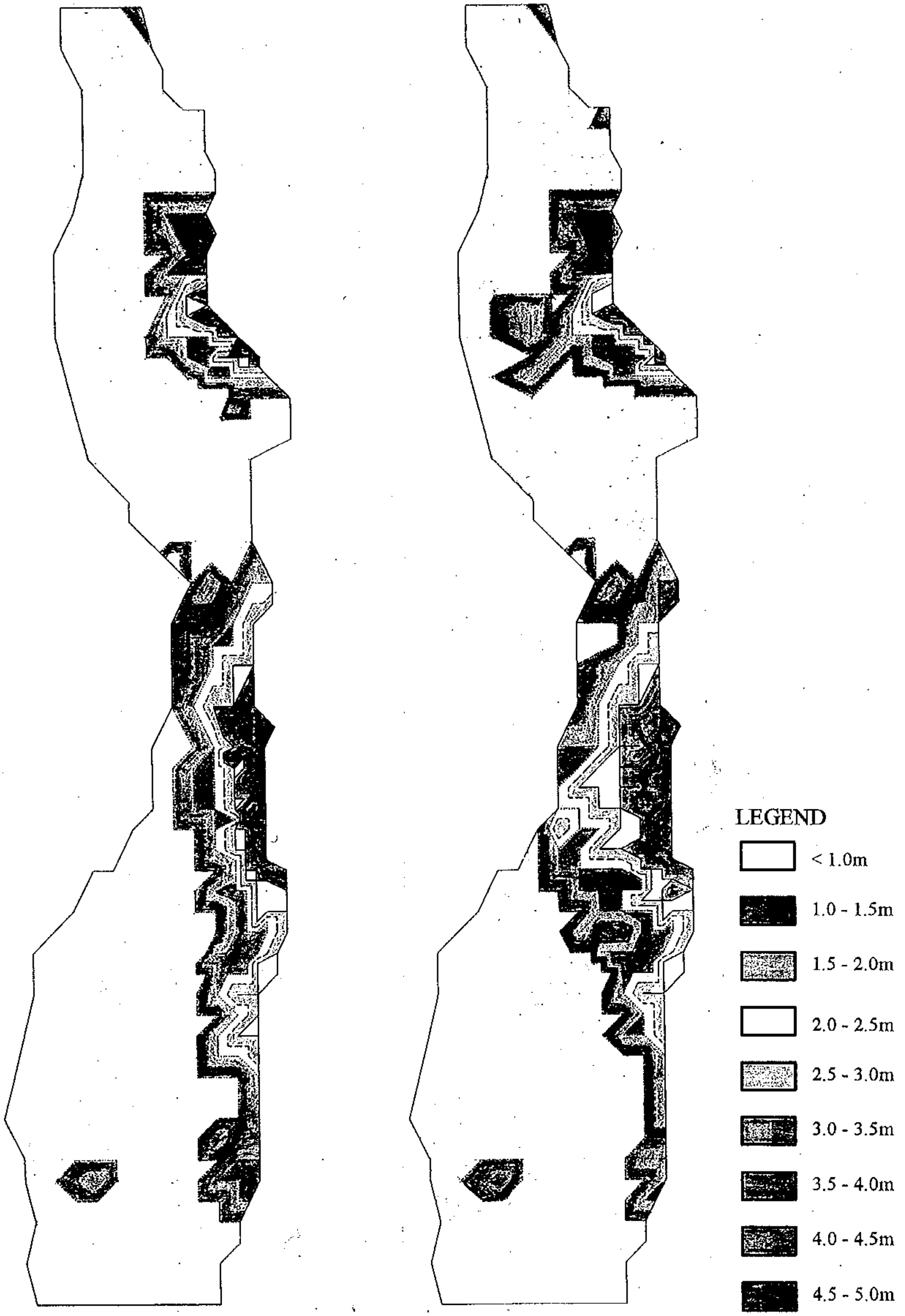

(1) PRESENT (APRIL 1994)

(2) FUTURE

Fig. 3.1.4	Simulated Drawdown on April Compared With October
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3.2 Surface Water Potential

3.2 SURFACE WATER POTENTIAL

3.2.1 Water Balance in Upper Tuul River Basin

The circulation of water between the atmosphere and the land is termed the hydrological cycle. As illustrated in Fig. 3.2.1, in Upper Tuul River Basin, water enters in the basin by precipitation such as snowfall and rainfall. The snow packed during the winter season from November to February gradually releases moisture to aquifer and streams as it melts, especially in the spring season of April and May. Some of water infiltrates and percolates into the basement rocks and alluvium, and is stored as bank storage. The rest of water flows along the valley as surface runoff, and is gathered forming the flow of Tuul River. The groundwater flows from basement rock through alluvium or directly into streams when the streams are not swollen by snowmelt or storm runoff.

The precipitation in the basin reaches the maximum in August, and more than 70% of precipitation occurs in the months from June to August. The maximum surface flow is recorded in this period usually. The surface runoff of this period is considered to be formed of mainly rainfall. Substantial volume of water is transpired and evaporates in the basin.

The surface water is diverted for irrigation in some parts of the basin, but its volume is considered negligibly small comparing with the total volume of precipitation. Ulaanbaatar City takes the municipal water withdrawing from the alluvial aquifer near by the City.

3.2.2 Annual Balance

The annual surface water balance of Upper Tuul River Basin is examined applying the annual record from 1946 to 1993, and the average values of each parameter are summarized below.

(Unit: million m^3)

Items	Precipitation (1)	Runoff (2)	Evapo-transpiration (3)	Present Water Demand (4)	Recoverable Volume (5)	Future Water Demand (6)	Balance (7)
- Balance at Ulaanbaatar Station (C.A. = 6,300km^2)	2,836	883	1,726	46	182	44	138
- Specific Value per km^2	0.45	0.14	0.27	-	-	-	-
- Balance for all the basin (C.A. = 9,650km^2)	4,344	1,352	2,644	84	264	86	178

Note: (5) = (1) - (2) - (3) - (4)
(7) = (5) - (6)

As seen in the above table, in the catchment area upstream, of the Zaisan Bridge of which catchment area is measured to be about 6,300km^2, 182 million m^3 of water is left for the future increase of water utilization. Since the future incremental utilization is estimated to be about 44 million m^3, the rest of water source is expected to be about 138 million m^3.

As for the catchment area covering whole of the expected water source areas, its balance is estimated applying specific values of catchment areas as shown in the above table. About 264 million m^3 of water is expected to be left for the future increase of water utilization, and about 178 million m^3 of water is still available even after deducting 86 million m^3 of the future utilization.

3.2.3 Seasonal Variations of Surface Water Balance

The parameters considered in the water balance study vary year by year depending upon the climate condition, and incoming and outgoing water volumes are not balanced sometimes on annual basis because of the storage effect of the basin. Some of precipitation may be stored in the basement rocks in the basin for some years, and contributes to the water balance a few years later.

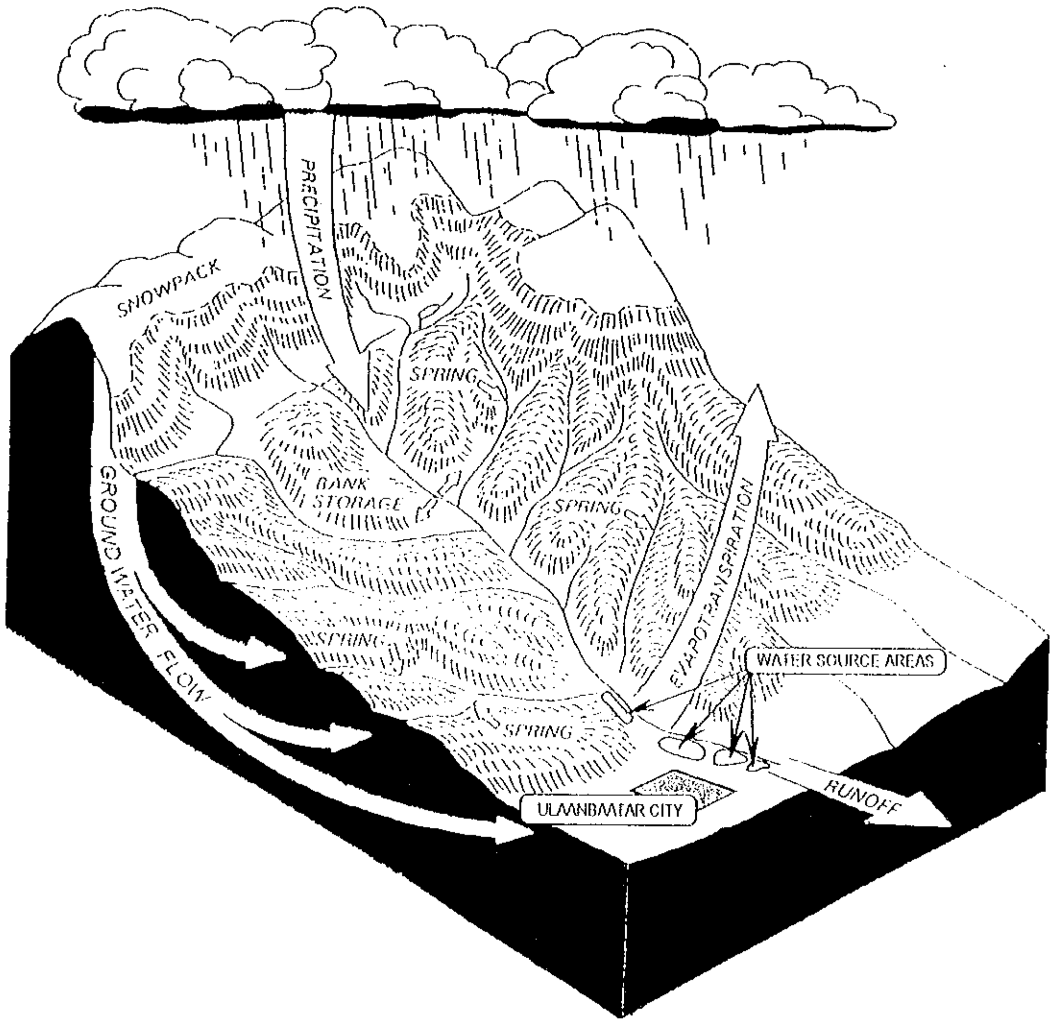
The water balance of the whole basin is worked out including all the expected water source areas, of which catchment area is measured to be 9,650km^2, as summarized below.

(Catchment Area: 9,650km^2) (Unit: million m^3)

	Items	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
(1)	Precipitation	16.8	36.3	49.9	130.5	216.1	807.1	1,419.3	1,244.9	568.7	122.2	86.5	41.8
(2)	Surface Runoff	0.0	0.0	0.2	16.8	172.6	169.4	523.9	527.2	415.3	97.4	22.8	3.1
(3)	Evapotranspir ation	0.0	7.8	68.0	147.5	366.2	521.9	573.3	485.3	331.9	114.6	27.3	0.0
(4)	Domestic Water Supply	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9	6.9
(5)	Recoverable Volume	9.9	21.6	-25.2	-40.7	-329.6	108.9	315.2	225.5	-185.4	-96.7	29.5	31.8
(6)	Future Water Demand	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
(7)	Balance	2.8	14.5	-32.3	-47.8	-336.7	101.8	308.1	218.4	-192.5	-103.8	22.4	24.7

Note: (5) = (1) - (2) - (3) - (4)
(7) = (5) - (6) Total of Balance: -20.4

As seen in the above table, seasonal variation of the balance is considered similar to that worked out for the basin upstream of Zaisan Bridge. The total of balance for the whole basin, however, indicates negative value (-20.4 million m^3), which suggests that some deficit is caused in the annual water balance. This calculation is conducted for the period from 1986 to 1993 means for as the last eight (8) years, and this period is considered a drought period in the long term balance calculation from 1946 to 1993. Therefore, the deficit volume of this eight (8) years is expected to be settled by the surplus storage which has been accumulated in the basin before 1986. Since the long term balance calculation shows that 178 million m^3 of the balance is still available in average after deducting the future water demand as mentioned in the foregoing subsection, it can be concluded that the deficit which is caused by imbalance in annual water balance calculation is considered to be settled by the storage volume, accumulated before that drought period.



$$P = ET + R + U + ST$$

Where; P: Precipitation
ET: Evapotranspiration
R: Surface Runoff
U: Utilized Water
ST: Stored Water

Fig. 3.2.1 Hydrological Cycle of Upper Tuul River Basin

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