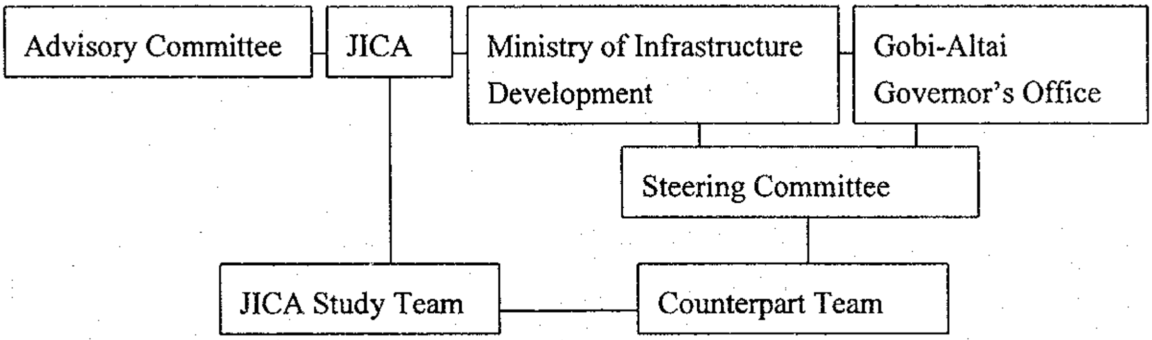
1.4 STUDY ORGANIZATION

1.4.1 General Organization

A general organization for the Study is described below.



1.4.2 Japanese Organization

The official agency of Japanese side to execute the Study is JICA. JICA organized an advisory committee to ensure the smooth and appropriate execution of the Study. The Study Team consists of 11 members and Advisory Committee consists of three members as follows.

JICA Advisory Committee

1	Specialist on water resources, JICA	Dr. Yuji MARUO
2	Officer, Ministry of Foreign Affairs	Mr. Takaaki ANDO
3	Project coordinator	Mr. UEKI (former) / Mr. SEKINE (present)

JICA Study Team

1	Team leader, Groundwater planner	Mr. Teruo TAHARA
2	Hydrogeologist 1, Hydrologist	Dr. Katsuhito YOSHIDA
3	Hydrogeologist 2	Mr. Yusuke OSHIKA
4	Water supply planner	Mr. Nobuyuki GONOHE (former) Mr. Susumu SAKAGUCHI (present)
5	Environmental expert Water quality analyst	Dr. Kazuhiko IKEDA
6	Geophysical expert 1	Dr. Takashi OHYA
7	Geophysical expert 2	Mr. Hiroyuki ITOGA
8	Drilling expert	Mr. Takashi SUZUKI
9	Planner / Economist	Mr. Haruo YAMANE
10	Public health expert	Mr. Eimitsu USUDA
11	Coordinator	Mr. Youji. SAKAKIBARA / Mr. Naoki YASUDA

1.4.3 Mongolian Organization

Ministry of Infrastructure Development (MID) and Gobi-Altai Governor's Office (GAGO) acted as the counterpart agency to the Study Team and provided necessary counterpart stuff. Mongolian Counterparts conducted the Study together with members of the Study Team. Good relationship and cooperation between Study Team and Mongolian counterparts had made good results overcoming the obstacles of language. Mongolian Steering Committee set up on September 1996 and Mongolian counterpart are listed in the following table.

Mongolian Counterpart June 19,1998

1	Team leader	U. BORCHULUUN, Officer, Department of Strategy Planning and Policy, MAI
2	Deputy team leader	R. DAGVADORJ, Director, Water Supply Company, Gobi-Altai province (Gobi – Altai Water Development Company)
3	Hydrogeologist	D. TSERENJAV, Senior research fellow in charge of Water Resources and Water Supply, Geoecology Institute
4	Hydrogeologist	R. BATTUMUR, Mineral Resources Department, MAI
5	Hydrologist	T. BAAST, Research Fellow, Geoecology Institute
6	Water supply planner	D. MYAGMAR, Senior officer, Department of Urban Development, Housing and Public Services, MID
7	Water supply planner	O. TSEDENDAMBA, Governmental Implementation Agency of Urban Services (GIAUS), MID
8	Water supply planner	D. MUNKHBAATAR, Senior officer, GIAUS, MID
9	Water supply planner	G. HURELHUU, Chief engineer, Public Service Department in Altai City (APSD)
10	Environmental expert	S. BARHAA, Officer, GAGO, State Inspector for Nature and Environment Control
11	Environmental expert	D.DORJ, Research fellow, Geoecology Institute
12	Drilling expert	Sh. YADMAA, (Gobi – Altai Water Development Campany)
13	Planner / Economist	Ts. NERZEDGARAM, Chief, Statistical Division, GGO
14	Public health expert	S. BATCHIMEG, Hygiene inspector
15	Public health expert	D. GOMBOSUREN, Director, Social Health Care Center, Gobi Altai Province

Member of Mongolian Steering Committee June 19, 1998

1	Chairman	Ts. DAMIRAN, Secretary of State, MID
2	Vice chairman	B. BATJAV, General Director, Department of Urban Development, Housing and Public Services, MID
3	Member	N. JANCHIVDORJ, Governor, Gobi Altai province
4	Member	B. JIGJID, Director General, GIAUS, MID
5	Member	Ts. SUKHBAATAR, Director, Department of Economic Cooperation, MID
6	Member	M. SAIJAA, Director, National Center of Hygiene, Epidemics and Virology (regulation agency)
7	Member	Ts. DAVAASUREN, Officer, Division of Foreign Relations, Ministry of Finance
8	Member	N. TEMUUJIN, Officer, Department of Foreign Relations and International Cooperation, Ministry of External Relations
9	Member	D. GANTIGMAA, Officer, Regulation Department on the Policy Implementation, Ministry of Nature and Environment
10	Member	S. CHULUUNKHUAYG, Scientific Secretary, Geoecology Institute
11	Member	B. BATMUNKH, Officer in charge of irrigation, Strategy and Planning Policy Department, MAI
12	Member	A. BUZMAA, Senior officer, Strategy Management and Planning Department, Ministry of Health and Social Welfare
13	Member	D. MYAGMAR, Officer, Department of Urban Development, Housing and Public Services, MID

1.5 REPORT

The Study reports are prepared as follows :

Main report,
Supporting report,
Executive summary report,
Data book, and
Mongolian summary

Main Report

The main report presents the summarized results of the Study. It mainly consists of three part as follows :

① a description for the background information of the present social and natural conditions of Gobi-Altai province and Altai city,

② a description for the master plan study of the long term development plan, and

③ a description for the feasibility study of the priority project.

Supporting Report

The supporting report describes the details of the same contents presented in the main report.

Executive Summary Report

The summary report presents the summary of the Study.

Data Book

The data book contains a basic data and information utilized and collected in the Study.

Figure 1.1 Flow Chart of the Study

Period	Phase	Stage	Components	Report
Sep. '96	Basic Study		Preparation	
Nov. '96	Basic Study	Stage I	Data collection & Review, Topographical Survey Hydrological measurement Investigation of Hydrogeology / Water Supply/ Development Plan / Economy / Social aspect	Inception Progress (1)
Feb. '97	Basic Study	Stage II	Evaluation of present condition, Identification of problems Planning of Stage III survey	Interim (1)
June '97 Aug. 97	Master Plan Study (M/P)	Stage III	Survey of water resources potential (1) , Water supply survey, Social-public health / water use survey, Preperation for preliminary hydrogeological maps, Planning of well construction	Progress (2)
Sep. '97	Master Plan Study (M/P)	Stage IV	Social assessment, Water demand projection, Preperation for Technology transfer and Hygiene seminar	Interim (2)
May '98	Master Plan Study (M/P)	Stage V	First seminar of technology transfer, Hygiene seminar, Survey of water resources potential (2), Well construction , Formulation of M/P, Selection of priority project	
Nov. '98	Master Plan Study (M/P) / Feasibility Study	Stage VI	Formulation of optimum pumping yield of existing water source, Feasibility Study, Overall evaluation of the project	Progress (3)
Jan. '99	Feasibility Study	Stage VII	Evaluation of M/P Feasibility Study, Overall evaluation of the project	
Feb. '99	Feasibility Study	Stage VII	Explanation & discussion on the Draft Final Report Second seminar of technology transfer	Draft Final
Mar. '99	Feasibility Study	Stage VIII	Making and submission of Final Report	Final

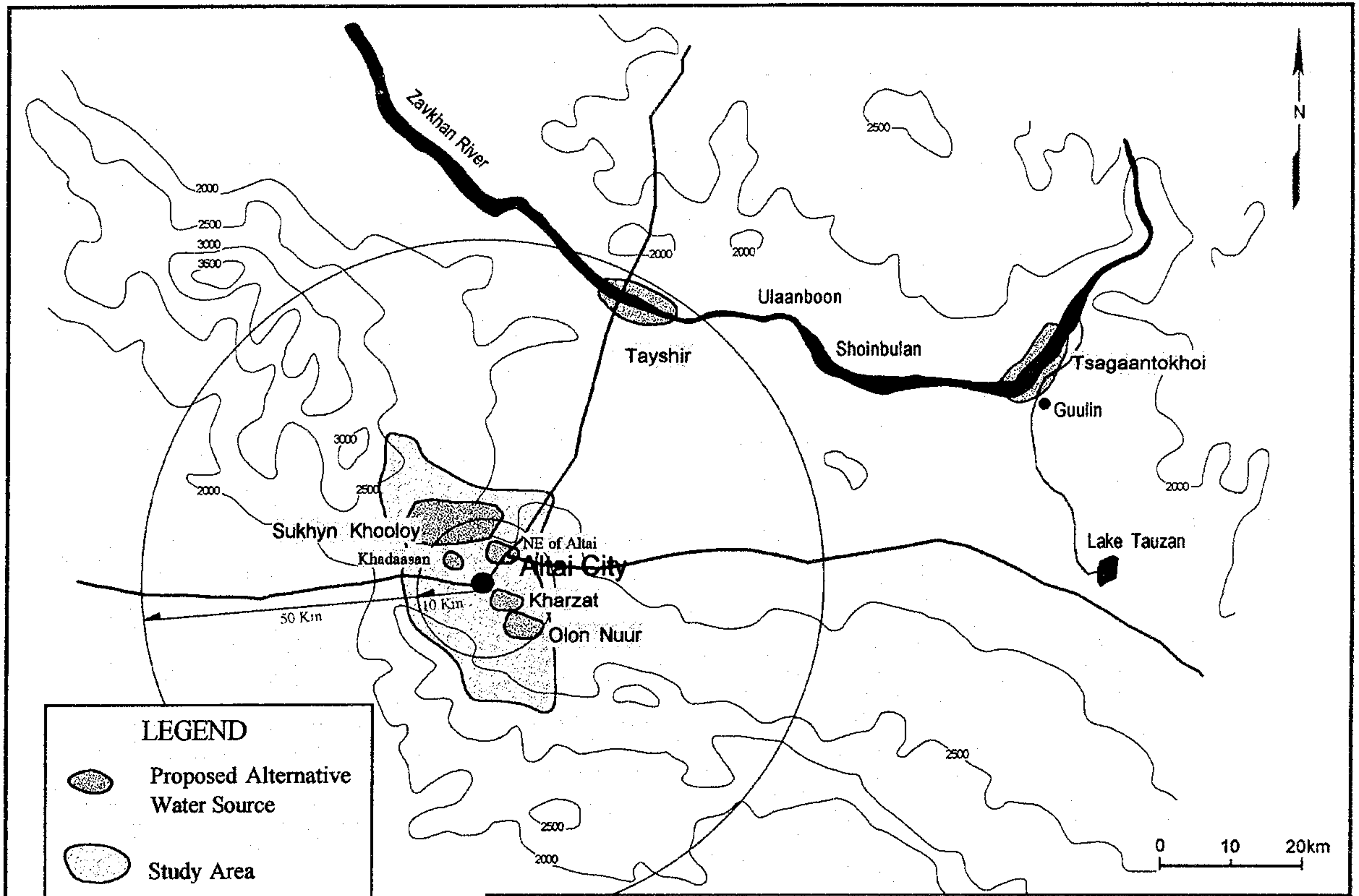


Figure 1.2 Study Area

JICA	The Study on Groundwater Development for Altai City

2 PRESENT CONDITIONS

2 PRESENT CONDITIONS

2.1 SOCIAL SECTOR AND HYGIENE EDUCATION

2.1.1 Objectives and Scope of Work

The objectives and scope of work for social sector and hygiene education are:

1) to grasp issues on socioeconomic profile, water consumption pattern, willingness to pay for improved water supply, and knowledge about hygiene among the residents of Altai City through social survey, and then incorporate the results into planning process,

2) to conduct hygiene education based on prepared plan and educational materials in the course of the Study,

3) to disseminate major findings, methodology of social survey, and significance of social analysis to Mongolian counterpart and related personnel through a seminar,

4) to conduct social analysis in order to extract social issues and integrate them into a master plan / proposed projects, and

5) to conduct a hearing survey regarding the people's view on the quality of water and health.

2.1.2 General View and Background Information

Altai City is expected to be not only a social, economic, and logistical center for both nomadic and sedentary life in Gobi Altai Province but also the base for future economic development in the Western region. The City is divided into two areas based on characteristic of dwelling pattern and infrastructure, central build-up area (apartment area) and ger area. The central build-up area comprises various administrative offices for public services, commercial and industrial buildings and one to three story residential flats (apartment buildings). Most of these buildings are linked to centrally organized piped heating and water supply. In ger areas, dwellers live in gers which are traditional round felt tents. Gers make up three masses, one in the north, another in southeast, and the other in the southwest. The town is compact enough to walk across to reach the farthest edge of ger area within an hour.

The City is a culturally and ethnically homogeneous and there is no social major social disparity among the people. Social services such as media, education, and social security were well developed during the former social regime. However, it is getting more difficult to maintain the current social services due to the shortage of public fund.

The people who live in gers, including wooden flats and single brick houses, have to get water through water wagon delivery. They carry water containers from a delivery point to their ger plot. This is mainly women and children's work. They bring various kind of container of 10 - 60 liter volume with or without a lid and carry them in their hands in helping each other. They don't use wheel carriers that are seen in Ulaanbaatar. In most cases, a family makes two round trips so the volume of water becomes 80-100 liter in total a day.

There is high expectation among the health professionals and the residents in Altai City for resolving the problems related to the quality of water. They claim that the current drinking water bring about negative health impact.
In fact, water related disease such as virus hepatitis (A), dysentery, and scabies categorized under the water-borne disease and water-washed disease are common in Altai City. In addition, the group interviews and discussion disclosed the existence of many diarrhea cases among children, which hinted the high prevalence of contaminated water. Diarrhea is one of the major causes of infant death in the country but the number of diarrhea cases is not exactly known in Altai City.

Hygiene education is not included in the curriculums of primary and middle schools but alternative media like the college of medicine, TV and radio broadcasting and Women's Association are potential promoters for the hygiene education.

2.1.3 Plan and Design of Social Survey

Two components were carried out in the course of the Study. One was a social survey through household interviews and group discussions on water-use and knowledge on hygiene and sanitation among the residents and institutions. The survey was expected to provide information and data for social analysis. A local contractor under the supervision of the Study Team undertook the actual field interviews.

2.1.4 Household Survey

One of the JICA Study Team members, who was responsible for social survey prepared an operational plan together with the design of questionnaires for households and institution survey prior to the fist field survey. The fieldwork of the survey was contracted out to a local consultant within the framework of the operational plan. Besides those prepared questionnaires, additional qualitative approach were supplementary used as well.

As some households live in brick apartment or wooden houses without piped water supply in ger area, random sampling method was applied for the sampling of household survey with the help of Esumbulg Villoge Administration Office. 200 samples were randomly drawn from the list of 1,251 households submitted by 4 district leaders (bag leader). In the case of institution survey, 20 institutions were listed by the local counter-part according to water consumption level and public importance.

The questionnaire prepared for household survey consists of 117 questions regarding socioeconomic profile, water consumption pattern, and willingness to pay for improved services, perception on the current service and knowledge about hygiene.

The questionnaire prepared for institution was used for interviewing with those in charge of the institutions. Some of the institutions were visited again so that raised questions were clarified.

Before the actual survey was conducted, preliminary survey was carried out on a trial basis followed by the training for the interviewers. From the response of these pre-testing, some questions were revised and then the necessary number of the questionnaire was printed.

The person responsible for the social survey of the JICA Study Team took a role of editor, who finally judged the validity of the answers of questionnaires during the survey. The local contractor recruited six field interviewers. The training of interviewers took two days using the prepared training sheets. Every interviewer was responsible for visiting 30 - 35 households. Quality Control and Data Analysis were also applied to the survey results at the end of fieldwork.

2.1.5 Results and Findings

(1) Household Survey

The survey team visited 213 out of 3,516 households (As of December 1996) from 24 June to 30 June 1997. A total number of 197 households actually responded to the interview. 124 households out of 197 dwell in a traditional ger and 73 households dwell in brick apartment or wooden flat.

Summary of number of people involved in the interview

	Dwelling Type			
Water Supply Type	Apartment	Non-*ger*	*Ger*	Total
Piped	37	0	0	37 (19%)
Non-piped	0	36	124	160 (81%)
Total	73		124	197 (100%)

Thirty-seven (37) out of 73 non-ger dwellers were residents of apartment with piped water supply. In other words, 160 households (81%) including 124 ger dwellers out of 197 sampled households depend on the delivery of the water from the water wagons (hereafter: non-piped households).

(2) Characteristics of Respondents and Households

The average age of respondents is 38 years, with average schooling for 10 years. 65% of the respondents were female.

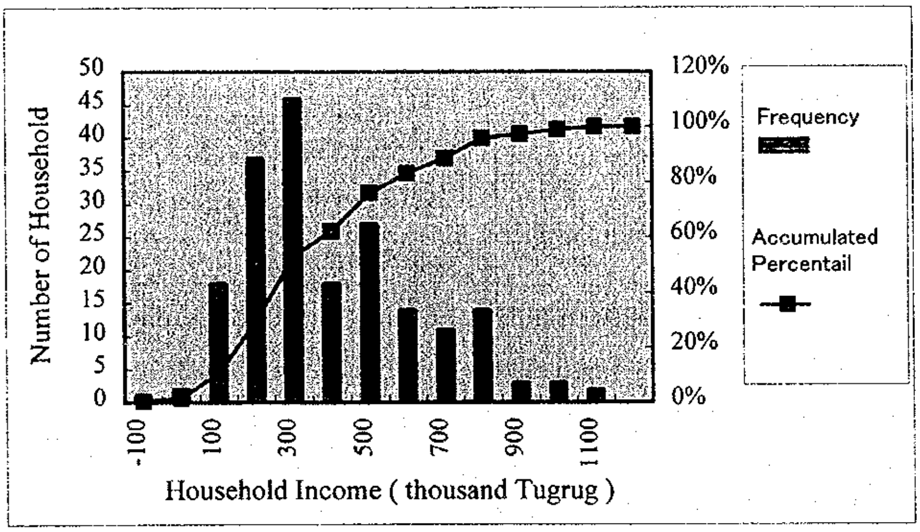
The average number of family member with the sampled households is 5.11 while 11% of respondents mentioned the residence of visitors in their houses.

(3) Socioeconomic Profile

The main income of the sampled households is from regular and temporary work (74%) and pension (29%) or both. In addition, 8 % of the households borrow money and 12% of them get financial or material support from relatives or friends for their living.

The median of the total income of the all sampled households July 1996 – June 1997 is Tg 299,940. In other words, 50% of the sampled households earned less than Tg 299,940 in the past 12 months. There were a few households with debt. The characteristics of the income levels of the households are shown in the chart below

The distribution of households by income

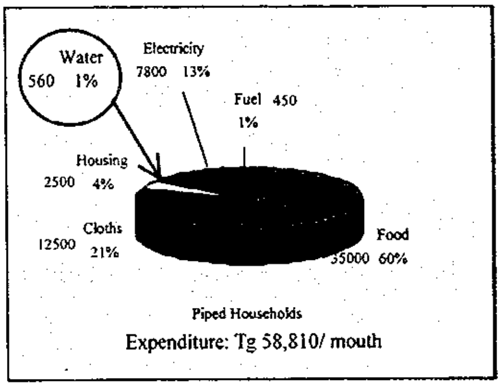


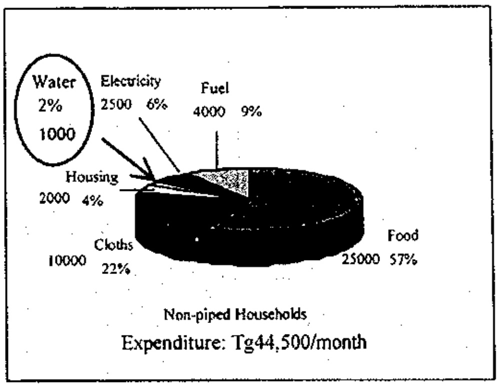
With regard to the expenditure, 50% of households spend more than Tg 47,920. If this were simply multiplied by 12 months, the median annual expenditure would be Tg 575,040, which exceed the estimated average annual income of Tg 299,940 by Tg 275,100.

They spent most of the income on food and clothing followed by fuel. The majority of respondents think that the autumn (October - December) and the winter (January - March) are the highest spending seasons.

The following are the figures of the median monthly expenses to the specific categories from both piped households and non-piped households.

Monthly expenses (proportion of expenses) by categories with non-piped households and non-piped households





The non-piped households spend Tg 1,000 (2% of monthly expenditure) for water out of Tg 44,500 of the average total expenditure while the piped households spend Tg 560(1% of monthly expenditure) out of Tg 58,810. As all of the piped households dwell in apartments, they are required to pay also for heating from 1 October to 1 May of the following year. Those who live in apartments, were estimated to spend Tg5,000 per month for heating.

(4) Water Usage and Service

General

Regarding water supply, fourteen (14) out of the 37 or 37% of piped households are not satisfied with the current service of water supply as shown in the Table below. Their reasons for dissatisfaction are as follows.

1) the water sometimes stops (79%),
2) the quality of water is not good (57%),
3) facilities are deteriorating (57%)

In spite of the primary complaints about the frequent interruption of service, they want authorities to improve the quality of water at first, then availability of the water for priority next. There was no respondent who selected the tariff level as a problem away piped-house holds.

Satisfaction of the service among piped households

50	Are you satisfied with the existing service on water supply?	☐ Yes 1		19	
		☐ Don't know 2		3	
		☐ No........ 3		14	
		Null		1	
		Total / No. respondents		37	
51	If "No" in the above question, in what respect are you not satisfied? You can select more than one.		"Yes"	count	%
		☐ Sometimes water stops coming /		11	79%
		☐ Water quality is not good		8	57%
		☐ Facilities are deteriorating		8	57%
		☐ Volume of running water is not enough		2	14%
		☐ Water tariff is too expensive		0	
		☐ Others (specify)		1	7%
		No. respondents to the above question		14	

Household Survey June 1997

As for the non-piped households, fifty-three (53%) of them are not satisfied with the existing way of getting water as shown in table below. Their answers are summarized as follows.

1) the water is not available whenever they want was placed as the first choice (94%).
2) the quality of water is bad (65%) and
3) the water delivery points are too far

Furthermore, they prefer yard connection (71%) to public kiosk (26%) as a choice for water supply service improvement. On the other hand, piped households selected "the quality of water should be improved" as the first place.

Satisfaction of the service among the non-piped households

No.	Question	Answer	Code		Count	%
68	Are you satisfied with the existing way of getting water?	☐ Yes	1		71	44%
		☐ Not sure	2		3	2%
		☐ No	3		84	53%
			Null		2	1%
		Total / No. respondents			160	100%
69	If "No" in the question above, answer the following questions What will be the source of water you want most and why?			"Yes"	count	%
		☐ House Connection	1		2	3%
		☐ Yard Connection	2		57	71%
		☐ Public kiosk	3		21	26%
		☐ Other (specify)	3		0	
		Total / No. respondents			80	100%
70	Because			"Yes"	count	%
		☐ Water is not available whenever you want			75	94%
		☐ Number of truck service is not sufficient			29	36%
		☐ Water delivery point is too far			41	51%
		☐ Water quality is not good			52	65%
		☐ Water tariff is too expensive			33	41%
		☐ Fetching water is burden of family's work			38	48%
		☐ Other (specify)			1	1%
		No. respondents to the above question			80	

Household Survey June 1997

Tariff Increase

As the answer to the question of "up to what level of water tariff they would be ready to pay if the situation is improved and managed by means of cost sharing", they responded as follows.

1) The piped households: 35% of increase to the current tariff level.
2) The non-piped households: 163% of increase to the current tariff level

Access

Regarding the water delivery service by the water wagons, 85% of the non-piped households have access to the water within 200m, although 7% of them have to walk more than 500 m to fetch water.

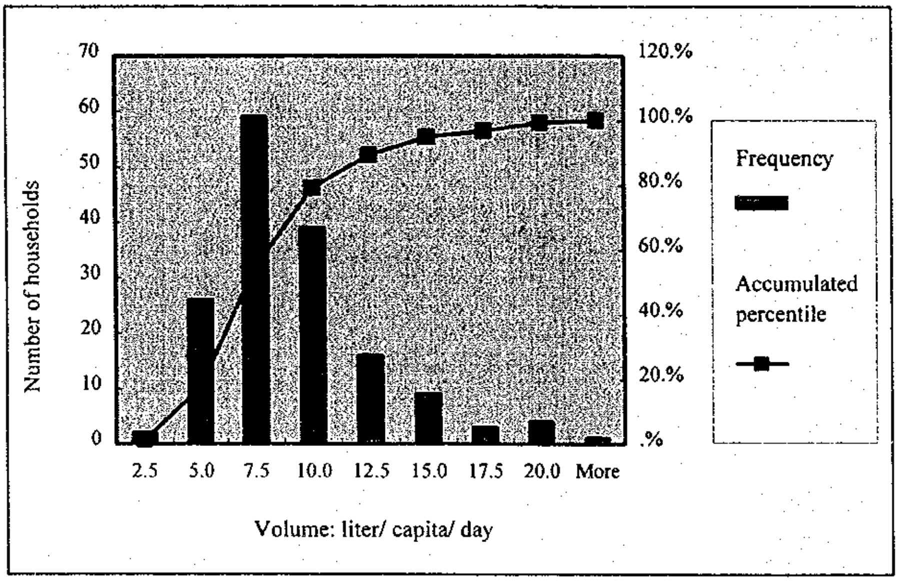
Workload

The average non-piped household carries 80.3 liters of water every other day and it takes 10.5 minutes for them to complete the workload by two persons.

Water Consumption

The following chart shows the distribution of the 128 non-piped households for the volume of water consumed per day per capita. The average volume of water used in a day per person is 8.6 l/d/c(liter per day per capiter. However, 31 out of 160 non-piped households think that they do not get enough water for their requirement.

Distribution of non-piped households for the volume of water consumption per day per person



Attitude toward payment of tariff

While 91 out of 160 non-piped households wish to receive piped water and are willing to pay for it, only 2 households actually answered that they would pay for the present level of tariff for piped water supply. As a matter of fact, the rest of 89 households answered they prefer the present tariff (1Tg/l)of water wagon delivery to the tariff of piped water supply and they would be ready to pay even for doubled charge (2Tg/l)for the wagon delivery. However this only means that they would like to reserve the current tariff level since the tariff of water wagon delivery was doubled recently as it has been done almost every year in the past.

Willingness to pay among the non-piped households that prefer upgrading of the service

74	In the future, water tariff for piped water supply likely to be raised to cover cost for improving and maintaining the system in good condition. In this event, up to how much would you be ready to pay for piped water supply service. Suppose a suiation in which you will get water in sufficient amount and good quality.	□ Present tariff level	1 Tg/l
		□ Maximum	10 Tg/l
	Please answer "yes" (meaning you are ready to pay) or "No" (meaning you are not ready to pay) to the tariff levels given by the interviewer.	□ Minimum	1 Tg/l
		□ Average	2.9 Tg/l
		□ Median	2 Tg/l
		□ % increase of the median	100%
		No. respondents to the above question	89

As for the other sixty-nine (69) out of 160 non-piped households, they are not interested in piped water supply. They would like to reserve or even reduce the current charge level of wagon delivery even if the service would not improve. In fact, 50% of this group answered that the current tariff should be reduced.

Willingness to pay among the non-piped households that are not interested in upgrading the service.

75	If you wish to continue getting water from water truck service and to solve the problems mentioned in Q70, cost sharing is needed to keep the system in good condition. Suppose a situation in which you will get water in sufficient amount and good quality, up to what level of water tariff would you ready to pay?	□ Present tariff level	1 Tg/l
		□ Maximum	12 Tg/l
	Please answer "yes" (meaning you are ready to pay) or "No" (meaning you are not ready to pay) to the tariff levels given by the interviewer.	□ Minimum	0.25 Tg/l
		□ Median	1 Tg/l
		□ Average	2.3 Tg/l
		□ % increase of the median	0%
		No. respondents to the above question	69

(5) Water Consumption Pattern

The average consumption of water for drinking and cooking of all the sampled households was 4.0 l/d/c and the one for personal hygiene and laundry was 5.8 l/d/c. While a few households use most of water for livestock, 95% of households use most of water for daily life such as drinking and personal hygiene.

(6) Social Disparity

In order to realize the difference in opinions or attitudes between two social groups that are on the opposite ends in terms of income, employment etc. Analytical statistics was applied if there was any difference in the answers among the social groups. It is noted that all the data collected are based on the respondent's perception but not on the objective measurement.

Lower income and higher income house holds

All sampled households were divided into two groups, lower income group and higher income group according to the income divided by the number of adults (15-60 years) in the households. The lower income group is the lowest quarter. The rest three-quarters were put under the higher income group. The results of the comparison are summalized as follows.

the average volume of water used in a day per person

lower income group	higher income group
7.9 liter	9.3 liter

The difference is statistically significant (t=2.1, P=0.035).
There is also a significant difference on schooling years as well.

Lower income households vs. higher income households

	Lower Income		Higher Income					
	$mean_i$	N_i	$mean_j$	N_j	t-value	P-value	X^2	df
Household income*	213,688	105	516,523	91	-	-	-	-
No. of household's members	5.8	106	4.3	91	5.71	4.18×10^{-8}	-	195
Volume of water used by per day per capita	7.9	91	9.3	69	-2.1	0.035	-	158
% of increase with the present tariff	148%	105	131%	88	0.55	0.57	-	191
Volume of water used for drinking and cooking	22.3	106	18.1	91	3.11	0.02	-	195
Volume of water used for personal hygiene and laundry	28.6	106	30.9	91	-1.099	0.27	-	195
No. of households that have diarrhea	10	106	6	91	-	-	0.529	1
No. of resopondents with higher education	43	15	59	89	-	-	12.4	1
No. of households that has health or hygiene education	23	105	24	89	-	-	0.67	1

Unemployed and employed household

The comparison based on employment status was also tested.

The volume of water used by the non-piped households

At least one (1) employed (source of income come from regular and temporary work)	No one is employed (no source of income)
8.5 l/d/c	6.4 l/d/c

There is a significant difference between the two groups (t=2.16, P=0.03).

Employed vs. unemployed

	Regular & Temporary Work		Unemployed					
	$mean_i$	N_i	$mean_j$	N_j	t-value	P-value	X^2	df
Household income*	361,694	144	252,022	18	1.86	0.06	-	160
No. of household's members	5.1	145	5.4	18	-1.059	0.55	-	160
Volume of water used by per day per capita	8.5	116	6.4	16	2.16	0.033	-	130
% of increase with the present tariff	152%	139	60%	34	1.66	0.98	-	155
Volume of water used for drinking and cooking	20.2	145	18.6	18	0.76	0.44	-	162
Volume of water used for personal hygiene and laundry	29.1	145	23.2	18	1.7	0.09	-	162
No. of households that have diarrhea	12	145	3	18	-	-	1.34	1
No. of resopondents with higher education	72	142	7	18	-	-	0.89	1

(7) Institution Survey

Public institutions where many people gather or stay in are usually the largest water consumers. The hospital is ranked as the largest consumer among the institutions. They consume 4,900 m^3 of water per month for laundry and cooking. The middle school and Medical College are also large water consumer of piped supply.

Among the private companies, the Ilch-Altai Heating Center(one of the CHC), and the Mandal Service Company consume more than 4,000 m^3 per month for heating and producing liquor respectively.

The large consumers tend to be unsatisfied with the existing service. The institutions approved only a little increase of tariff level regardless of their satisfaction with the current service.

2.1.6 Dissemination Seminar for Social Survey

In order to introduce the major findings and the survey approach applied to the Study, a technical seamier was held in Ulaanbaatar inviting the Mongolian counterparts and related personnel. The seminar was also expected to provide opportunity for relevant individuals to give feedback on the findings. Around 50 people from various Ministries including academic institutes and civil service agencies attended the seminar.

2.1.7 Hygiene Education Program

To promote the awareness of water usage and hygiene, an implementation of hygiene education was planned as one of the Study components. In fact, the household survey revealed necessity of more water consumption among non-piped households and the water quality analysis indicated bacteria contamination of stock water in gers.

Booklet and poster were chosen as media of education and then school children were focused on as a target group, as there is no formal health education for school children. General framework of this plan was consulted with the Ministry of Health and Social Service as a responsible agency. They assured that the produced materials would be used as a supplementary booklet to the health education textbook for school children, which is now under discussion within the Ministry of Education.

The actual preparation of implementation plan and its educational materials was contracted out to a local consultant. The contractor team, consisting of a moderator, an epidemiologist, and an illustrator, together with the staff from Public Health Center of Gobi-Altai engaged in organizing series of discussions and meetings in Altai City. While the whole process was consulted with the person in charge of the JICA Study Team, the participatory approach was encouraged as much as possible.

In order to develop the implementation plan and its education materials, the following people were involved in the series of group discussions organized by the contractor team and the Public Health Center.

- 20 health volunteers
- 5 school children (Grade 4 and 5)
- 16 district leaders and citizen's representatives
- 17 court employees

An implementation plan for hygiene education was developed by the staff of Public Health Center and the contractor team under the guidance of the JICA Study Team member. . The followings were materialized through the above activities.

1) "Water and Health", A4, 30 page booklet with 29 color illustrations
2) "Water and life", A1 color poster.
3) Implementation Plan for Hygiene Education

As of October 31st of 1998, the Gobi-Altai province social health center conducted seven(7) times of trainers training for schoolteachers and health volunteers and six(6) times of hygiene education for children and mothers. In total 909 people participated in the program with the provision of 426 hygiene education booklets.

2.1.8 Quality of Water and Health

According to the household survey, around 60% of the people in Altai City perceive that the quality of drinking water is bad. In the direct interview to those who answered that the quality of water is bad, they said that hardness of water brings about negative impact on health while mentioning various kind of disease.

In addition, the former director of Pubic Health Center of Gobi-Altai suspects that there is an association between concentration of certain minerals including higher magnesium or calcium ratio (Mg/Ca) in drinking water and morbidity of the people in Altai City. In this context, the National Institute of Public Heath supported him to conduct the epidemiological study on the relation between the quality of water and health in Altai City. They conducted health check for 2,017 residents living more than 5 years in Altai City together with 251 residents of neighboring rural area as a control group. The summary of the result concludes that the morbidity of digestive tract disease, cardiovascular disease, and urine-genital tract disease is higher among Altai residents who drink Kharzt water than those of the control group. It recommend lowering magnesium concentration and increasing fluoride concentration for improvement.

The Study Team can not comment on the result of the above issue since the Study team only has the summary of the document. However, Study team points out limitation of its validity on the epidemiological study regarding the following aspects.

- Bias : Besides its methodological weakness (descriptive study analytic epidemiology), a health check usually results in increased morbidity of target population compared with regular health statistics (systematic error)
- Confounding: The study doesn't seem to consider other risk factors of the

diseases at all such as smoking, drinking, gene, sex, age, stress, eating habit etc.

- Biological creditability: The belief in the existence of biological mechanism of the above cause – effect of the chemical substances (Mg/Ca balance, florid etc.) on human health to cause the diseases are not known or postulated. It also forgot the human homeostasis which is a mechanism to keep a certain standard such as concentration of minerals in a body from environment change.
- Consistency: There isn't any similar report or study that support the above result.

2.1.9 Dissemination Seminar at Altai City

The Study Team carried out water quality analysis in 1997 and 1998 in order to verify the past data on water quality. The water quality analysis and its result are described in detail in Section 2.8. The obtained result is consistent with the past data showing slightly higer concentration in magnesium and iron for Kharzat water by the Mongolian standard. However the Study Team believes that the water in Altai City is not so bad as they claim, considering the water quality of some other countries.

In order to disseminate the Study Team's view on water and health to the people in Altai City, a mini-seminar was held in Altai City inviting those who represents the people in Altai City.

As shown in the below table, the concentration of magnesium of the Kharzat water is slightly higher than the Mongolian standard. However, Japan and most other countries do not have such a ceiling level of magnesium because Mg is not regarded as a harmful substance to human health. The Study Team acknowledges that some people who usually drink softer water elsewhere get diarrhea by drinking water in Altai due to the existence of magnesium and sulfate ion. But people usually adapt themselves to this new environment in a week or two. The Study Team could not find any information to prove the relationship between magnesium (or ratio of magnesium and calcium) and health status through possible worldwide sources.

Water Quality Standard and Guideline of the World

(for Hardness, Calcium, and Magnesium)

Standard / Guideline	Total Hardness	Calcium	Magnesium
Study result(water supply)	199 mg $CaCO_3$/l	28 mg/l	31mg /l
Mongolian Standard	350 mg $CaCO_3$/l (7m eq/l)	100mg/l	30mg /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	150mg/l	80mg/l

Prepared by JICA Study Team

2.1.10 Social Analysis

Social analysis is applied to analyzing social issues in the master plan and future project implementation. The followings are the major planing issues.

(1) Positive and negative influences of the project

The people will have either benefit (+) or be negatively influenced (-) from the future plan / projects as summarized below.

Negative influence

(-) 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 from the current tariff level. As indicated in the result of the household survey, the lower income group of non-piped household consume less volume of water per day per person than the volume of higher income group. This is probably because of financial difficulty.

Since the consumption amount even for the higher income group is insufficient for required volume, it is recommended that exemption system of water charge for lower income group - unemployed and single female headed households should be revised periodically in accordance with local poverty level.

Benefit

(+) The proposed program for water supply system, which plans the installation of kiosk type's water delivery points in the ger area, will facilitate the availability of water in terms of time and distance. This also will lead to the increase in water consumption for non-piped households. The frequent supply of water is expected to reduce the habit of storing water and bring about less opportunity of contamination.

Negative influence

(-) However, 20% of non-piped households will not gain the very benefit of kiosk type of water supply which are designed to serve residents within 250m radius. This is because 20% of them live more than 250m away from any of the planned kiosks. Therefore, it is recommended that the water supply department promote the use of water cart.

(2) Increase the likelihood to identify whether and how the plan / projects will be sustained.

The people in Altai City look forward to having a device to remove excess minerals, in particular magnesium, from the current drinking water. However, the evidence that the water is not good for health is still vague or unfounded. Therefore, this can not be an established need in the proposed project but can be regarded as inconstant demand.

(3) Increase the capacity to identify whether the plan / projects will meet specific equity objectives.

A disparity of unit water price between non-piped households and piped households should be revised to fill the gap by opening the fact to the public. To minimize the gap on the ratio of water charge to income can be the objective for the time being to begin with.

2.2 ECONOMY

2.2.1 Mongolia

Mongolia has been in the process of transition from a centrally planned to a market oriented economy since around 1990. Due to a number of external shocks and internal political and economic instability, Mongolia experienced an economic and financial crisis in the early 1990's. The external shocks were triggered by the disintegration of the Council for Mutual Economic Assistance (CMEA), formed by former communist block countries. Mongolia depended on CMEA largely in terms of external trade and economic assistance. The decline in world prices of Mongolia's major export commodities such as copper and cashmere were other factors adversely affecting the Mongolian economy. Domestically, Mongolia started political reforms to adopt a democratic system since 1990 in parallel with transforming its economic system into a market economy. While these internal challenges were tackled, Mongolia failed to cope properly with the changes in the external economic condition. The economy shrank by about 30%, unemployment rose, and poverty population increased between 1990 and 1993. In 1993, however, the Mongolian economy hit the bottom and showed a sign of recovery. This upturn was due mainly to the improved macroeconomic management with the assistance of international aid organizations and the progress in structural reform stimulating private sector activities. The GDP growth rates, which turned negative in 1990 and remained so until 1993, became positive in 1994 after four-year successive shrinks as shown below.

GDP Growth Rates (%/year)

1986 : 9.4	1991 : - 9.2	1996 : 2.4
1987 : 3.5	1992 : - 9.5	1997 : 3.3
1988 : 5.1	1993 : - 3.0	
1989 : 4.2	1994 : 2.3	
1990 : - 2.5	1995 : 6.3	

Relatively high growth in 1995 was mostly due to the rise in copper price in the world market. The growth rate in 1998 is estimated to be not more than 3.5%.

2.2.2 Gobi Altai Province

The following table gives an outline of Gobi Altai Province compared with the nation.

Outline of Gobi Altai Province Compared with the Nation for 1995

Item	Mongolia	Gobi Altai	(%)
Land area (square km)	1,566,500	142,000	9.1
Population	2,317,500	72,921	3.1
Population density (person/sq.km)	1.5	0.5	-
Unemployment	23,605	1,621	6.9
Local budget expenditure (000Tg)	147,730,600	1,585,461	1.1
Number of livestock (000 head)	28,572	2,103	7.4
Sown land (ha)	356,466	513	0.1
Total harvest (ton)	359,903	1,782	0.5
Industrial output (million Tg)	302,274	808	0.3
Transport cargo turnover (000 tons*km)	1,266,400	4,476	0.4

Source : (a) Mongolian Economy and Society in 1995, (b) Gobi Altai , Province Governor's Office

Gobi Altai Province is characterized as having a large land area accounting for 9% of the national land with a low level of settlement. This resulted in average low population density of 0.5 persons per km^2, which is one-third of the national density. The major industry of the province is agriculture production, especially animal husbandry. The number of livestock reached 2.1 million in 1995, accounting for 7.4% of that of Mongolia. In terms of the total number of livestock, Gobi Altai Province holds the fourth place in Mongolia. The numbers are especially high for camel, sheep and goat.

In contrast, crop cultivation activities stay at a low level. Industrial production and transportation also show lower level of activities. Unemployment is high in Gobi Altai reflecting a greater degree of production reduction and loss of job opportunities.

2.2.3 Altai City

The population of Altai City numbered 17,761 in 1997 with the following detail.

Total :	17,761
by settlement pattern	
Apartment Area :	3,245 (18%)
Ger Area :	14,516 (82%)

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 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

2.3.1 General

In the groundwater balance study, it is important and essential to consider surface water balance which may recharge to aquifer in the ground. The following factors are considered and measured as illustrated in Figure 2.3.1.

- Precipitation such as rainfall, snowfall, etc.
- Evaporation
- Infiltration to underground regarded as recharge to aquifer

However in reality, there are some restrictions that make this kind of study difficult. In the case of this study for example, absolute small amount of rainfall, freezing temperature in winter are those restrictions. Therefore the recharge to the aquifer was estimated by a different approach as described in chapter 2.6.

2.3.2 Meteorological Observation Station and Available Data

There exist one (1) meteorological station under operation and another abandoned in the Study Area as listed below:

Station	Year of Establishment	Altitude (m)	Observation Item
Altai City (Airport)	1954	2,180.7	Temperature, precipitation, humidity air pressure, wind, evaporation
Khan Tayshiryn (Mountain)	1978	2,890.0	Temperature, precipitation, humidity air pressure, wind

The location of these meteorological stations is indicated in Figure 2.3.2.

In Altai City station, the meteorological observation has been conducted over 40 years since 1954, and valuable data were accumulated. Temperature, precipitation, humidity, air pressure, and wind have been observed at this station. Khan Tayshiryn station was in operation only for 11 years from 1978 and has been abandoned.
The parameters and periods of meteorological data collected for each station are illustrated in Figure 2.3.3.

2.3.3 Meteorological Characteristics

Altai basin is characterized by a rainy season from June to August. The precipitation of this season accounts for about 64% of the annual one. Average annual precipitation of Altai and Khan Tayshiryn stations are calculated to be 181.6mm and 200.4mm, respectively. Monthly mean temperature in the basin varies from a minimum of -18.6°C in January to a maximum of 14°C in July at Altai City station and from a minimum of -19°C in February to a maximum of 8.6°C in July at Khan Tayshiryn station. Annual average temperature is calculated to be -1.7°C at Altai City station and -5°C at Khan Tayshiryn station. Annual average humidity is calculated to be 53.9% and 58.7% at Altai City and Khan Tayshiryn stations, respectively. Climates for Altai City and Khan Tayshiryn are illustrated in Figure 2.3.4.

The details of each meteorological parameter are discussed below.

(1) Precipitation

Based on the collected precipitation data, average monthly precipitation is calculated for each station as tabulated below.

Station	Average Monthly Precipitation (mm)												Total (mm)
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
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

The annual average precipitation varies from about 100mm to 280mm at Altai City station and from 110mm to 295mm at Khan Tayshiryn station.
As tabulated below, about 64% of precipitation in average concentrates during rainy season from June to August.

Station	Annual Precipitation (mm)	Precipitation in Rainy Season (mm)	Percent to Annual Precipitation
Altai City	181.6	119.2	66%
Khan Tayshiryn	200.4	126.0	63%
Average			64%

Probability analysis was made for the precipitation of annual and rainy season at Altai City and Khan Tayshiryn stations. The results of the probability analysis by using Gumbel's distribution method are summarized in Table 2.3.1.and Figure 2.3.5. The result indicates that even for a considerably long period of time such as 100 years, only a double amount of present annual rainfall is expected.

In this study daily rainfall was also observed in 1997 and 1998 by the JICA Study Team. The result is summarized as the monthly total in the table below.

Monthly Rainfall in mm

	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1997	-	-	-	-			83.7	1.2	11.6	-	-	-	96.5
1998	-	-	-	-	15.9	10.6	113.7	13.1	7.1	-	-	-	160.4

Note: Data obtained by the JICA study Team

(2) Temperature

Monthly mean, maximum and minimum temperature records were collected. Monthly average and annual maximum and minimum temperatures are tabulated as follows.

Station	Average Monthly Temperature (ºC)												Ave.
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	(ºC)
Altai City	-18.6	-16.2	-9.1	-0.6	6.9	12.7	14.0	12.7	6.3	-1.9	-10.3	-16.0	-1.7
Khan Tayshiryn	-18.6	-19.0	-13.4	-5.8	3.1	7.7	8.6	7.2	2.3	-4.5	-11.9	-16.2	-5.0

Note : Altai City data from 1954 to Aug. 1996; Khan Tayshiryn data from 1978 to 1986

The absolute maximum temperature is as high as 29.7ºC in Altai City, while that for Khan Tayshiryn in mountainous area reaches only about 22.5ºC. In Altai City, the absolute minimum reaches -40.8ºC though it is located at lower elevation.

The Data for Recent Years

The data of daily temperature, which are the maximum and the minimum air and ground temperature, were collected in this study. This data together with water level records of the wells is expected to give a detailed account for hydrogeological conditions of the study area. The detail is described in chapter 2.6. The monthly average of the data was tabulated.

Average Maximum and Minimum of Daily Temperature (Degree C)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max. Air	1997	-	-	-	-	-	19.9	20.9	20.5	12.9	8.5	-4.6	-6.3
	1998	-11.9	-3.9	-1.8	9.1	14.3	21.2	19.8	20.3	18.9*	-	-	-
Min. Air	1997	-	-	-	-	-	6.8	8.4	7.0	0.3	-6.0	-16.2	-20.1
	1998	-25.4	-18.4	-17.0	-2.4	1.1	7.1	9.3	8.0	5.6*	-	-	-
Max. ground	1997	-	-	-	-	-	39.9	38.6	37.6	29.1	22.2	1.7	-3.7
	1998	-6.1	4.3	12.8	21.5	34.6	40.5	36.8	41.5	37.5*	-	-	-
Min. ground	1997	-	-	-	-	-	3.7	5.8	3.6	-3.9	-11.0	-21.0	-24.6
	1998	-27.2	-22.3	-18.4	-7.0	-2.1	4.2	6.6	5.1	2.2*	-	-	-

* Average of the first half of September 1998

(3) Humidity

Monthly mean humidity records were collected and the following table shows their average for each meteorological station.

Station	Average Monthly Humidity (%)												Ave. (%)
	Jan.	Feb.	Mar	Apr.	May	Jun.	Jul.	Aug	Sep.	Oct.	Nov.	Dec.	
Altai City	65	61	53	45	42	47	57	52	52	51	58	64	54
Khan Tayshiryn	66	62	64	56	52	57	62	57	58	42	66	62	59

Note: Altai City data from 1954 to 1990; Khan Tayshiryn data from 1978 to 1983

Humidity reaches its minimum of 42% in May and increases to the maximum of 65% in January at Altai City station. Those in mountainous area of Khan Tayshryn are 66% for the maximum in January and 42% for the minimum in October.

(4) Wind

Monthly mean wind velocity records were collected and the following table shows their average for each meteorological station. Average data for wind velocity were collected at Altai and Khan Tayshiryn stations.

Station	Average Monthly Wind Velocity (m/sec)												Ave. (m/sec)
	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
Altai City	2.8	3.1	3.5	4.5	4.5	3.8	3.3	3.2	3.3	3.6	3.6	2.9	3.5
Khan Tayshiryn	4.3	5.0	5.2	6.3	5.6	3.8	3.7	4.4	3.9	5.1	5.6	4.9	4.8

Note: Altai City data from 1954 to 1990; Khan Tayshiryn data from 1978 to 1983

The data shows that spring is the most windy season in a year. People suffer from strong sand storm in this season.

(5) Evaporation

Evaporation records from the past were collected and the following table shows the monthly average for Altai City meteorological station.

Station	Average Monthly Evaporation (mm)												Annual Total (mm)
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
Altai City	-	-	-	57.6	100.1	125	129	113	91	50.5	-	-	665.8

Note: Altai City data of 1987 and 1988

The observed daily evaporation is 1.8 mm/day in average (if the evaporation during the winter season is assumed to be zero). Evaporation from November to March is not indicated on collected data because of the freezing temperature. The maximum evaporation period occurs in July.

The Study Team also measured the evaporation from July 1 1997 to October 31, 1998.

Monthly Evaporation in mm

Station		Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Altai City	1997	-	-	-	-	-	-	238.7	179.2	136.2	-	-	-
	1998	-	-	-	-	182.2	217.0	166.5	146.5	136.1	68.1	-	-

Evaporation from November to April is not indicated on collected data because of under freezing temperature. (See the section of Temperature) Data obtained by the Study Team.

The daily average evaporation calculated from the given data is 1.7mm (if the evaporation during the winter season is assumed to be zero)

2.3.4 Hydrological Station and Available Data

The following hydrological stations are available in Zavhan River system. The river water level and discharge are observed at these stations. The locations of the above hydrological stations are presented in Figure 2.3.6.

Station	River System	Year of Establishment	Catchment Area (km^2)	Observation Item
Guulin	Zavhan River	1971	12,200	Water level / discharge
Durveljin	Zavhan River	1977	--	Water level / discharge

Daily mean discharge was collected at Guulin station from 1972 to 1981 and at Durveljin station from 1977 to 1986. The data for 1981 and 1985 was not available because of damage of equipment used for the measurement. The monthly mean discharge was also collected in the same period at each station. The kind and period of the collected data are indicated in Figure 2.3.3.

(1) Zavkhan River System

Zavhan River (flows in the northwestern part of Mongolia) and its length is measured to be about 780km,. The river flows southward originating in Khangai Mountains. The flow changes its direction to west near Guulin Village, and runs to the north of Altai City. The river changes again its flow direction to northwest near Tayshir, and flows into Hyargas Lake.

(2) Hydrological Characteristics

Seasonal Variation of River Discharge

The data on monthly mean discharges of the Guulin and Durveljin stations were collected from 1971 to 1981 and from 1977 to 1986, respectively. Daily mean discharges at these stations were also collected from 1972 to 1981 and from 1977 to 1986, respectively. The average monthly discharges were calculated based on those data as tabulated below.

Station	Average Monthly Discharge (m^3/s)												Ave. (m^3/s)
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
Guulin	-	0.01	0.22	7.27	16.11	13.82	24.08	21.38	18.62	9.61	2.52	0.21	9.49
Durveljin	1.09	0.95	2.44	13.66	16.75	23.23	32.48	28.52	29.30	15.23	4.81	1.62	14.17

Note: Guulin data from 1971 to 1981; Durveljin data from 1977 to 1986 (missing: 1981, 1985)

Average annual discharges are calculated to be 9.49m^3/s and 14.17m^3/s for Guulin and Durveljin stations, respectively. Average specific discharge is calculated to be 0.78 l/s/km^2 for Guulin station. The discharge reaches its peak in July. The river water at Guulin station becomes frozen at the end of November or beginning of December, while that at Durveljin station happens in December normally. After winter season the frozen river starts to melt in March, the discharge gradually increases and reaches its maximum during the rainy season between June and August.

Maximum and minimum daily mean discharges were also calculated based on the collected daily mean discharge data as presented below.

Station	Maximum and Minimum Daily Mean Discharge (m^3/s)											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Maximum Daily Mean Discharge												
Guulin	-	0.38	7.57	39.0	145.0	59.0	153.0	78.5	80.6	65.7	14.6	4.13
Durveljin	6.59	6.68	49.8	38.0	57.40	294.0	76.1	84.1	90.0	43.6	18.1	8.7
Minimum Daily Mean Discharge												
Guulin	-	-	-	-	0.51	0.5	1.72	1.53	1.28	0.51	-	-
Durveljin	6.37	-	-	0.13	2.0	3.82	4.08	3.37	3.9	0.01	-	-

The recorded maximum daily mean discharges reach $153m^3/s$ and $294m^3/s$, in Guulin and Durveljin stations, respectively. While the minimum discharges during the rainy season (June to August) reach only $0.50m^3/s$ and $3.37m^3/s$, respectively.

Probability Analysis

Annual average runoff volumes at Guulin and Durveljin stations are calculated to be about 299 and 447 million m^3 respectively. As tabulated below, about 52% of annual runoff in average concentrates during rainy season from June to August.

Station	Annual Runoff (mill. m^3)	Runoff in Rainy Season (mill. m^3)	Percent to Annual Runoff
Guulin	299.20	161.25	54%
Durveljin	446.97	223.61	50%
Average			52%

Probability analysis was made for the annual runoff and for the runoff of rainy season at Guulin and Durveljin stations. The results of probability analysis by using Gumbel's distribution method are summarized in Table 2.3.1.

River Discharge of Small River in the Study Area

JICA Study Team measured the river discharge in the Study Area for four (4) rivers (refer to Figure 2.3.2) :

Khadaasangyn Am river,
Mandaliin Aryn Am river,
Esuitiin Sair river, and
Hanginaagiin Hooloy River.

These river don't have flow normally. Some flow can be seen in some rivers only during or after heavy rainfall. The measurement was therefore carried out right after the rain had stopped . The river discharge was measured using a concrete pipe and a bucket. The results are as follows.

River discharge measured in 1997 (unit : liter/second)

River	June 27	July 18	August 1	Sept. 1	Oct. 1
Hadaasan river	0.57	0	0.7	0	0.2
Mandaliin Aryn Am River	0	0	0	0	0
Esuitiin Sair river	0.51	62.5	0	0	0
Hanginaagiin Hooloi river	1.03	-	0.7	0.65	0.3

June 23, 24, 25 were rainy days.
It rained heavily in July 16 and 17
Data could not be informed from Altai City

The result shows that even after a rainfall, no flow was observed at some rivers. However, in the field study in 1998, a considerable amount of flow was observed at Esuiitin Sair river in July after unusually heavy and long rain.

Table 2.3.1 Results of Probability Analysis by Gumbel's Distribution Method

Rainfall for Altai City and Khan Taishir

Return Period (Years)	Annual Rainfall (mm)		Rainy Season's Rainfall (mm)	
	Altai City	Khan Taishir	Altai City	Khan Taishir
2	174	191	112	118
5	218	241	152	161
10	247	274	178	189
20	275	306	203	215
30	291	325	217	231
50	311	348	235	250
70	324	363	247	263
100	338	379	260	276

* rainy season: June to August

Runoff for Guulin and Durveljin

Return Period (Years)	Annual Maximum Discharge (m^3/s)		Rainy Season's Runoff (mill. m^3)	
	Guulin	Durveljin	Guulin	Durveljin
2	66	86	144	203
5	114	165	239	316
10	146	217	302	391
20	176	267	362	463
30	193	296	397	505
50	215	332	440	557
70	229	356	468	591
100	245	381	499	627

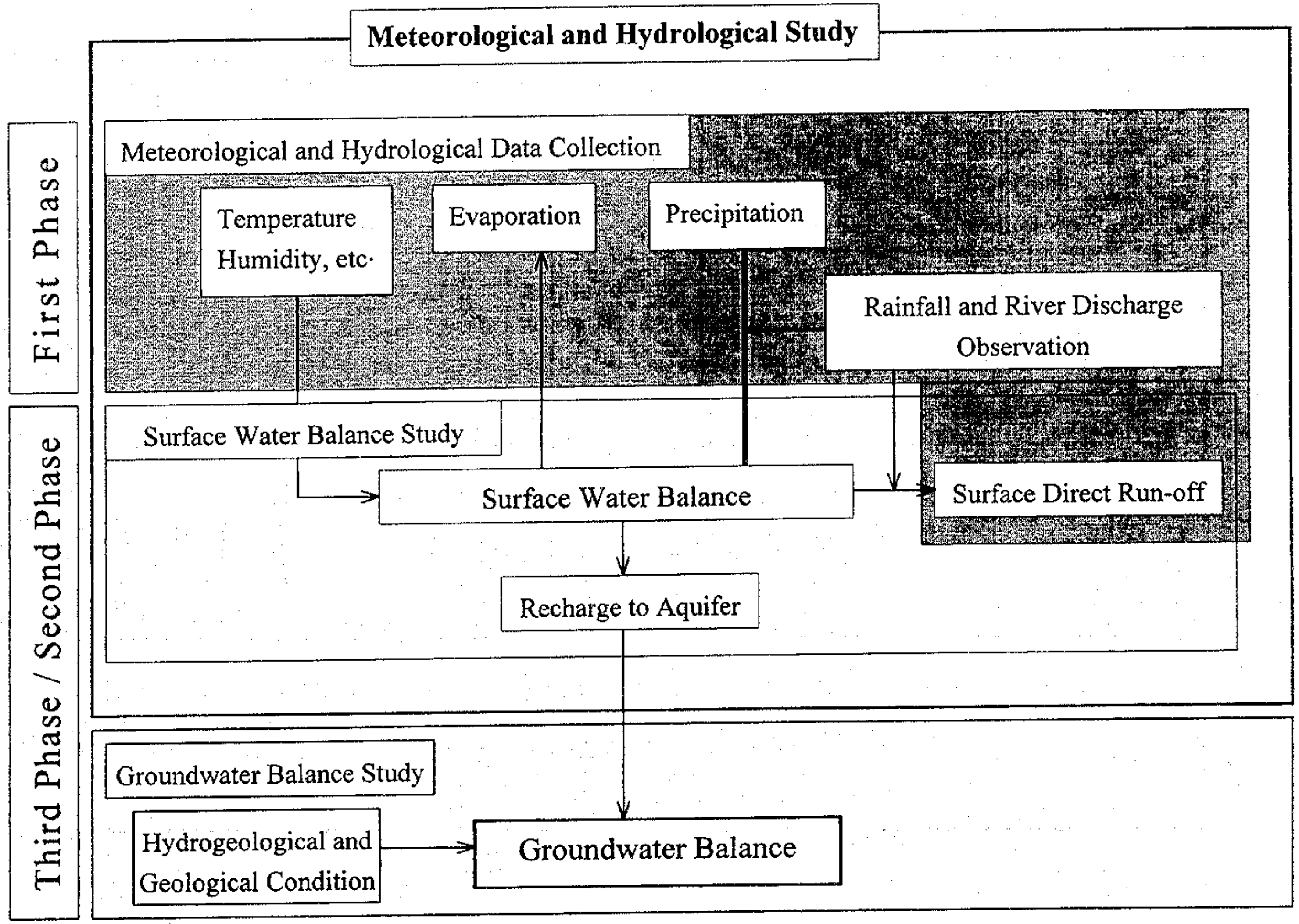


Figure 2.3.1	Flow Chart of Meteorological and Hydrological Study
JICA	The Study on Groundwater Development for Altai City

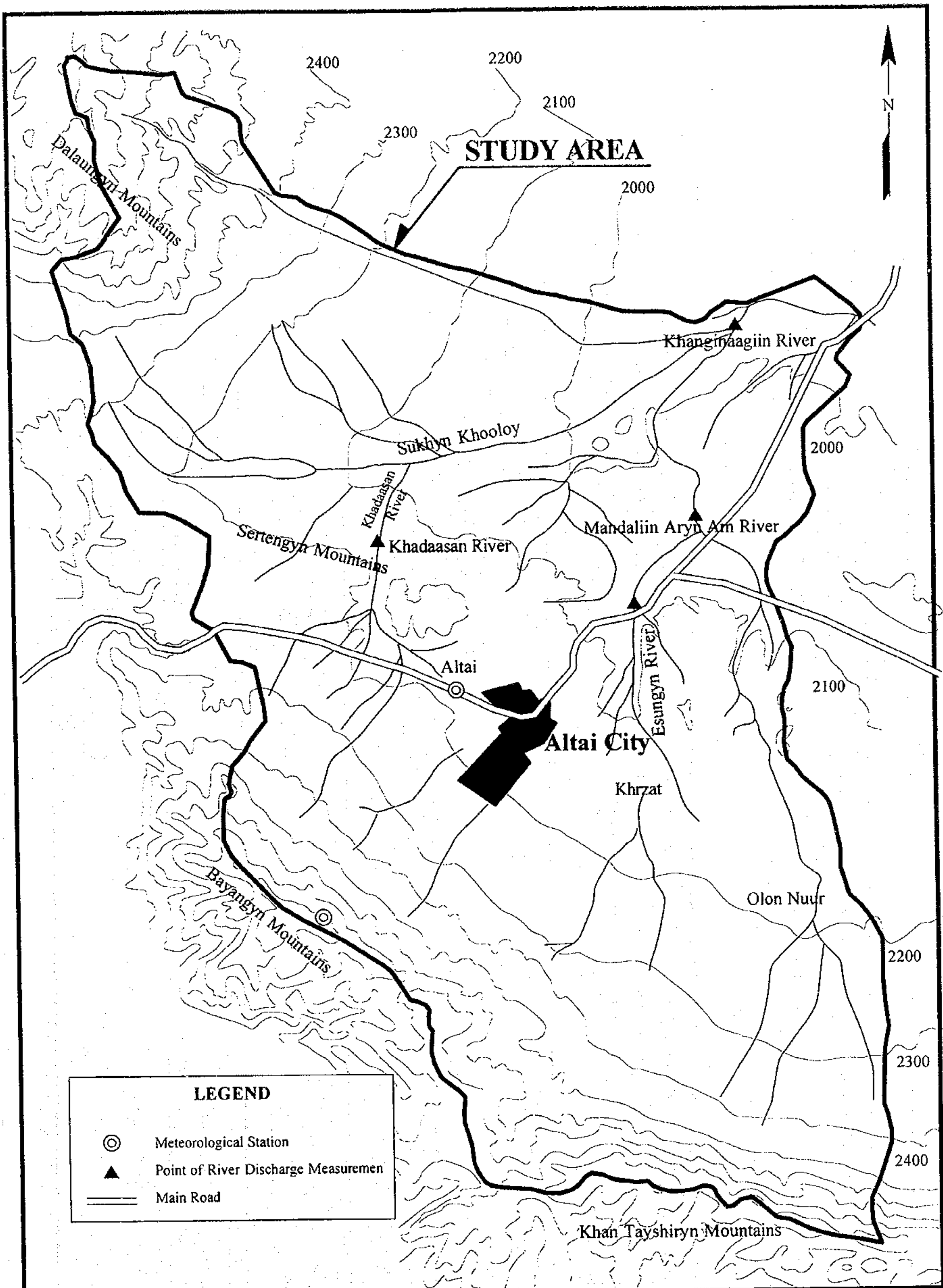
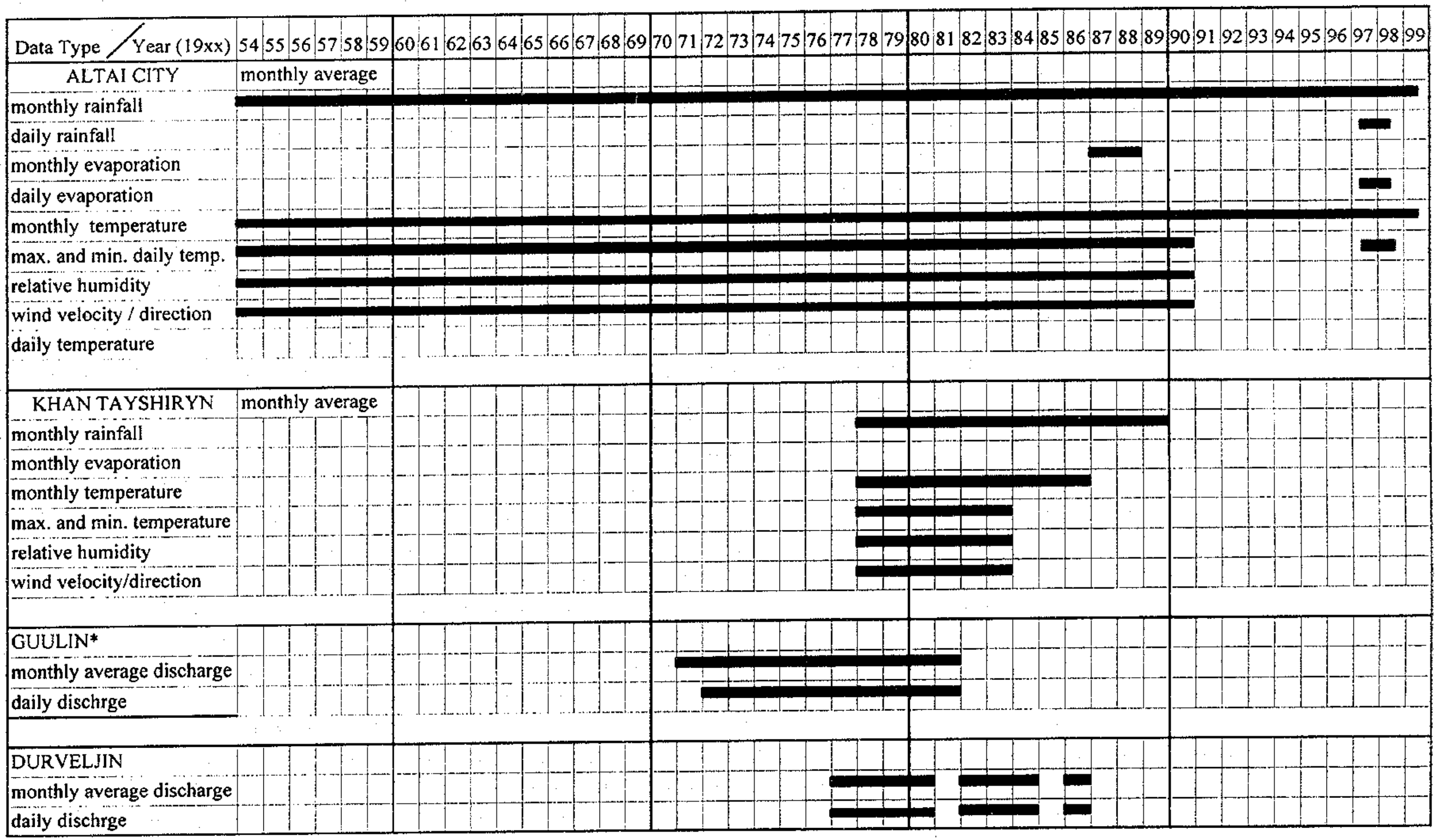


Figure 2.3.2 Location of Meteorological Station and Point of River Discharge Measurement

JICA	The Study on Groundwater Development for Altai City



* : Catchment area = 12,000Km^2

Figure 2.3.3 Collected Meteorological and Hydrological Data

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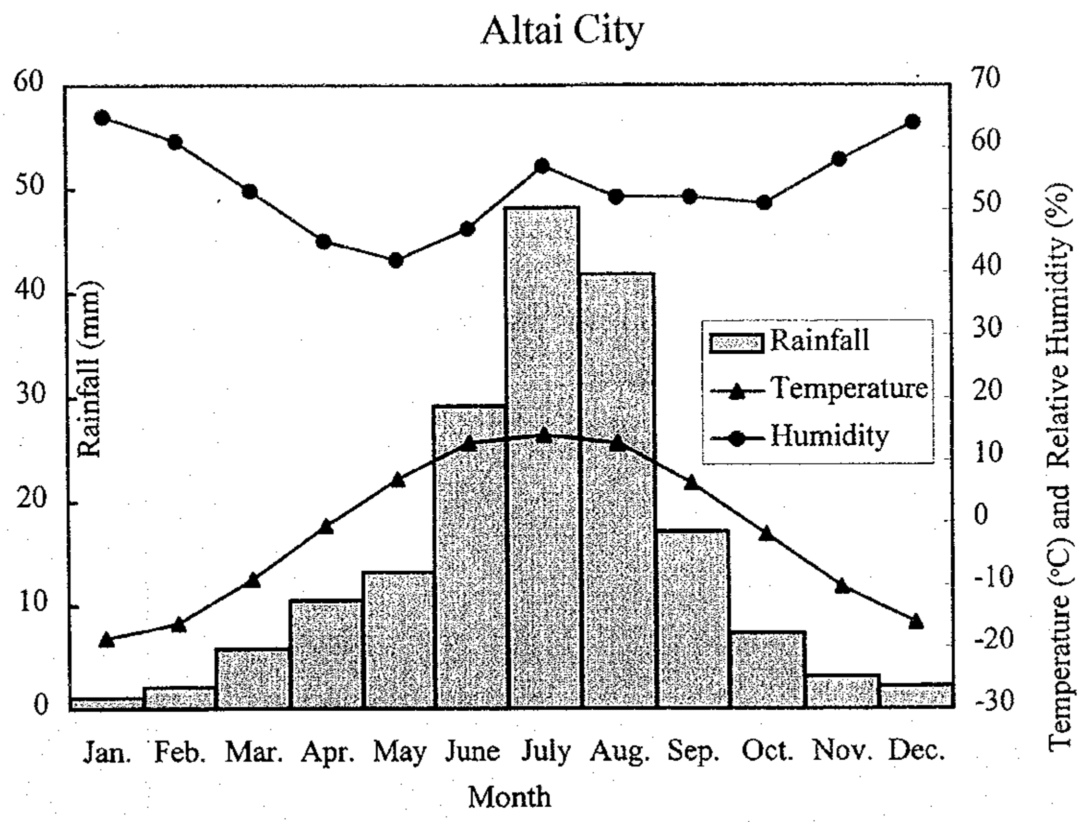

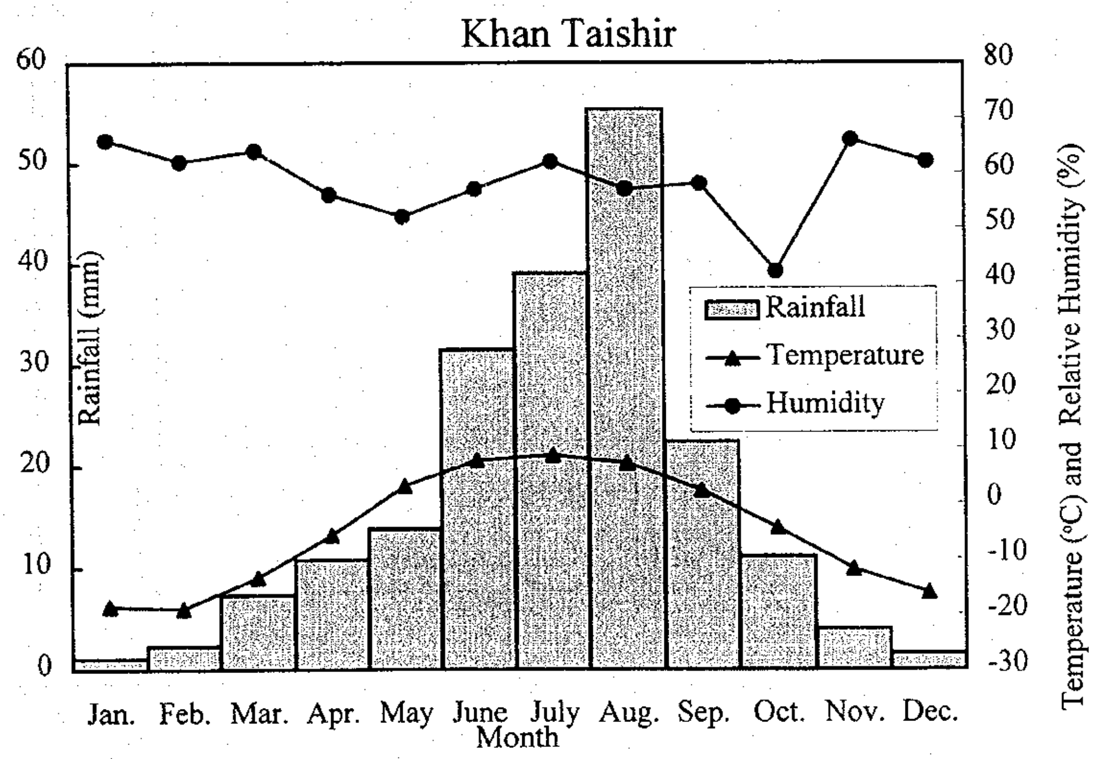

Figure 2.3.4 Monthly Average Rainfall, Temperature and Relative Humidity

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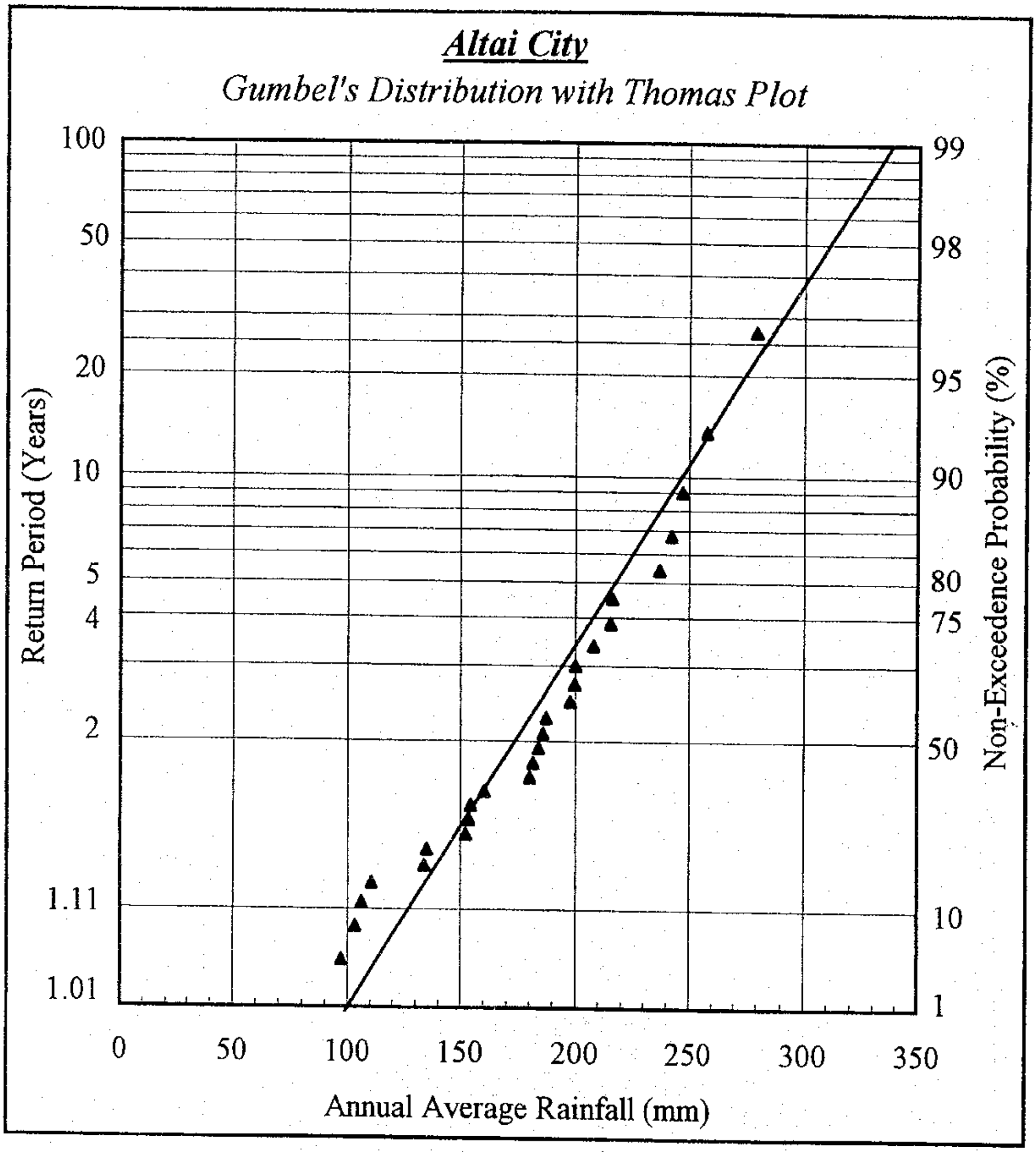

Figure 2.3.5 Probability of Annual Average Rainfall in Altai City	
JICA	The Study on Groundwater Development for Altai City

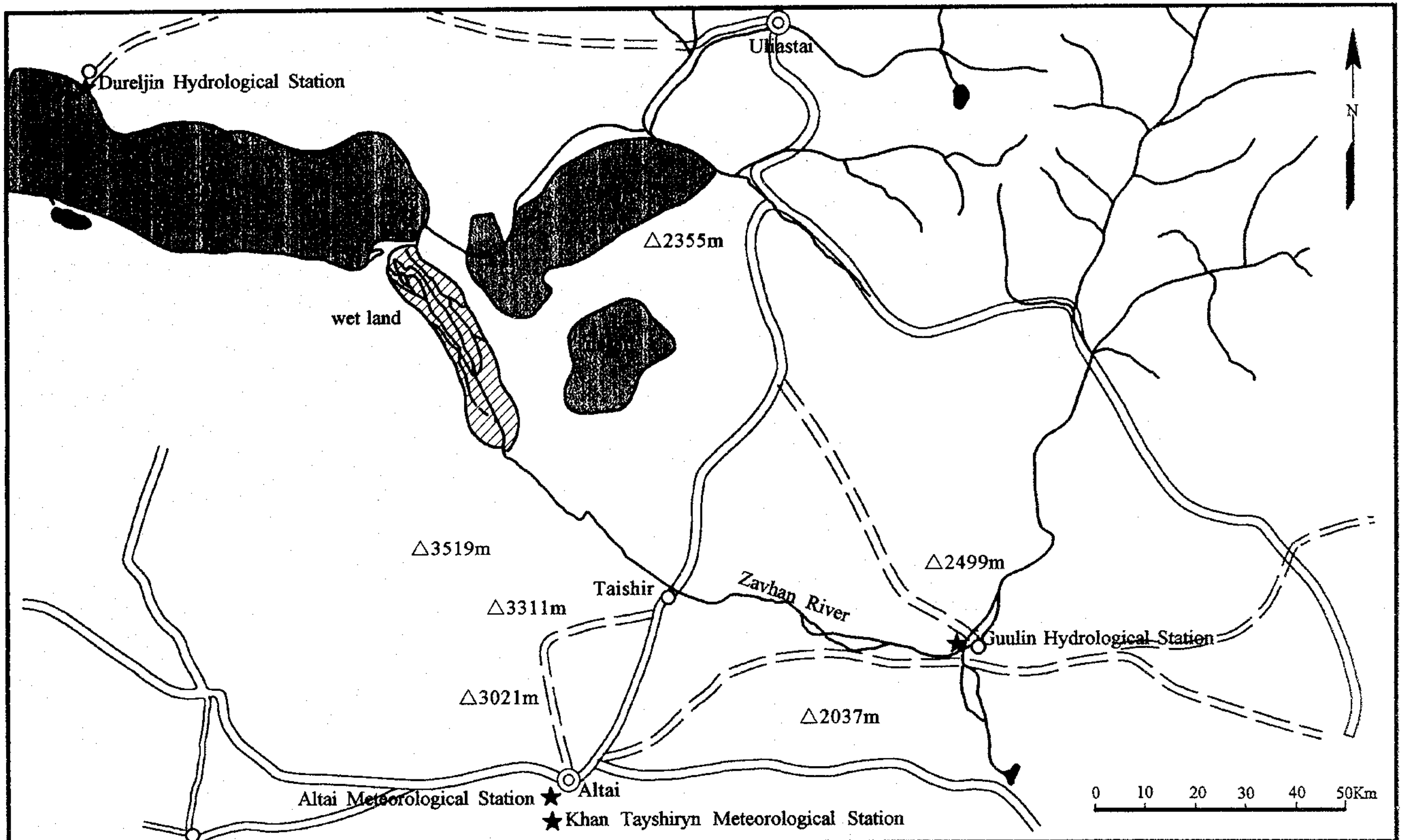

Figure 2.3.6 Location of Hydrological Stations

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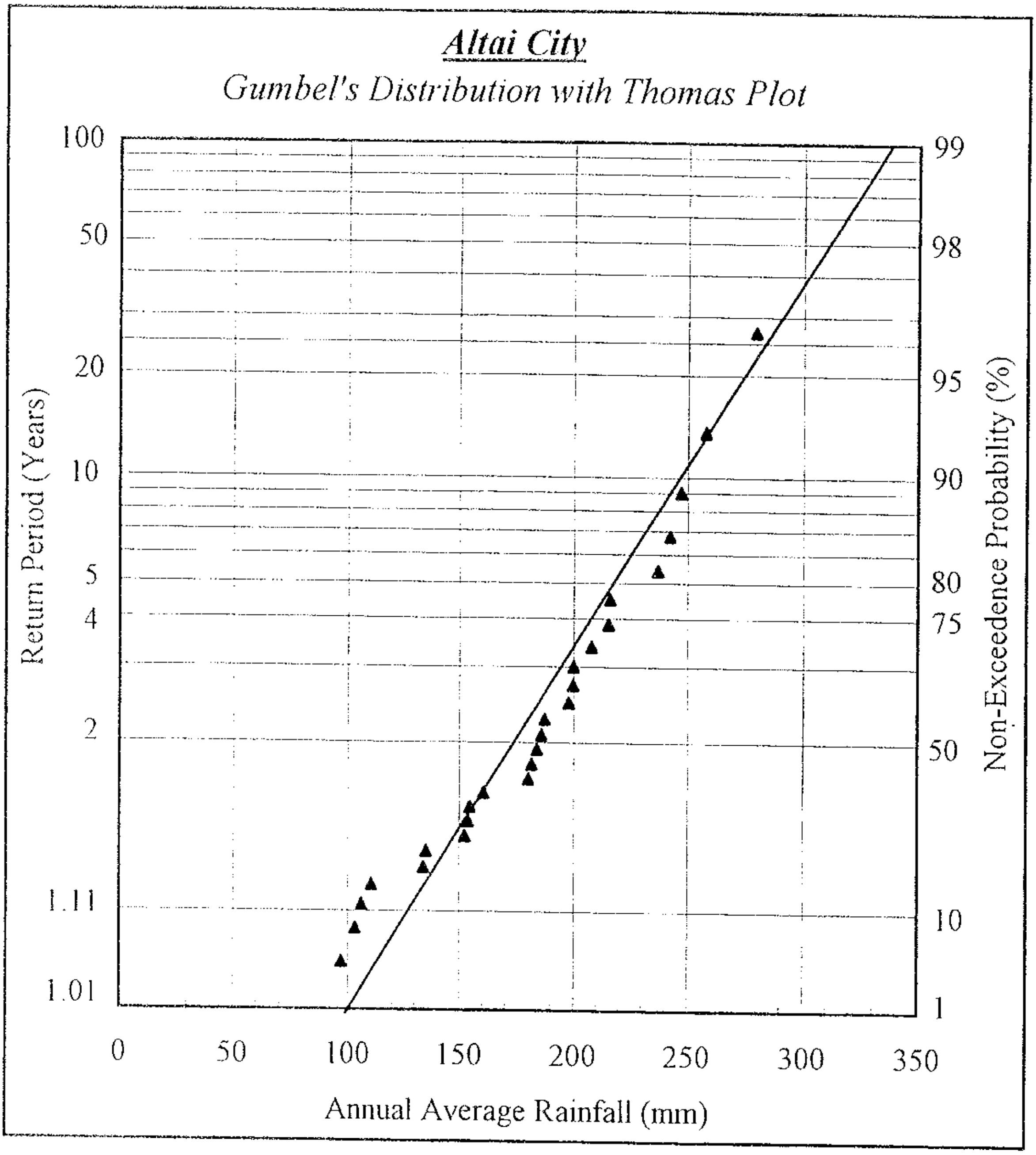

Figure 2.3.5 Probability of Annual Average Rainfall in Altai City	
JICA	The Study on Groundwater Development for Altai City

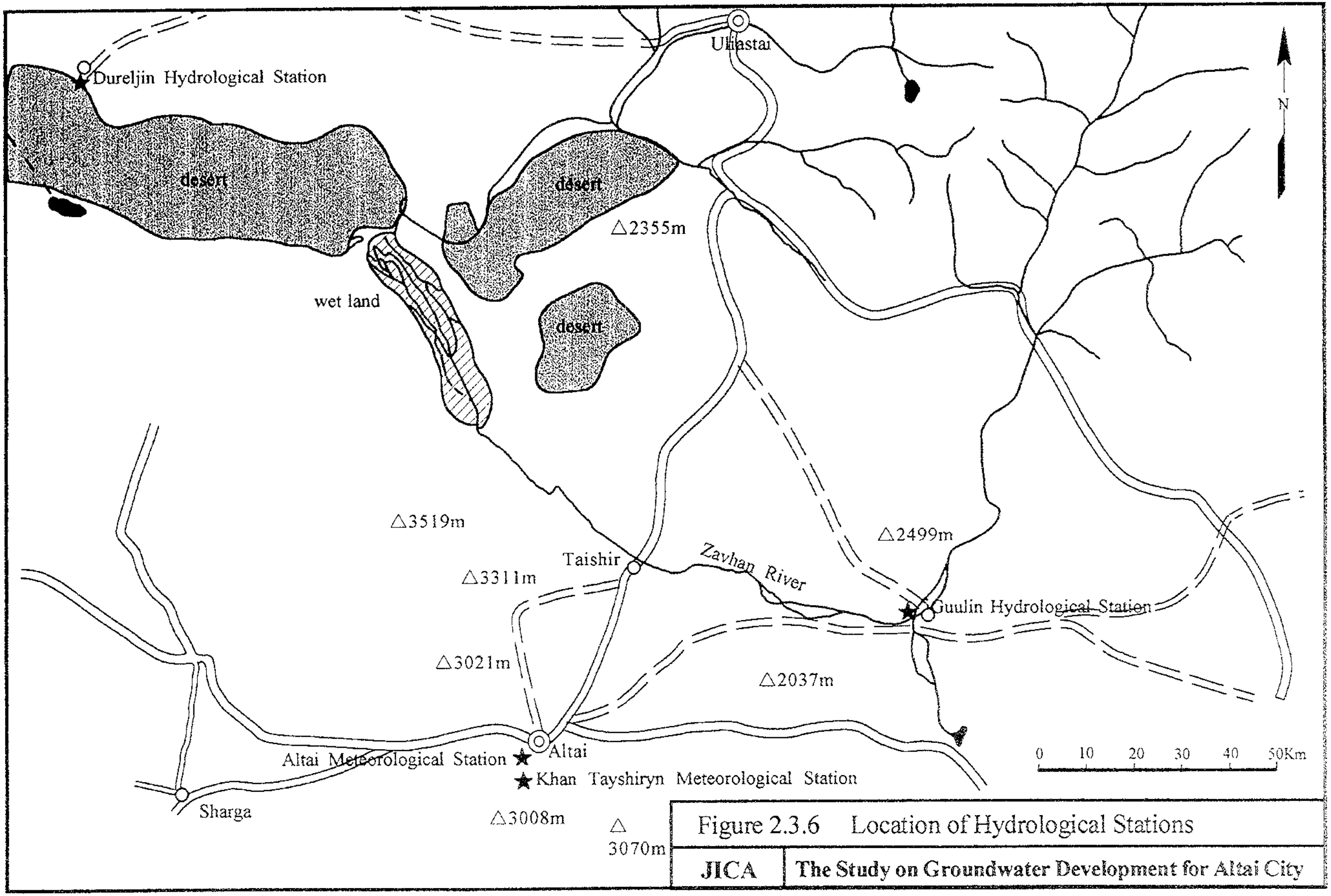

Figure 2.3.6 Location of Hydrological Stations

JICA	The Study on Groundwater Development for Altai City

2.4 TOPOGRAPHY AND GEOLOGY

2.4.1 Outline of the Investigation

One of the aims of this study is to estimate the capacity of groundwater resources that are roughly classified into the following two types of resources, alluvial deposit and fractured zone in basement rocks that are expected to form good aquifers. Therefore, geological investigation was first conducted to clarify the distribution and property of alluvial deposits and fractured zones. The items for the investigation are as follows:

- collection of existing geological data ,
- interpretation of satellite images and aerial photographs,
- analysis of collected data,
- geological field reconnaissance, and
- making a geological map.

2.4.2 Regional Topography and Geology

(1) Topography

Mongolia is a mountainous country. Basically, its topography is characterized by mountains, hummocks and high denudation plains, forming three major regions on its surface. Mountains (1,500~3,000m) occupy more than 40 percent of Mongolia's total territory, hummocks (1,000~1,500m) 40 percent and denudation plains about 15 percent. Within Mongolia, mountains are found mainly in the northern and western regions, and denudation plains in the southeast; hummocks, equally distributed on its entire territory, are highly developed in the desert area which is a closed-drainage region south of the continental watershed.

(2) Geology

Tectonically, Mongolia comes under the Ural-Mongolian Paleozoic fold belt, and only a portion of it belongs to the Mediterranean - Central Asiatic branch of Tethys. The country is divided into seven structural units of folded zones as follows (refer to Figure 2.4.1).

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

The geology of Mongolia comprises metamorphic, magmatic and clastic complexes of all geological ages. The surface of the mountains usually has Precambrian and Paleozoic geosynclinal complexes, characterized to a significant extent by deformations and metamorphic changes. In inter-mountain hollows and in a considerable part of Gobi, Mesozoic and Cenozoic sediments cover the faulted foundations.

The Study Area belongs to North Mongolian Folded Zone. Vendo and Riphean Systems of Precambrian period are mainly distributed in the area(refer to Figure 2.4.2). Cambrian system is intercalated with these basement rocks which are intruded by granitic rocks of the Devonian and Permian period, and covered locally by the Tertiary and Quaternary deposits. These systems are generally distributed in zonal arrangement extending from northwest to southeast. Every system is unconformable to the others and complexly folded and faulted.

2.4.3 Topography in the Study Area

The Study Area is located at the northern part of Altai Mountains with maximum width of 25 km and maximum length of 46 km covering about 600 km^2. The altitude of the City is about 2,040 to 2,180 meters above sea level (m A.S.L).

Based on the field reconnaissance, satellite images and the aerial photograph interpretation, the following five topographic units were established in the Study Area (shown in Figure 2.4.3) :

Mountain I,
Mountain II,
Hilly Area,
Undulated Area, and
Flat Plain Area

General characteristics for each unit is shown in Table 2.4.1 and the detail for each unit is described in chapter 4 of the Supporting Report.

The Study Area is closed in by two mountain ranges bounded mostly by large regional faults that run northwest-southeast (NW-SE) and west-northwestern - east-southeastern (NWW-SEE) in direction as shown in Figure 2.4.2. The former mountain range is Khan Tayshiryn mountains and the latter is Sertengyn mountains. Sertengyn mountain range separates the Study Area into two hydrographic basins; the northern basin named Sukhyn Khooloy area and the southern basin named Kharzat - Olon Nuur area.

In macroscopic view, the Study Area is situated in the southern margin of the catchment area of Zavkhan river. Hydrographycally, the Study Area corresponds to Khanginaagyn Khooloy River catchment area, and it's five sub-catchment areas; Sukhyn Khooloy River (approx.186 km^2), Undur Tsakhirsayr River (approx. 81 km^2), Hadaasan River (approx.54 km^2), Mandaliin Aryn Am River (more than 123 km^2), and Euitiin Sair River (approx.155 km^2), from the north to the south as shown in Figure 2.4.4.

2.4.4 Interpretation of Satellite Images

(1) General

Using satellite images with a scale of 1/100,000 and 1/250,000 which cover the entire Study Area, interpretation of the images was conducted with the aim of finding out general features of the fault system. The aerial photographs of the Study Area with a scale of 1/47,000, was also interpreted. The results are shown in Figure 2.4.5.

(2) Results

Lineaments observed in the study area are classified into three types from the view points of their clearness and geological significance as follows.

Solid line :	clear and continuous lineaments that displace another lineament and geological structure.
Broken line :	rather unclear lineaments that are continuation of aforementioned clear lineaments.
Dotted line :	indistinct lineaments that develop irrelevantly to the geological structures.

Lineaments observed in the Study Area also can be divided into four types based on their shape and orientation as shown in the following.

NW~NWW :	Lineaments with this direction harmonizes with the Khan Tayshiryn Mountains trend and its geological structure, and this may be one of the oldest lineaments.
N-E :	Lineaments with this direction may have been formed simultaneously as NW~NNW lineament.
N-S :	Lineaments with this direction develop in granitic rocks.
Ring-shaped :	Ring-shaped lineaments represent peculiar topographical and geological conditions, such as contacts of intrusive granitic rocks with the surrounding country rocks.

Generally, lineaments are clear in Khan Tayshiryn Mountains located in the northwestern and the southern part of the Study Area, but indistinct in the northern and eastern part of the Study Area.

2.4.5 Geophysical Prospecting

In order to understand geological structure and hydrogeological settings of the study area, two kinds of geophysical surveys were carried out. They are :

1) DC resistivity sounding survey : to clarify the Alluvial basin structure and a part of hydrogeological characteristics, and
2) VLF electromagnetic survey : to clarify the distribution of fractured zone.

Both methods intend to detect changes in electrical conductivity in the earth for the purpose of obtaining more information on the subsurface geological structure.
Figure 2.4.6 shows the location of them.

(1) DC Resistivity Sounding Survey

DC resistivity sounding method is to study changes of geoelectrical structures in nearly horizontally layered earth. It is therefore used to obtain detailed information on the underground layered structure of sediment, especially the distribution of basement rocks.
The survey provided vital data to complement the data of geological cross section of the Study Area. The outcome of the combination of the data is presented as Figure

2.4.8.

(2) VLF-EM Survey

VLF electromagnetic (VLF-EM) survey is to detect conductive or resistive zones within a depth of 20 to 30 meters in the ground aiming to delineate vertical sheets with some conductivity changes in the host rock. Therefore it is expected to detect and locate possible fracture zones which appear as lineaments on satellite images and aerial photographs.

Several anomalies were detected along No.1 to No.6 line at the northeast foothill of Bayangyn mountains along the regional faults. Several clear anomalies were also detected at the northeast side of Altai City (line No.7 to 11). Some anomalies may be traced through two to three lines in northwest-southeast direction. Anomalies along lines 14, 15, 21 and 16 can be traced northeast-southwest direction and those along lines 17, 30 and 22 can be traced northwest-southwest direction.

Distribution of Faults and Their Characteristics

Since several lineament zones were recognized as a result of satellite image interpretation and VLF survey, supplementary geological field survey was conducted with the aim of further investigating the lineament zones which are expected to form large fractured zones in the basement rocks.
Although some of the detected lineaments are clear and stretch out over the study area, neither the VLF survey nor the field survey indicated the presence of such conspicuous fractured zones. Presumably this is because the geology of the study area is quite old and there has been no recent tectonic movements that could have generated cracks in basement rocks on a large sale. In spite of the absence of such fractures, a lot of open cracks and joints are observed in the rocks exposed in Khadaasan area for example. They are expected to convey and keep at least some amount of water.

2.4.6 Stratigraphy and Geology in the Study Area

(1) General

In the Study Area, Lower-Proterozoic(Riphean, Vendian), Cambrian, Devonian, Neogene geological systems are distributed. Quaternary sediments are unconsolidated and overlie the aforementioned system as a thin sedimentary cover.

These pre-quaternary formations except for the Tertiary are hard consolidated metamorphic rocks and serve as the bottom of the groundwater basin. Every geological formation has unconformable relationship to each other. Details and distribution of geological components are shown in Table 2.4.2 and Geological map of the Study Area in Figure 2.4.7 and 2.4.8 combining the results of geophysical prospecting.

Briefly speaking, the Hilly and Mountainous areas are underlain chiefly by Precambrian metamorphic rocks, which are intruded by granitic rocks of Precambrian-Riphean series. Carbonate rocks of Cambrian period outcrop in the southern mountain area. On the other hand, in the undulated and flat plain area, Quaternary unconsolidated sediment is widely distributed and small outcrops of Devonian and Tertiary sedimentary rocks are scattered in the northern part of the study area.

(2) Basement rocks

As mentioned briefly before, the basement rocks in the Study Area are mostly those of the Precambrian. In the mountain range at the southwestern margin of the Study Area, the dominant rock types are basic plutonic and metamorphic rocks such as peridotite and serptntinite. On the other hand in the central and northern part, more acidic rocks such as acidic gneiss and quartzite are commonly observed.

(3) Neogene System

Neogene system is widely distributed in the northern basin of Sukhyn Khooloy, but the majority of this system is covered by Quaternary sediments. Small outcrops are exposed around Zatogay Khooloy. Lithological component is represented mainly by friable but impermeable reddish clay with sand and gravel layers. Total thickness of this system at Sukhiin Khooloy is around 41 meters.

(4) Quaternary Deposits

In the Study Area, Quaternary deposits are widely distributed at central lower part of the relief such as undulated and flat plain unit areas including intermountain valleys. This type of deposit is mainly composed of alluvial fan, talus, flood plains, and recent river deposits. The age may vary from lower Pleistocene to upper Holocene. Since these deposits are expected to form good aquifers, their characteristics are described in detail in the following.

Fan deposits (Q II-III)

Fan deposits are distributed at mouths of rivers and its tributaries along skirts of mountain area. The fan deposits consist of gravel rich deposits that originated in the surrounding mountain area. The thickness of the fan deposits is estimated at 30 meters or more at southwestern - southern boundary of the basin. The fan deposits usually form unconfined aquifers. In Sukhin Khooloi, many springs at the fringes of fan deposits are found.

Talus deposits (Q II-III)

Talus deposits are distributed at piedmonts. Their lithological components are clay, sand and pebble to boulder that are angular to sub-angular with poor sorting.

Recent river deposits (QIV)

Recent river deposits are distributed along the principal river courses (traces) like Sukhyn Khooloy, Mandaliin Aryn Am, Euitin Sair, Khanginaagyn Hooloy, etc. and along their main tributaries. This deposit consists of silt, sand, and partly gravel. The gravel is angular to subangular with bad sorting because of short river length, low frequency of flood, and fractured rocks exposed in the mountain area. Impermeable clay layers exist near the land surface in some depressions, where many swamps with salty water-ponds are commonly observed.

(5) Geological Structure in the Study Area

The Study Area is located at the southern edge of North Mongolian Folded Zone, where the direction of folding axis is deflected northward, extending NW-SE, NWW-SEE in direction. Faults with similar orientation develop along the northern boundary of Sertengyn and southeastern wing of Khan Tayshiryn mountain range along its midslope. Along these regional faults, neighboring formations are complexly folded, sheared, fractured, and faulted. Springs are found along these regional faults and fissure water is expected to be found as well.