JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF INFRASTRUCTURE DEVELOPMENT (MID)
THE GOVERNMENT OF MONGOLIA

THE STUDY ON GROUNDWATER DEVELOPMENT FOR ALTAI CITY IN MONGOLIA

FINAL REPORT

MAIN REPORT

MARCH 1999

PACIFIC CONSULTANTS INTERNATIONAL
MITSUI MINERAL DEVELOPMENT ENGINEERING CO., LTD

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In this report, project costs ate estimated based on December 1998 prices with an exchange rate of US$ 1 = Mongolian Tugrug 890 (US$ 1 = Yen 117.5).

PREFACE

In response to a request from the Government of Mongolia, the Government of Japan decided to conduct the master plan and feasibility study on Groundwater Development for Altai City in Mongolia and entrusted the study to the Japan International Cooperation Agency (JICA).

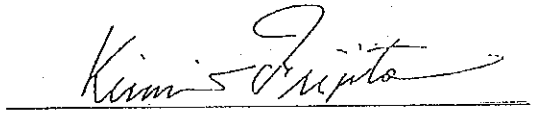
JICA sent to Mongolia a study team headed by Mr. Teruo TAHARA, Pacific Consultants International (PCI) and composed of staff members of PCI and Mitsui Mineral Development Engineering Co., Ltd., four (4) times between September 1996 and March 1999.

The team held discussions with the officials concerned of the Government of Mongolia, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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

I wish to express my sincere appreciation to the officials concerned of the Government of Mongolia for their close cooperation extended to the team.

March 1999



Kimio Fujita
President
Japan International Cooperation Agency

THE STUDY ON GROUNDWATER DEVELOPMENT FOR ALTAI CITY

March 1999

Mr. Kimio Fujita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

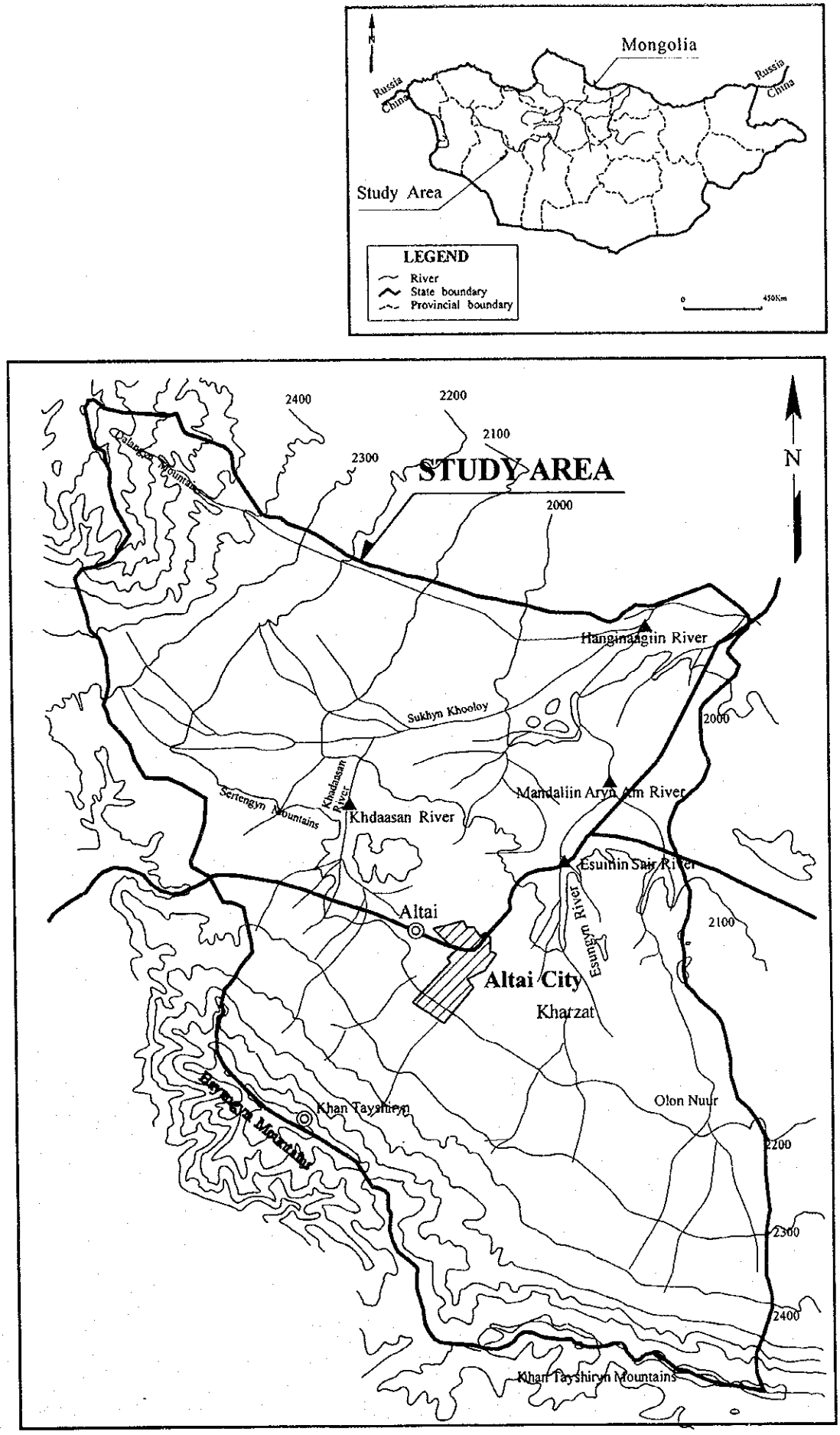
We are pleased to submit the final report entitled "The Study on Groundwater Development for Altai City". This report has been prepared by the Study Team in accordance with the contract signed between Japan International Cooperation Agency and Pacific Consultants International in association with Mitsui Mineral Development Engineering Co.,Ltd.

The report consists of Executive Summary, Mongolian Summary, Main Report, Supporting Report, and Data Book. Executive Summary summarizes the results of the Study. Main Report presents the results of the whole study including Master Plan for the development of water resources and water supply, Feasibility Study on the groundwater development for a high priority project selected from the Master Plan Study. Supporting Report describes the technical details of the Study. Data book has been prepared and submitted herewith.

All members of the Study Team wish to express grateful acknowledgments to the personnel of your Agency, Advisory Committee, the Ministry of Foreign Affairs, the Embassy of Japan in Mongolia, Mongolia Office of Japan International Cooperation Agency, and also to the officials and individuals of the Government of Mongolia for their assistance extended to the Study Team. The Study team sincerely hopes that the result of the Study will contribute to the improvement of the water supply condition and social and economic development in Altai City.

Yours Faithfully,

Teruo TAHARA
Team Leader


N
Mongolia
Russia
China
Russia
China
Study Area
LEGEND
River
State boundary
Provincial boundary
0
450Km
STUDY AREA
N
2400
2200
2100
2300
2000
Hanginaagiin River
Sukhyn Khooloy
2000
Mandaliin Aryn Am River
Khdaasan River
Khdaasan River
Sertengyn Mountains
Esuniin Sair River
Esungyn River
Altai
2100
Altai City
Kharzat
Olon Nuur
Khan Tayshiryn
2200
2300
2400
Khan Tayshiryn Mountains

Study Area

SUMMARY

SUMMARY

1. INTRODUCTION

The objectives of the Study are:

① to formulate a master plan on water resources development (focusing on groundwater) and improvement of water supply system for Altai City for the target year of 2015,
② to conduct a feasibility study for the priority project identified in the master plan for the target year of 2005, and
③ to pursue the technology transfer to the counterpart personnel in the course of the Study.

The Study area covers an area of about 600 km^2. The detailed groundwater development study covered the area of "Kharzat" and "Sukhyn Khooly" Tsagaantokhoy and Tayshir along the Zavkhan River were also investigated as for alternative water sources by reviewing previous studies.

2. PRESENT CONDITION

2.1 SOCIAL SECTOER AND HYGIENE EDUCATION

(1) Social Characteristics

The City is culturally and ethnically homogeneous and there is no social major disparity among the people.

Other Information from Household Survey

- Median of total annual income : Tg. 299,940 (monthly : Tg.24,995)
- Median of total monthly expenditure : Tg. 44,500 (ger) to Tg.58,810 (apartment)
- Distance to water delivery point of ger dwellers : within 200m for 70%
- Ger dwellers hope to get water whenever they want and to reduce the water tariff
- the people are looking forward to having a method and device to lower some high mineral contents in drinking water.

(2) Water Quality and Health

Around 60% of the people perceive that the quality of drinking water in Altai City is not good. They think that hardness of water brings about diseases. In addition, some authority believe that higher magnesium and calcium ratio increases the morbidity.

The water quality analysis of the Study Team revealed that the most of chemical substances including hardness in Altai City's water are almost within the range of Mongolian standard.

The concentrations of magnesium is slightly higher than the Mongolian standard while Japan and most countries do not have such a ceiling level of magnesium as shown in the following table.

Water Quality Standards and Guidelines for Hardness, Calcium, and Magnesium

Standard / Guideline	Total Hardness	Calcium	Magnesium
Study result(water supply)	199 mg $CaCO_3$/l	28 mg /l	31 mg /l
Mongolian Standard.	350 mg $CaCO_3$/l (7 m eq/l)	100 mg /l	30 mg /l
EU (1995)	-	-	-
WHO health	-	-	-
WHO complaint	500 mg $CaCO_3$/l	-	-
Japanese standard	300 mg $CaCO_3$/l	-	-
US standard	-	-	-
Bulgarian standard	600 mg $CaCO_3$/l	150 mg/l	80 mg/l

- : no ceiling value

It is difficult and inappropriate to conclude the direct causality between water quality and non-infectious disease, in particular chronic disease, since there are many risk factors to non-infectious disease such as smoking, drinking, gene, age, sex, eating habit, and so on.

(3) Hygiene Education

Gobi-Altai Province Social Health Center conducted seven times of trainer's training for schoolteachers and health volunteers and six times of hygiene education for children and mothers using the textbook prepared by the Study Team. In total 909 people participated in the program.

(4) Social Analysis

Benefit (+) and disadvantage (-) from the future plan / projects.

- While the higher income group of ger dwellers approved 161% of increase, the lower income group of them approved 80% of increase to the current tariff level.

+ Installation of kiosk will facilitate the availability of water in terms of time and distance. It is expected to reduce the habit of storing water and bring about less opportunity of contamination.

- However, 20% of ger dwellers will not gain water within 250m radius.

Water tariff

A disparity of unit water price between ger dwellers and apartment dwellers should be revised by opening the fact to public.

2.2 ECONOMY OF ALTAI CITY

(1) Population

The population of Altai City in 1996 and 1997 is summarized below.

Year	Population
1995	20,068
1996	17,121
1997	17,761

The decline in 1996 (14.7%) was due mainly to the recounting of the population. The population until 1995 had been over estimated as a result of over-declared food card number in the old regime.

(2) Economy

Altai City is the center of manufacturing activities and the nodal point and logistic center for agriculture production and distribution in Gobi-Altai Province. Most of the manufacturing activities in Gobi Altai Province are found in Altai City. In terms of industrial output, those of Altai City have been accounting for a range of 80% to 96% of all the industrial output in the province since 1991. Altai City plays a minor role in agriculture production in Gobi Altai Province with agriculture labor force accounting only for 5% of the total labor force of the city. Its role is found more in the processing, trading, and consumption of agriculture products. Traditional large industries experienced a drastic fall in production level between 1990 and 1992 and have tended to be stagnant since then. Small scale production and commercial activities, on the contrary, are gradually expanding. The overall economy of Altai City seems to be expanding little by little, supported by agriculture related activities and small scale and new production and commercial activities.

2.3 METEOROLOGY AND HYDROLOGY

(1) Meteorological Characteristics

Precipitation

Altai basin is characterized by a rainy season from June to August, whose precipitation accounts for about 64% of the annual precipitation as caluculated bellow.

Station	Average Monthly Precipitation (mm)												Total
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	(mm)
Altai	1.1	2.1	5.8	10.5	13.2	29.2	48.2	41.8	17.1	7.3	3.1	2.2	181.6
Khan Tayshiryn	1.1	2.3	7.3	10.8	13.8	31.5	39.1	55.4	22.4	11.1	4.0	1.6	200.4

Note : Altai City ; data from 1955 to Aug. 1996; Khan Tayshiryn data from 1978 to 1989

JICA Investigation

The results of evaporation and rainfall measurement conducted by the JICA Study Team are shown below.

Monthly Evaporation and Rainfall in mm

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Evaporation												
1997	-	-	-	-	-	-	238.7	179.2	136.2	-	-	-
1998	-	-	-	-	182.2	217.0	166.5	146.5	136.1	68.1	-	-
Rainfall												
1997	-	-	-	-	-	-	83.7	1.2	11.6	-	-	-
1998	-	-	-	-	15.9	10.6	113.7	13.1	7.1	-	-	-

In 1997 and 1998, rainfall was exceptionally high in July.

(3) Hydrological Characteristics

Annual average runoff volumes at Guulin and Durveljin stations in Zavkhan River are calculated to be about 299 (9.49m^3/s) and 447(14.17m^3/s) million m^3 respectively. About 52% of annual runoff in an average concentrates during the rainy season from June to August.

River Discharge of Small River in the Study Area

JICA Study Team measured the river discharge in the Study Area for four (4) rivers of Khadaasangyn Am river, Mandaliin Aryn Am River, Esuitiin Sair River, and Hanginaagiin Khooloy River.

These rivers do not have flow normally. Only during or after a heavy rainfall, flow can be seen in some rivers.

2.4 TOPOGRAPHY AND GEOLOGY

Altai City is located at the northern mountain foot of Altai mountain range with the altitude of 2,040 to 2,180 meters.

Quaternary fan deposits are distributed in the south of Altai City and unconfined aquifer in these deposits is utilized for the water resources for domestic water for Altai City.

Clayey lake deposits of Neogene period underlie Quaternary fan deposits in the Study area. These deposits are aquiclude.

The basement rocks are mainly composed of Precambrian ultra-basic rocks of peridotite, serpentine in the Altai mountain range and Precambrian gneiss, quartzite, and schist in the vicinity to north of Altai City.

The structural faults and fractured zones are distributed in the basement rock in the direction of east-west and northwest-southeast, and a part of the fractured zone bear the fissure water.

2.5 HYDROGEOLOGY

(1) Groundwater Table

Groundwater levels of the observation wells were measured periodically from June 1997 to October 1998.

The observation wells were divided into three groups of "A" (deep wells), "B" (shallow wells), "C" (shallow wells in Sukhyn Khooloy).

The water levels of Group "B" and "C" start going down soon after the end of rainy season, which was July in 1997 and 1998. Meanwhile the levels of Group "A" continue to rise until the end of October. From the beginning of February the groundwater levels of Group "B" wells commence to increase, though the water levels of Group "A" keep decreasing until the middle of April.

(2) Hydrogeological Characteristics

Quaternary Aquifer

Water Resources	Specific Capacity Sc (m^3/day/m)	Hydraulic cond. K (m/day)	Transmissivity*1 T (m^3/day/m)	Pumping yield Q (liter/sec.)
Kharzat	1-864	0.07–9.4	157-565 (av.360)	0.01–12.4 (av.3.15)
Olon Nuur	1-93	0.1-16.3		1.2-7.1 (av.2.51)
Sukhyn Khooloy*2	187max	4.57-8.3max		0.18-10.6 (av.3.59)

*1: estimate from specific capacity
*2: This resource is not fit for water source. Value is from local area.

JICA test well B-6 located in Olon Nuur has a transmissivity of more than 1,000 m^3/day/m with a hardness of 257.5 mg$CaCO_3$/l. This is considered to be an excellent aquifer for water supply. B-5 well located in the border of Kharzat and Olon Nuur have intermediate potential for water supply with a transmissivity of 39 m^3/day/m and a hardness of 225 mg$CaCO_3$/l. Other JICA test wells have low productivity with a hardness of 845 to 1950 mg$CaCO_3$/l.

Neogene Aquifer

This aquifer underlies quaternary aquifer of Kharzat, Olon Nuur, and Sukhyn Khooloy. It is distributed widely in Sukhyn Khooloy.

It is reported that pumping yield is 0.2 to 0.4 liter / second and the Neogene aquifer is not suitable water source for water supply.

Fissure Aquifer

It is reported by the previous investigation that the pumping yield was 1.6 to 14.4 liter/second.

JICA test well of A-4 located northeast of Altai City has recorded a pumping yield of about 16 liter/second with the transmissivity of about 200 m^3/day/m. This is considered to be a good aquifer but the hardness of this fissure water is 1875 mg $CaCO_3$/l.

Transmissivity of other wells are 1.3 m^3/day/m (hardness; 1,000 mg$CaCO^3$/l) in A-1 well, 10.4 m^3/day/m (hardness; 372.5 mg$CaCO^3$/l) in A-2 well, and 7.4 m^3/day/m (hardness; 362.5 mg$CaCO^3$/l) in A-3 well.

(3) Groundwater Resources

Possible water resources are listed below in and around the Study Area.

① Kharzat water source : available to expand
② Olon Nuur : available to develop
③ Sukhyn Hooly : bad water quality
④ Khadaasan River : lower to medium quantity.
⑤ Northeast of Altai: fissure aquifer, sufficient quantity, but bad water quality (hardness; 1876 $mgCaCO_3/l$)
⑥ Tsagaantoghoy : sufficient water quantity, but too far (98 km) and too low (280m lower than Altai), 3 to 5 booster pumps will be required.
⑦ Zavkhan Riverbed at Taishir : sufficient water quantity, but too far (45km) and too low (470m lower than Altai), 5 to 6 booster pumps will be required

Kharzat water source shall be given priority for the development.

(4) Groundwater Storage of Kharzat Water Source

Groundwater volume is estimated to be from 26.9 $x10^6$ m^3 in minimum and 40.3 x 10^6 m^3 in maximum depending on the estimation for the storativity of 0.1 to 0.15.

(5) Groundwater Balance

Recharge Volume

The recharge volume of Kharzat aquifer is estimated below.

Recharged Volume to Aquifer

Area	Catchment area	Precipitation	> 8mm/d in a year	Recharged precipitation	Recharged volume
Kharzat	about 70km^2	181.6 mm	34 mm	25.4mm/year (14% of total)	4,870 m^3/d, or 1,778,000 m^3/year

The result of the continuous water level observation indicates that rainfall affects the water table if it is over eight millimeters per day (8mm/day). 16 % of annual precipitation may infiltrate to the ground. Two percent of precipitation may be considered to become interflow and to move laterally above water table.

No recharge is expected in winter season of November to middle of April.

Groundwater Utilization

The present total yield of Kharzat production wells is 960 m^3/day in average and 1,150 m^3/day in maximum.

2.6 ECOLOGY AND ENVIRONMENT

(1) Ecology in Altai City

Fauna

The development of Altai City has reduced the distribution of large mammals near the city, however some animals are still observed in the survey area. Common mammal species are Brandt's Vole, Tolai Hare, Siberian Marmot, Red Fox and Corsac Fox, and common bird species are Northern Wheatear, Arctic Warblar, Tree Sparrow, White Wagtail, Horned Lark, Northern Raven and Rock Pigeon. Around Khadaasan River a variety of birds of prey were seen. In wet season (spring and summer), some waterfowls visit temporary wet lands. Common insects are arid steppe locusts and grasshoppers.

Flora

A great part of the land near Altai City is used as pasture land. Overgrazing near the city and the present chaotic sprawl of roads have caused damage to the soil and vegetation.

The vegetation cover near Altai City can be divided into two types of "Arid desert vegetation" and "Desert steppe vegetation".

(2) Law and Regulation

Mongolia has more than 20 environmental laws and regulations. Mongolia has also ratified the international conventions and treaty related to the environment.

(3) Executing Agency

Ministry for Nature and Environment (MNE) has the responsibility for investigation, monitoring, conservation, and protection of the natural and social environment.

(4) Initial Environment Examination (IEE)

In Mongolia, IEE is regarded as the General Environmental Screening Process in conformity with the Mongolian Law on Environmental Impact Assessment approved by the Parliament of Mongolia on January 22, 1998. For this project, it was carried out on May 22, 1998 by State Senior Inspector in Policy and Coordination Department of the Ministry of Nature and the Environment.

(5) Mongolian Environmental Impact Assessment

The following laws stipulate the Environmental Impact Assessment (EIA).

"Mongolian Law on Environmental Impact Assessment" (date effective; February/20/1998), and Annex, Annex1, and Annex2.

The Ministry and the local government will conduct the screening and choose the required level of EIA study as follows.

- No further study of EIA is required
- Item-wise EIA study is required
- Full scale study of EIA is required

If it is required, a licensed environment impact assessment company will conduct the EIA study for the project under the supervision of the government. The results of EIA study are made open to the public. The government makes a decision whether to implement the project or not on the basis of the results.

2.7 WATER QUALITY

Water Quality of Well

All the existing wells except SW-6 are not good for drinking because of the high concentration of hardness, magnesium and sulfate.

JICA test wells except B-5 and B-6 are not good for drinking, because of the high concentration of hardness, magnesium, and sulfate.

Water Quality of Water Supply System

The concentration of magnesium is slightly higher than the Mongolian standard. Total coliforms exceed the standard in water of reservoir, tap water, water of water wagon, and stored water in ger. Other items are within the standard.

2.8 WATER SUPPLY SYSTEM

(1) Condition of Water Supply Service

Service Area

The potable water is supplied to the central area (apartment area; approximately 90 ha) by pipe network system and to the whole ger area (approximately 224ha) by water wagon transportation system.

Population in Service Area

Category	Population	Number of household	Family size
Apartment Dwellers	3,245	488	6.6
Ger Dwellers	14,516	2,661	5.5
Total	17,761	3,149	5.6

(2) Present Water Supply System

The system is operated and managed by Altai City Public Service Department (APSD). APSD is responsible for supplying water up to eight Communal Heating Center (CHC that supply hot water during the cold season to the central area). In ger area, water is supplied every day by four (4) water wagons with a tank capacity of 4 m^3 to 4.75 m^3.

Water Supply Facilities and Capacity (October 1998)

Production well	1,200 m^3/day	25 m^3/hr x 24hrs x 4 units (1979, 1986, 1995), two of them are utilized, 1 is spare, 1 is under repairing
Transmission pipe	-	Dia.150mm x 2 lines, 3.4km x 2 = 6.8km
Reservoir	2,000 m^3	1,000 m^3 x 2 ponds
Distribution pump	180 m^3/hr	90 m^3/hr x 24hrs x 3 units (1 is spare)
Distribution pipe	-	Dia.200mm x 5600m + dia.125mm x 135m, iron pipes
Water wagon	Max. 78m^3/day	4cars (4m^3 x 3cars + 4.75m^3 x 1car)

(3) Actual Water Supply Amount

The water supply amount in the winter season is higher than that of summer season by about 20%. This suggests that the additional water is used for CHC in winter season.

Season	Amount (m^3/d)	Remarks
summer	860	Late night: 6.5 m^3 /hour (leakage ?)
winter	1,060	Late night: 35-38 m^3 /hour (leakage ?) Peal flow: 9-10AM (Friday), 10-11AM (Saturday)

Summer season: middle of May to September
Winter season: October to middle of May

(4) Water Consumption

Domestic Use

(unit: m^3)

Type of Dweller	Monthly Consumption (1997-1998)												Annual Amount
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
Apart.	4950	4950	4950	5202	5202	5202	5202	5202	5202	5202	5202	5202	61,668
Ger	940	980	988	1194	1301	1331	1108	1259	1663	1378	1213	1734	15,089

Apartment : daily mean; 169.0 m^3, daily max. 185.3 m^3
Ger : daily mean; 41.3 m^3 , daily max. 57.8 m^3

Institutional Use

(m^3/day)

Category	Annual Average Consumption		Monthly Maximum Consumption	
1. Total Institution	136	93.8%	229	94.2 %
CHC	(16)	(11.0)%	(140)	(57.6)%
2. Total Industries	9	6.2%	14	5.8%
Ground Total	145	100%	243	100%

3. MASTER PLAN STUDY

3.1 WATER RESOURCES

(1) Evaluation of Groundwater Resources

Kharzat water resources shall be given priority for the water source development from the viewpoints of the potential, water quality, and economy as described below.

Examination for Groundwater Resources

Water resources	Aquifer type	Dis-tance* (km)	Altitude (m)	Potential	Water quality	Hardness (mg/l)	Const-ruction cost	Run-ning cost	Priority
Kharzat	Alluvial	4-6	2180	big	good	225	low	low	1
Olon Nuur	Alluvial	8-9	2190	big	good	256	low	medium	2
Skhyn Hooloy	Quarter-nary	8-10	2050	medium	bad		medium	high	-
Khadaason	fissure	6-7	2150	small	medium	363	medium	high	-
NE of Altai	fissure	2-3	2120	medium	bad	1875	low	medium	-
Tsgaantokhoy	Alluvial	98	1890	big	good	406	high	high	-
Tyshir	Alluvial	45	1700	big	good	-	high	high	-

*: distance from the governor's office (elevation is 2170 meters)

(2) Groundwater Potential of Kharzat Groundwater Resources

More than 3,000 m^3/day may be safe yield.

$$\text{Total potential} = (\text{Storage volume} + \text{recharge volume}) - (\text{utilization} + \underset{\text{discharge}}{\text{baseflow*}})$$

(*baseflow: estimated almost zero)

Potential of Groundwater Resources of Kharzat (unit: m^3/day)

Water source	Recharged volume	Utilized volume	Safe yield
Kharzat	4,870	1,150	> 3,000

Storage volume of groundwater (26,900,000m^3) can be utilized with the monitoring of water table and water quality especially for drought years. Groundwater table recovers every May in normal, and no serious impact is expected for groundwater.

3.2 POPULATION AND WATER DEMAND FORECAST

(1) Socio-economic Framework

The following economic growth targets for Altai City were set.

Economic Growth Targets (%/year)

	1996-2005	2005-2015
Whole economy	3.0	4.0
Industry	4.0	5.0

(2) Population Forecast

Projected Population in Altai City

Year	Ger	Apartment	Total
1997	14,516	3,245	17,761
2005	15,357	3,433	18,790
2015	17,131	3,830	20,961

(3) Water Demand Forecast

The current total water demand for Altai City is calculated by adding the loss volume to the actual consumption. The loss rate is estimated to be about 30% of daily consumption. However it will be improved step-wise with the completion of water supply facility constructions in the year of 2005 and 2015. The target is set for 25% in 2005 and 20% for 2015.

Water Demand Forecast

	Category	Population (persons)	Served Raito (%)	Unit Demand in max (l/c/d)	Water Demand (m^3/d) mean.	max.	Remarks
1997 - 1998	Apartment	3,245	100	150	487	487	
	Ger	14,516	62 (100)	8.6 (5.2)	41	78	
	Institution	(31)	-	-	136	229	on the basis of 1998
	Industry	(3)	-	-	9	14	on the basis of 1998
	Loss	-	-	-	287	324	As 30% of Total
	Total	17,761			960	1,150	Actual consumption
2005	Apartment	3,433	100	150	515	515	
	Ger	15,357	100	20	163	307	mean=max x (41/78) =0.53Max
	Institution	(38)	-	-	167	282	Annual 3% in Growth Rate.
	Industry	(4)	-	-	12	19	Annual 4% in Growth Rate.
	Loss	-			283	377	As 25% of Total
	Total	18,790			1,140	1,500	
2015	Apartment	3,830	100	150	575	575	
	Ger	17,131	100	40	363	685	
	Institution	(56)			248	417	Annual 4% in Growth Rate.
	Industry	(7)			20	31	Annual 5% in Growth Rate.
	Loss	-			294	432	As 20% of Total
	Total	20,960			1,500	2,140	

3.3 DEVELOPMENT PLAN

(1) Design Condition

Design condition for the establishment of water supply services is recommended as follows.

Design Condition

Item	1997	2005 (FS)	2015 (MP)
Population	17,761	18,790	20,961
Service ratio (%)			
Apartment dwellers	100	100	100
Ger dwellers	60-100	100	100
Unit water demand (l/c/day)			
Apartment dwellers	150	150	150
Ger dwellers	8.6	20	40
Water supply method*			
Apartment area	Pipeline / tap		
Ger area	Pipeline / kiosk 1000 - 1500 residents / 1 kiosk within 250m radius / 1 kiosk		
Growth rate of water demand (%/year)		1998 - 2005	2006 - 2015
Institution	-	3	4
Industry	-	4	5
Effective water ratio (%)	70	75	80
Dairy maximum water demand (m^3/day)	1,150	1,500	2,140
Hourly maximum water demand (m^3/hour)	65	133	205

* : Distribution area will be divided into four of Central area, ger area G-1, G-2, and G-3.

(2) Water Resources Development

Development Capacity for Kharzat Water Source

Future maximum water demand is estimated at 2,140 m^3/day in the year of 2015. On the other hand, the existing production capacity in 1997 is 1,150 m^3/day in maximum. An additional 990 m^3/day shall be developed by the year of 2015.

Development Capacity in 2015 (Unit: m^3/day)

	Item	Production capacity
A	Future production demand in a maximum	2,140
B	Existing production capacity in a maximum	1,150
C	Future development capacity (=A-B)	990

Development Plan for Kharzat Water Source

The optimum pumping yield for a well is examined with Theis non-equilibrium equation on the basis of the following assumed figures:

- transmissivity is 360 m^2/day in a mean value in the area,
- storage coefficient of 0.005 is adopted because of semi-confined aquifer in deeper part, and
- pumping duration is 10 years or 3650 days.

The result of estimation of drawdown in 2005 and 2015 is shown in the table below.

The operation of three wells is sufficient for water demand in 2005.

In 2015, if the pumping wells are operated attentively with a water level monitoring, four wells will be adequate for the water demand. But, these four existing wells are deteriorating. Consequently, these wells shall be reconstructed before 2015 and it is recommended that a spare well should be constructed anew.

Estimated Drawdown in 2005 and 2015

	Year	1997-98	2005	2015	*1 2015 max
	Water demand (average) (m^3/day)	960	1140	1500	*2,140*
Number of wells					
2	Pumping rate a well (m^3/day)	480x2	570x2	750x2	*1070x2*
	Drawdown (Pumping)	-2.63 m	-3.12 m	-4.11 m	*-5.87 m*
	Drawdown (Interference)	-1.17 m	-1.38 m	-1.82 m	*-2.6 m*
	Total drawdown in a well	-3.80 m	-4.50 m	-5.93 m	*-8.47 m*
3	Pumping rate a well (m^3/day)		380x3	500x3	*714x3*
	Drawdown (Pumping)		-2.08 m	-2.74 m	*-3.91 m*
	Drawdown (Interference)		-0.92x2 m	-1.21x2 m	*-1.73x2 m*
	Total drawdown in a well		-3.92 m	-5.16 m	*-7.37 m*
4	Pumping rate a well (m^3/day)			375x4	*535x4*
	Drawdown (Pumping)			-2.06 m	*-2.93 m*
	Drawdown (Interference)			-(0.91x2+0.79)m	*-(1.30x2+1.03)m*
	Total drawdown in a well			-4.67 m	*-6.56 m*
5	Pumping rate a well (m^3/day)			300x5	*428x5*
	Drawdown (Pumping)			-1.64 m	*-2.35 m*
	Drawdown (Interference)			-(0.73+0.64)x2 m	*-(1.04+0.91)x2 m*
	Total drawdown in a well			-4.38 m	*-6.25 m*

- Well location; every 100 m on a straight line
- *1 : as a reference

3.4 OPERATION AND MAINTENANCE PLAN

(1) Institutional Strengthening

Water Tariff

It has been made clear by JICA Study Team that people of the service area can afford a rise in the water tariff, if sufficient and safe water is supplied. Consequently, water tariff shall be determined on the basis of financial aspect of water supply operation and management.

Establishment of Meter System

It will be necessary to install meters in apartments for user and supply facilities. APSD has to establish the inspection system of meter and collection system of water tariff for consumption.

Reduction of Leakage

The causes of leakage should be identified and the proper measures should be taken toward the alleviation of leakage. People shall have the awareness of saving water to reduce leakage from taps and valve of toilet. On the other hand, APSD shall improve the superannuated distribution pipes to reduce leakage from the pipelines.

Introduction of Strict Financial Management

Investment cost of expansion and reconstruction of facilities and O/M cost should be paid by APSD in order to achieve the self-operation.

Organization

Staff should be increased in sections of water tariff collection, procurement, and controlling various equipments.

If the pipeline network expands to the ger area, wastewater generation from ger area also will increase. In this case enforcement of sewerage section may be necessary.

(2) Legal Strengthening

The following legal issues should be considered in order to accomplish self-operation.

① Establishment of standards for industrial products

② Independence from Altai Municipality

(3) Training System

Operation and Maintenance (O/M) manuals for mechanical and electrical equipment should be prepared and training of employee for O/M should be done.

(4) Hygiene Education Plan

Measures against contamination of drinking water

Other than technical improvement of water quality test, it is important to make the residents of ger area know that the responsibility of water quality lies on the residents once the water has been delivered to the ger area. It is recommended for Social Health Center to conduct often a microbiological test on stock water in ger so that they can monitor the hygienic situation in ger area. It should be noted that the water analysis is done to monitor the condition of drinking water not to measure the true risk of the people. Therefore, it is encouraged to promote the understanding on the role of water analysis as well as exchanging information between APSD and Social Health Center.

In order to increase the hygiene practice among the residents in Altai City, the following approaches are recommended.

Increase of awareness on hygiene practice and water consumption

Target group	: All the residents in Altai City
Media	: Local radio and TV
Expected outcome	: The all residents of Altai City apply the knowledge of hygienic practice to their daily life.
Implementation body	: Gobi-Altai Social Health Center / Governors' office

Proper management of stock water and water consumption

Target group	: Residents in ger area
Media / Promoter	: Health Volunteer
Expected outcome	:The risk of water-borne and water-washed disease will be lowered through the proper management and use of stock water and increase of water consumption.

Water and health

Target group	: School children
Media	: School Class
Expected outcome	: The basic knowledge on hygiene will be put into practice in their life.

3.5 MONITORING PLAN

(1) Groundwater

Groundwater shall be utilized sustainablly for the public and the economic activity under the proper management.

Monitoring shall be continued at the existing meteorological and hydrological stations, and some of test wells of JICA as follows.

Existing meteorological stations and observation wells
B5 : Kharzat water resources of Alluvial aquifer
B6 : Olon Nool water resources of Alluvial aquifer
A3 : Khadaasan water resources of fissure aquifer
A4 : NE of Altai City water resources of fissure aquifer

The following items shall be measured and investigated.

① Groundwater table
② Hydrological and meteorological data
③ Groundwater quality
④ Groundwater utilization
⑤ Making inventory and database
⑥ Establishment of groundwater management plan

All database and information shall be opened to the public. This is to improve the awareness for saving water, preservation of the environment, and for sustainable development that groundwater is limited natural resources.
Groundwater shall be managed and preserved not only by the government but also by the public and its users. Otherwise, the irregular development of groundwater and pollution cannot be controlled.

(2) Water Supply Facilities

It is also required that the monitoring of water supply facilities for proper operation and maintenance as follows:

- water quality of raw water and distributed water,
- residual chlorine at the water tap of the end of pipeline,
- distributed water pressure at pumping station, and
- supplied water pressure at the end of pipelines.

3.6 COST ESTIMATION

The total investment cost is estimated to be 3,031,061 US dollars which includes the construction cost, land acquisition cost, engineering cost and physical contingency as shown below.

Investment Cost

Unit : US Dollar

Work Item	Nos	Amount	Year	
			2000-2005	2006-2015
A. Direct Construction Cost		1,916,876	630,108	1,286,768
		1,274,733 / 642,143	382,466 / 247,642	892,267 / 394,501
(1) Intake facility				
·Reconstruction of existing well	4 Wells	263,078	197,308	65,770
		230,547 / 32,531	172,910 / 24,398	57,637 / 8,133
·New production well	1Wells	65,770		65,770
		57,637 / 8,132		57,637 / 8,133
(2) Transmission facility				
·New pipe-line (φ200 x 2line)	3.5Km	311,500	0	311,500
		245,000 / 66,500	0 / 0	245,000 / 66,500
(3) Distribution facility				
·Water level indicator				
① Electrode	2 Sets	6,694	6,694	0
		6,586 / 108	6,586 / 108	0 / 0
② Transmit Cable	1 Lot	47,805	47,805	0
		40,659 / 7,146	40,659 / 7,146	0 / 0
·Water wagon	3 Cars	52,800	52,800	0
		50,400 / 2,400	50,400 / 2,400	0 / 0
·Water cart	2792 Sets	92,136	92,136	0
		0 / 92,136	0 / 92,136	0 / 0
·Water kiosk	14 Unit	71,484	51,060	20,424
		0 / 71,484	0 / 51,060	0 / 20,424
·Reservoir	2 Ponds	78,140	0	78,140
		0 / 78,140	0 / 0	0 / 78,140
·Pipe-line (φ150~250)	11Km			
① G-1 Area	(3.6Km)	192,700	38,540	154,160
		128,260 / 64,440	25,652 / 12,888	102,608 / 51,552
② G-2 Area	(1.3Km)	67,500	51,975	15,525
		40,500 / 27,000	31,185 / 20,790	9,315 / 6,210
③ G-3 Area	(3.7Km)	184,500	91,790	92,710
		110,700 / 73,800	55,074 / 36,716	55,626 / 37,084
④ Central Area	(3.4Km)	186,520	0	186,520
		121,160 / 65,360	0 / 0	121,160 / 65,360
·Pump Station (Including Pump)	1 St.	206,297	0	206,297
	-	157,714 / 48,583	0 / 0	157,714 / 48,583
·Chlorinating equipment	Unit	53,250	0	53,250
		53,250 / 0	0 / 0	53,250 / 0
·Water level indicator	Set	36,702	0	36,702
		32,320 / 4,382	0 / 0	32,320 / 4,382
B. Land Acquisition Cost	-	0	0	0
C. Construction Cost (A X 1.25)	-	2,396,095	787,635	1,608,460
D. Design & Supervision (C X0.1)	-	239,610	78,764	160,846
·Detailed Design (C x 0.05)	-	119,805	39,382	80,423
·Supervision (C x 0.05)	-	119,805	39,382	80,423
E. Physical Contingency {(C+D) X 0.15)}	-	395,356	129,960	265,396
Total (C+D+E)	-	3,031,061	996,359	2,034,702

Note 1) Exchange Rate : US$ 1.00 = Yen 117.5 US$ 1.00= Tg 890

2) ① / ② ③ ① Total ② Foreign Portion ③ Local Portion

3.7 IMPLEMENTATION PROGRAM

The improvement and expansion of water resources and water supply facilities shall be proceeded step by step on the basis of implementation schedule shown in the following figure.

Implementation Schedule

Work Item	Nos	Year (2000-2015)															
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
(1) Intake facility																	
・Reconstruction of existing well (Including submersible pump)	4 Wells			━	━				━								
・New construction of production well (Including submersible pump)	1Wells									━							
(2) Transmission facility																	
・New pipe-line (Φ200 x 2line)	3.5Kms								━	━							
(3) Distribution facility																	
・Water level indicator	2 Sets			━													
・Water wagon	3 Cars		━														
・Water cart	2,792 Sets		━														
・Water kiosk	14 Units				━	━					━						
①G-1 area	(6)				(2)						(4)						
②G-2 area	(3)				(3)												
③G-3 area	(5)					(5)											
・Reservoir	2 Ponds										━						
・Pipe-line (Φ150~250)	11Kms				━	━				━	━	━	━	━	━		
①G-1 area (Φ150~200)	(3.6)				(0.7)					(2.9)							
②G-2 area (Φ150)	(1.3)				(1.0)										(0.3)		
③G-3 area (Φ150)	(3.7)					(1.8)								(1.2)	(0.7)		
④Central area (Φ150~250)	(3.4)										(2.0)	(0.8)	(0.6)				
・Pump Station (Including Pump)	1 St.									━	━						
・Chlorination equipment	1 Unit										━						
・Water level indicator	1 Set										━						

■■■ breakdown

3.8 IMPROVEMENT PLAN FOR SANITATION

The following sanitary measures should be taken to protect the sources of drinking water after water supply facilities are expanded in 2005 and 2015.

- Central apartment area: improvement of sewer and waste water treatment capacity
- Ger area: installation of personal or community treatment facilities

The following sanitary zones should be established to protect the sources of domestic water.

I - (100m) strictly prohibited zone.
prohibit setting up of any sources of possible pollution in this zone
II -(300m) zone under protection.
III-(1,000m) monitoring zone.

Bacteriological and chemical analyses should be carried out in these zones.

3.9 PROJECT EVALUATION FOR MASTER PLAN

(1) Economic Analysis

The following table summarizes the result.

Result of Economic Evaluation of Mater Plan

Case	EIRR (%)	B/C	NPV (10^3)
Standard	14.5	1.23	591
Cost 10% up	12.4	1.12	339
Benefit 10% down	12.1	1.11	280
Cost 10% up plus benefit 10% Down	10.3	1.01	29

EIRR: economic internal rate of return,
B/C: benefit-cost ratio,
NPV: net present value

The EIRR for the standard case is derived at 14.5% indicating high economic return of the master plan, compared with an opportunity cost of capital or cut-off EIRR at 10%.

The economic evaluation was carried out based on the following assumptions.

1) An assumed life of the pipelines at 25 years.
2) The estimated costs are as follows.

Investment cost:	$ 3,031 thousand in total
Operation and maintenance cost:	$ 82 thousand per year in 2015 and thereafter
Replacement cost:	$ 1,593 thousand in total

3) Economic benefit by domestic water supply is estimated based on the prevailing water charges and the surveyed willingness-to-pay of the consumers.

Economic Benefit by Domestic Water Supply

Item	Unit	Minimum requirement	Commercial commodity
Value	Tg/m^3	1,875	67
	$/m^3	2.11	0.08
Net water use in 2015			
Apartment	l/c/d	20	130
Ger	l/c/d	20	1.2
Population in 2015			
Apartment	No.	3,830	
Ger	No.	17,131	
Economic benefit in 2015 and thereafter	10^3 $/year	322	14

4) Economic benefit of industrial and institutional water supply was estimated based on the present revenue, by water sale, surveyed willingness-to-pay for water of the industries and institutions, and annual growth rates at 3.5 % per year until 2005 and 4.5% per year between 2005 and 2015. The following economic benefits were derived.

2005 :	$ 112 thousand per year
2015 and thereafter :	$ 174 thousand per year

(2) Financial Analysis

The objectives of a financial analysis are:

- to derive appropriate water charge and
- assess financial viability of the master plan for APSD by a financial internal rate of return.

An analysis was made to derive fair water charges for ger and apartment dwellers from the perspectives of **cost recovery** and **affordability**. It was found that an appropriate target for cost recovery would be the one where operation and maintenance cost is covered by

water sale revenue. A target beyond this level would pose a difficulty in terms of affordability for residents. It is assumed that the present tariff for industries and institutions remain unchanged. The following table compares the existing water charges and the proposed water charges for 2005 and 2015.

Proposed Water Charges for Domestic Water

(Unit : Tg/m^3)

	Existing	2005	2015
Ger	1,250	566	283
Apartment	56	64	86
Industry / Institute	900	900	900

Under these water charges, the proportion of the expenditure on water to monthly income stays within 5% for the population with a per capita income of less than Tg.10,000 per month. The population of this category accounts for 80% of ger dwellers and 40% of apartment dwellers.

The financial internal rate of return (FIRR) of the master plan under these proposed water charges is negative. It would be necessary for the government to subsidize the investment cost and replacement cost for implementing the project. Financial autonomy for APSD would be achieved for operation and maintenance portion.

(3) Social Evaluation

Proposed project on water supply system mainly focused on the improvement of water supply in the ger area aiming at increasing chances of water availability. Although the resident of ger area cited yard connection as a preferable choice, it is not technically feasible. As mentioned in social analysis, no negative impact on the proposed project is recognized in terms of religion and social custom, acquisition of land for the project, and water seller.

(4) Analysis for the Beneficiaries

While the higher income group of non-piped households approved 161% of increase, the

lower income group of non-piped households approved 80% of increase to the current tariff level. It is recommended that waving system of water charge for lower income group - unemployed and single female headed households should be revised periodically in accordance with local poverty assessment.

The proposed installation of water kiosk will facilitate the availability of water in terms of time. This also will lead to the increase in the water consumption for non-piped households. The frequent supply of water will reduce the habit of stock water and bring about less opportunity of contamination.

However, 20% of non-piped households will not gain the very benefit of kiosk type of water supply since a fixed single kiosk are planned to cover radius of 250m. It is recommended that the water supply department promote the use of water cart.

(5) Initial Environmental Examination (IEE)

General

As a result of screening conducted by MNE, "Scope of Actions" was drawn up.

Scope of Actions

a) The following items should be investigated by a specialized organizations.
   - Water
   - Soil
   - Flora and Fauna
   - Historical and Cultural Monuments

b) It shall be worked out an environmental plan of action and environmental monitoring program.

c) The detailed environmental impact assessment (EIA) statement should be submitted to the MNE on the basis of the Law on Environmental Impact Assessment. It is submitted in September 1998.

3.10 SELECTION OF THE PRIORITY PROJECT FOR THE FEASIBILITY STUDY

Considering the above mentioned criteria such as groundwater potential, water demand, and economy, the priority project of the water supply development has been selected It recommends to improve the existing water supply facilities of production wells, transmission pipes, distribution pump. It also recommends procurement of water wagon and water cart and to construct the main distribution pipe and kiosk for some ger area. These shall be examined in an implementation design in the feasibility study.

4. FEASIBILITY STUDY

4.1 DESIGN CONDITION

(1) Target year	: 2005
(2) Future population in 2005	: 18,790
(3) Population served	: 18,790 (apartment; 3,433, ger; 15,357)
(4) Service area	: whole apartment and ger area
(5) Future water demand in 2005	: 1,500 m^3/day in maximum
(6) Additional development capacity	: 350 m^3/day in maximum
(7) Water source and its potential	: Kharzat, more than 3,000 m^3/day

4.2 DEVELOPMENT PLAN

The development of water supply facilities shall proceed as follows.

Required facilities to increase the capacity of water supply

Measures	Facilities
Improvement of existing facilities	1, reconstruction of 3 wells (total 4 wells; one is spare) 2, replacement of submersible motor pump with control system : 0.42m^3/min x 65m x 3 unites (total 4 pumps; one is spare)
Construction of new facilities	1, water level indicator system for reservoir : 2sets 2, procurement of water wagon ; 5m^3 x 3 cars 3, procurement of water cart : 2792 (households) sets 4, distribution pipe for ger area G-2, G-3, and a part of G-1 : dia.150-200mm x 3.9km 5, water kiosk: G-1; 2 sites, G-2; 3 sites, G-3; 5 sites

4.3 OPERATION AND MAINTENANCE PLAN

Institutional Strengthening

- Introduction of appropriate water tariff
- Implementation of meter measuring system

- Reduction of water leakage
- Introduction of strict financial management
- Establishment of functional organization

Improvement of Data Arrangement

Daily or monthly operation data of water consumption, electric power consumption, chemical dosing quantity and other necessary data shall be arranged systematically and checked well under the strengthened organization.

Training System

There are 45 employees including director in APSD. They are too specialized in their specific field of work.

Therefore appropriate training system is necessary to make them master the comprehensive operation and maintenance technique.

Hygiene Education Plan

In order to increase the hygiene practice among the residents in Altai City, the following approach are recommended.

- Increase of awareness on hygiene practice and water consumption
- Proper management of stock water and water consumption
- Water and health

4.4 MONITORING PLAN

The following items should be regularly measured or studied for the purpose of monitoring the present conditions and accumulating data for the future use.

For water sources

- groundwater level,
- hydrological and meteorological data,
- groundwater quality, and
- groundwater utilization.

For water supply facilities

- water quality of raw water and distributed water,
- residual chlorine at the water tap of the end of pipeline,

- distributed water pressure at pumping station, and
- supplied water pressure at the end of pipelines.

4.5 COST ESTIMATION

The total investment cost by the year of 2005 amounts to 996,359 US dollars which includes the direct construction cost, overhead cost, land acquisition cost, engineering (design & supervision) cost, and physical contingency. Its break down is shown below.

Investment Cost until the Year of 2005 (Unit : US Dollar)

Work Item	Nos	Total Cost (2000~2005)	
A. Direct Construction Cost	-	630,108	
		382,466	247,642
(1) Intake facility		197,308	
·Reconstruction of existing well	3 Wells	197,308	
		172,910	24,398
(2) Distribution facility		432,800	
· Water level indicator			
① Electrode	2 Sets	6,694	
		6,586	108
② Transmit Cable	1 Lot	47,805	
		40,659	7,146
· Water wagon	3 Cars	52,800	
		50,400	2,400
· Water cart	2792 Sets	92,136	
		0	92,136
· Water kiosk	10 Unit	51,060	
		0	51,060
·Pipe-line (φ150~250)	3.9 Km		
① G-1 Area	(1.0Km)	38,540	
		25,652	12,888
② G-2 Area	(1.0Km)	51,975	
		31,185	20,790
③ G-3 Area	(1.9Km)	91,790	
		55,074	36,716
B. Land Acquisition Cost	-	0	
C. Construction Cost (A X 1.25)	-	787,635	
D. Design & Supervision (C X0.1)	-	78,764	
·Detailed Design (C x 0.05)	-	39,382	
·Supervision (C x 0.05)	-	39,382	
E. Physical Contingency {(C+D) X 0.1	-	129,960	
Total (C+D+E)	-	996,359	

Note 1) Exchange Rate : US$ 1.00 = Yen 117.5 US$ 1.00= Tg 890

2) ① Total ② Foreign Portion ③ Local Portion

4.6 IMPLEMENTATION SCHEDULE

Implementation schedule on priority project is proposed as shown below.

Implementation Schedule

Work Item	Nos	Year (2000-2005)					
		2000	2001	2002	2003	2004	2005
(1) Intake facility							
・Reconstruction of existing well (Including submersible pump)	3 Wells			■	■		
(2) Distribution facility							
・Water level indicator	2 Sets			■			
・Water wagon	3 Cars		■				
・Water cart	2,792 Sets		■				
・Water kiosk	10 Units				■	■	
①G-1 area	(2)				(2)		
②G-2 area	(3)				(3)		
③G-3 area	(5)					(5)	
・Pipe-line (Φ150～250)	3.9 Kms				■	■	
①G-1 area (Φ150～200)	(1.0)				(1.0)		
②G-2 area (Φ150)	(1.0)				(1.0)		
③G-3 area (Φ150)	(1.9)					(1.9)	

4.7 DISBURSEMENT PLAN

The proposed disbursement of the project is shown below.

Disbursment Plan

(Unit : US Dollar)

Work Item	Nos	Year 2000 - 2005												Total Cost (2000~2005)	
		2000		2001		2002		2003		2004		2005			
A. Direct Construction Cost	-			144,936		186,038		181,815		117,320				630,108	
				50,400	94,536	162,519	23,520	114,474	67,341	55,074	62,246	0	0	382,466	247,642
(1) Intake facility														197,308	
- Reconstruction of existing well	3 Wells					131,539		65,770						197,308	
						115,274	16,266	57,637	8,133					172,910	24,398
(2) Distribution facility														432,800	
- Water level indicator															
① Electrode	2 Sets					6,694								6,694	
						6,586	108							6,586	108
② Transmit Cable	1 Lot					47,805								47,805	
						40,659	7,146							40,659	7,146
- Water wagon	3 Cars			52,800										52,800	
				50,400	2,400									50,400	2,400
- Water cart	2792 Sets			92,136										92,136	
				0	92,136									0	92,136
- Water kiosk	10 Unit							25,530		25,530				51,060	
								0	25,530	0	25,530			0	51,060
- Pipe-line (φ150~250)	3.9 Km														
① G-1 Area	(1.0Km)							38,540						38,540	
								25,652	12,888					25,652	12,888
② G-2 Area	(1.0Km)							51,975						51,975	
								31,185	20,790					31,185	20,790
③ G-3 Area	(1.9Km)									91,790				91,790	
										55,074	36,716			55,074	36,716
B. Land Acquisition Cost	-	0		0		0		0		0		0		0	
C. Construction Cost (A X 1.25)	-	0		181,170		232,547		227,268		146,650		0		787,635	
D. Design & Supervision (C X0.1)	-	9,059		20,686		22,991		18,696		7,333		0		78,764	
- Detailed Design (C x 0.05)	-	9,059		11,627		11,363		7,333		0		0		39,382	
- Surpervision (C x 0.05)	-			9,059		11,627		11,363		7,333		0		39,382	
E. Physical Contingency ((C+D) X 0.15)	-	1,359		30,278		38,331		36,895		23,097		0		129,960	
Total (C+D+E)	-	10,418		232,134		293,869		282,859		177,080		0		996,359	

Note 1) Exchange Rate : US$ 1.00 = Yen 117.5 US$ 1.00= Tg 890

2) ① Total ② Foreign Portion ③ Local Porti

4.8 OPERATION AND MAINTENANCE COST

Operation and Maintenance Cost

The annual average O/M costs after the completion of each construction works without replacement cost (as of 1998) are estimated below.

Annual Operation and Maintenance Cost

Item	Unit	Year (2000-2005)						Total
		2000	2001	2002	2003	2004	2005	
Daily Mean Demand	m3/day	1,011	1,037	1,063	1,089	1,114	1,140	
Hourly Maximum Demand	m3/h	86.4	95.6	104.9	114.1	123.3	132.5	
1. Electric Power Cost (US$0.126/KwH)	US$/Year	32,600	37,173	37,699	31,213	31,558	31,917	202,160
·Electric Consumption	KwH/Year	258,727	295,022	299,198	247,726	250,463	253,310	
①Intake Pump (Existing)	KwH/Year	162,367	166,542	170,718				
②Intake Pump (Reconst. & New)	KwH/Year				119,246	121,983	124,830	
③Distribution Pump (Existing)	KwH/Year	96,360	128,480	128,480	128,480	128,480	128,480	
④Distribution Pump (New)	KwH/Year							
2. Chemical Cost (US$0.34/Kg)	US$/Year	916	939	963	987	1,009	1,033	5,847
·Chemical (Cl_2) Consumption	Kg/Year	2,693.81	2,763.09	2,832.36	2,901.64	2,968.25	3,037.53	
3. Personnel Cost	US$/Year	10,598	10,598	11,771	11,771	13,456	15,141	73,335
4. Repair Cost (1% of Const.-Cost)	Lot	0	0	1,812	4,137	6,410	7,876	20,235
Total Annual M & O Cost	US$/Year	44,113	48,710	52,245	48,108	52,433	55,967	301,576

The equipment shall be periodically replaced at the end of its life span. The detail replacement cost is shown in the following table.

Replacement Cost

Unit : US Doller

Work Item	Unit	Life Span	Year (2000-2005)						Total
			2000	2001	2002	2003	2004	2005	
Intake facility (Exist. & New)					164,423	82,212			246,635
·Well	Year	15			30,660	15,330			45,990
·Pump house	Year	40			6,710	3,355			10,065
·Intake pump	Year	15			116,531	58,266			174,798
·Collection pipe	Year	25			10,522	5,261			15,783
Distribution facility	Year			181,170	68,124	145,056	146,650		541,000
·Water level indicator	Year	15			68,124				68,124
·Water wagon	Year	10		66,000					66,000
·Water cart	Year	15		115,170					115,170
·Water kiosk	Year	40				31,913	31,913		63,826
·Pipe-line (Φ150~250)	Year	25				113,143	114,738		227,881
Total of Replacement Cost	-	-		181,170	232,547	227,268	146,650		787,635
Every 10 Years				66,000					66,000
Every 15 Years				115,170	215,315	73,596			404,081
Every 25 Years					10,522	118,404	114,738		243,664
Every 40 Years					6,710	35,268	31,913		73,890

Note 1) Exchange Rate : US$ 1.00 = Yen 117.5 US$ 1.00= 1g 890

4.9 IMPROVEMENT PLAN FOR SANITATION

The following sanitary measures should be taken to protect the sources of drinking water after water supply facilities are expanded in 2005 and 2015.

- Central apartment area: improvement of sewer and waste water treatment capacity
- Ger area: installation of personal or community treatment facilities

The following sanitary zones should be established to protect the sources of domestic water.

I - (100m) strictly prohibited zone.
prohibit setting up of any sources of possible pollution in the I-zone
II -(300m) zone under protection.
III-(1,000m) monitoring zone.

It should be carried out bacteriological and chemical analyses in these zones.

4.10 PROJECT EVALUATION

(1) Economic Analysis

The following table summarizes the result.

Result of Economic Evaluation of Priority Project

Case	EIRR (%)	B/C	NPV (10^3)
Standard	16.3	1.38	532
Cost 10% up	14.3	1.25	391
Benefit 10% down	14.1	1.24	337
Cost 10% up plus benefit 10% Down	12.3	1.13	196

EIRR: economic internal rate of return,
B/C: benefit-cost ratio,
NPV: net present value

The EIRR for the standard case was derived at 16.3% indicating high economic return of the priority project, compared with an opportunity cost of capital or cut-off EIRR at 10%. The assumptions for the analysis on the master plan were also employed. The following are the used values and the estimated economic benefit.

Economic Benefit in 2005

Item	Unit	Minimum requirement	Commercial commodity
Value	Tg/m^3 \$/m^3	1,875 2.11	67 0.08
Net water use in 2005			
Apartment	l/c/d	10.6	139.4
Ger	l/c/d	10.6	0
Population in 2005			
Apartment	No.	3,433	
Ger	No.	15,357	
Economic benefit in 2005 and thereafter Domestic water	10^3 \$/year	153	13
Industrial/Institutional water	10^3 \$/year	112	

(2) Financial Analysis

The FIRR for the priority project was derived at 4.6% based on the derived water charges in 2005, indicating the possibility that the fund for implementing the priority project could be procured from the source with an interest of less than 4.6% per year.

(3) Environmental Impact Assessment (EIA)

EIA was conducted for the priority project site of Kharzat water source and new water supply facilities.

1) Expected Environmental Impacts

Construction of Water Supply Facilities

Item	Judgement
Drilling noise for human being (including livestock) and fauna (especially in breeding season)	small negative impact
Degradation of vegetation / subsoil by drilling work, (10-30 m^2)	small negative impact
Degradation of vegetation / subsoil by constructing distribution pipeline (30 m x 3.9 km: affected area 12ha)	large negative impact
Employment	small positive impact
if construction workers are locally employed,	impact is positive.
if construction workers are employed from other places,	impact is negative.

Operation of Water Supply Facilities

Item	Judgement
Stable water supply, especially for Ger areas	large positive impact
Degradation of groundwater, wetland, vegetation and subsoil if overusing the groundwater	large negative impact
Employment (changing types of job)	small impact

2) Mitigation of Impacts

- Inform the construction detail before the commencement
- Prevent the degradation of vegetation and subsoil from the construction work
- Prevent the degradation of groundwater from overusing
- The following sanitary scheme should be established to protect the sources of drinking water:

  I - (100 m) strictly prohibited zone,

  II - (300 m) zone under protection,

  III - (1,000 m) monitoring zone,

  and prohibit setting up of any sources of possible pollution in the I-zone.

3) Monitoring and Management

Construction Phase

After the construction of a facility vegetation and subsoil in the affected area should be monitored, and if necessary, some measure should be taken.

Operation Phase

Water level and quality of groundwater, vegetation and subsoil should be monitored, and if necessary some measures should be taken.

5. CONCLUSION AND RECOMMENDATION

Conclusion

The project evaluation revealed that both the master plan and priority project were feasible, therefore worth promoting to the implementation stage. The project would contribute to the improvement of the living standard of Altai people and support economic development in the city. An appropriate financial arrangement would be needed considering the low financial return of the project. No adverse impacts are envisaged in the environmental and social aspects.

Recommendation

(1) At present ger dwellers have great disadvantage in that water wagons deliver water a couple of times in a day for them, while apartment dwellers get water by taps any time. Ger dwellers cannot get water whenever they want. Therefore, improvement of water supply service for ger dwellers shall be given priority.

(2) Disparity of water tariff between apartment dwellers and ger dwellers shall be revised. To start with, the above mentioned fact should be opened to the public.

(3) People have to change the awareness for water quality that high mineral concentrations in water affect their health. Actually, the chemical contents are below the Mongolian standards except magnesium. The problem is the total coliform in water, especially in the stored water in ger. Water in Altai City is not as bad as they claim, considering the water quality analysis result and especially when it is compared with water quality and standards of some other countries. Hygiene education for the public shall be conducted through radio, television, by the public health center and school with following objections:

- increase of awareness on hygiene practice and water consumption,
- proper management of stock water and water consumption, and
- water and health.

(4) Epidemiological survey that started from 1998, shall be continued to clarify the cause of chronic diseases.

(5) The drawdown in operation of wells should be kept around four to six meters to conserve the limited natural resources of groundwater.

(6) The loss ratio of leakage should be improved step-wise. Water meters shall be installed at the pumping station, apartment buildings, public buildings, and in each apartment. APSD has to inspect meters and find the point of leakage in order to improve the water supply facilities. Inspection staff in APSD should be strengthened.

(7) All information shall be opened to the public to improve the people's awareness for saving water, preservation of the environment to spread the idea that groundwater is limited natural resources.

MAIN REPORT

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3. MASTER PLAN STUDY

Hydrogeological Map is attached at the end of the book.

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Abbreviations

ADB	Asian Development Bank
APSD	Altai Public Service Department
ASL	Above Sea Level
AWSD	Altai City Water Supply Department (previous name for APSD)
B/C	Benefit - Cost Ratio
BOD	Biochemical Oxygen Demand
CCT	Computer Compatible Tape
CHC	Communal Heating Center
CITES	Convention International Trade in Endangered Species of Wild Fauna and Flora
CMEA	Council for Mutual Economic Assistance
COD	Chemical Oxygen Demand
DPT	Diphtheria Pertussis Tetanus
DTH	Down The Hall (rotary percussion drilling)
EC	Electric Conductivity
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EM	Electro Magnetic
FIRR	Financial Internal Rate of Return
G. L.	Ground Level
GDP	Gross Domestic Product
GIAUS	Governmental Implementation Agency of Urban Services
GPS	Global Positioning System
GRDP	Gross Regional Domestic Product
I.D.	Inside Diameter
IEE	Initial Environmental Examination
IMR	Infant Mortality Rate
IUCN	Red list of world Conservation Union
JICA	Japan International Cooperation Agency
l/c/d	liter Per Capita Per Day
l/d/c	Liter per Day per Capita
LEIAC	Licensed Environmental Impact Assessment Company
M/P	Master Plan
MAI	Ministry of Agriculture and Industry
MID	Ministry of Infrastructure Development
MLH	Mongolian Law on Hunting
MLNP	Mongolian Law on Natural Plants
MMR	Maternal Mortality Rate

Abbreviations

MNE	Ministry of Nature and Environment
MSS	Multi Spectrum Scanner
MW	Mega Watt
NDB	National Development Board
NPV	Net Present Value
O/M	Operation and Maintenance
ORS	Oral Rehydration Solution
/c/d	Per Capita Per Day
P.W.L.	Pumping Water Level
S.W.L.	Static Water Level
SP	Spontaneous Potential
SPR	Single Point Resistivity
SS	Suspension Solid
TM	Thematic Mapper
UNDP	United Nations Development Program
UNICE	United Nations Children's Fund
VES	Vertical Electric Sounding
VLF	Very Low Frequency (electromagnetic survey)
WHO	World Health Organization
WWTP	Wastewater Treatment Plant

1 INTRODUCTION

1 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The Government of Mongolia established "the Regional Development Plan of Western Five Provinces" including Gobi-Altai Aimag in 1993. The Government of Mongolia also adopted the Decree 119 of some measures on development of Gobi-Altai province in July 5, 1995. It is reported in the development plans that the shortage of water quantity and bad water quality had restricted the development of western part of Mongolia and Gobi-Altai province. Consequently, the improvement of quantity and quality of water in Altai city which is the capital and center of Gobi-Altai province, shall be given priority to promote the development.

Recently, Altai city has frequently encountered the suspension of water supply due to the superannuated water supply facilities and exhausted groundwater resources.
Altai city requested to improve the water supply facilities to the Ministry of Infrastructure Development. But, the central government could not cope with the improvement of water supply facilities in Altai city due to the shortage of budget and manpower.
Accordingly, the Government of Mongolia requested the technical assistance from Japanese Government in the formulation of a master plan for the water resources development and a feasibility study of high priority project for Altai city.

In response to the request of the Government of Mongolia, the Government of Japan decided to conduct the Study on Groundwater Development for Altai City (hereinafter referred to as "the Study") in accordance with the relevant laws and regulations in force in Japan. In May 1996, the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched a mission headed by Mr. Makoto AOKI to Mongolia for the preliminary survey as well as discussions on the scope of work for the Study. The scope of work was agreed upon between the Government of Mongolia and JICA mission on May 18, 1996.

JICA, the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, will undertake the study in close cooperation with the authorities concerned of Mongolia.

Ministry of Infrastructure Development and Gobi-Altai Governor's Office act as counterpart agency to the Japanese Study Team and also as coordinating body in

relation with other organizations for smooth implementation of the Study.

In September 1996, Pacific Consultants International in association with Mitsui Mineral Development Engineering Co., LTD. (hereinafter referred to as "the Study Team") was appointed by JICA to conduct the Study. And in the same month, JICA dispatched the Study Team headed by Mr. Teruo TAHARA to conduct the first field survey in Mongolia.

Since September 1996 to February 1999, JICA Study Team has conducted the Study.

Flow Chart of the Study is shown in Figure1.1

1.2 OBJECTIVES OF THE STUDY

The objectives of the Study are :

(1) to formulate a master plan on water resources development (focusing on groundwater) and improvement of water supply system for Altai city for the target year of 2015,
(2) to conduct a feasibility study for the priority project identified in the master plan for the target year of 2005, and
(3) to pursue the technology transfer to the counterpart personnel in the course of the Study.

1.3 STUDY AREA

The Study area covers an area of about 600 km^2 as shown in Figure 1.2. The detailed groundwater development study covered the area of "Kharzat" and "Sukhyn Khooloy" as shown in Figure 1.2. Tsagaantokhoi and Taishir along the Zavkhan river were also investigated as alternative water sources by reviewing previous studies.