No.

Water Supply and Sewerage System Co. of Darkhan City
Mongolia

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR IMPROVEMENT OF WATER SUPPLY FACILITIES AT DARKHAN CITY
IN
MONGOLIA

November 2008

JAPAN INTERNATIONAL COOPERATION AGENCY

TOKYO ENGINEERING CONSULTANTS CO., LTD.

GE
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PREFACE

In response to a request from the Government of Mongolia, the Government of Japan decided to conduct a basic design study on the Project for Improvement of Water Supply Facilities at Darkhan City in Mongolia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Mongolia a study team from May 19 to June 22, 2008.

The team held discussions with the officials concerned of the Government of Mongolia, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Mongolia in order to discuss a draft basic design, and as this result, the present report was finalized.

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

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

November 2008

Ariyuki Matsumoto
Vice-President
Japan International Cooperation Agency

November 2008

LETTER OF TRANSMITTAL

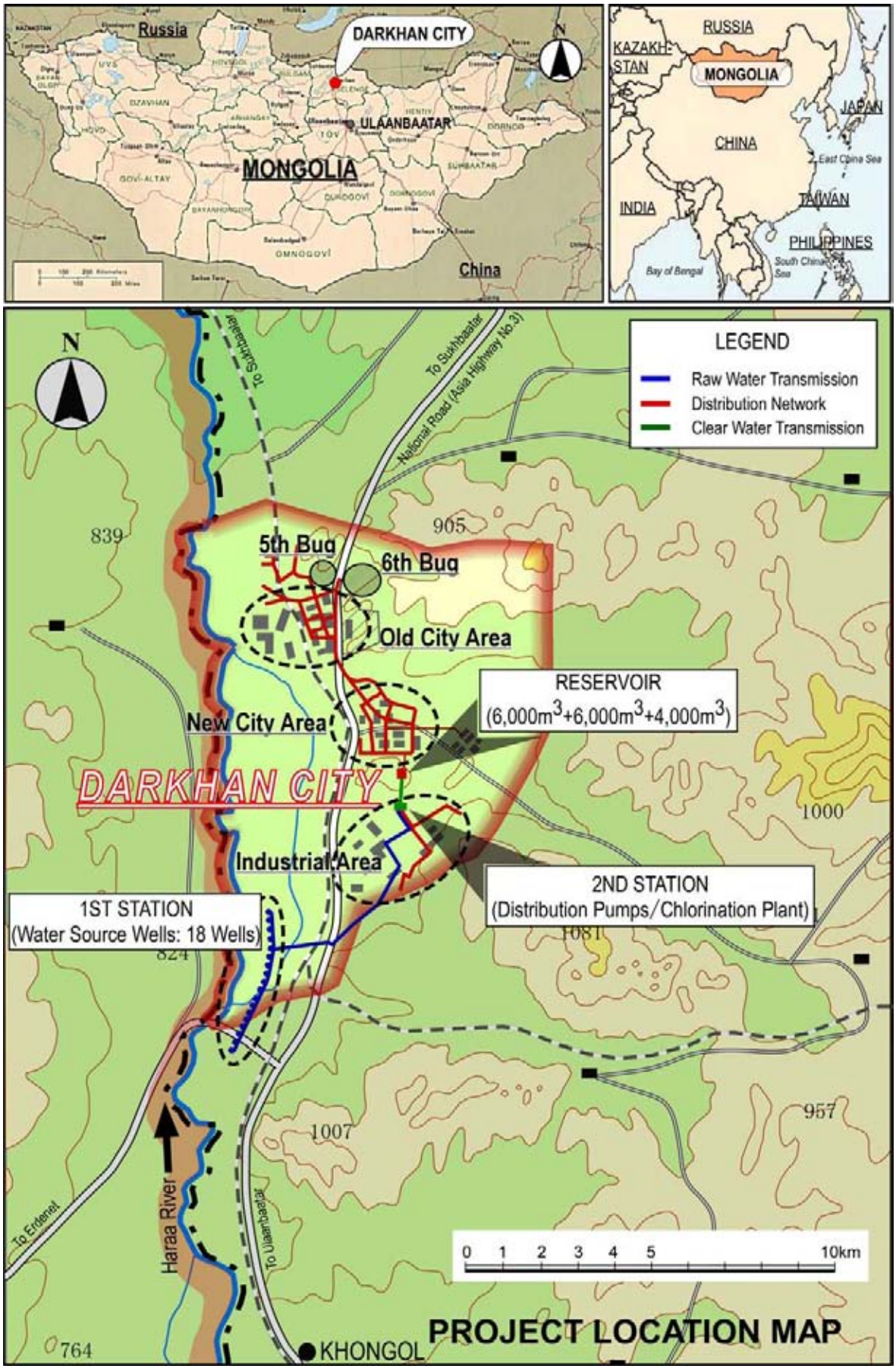
We are pleased to submit to you the basic design study report on the Project for Improvement of Water Supply Facilities at Darkhan City in Mongolia.

This study was conducted by Tokyo Engineering Consultants Co., Ltd. under a contract to JICA, during the period from May to November 2008. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Mongolia and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

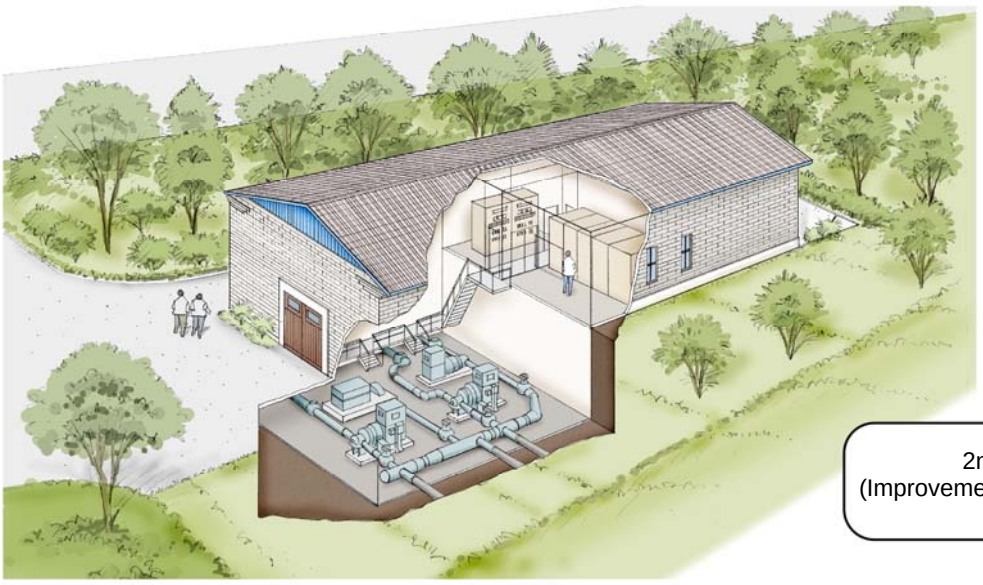
Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

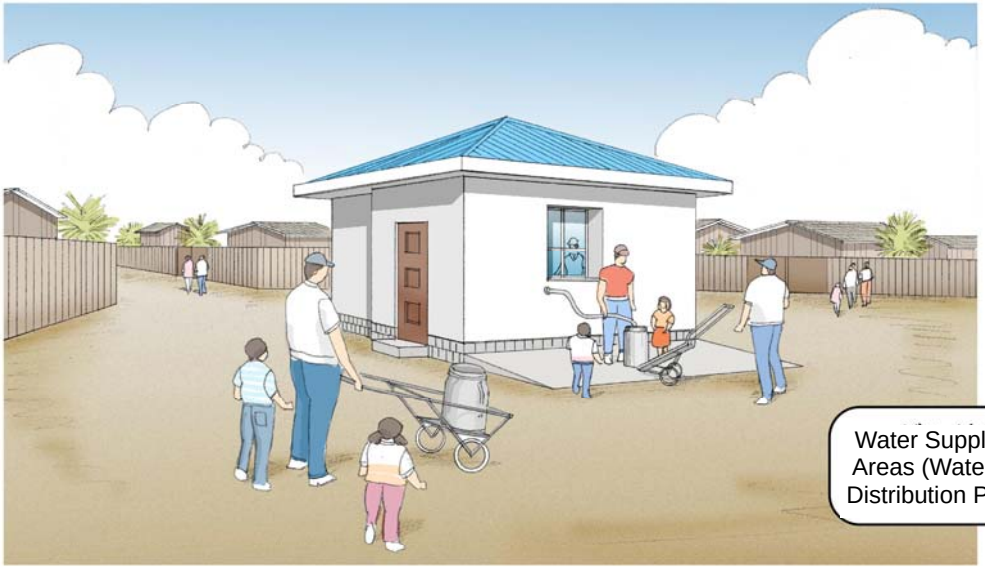
Soichiro Yumoto
Project Manager,
Basic Design Study Team on
the Project for Improvement of
Water Supply Facilities
at Darkhan City in Mongolia,
Tokyo Engineering Consultants Co., Ltd.


Russia
DARKHAN CITY
ULAANBAATAR
MONGOLIA
China
RUSSIA
KAZAKH-STAN
MONGOLIA
CHINA
JAPAN
East China Sea
INDIA
TAIWAN
PHILIPPINES
Bay of Bengal
South China Sea
N
LEGEND
Raw Water Transmission
Distribution Network
Clear Water Transmission
To Sukhbaatar
To Sukhbaatar (Asia Highway No.3)
National Road
839
905
5th Bug
6th Bug
Old City Area
RESERVOIR
(6,000m3+6,000m3+4,000m3)
New City Area
DARKHAN CITY
1000
Industrial Area
2ND STATION
(Distribution Pumps/Chlorination Plant)
1ST STATION
(Water Source Wells: 18 Wells)
824
1081
957
1007
Haraa River
To Erdenet
To Ulaanbaatar
0 1 2 3 4 5 10km
764
KHONGOL
PROJECT LOCATION MAP

1st. Station
(Improvement of 10 Pump Units)



2nd. Station
(Improvement of 3 Pump Units)



Water Supply Facilities in Ger Areas (Water Kiosks: 12 Nos., Distribution Pipelines: 7,326 m)

OUTLOOK ON PROJECT FACILITIES

SITE PHOTOS

Overview of Darkhan City

The new Darkhan area expands near side in the photo, and the far side is the old Darkhan area. The population of the city is about 75,000 (2007) including the ger areas expanding on the hilly areas.

Pump House of 1st Station (1)

The old type of the pump house constructed in 1965, of which pump room is on the ground floor. The a single swing door is set at the entrance causing the easy intrusion of cold air from outside. The lighting is required even in day time because there is no window on the wall.

Inside of Pump House of 1st Station (1)

The pumping equipment is aged and it is necessary to replace whole facilities. The heaters are provided on the wall in the left side of the photo, and the heating system is inefficient causing the increase of electricity expenses.

Pump House of 1st Station (2)

The new type of the pump house constructed around 1985. The power supply system shown near side is broken and not functioning.

Inside of Pump House of 1st Station （2）

The pump room is set under ground, and the pipes are aged. The heater on the left wall is inefficient and causes the increase of electricity expenses.

Overview of Pump Units in 2nd Station

All of the pump units are aged and three units other than the 3rd one from the left side are not functioning due to breakdown resulting in the shortage of water transmitted.

Chlorinator

Thereare two chlorination systems, but both are out of order. They have been left broken more than 10 years, and raw water has been distributed without any disinfections so far.

Existing Water Kiosk in Ger Area of 6th Bag

The mount in front of the kiosk house is used for refilling water to the tank of $4m^3$ inside of the house. Water is sold when there is water in the tank only, and the time of selling water is limited.

Truck Crane

It is aged more than 30 years, and there are many troubles on the crane and the vehicle parts causing the frequent troubles at the time of dispatch.

Mobile Welder

It is aged more than 30 years, and both of welder and vehicle are deteriorated with frequent troubles as same as the track crane.

ABBREVIATIONS

ADB:	Asian Development Bank
ASTM:	American Society for Testing and Materials
Bag:	A minimum administrative unit of Mongolia
BHN:	Basic Human Needs
BS:	British Standards
cm:	Centimeter
cm^2:	Square centimeter
DIN:	Deutsche Industrie Normen
EBRD:	European Bank for Reconstruction and Development
EGSPRS:	Economic Growth Support and Poverty Reduction Strategy Paper
g:	Gram
Ger:	Portable, felt-covered, wood lattice-framed dwelling structure used by nomads in Mongolia
GDP:	Gross Domestic Product
GOST:	State Committee of Russian Federation for Standardization and Metrology (ГОСТ - Государтсвенные стандарты)
IBRD:	International Bank for Reconstruction and Development
IDA:	International Development Association
IEE:	Initial Environmental Evaluation
IMF:	International Monetary Fund
ISO:	International Organization for Standardization
JIS:	Japanese Industrial Standards
JPY:	Japanese Yen
JICA:	Japan International Cooperation Agency
KfW:	Kreditanstalt für Wiederaufbau
kg:	Kilogram
km:	Kilometer
km^2:	Square kilogram
liter:	Liter
liter/day:	Liter per day
liter/capita/day:	Liter per capita per day
m:	Meter
m^2:	Square meter
m^3:	Cubic meter
m^3/sec:	Cubic meter per second
m^3/hr:	Cubic meter per hour
m^3/day:	Cubic meter per day:
mm:	Millimeter
MIAT:	Mongolian Airlines (МИАТ - Монголын Иргэний Агаарын Тээвэр)
MNT:	Mongolian Tugrik
MOF:	Ministry of Finance

MR:	Mongolia Railway
MRTCUD:	Ministry of Road, Transport, Construction and Urban Development
NRW:	Non-Revenue Water
PNIIS:	Production and Research Institute of Civil Engineering for Construction (ПНИИС - Производственно-научный и изыскательский институт для строительства)
t:	Ton
ULM:	Ural Mongolia Lineament
UNDP:	United Nations Development Programme
USD:	United States Dollar
Water Kiosk:	A small house to sell the drinking water to the people living in the areas like the ger areas where any house not served by piped system because sufficient distribution networks are not provided. It is operated by WSSSC and a vender is assigned for selling water to the people who carry water containers by themselves.
WSSSC-Darkhan:	Water Supply and Sewerage System Co. of Darkhan City
WTO:	World Trade Organization

SUMMARY

1. Mongolia is the landlocked country surrounded by Russia and China in northern and southern sides, respectively. Its land area is 1,560,000 km^2 (about four times of Japan) and the population is about 2,630,000 (2007). The Darkhan city is located 219 km north of Ulaanbaatar, and it was constructed around 1965 on the right bank of the Haraa river, one of the tributaries of the Selenge river flowing into the Baikal lake. The city having the population of about 75,000 in 2007 is the third largest one after Ulaanbaatar and Erdenet. The city area is developed on the flat plane of about 700 m altitude surrounded by the hilly areas with mild slope of which bedrock is mainly composed of sandstone. The temperature varies widely from the minimum of -30.8 ^oC in 2007 to the maximum of 40.5^oC in 2007, and the climate is categorized into the continental arid zone characterized by long and cold winter and short summer to which the most of the annual precipitation concentrates. The annual average temperature is 3.2 ^oC in 2007 and the annual precipitation is 330 mm in 2007, which is considered to be one fifth of the average value of Japan.

2. The surrounding areas of the Darhan city is considered as the granary area for wheat cultivation, and also as the industrial area. Since the Asian Highway No. 3, one of the paved main road of the country, runs between Ulaanbaatar and Darkhan and the international railway passes the city, the Darkhan city and surrounding areas are considered to be blessed with potential of economic development. In Action Plan of the Government of Mongolia for 2004-2008, the city is listed as the core city of the central zone.

3. The water supply system of the Darkhan city was constructed under the former Soviet Union, but their functions are being declined remarkably because of lack of spare parts and technical assistance after the collapse of the union. The water production of 7,045,000 m^3/year in 2004 is decreased to 4,955,000 m^3/year in 2007 because of the troubles of main water facilities such as pump units, etc., and the water production of the city does not catch up the demand of the population-increasing areas. If the water production decreases more, water supply volume may be short causing wide and long suspension of supply services. In case that the water supply service is suspended long time, such lack of BHN (Basic Human Needs) may give a large impact to the residents of Darkhan. Therefore, the replacement of such aged facilities is considered as the urgent issue to be solved.

4. Under the above situations, in May 2006, the Government of Mongolia requested the Government of Japan for the grant aid for the rehabilitation and replacement of the existing water supply facilities to improve the water supply system of the Darkhan city including the ger areas in the surrounding. In response to the above request, the Japan International Cooperation Agency (JICA) sent the preliminary study team to Mongolia in October 2007 in order to clarify the contents of the request.

5. Based on the confirmed contents of the request, the Government of Japan decided to conduct a basic design study on the project, and the JICA sent to Mongolia a study team from May 19 to June 22, 2008. The basic design team conducted a field study at the study area, and after the team returned to Japan, further studies were made. Then, a mission was sent to

Mongolia in order to discuss a draft basic design from September 19 to 28, 2008, and as a result, this report was finalized. The result fo basic design report is summarized below.

6. This project is to construct the water supply facilities for the ger areas in the 5th and 6th bags, to procure and install the equipment required for the replacement of the intake pump units of the 1st station, and to procure the equipment necessary for the operation and maintenance of the water supply facilities, in order to secure the stable and safe water supply to the people of the Darkhan city. The software assistance for the proper operation and management of the constructed and installed equipment and facilities will also be provided to assure the smooth project start.

7. The basic design for the project was carried out based on the following conditions.

7.1 The target year is set for 2011 when the project implementation will be completed, the population for 2011 is set for 91,000 based on the latest population of 2007 (74,526) and the natural increase of 1.5 %/year.

7.2 The water supply facilities of the Darkhan city have not been substantially rehabilitated since the supply system was expanded around 1985, but the repair and maintenance works which do not need the replacement of the expensive spare parts have been carried out. Therefore, most of the facilities are still functioning at present though their conditions are quite inadequate. The consciousness of the technical staff of WSSSC responsible for the operation and maintenance of the water facilities is fair, and their services have been practiced on the technical level enough to conduct the ordinary and regular operation and maintenance services. The facilities and equipment to be procured under the project should be managed by them without any new technology as much as possible.

7.3 The remote control system is requested for the operation of the pump units of the 1st and 2nd stations. In the present operation system, verbal instructions are sent to the sites through the wireless communication system because the operation panels for the remote control are out of order, resulting in various troubles in operation. Therefore, the present manual operation system will be improved adding the remote on-off system without automatic operation system as the minimum grade to be applied.

7.4 As for the intake pump units of the 1st station, 10 units of the submersible motor pump units with the capacity ($160m^3$/hr) same as the existing units are applied to reduce the operation and management costs.

7.5 The replacement of all four (4) units of transmission pumps are requested for the 2nd station, but three (3) units out of them are replaced in order to reserve one (1) unit for the further expansion in future. The water demand for the population of 91,000 estimated for 2011 will be transmitted to the reservoirs by these three (3) pump units to be replaced.

7.6 As for the water supply facilities to be constructed for the ger areas in the 5th and the 6th bags, those with same specification and structure as applied in the facilities for the 7th bag constructed with the finance of ADB are adopted for the smooth operation and maintenance of the facilities.

7.7 The track crane and the mobile welder have been used for about 30 years and gotten troubles frequently due to oldness, but they are dispatched to the site for repairing the broken pipes and intake pump units with 13 - 20 days a month, and are considered as essential equipment for the operation and maintenance. In the winter season, they are parked in the parking lots with the best heating condition in the garage in order to provide against the urgent dispatch, which shows that the said equipment is considered essential for the operation and maintenance of the facilities. It is impossible to use the leased or rent vehicles for this urgent dispatch, and then each one (1) unit of vehicle will be procured under the project in order to establish the system for the smooth operation and maintenance services.

7.8 Since 2005 the WSSSC has promoted to install flow meters, and the demand of installation of meters is increasing recently resulting in the shortage of flow meters available in the WSSSC office. The 1,500 flow meters which are planned to be installed in 2011 are procured in order to realize the smooth water charge collection.

7.9 Since the project area is located in the cold area of which temperature reaches 20 - 30 ^{o}C below zero. Especially in the coldest period, it is necessary to take special care of the electronic equipment which has driving parts in order to avoid freeze of such equipment. Electronic devices such as remote control devices for the intake pumps have to be installed in the pump house and if necessary heat insulation works such as space heaters have to be provided considering that the driving parts of such control devices may not be react properly. The project should be planned so that the construction work can be done continuously during the coldest period in order to use the limited construction period effectively. The construction schedule should be arranged efficiently taking into account the works to be able to do during both the warm and the coldest periods.

7.10 The procurement contractor is planned to carry out operation and maintenance training for WSSC staff on equipment/facilities delivered during commissioning, and then accordingly it is considered that WSSSC staff can reach a certain level of operation and maintenance of water supply system. Since the operation of intake pumps in the 1st station through the remote control system and that of transmission pumps in the 2nd station requires the overall judgment, it is necessary to prepare operation manuals and to train the operation staff through OJT on such operation and maintenance of these facilities. In addition, the chlorinator has been left broken more than 10 years, and there is no staff having the experiences in operation of the chlorinator. Therefore, it is necessary to train the operation staff on the operation and maintenance of the said chlorinator. In order to commence the operation and maintenance of such water supply facilities smoothly, the software assistance will be provided to the operation staff of WSSSC consisting of seminars and OJT.

8. The features of the facilities and equipment provided under the project are summarized in the following table.

Summary of Facilities and Equipment Provided under the Project

Component	Numbers
1. 1st Station	
(1) Replacementof Intake Pump (160 m^3/hr)	10 sets
(2) Operation Control System (Manual Remote Operation)	1 set
(3) Portable Water Level Gauge	2 nos.
(4) Flow Meter	2 nos.
2. 2nd Station	
(1) Replacement of Transmission Pump (640 m^3/hr)	3 sets
(2) Automatic Operation Control System (Manual Operation)	1 set
(3) Flow Meter	3 nos.
3. Chlorination System	
(1) Chlorinator	1 set
4. Water Supply System for Ger Area	
(1) Kiosk House	12 nos.
(2) Distributiion Pipeline (150mm dia.)	7,326 m
5. Operation and maintenance Equipment	
(1) Track Crane	1 no.
(2) Mobile Welder (Truck Mounted Type)	1 no.
(3) Water Quality Analysis Equipment (Spectrophtometer, Incubator, Dry Oven)	1 set
(4) Customer Water Meter	1,500 nos.

Activities and Contents of Software Assistance

Activities	Contents
(i) Intake and Transmission Pumps	Compiling operation manual (Mongolian)
	Seminar/Workshop: Basic operation conforming to the manual, Demand responsive operation on water quantity
	Operation OJT: Confirmation of check-up points and operation procedures, Operation practice, Daily operation record / management report, Efficient operation optimizing electric utility rate
(ii) Chlorination Facilities	Seminar/Workshop: Basics of chlorine disinfection, Basic operation, Injection rate control, Safety control
	Operation OJT: Operation practice, Emergency response for accident/troubles, Daily operation record with injection data
(iii) Relay Pump in Kiosk	Seminar/Workshop: Knowledge of pumping works, Basic pump operation
	Operation OJT: Precaution/Notices on pump operation, Operation practice with proper procedures, Daily operation record/management report

9. By implementing the project, the present (2007) water production of 13,575m^3/day will be increased to 21,800 m^3/day (2011), the risks of decrease of water production and suspension of water supply service will be mitigated, and the water supply amount required for the future increased population of the Darkhan city (the present 75,000 in 2007 will be increased to 91,000 in 2011) will be secured. As for the water consumption per capita, the present 140 liter/capita/day will be increased to 170 liter/capita/day in the apartment area and the present 25 liter/capita/day will be to 35 liter/capita/day in the ger area. The safe water of which residual chlorine is not less than 0.3 mg/liter will be supplied by applying the chlorination. By the software assistance, the operation and maintenance staff of WSSSC will be prepared for the smooth operation and maintenance of the facilities and equipment to be constructed and replaced.

10. The costs covered by Mongolian side are listed below:

Costs Covered by Mongolian Side

(Unit: Million MNT)

Items	Costs
(1) Provision of the electric power lines to each water kiosk in the 5th and the 6th Bags (230 V)	13.2
(2) Personnel Assignment for Project Implementation	14.5
Total	27.7

11. The implementation period of the project is set for 25.5 months consisting of 3.5 months for the detailed design and 22.0 months for the construction, procurement, installation and commissioning.

12. The beneficiary of the project is whole of the residents of the Darkhan city, the third largest one in Mongolia, of which population is estimated as many as 91,000 for 2011, contributing to the improvement of BHN of the poverty group of the city. The water facilities to be replaced and constructed under the project as well as the operation and maintenance equipment to be procured are planned to be operated, maintained and utilized effectively by WSSSC on sustainable basis. The project is also planned to contribute to the improvement of sanitary conditions of the residents based on EGSPRS to realize the Action Plan of the Government of Mongolia with the purpose of poverty reduction. The project will not give any adverse impacts, too. In these contexts, the project is considered appropriate to the Japanese grant aid.

13. The operation and maintenance of the water supply facilities to be replaced and constructed will be the responsibility of WSSSC, and its technical level for this responsibility is considered acceptable, but the improvement of the WSSSC's financial standing is essential to implement the project smoothly and effectively as well as to continue the water supply services on sustainable basis. The activities for installation of customer water meter being promoted by WSSSC at present are considered as one of the important keys for the improvement of financial standing, and these activities and efforts should be continued to establish proper and smooth water charge collection system.

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR IMPROVEMENT OF WATER SUPPLY FACILITIES AT DARKHAN CITY
IN
MONGOLIA

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Exchange Rate

1 USD = 106.73 JPY
1 USD = 1,168.77 MNT
1 MNT = 0.091 JPY

CHAPTER 1 BACKGROUND OF THE PROJECT

CHAPTER 1 BACKGROUND OF THE PROJECT

Mongolia is the landlocked country surrounded by Russia and China in northern and southern sides, respectively. Its land area is 1,560,000 km^2 (about four (4) times of Japan), and 79 % is covered by grassland. The population is about 2,630,000 (2007) and the GDP per capita is about 1,288 USD (2007). Since 1990, the country has shifted from socialism to democracy, adopting the market economy.

Most of the social infrastructures developed with the assistance of the former Soviet Union is getting older and their functions have been declined. On the other hand, many peoples have been migrating to the capital city of Ulaanbaatar, which causes various social issues such as adverse effects and widening disparity between the capital and the rural areas. In order to mitigate the population concentration to Ulaanbaatar and to facilitate the sustainable growth of the country, it is considered important to improve and upgrade the social infrastructures of the core towns of the zone like the Darkhan city.

The Darkhan city is located 219 km north of Ulaanbaatar, and the surrounding areas are the granary area for wheat cultivation. The city is considered as the industrial area also; third largest city in the country after Ulaanbaatar and Erdenet. Since the Asian Highway No. 3, one of the paved main road of the country, runs between Ulaanbaatar and Darkhan and the rail way connecting the Russian border to Ulaanbaatar passes Darkhan, the Darkhan city and surrounding areas are considered to be blessed with potential of economic development. In Action Plan of the Government of Mongolia for 2004-2008, the Darkhan city is listed as one of core cities of the central zone.

The water supply system of the Darkhan city was constructed under the former Soviet Union, but their functions are being declined remarkably because of lack of spare parts supply and technical assistance after the collapse of the union. Although the efforts of the Water Supply and Sewerage System Co. of Darkhan City (hereinafter referred to as WSSSC) for repairing the facility, it is difficult for them to improve their main water facilities substantially due to shortage of budget, etc. Furthermore, the water supply capacity of the present system does not catch up the increasing demand in the population-increasing areas, and it is impossible to increase the water production to fulfill the increasing water demand due to the migration of workers and their families which will be caused by the industrial development in Darkhan.

Under the above situations, the improvement of the water supply system in Darkhan is considered as one of the issues to be solved urgently. In May 2006, the Government of Mongolia requested the Government of Japan for the grant aid for the rehabilitation and replacement of the existing water supply facilities to improve the water supply system of the city including the ger areas of the surrounding areas.

In response to the above request, the Japan International Cooperation Agency (hereinafter referred to as JICA) sent the preliminary study team to Mongolia in October 2007 in order to clarify the contents of the request. As a result the contents of the request were confirmed as shown below.

[Contents of the Request]

(i) Rehabilitation of water supply facilities (replacement of intake pump units and transmission pump units, improvement of operation control system, provision of the relating instruments)
(ii) Replacement of the existing chlorinator
(iii) Construction of water kiosks
(iv) Procurement of operation and maintenance equipment (vehicles for repairing, water quality analysis devices, flow meters, etc.)

CHAPTER 2 CONTENTS OF THE PROJECT

CHAPTER 2 CONTENTS OF THE PROJECT

2.1 Basic Concept of the Project

This project is to construct the water supply facilities for the ger areas in the 5th and 6th bags, to procure and install the equipment required for the replacement of the intake pump units of the 1st station, and to procure the equipment necessary for the operation and maintenance of the water supply facilities, in order to secure the stable and safe water supply to the people of the Darkhan city. The software assistance for the proper operation and management of the constructed facilities and installed equipment will also be provided to assure the smooth project start.

The following effects are expected by implementing the project.

(1) Direct Benefits

(i) The present (2007) water production of 13,575m^3/day will be increased to 21,800 m^3/day.

(ii) The risks of decrease of water production and suspension of water supply service will be mitigated, and the water supply amount required for the future increased population of the Darkhan city (the present 75,000 in 2007 will be increased to 91,000 in 2011) will be secured.

(iii) The present water consumption per capita will be increased; the present 140 liter/capita/day will be increased to 170 liter/capita/day in the apartment area and the present 25 liter/capita/day will be to 35 liter/capita/day in the ger area.

(iv) The disinfection by chlorination will be started and the safe water of which residual chlorine is not less than 0.3 mg/liter will be supplied.

(v) The staff of WSSSC will be prepared for the smooth operation and maintenance of the facilities and equipment to be constructed and replaced by the software assistance.

(2) Indirect Benefits

(i) The installation of customer water meter which has been promoted with the WSSSC's efforts will be diffused smoothly and sustainablly by the water meters to be porocured under the project, and the proper water charge collection will be conducted to increase revenue.

(ii) By replacing the aged facilities, it becomes possible to operate the facilities effectively without any troubles, and the expenses for heating and repairing will be decreased.

(iii) It becomes possible for WSSSC to analyze the water qualities on the parameters of which they have to analyse periodically on their responsibility.

The project features are summarized in Table 2.1.

Table 2.1 Summary of the Project

Narrative Summary	Indicators	Means of verification	Important Assumptions
Overall Goal I - Sanitary environment of the Darkhan city resident is improved.	- Water supplied Population - Quality of feed water	- Annual report of the water and sewerage public corporation (WSSSC) - ditto	- The management of WSSSC is continued.
Project Objective - Service situation of feeding water to the resident in Darkhan city is improved.	- Coverage rate of water supply - Coverage population of water supply - Quality of supplied water - Yield of water source	- Annual report of WSSC	- WSSSC is continuously managed.
Output - Water supply facilities in Darkhan city are improved.	- Sales quantity of water at the 5th and the 6th bags - Amount of electric consumption at the water source well lifting pump station and the transmission- pump station - Operation time of the water source well lifting pump station and the transmission- pump station - Produced water quantity - The watering water quality (Residual chlorine) - Number of failure and recovery cases - Water fee payment rate	- Annual report of WSSSC - Materials and data of WSSSC - The pump operation daily report - Annual report of WSSSC - The water analysis record - The operating daily report - Annual report of WSSSC	- WSSSC uses facilities effectively as in the purpose and manages water supply facilities properly.
Activities Japanese side [Facilities] - The construction of the kiosk in 12 places and water pipeline (6km) (The 5th and the 6th bags) [Equipment procurement] - Procurement of the well pump (including plumbing parts, etc.), operation control system and installation (The procurement of the portable-type water level gauge) - Procurement of the transmission-pump, the automatic control board, flow-meter and installation - Procurement of chlorine desterilization equipment and its installation. - Procurement of the equipment (crane-track and the welding machine) for maintenance - Procurement of the water analysis equipment - The procurement of the water meter 【Software assistance】 - Implementation of technical assistance Mongolian side - Securing facility building lot - Operation and maintenance of the facilities and the equipment	Inputs Japanese side * - Fund for facility construction, and equipment procurement - Personnel for the project implementation - Securing personnel for software assistance	Mongolian side** - Facility building lot - Arrangement spaces for equipment installation - Expenses and personnel for operation and maintenance	- The management plan of WSSSC isn't changed. Precondition - Personnel who are necessary for the management of the requested facilities and equipment are secured. - Facility building lot is secured.

(Note) * : Undertakings of Japanese grant aid ** : Undertakings of Mongolian side

2.2 Basic Design of the Requested Japanese Assistance

2.2.1 Design Policy

The contents of the request confirmed in the Minutes of Discussions of the Preliminary Study signed in November 2007 and this Basic Design Study signed in May 2008 are presented in Table 2.2.

Table 2.2 Confirmed Contents of the Request

Requested Component	Preliminary Study		Basic Design Study	
	Quantity	Priority	Quantity (*1)	Priority (*2)
1st Station				
(1) Replacement of Intake Pump	160 m^3/hr x 12 nos.	1	160 m^3/hr x 12nos. (*1)	A
(2) Operation Control System	1 set	1	1 set	A
(3) Portable Water Level Gauge	2 nos.	1	2 nos.	B
(4) Discharge Meter	-	-	2 nos.	B
2nd Station				
(1) Replacement of Transmission Pump	550 m^3/hr x 4 nos.	1	550 m^3/hr x 4 nos.	A
(2) Automatic Operation Control System	1 set	1	1 set	A
(3) Discharge Meter	5 nos.	1	3 nos	B
Chlorination System				
(1) Chlorination System	1 set	2	1 set	A
Water Kiosk for Ger Area				
(1) Kiosk House	12 houses	3	12 houses	A
(2) Distribution Pipeline	6,000 m (150mm dia.)	3	6,000 m (150mm dia.)	A
Operation and Maintenance Equipment				
(1) Truck Crane	1 no.	4	1 no.	A
(2) Welding Machine (Pick-up Track, Generator, Welding Machine)	1 no.	4	1 no.	A
(3) Water Quality Analysis Equipment	1 set	4	1 set	B
(4) Water Meter	1,000 nos.	4	1,000 nos.	B

(*1) The above table indicates the requests of Monglian Government and quantities and specifications may be subject to change.
(*2) A: Absolutely necessary B: Necessary but next to A

Other than the ones stated in the above table, it was requested to provide software assistances on the operation of the water supply facilities. Considering the above, the basic design for the project is carried out based on the following conditions.

1) Natural Environmental Conditions

- Since the project area is located in the cold area of which temperature reaches 20 - 30 ^oC below zero, such coldness may affect largely on transmission and distribution facilities. Especially in the coldest period, it is necessary to take special care of the electronic equipment which has driving parts in order to avoid freeze of such equipment. To avoid freeze of the water in pipes in midwinter, it is required i) to bury the pipes with a depth more than 3.5m preventing the exposure of the installed pipes, ii) to provide insulation materials or any other heat-retaining devices to those exposed, and/or iii) to design the facilities so as to purge the water inside during the unused period. In addition, electronic devices such as remote control devices for the intake pumps have to be installed in the pump house and if necessary heat insulation works such as space heaters have to be provided considering that the driving parts of such control devices may not be react properly.

2) Socio-economic Conditions

- There is no socio-economic issue to be solved, because all the pump units and relating

electric facilities to be replaced under the project are installed in their existing pump houses or buildings, and there is no structure to be constructed newly. In addition, the water supply facilities for ger areas to be constructed under the project are planned to be located in public roads based on the cadastral maps thereof, and it is not necessary to acquire any lands for constructing and to install project facilities. It has been confirmed that there is no socio-economical issue by the EIA conducted by the Mongolian side.

- There exist some narrow sections in the routes of distribution pipelines. It is necessary to disseminate the information on the period and timing of construction works to the residents along the public roads through the explanatory meetings with them in order to facilitate their cooperation for the smooth implementation of such construction works.

3) Construction/Procurement Conditions

- In the design of the water supply facilities in the ger areas of the 5th and the 6th bags, it is necessary to utilize the materials and equipment locally available in Mongolia for the smooth operation and maintenance of the project facilities after the completion of project implementation as same as those in the 7th bag area constructed under the finance to ADB.
- Since Mongolia had been a socialist state under affect of the former Soviet Union, they have used the equipment made in Russia and Eastern Europe and are familiar with the operation of this kind of equipment. However, many companies come into the Mongolian market from the neighboring China recently and some of them have their agents in Ulaanbaatar. Therefore, the equipment under this project has to be procured from the manufactures who have their local agents in Mongolia to obtain consumables and spare parts easily.
- The materials and equipment to be incorporated in the construction works should conform to the international standards such as JIS, BS, DIN, ISO, ASTM, GOST and those compatible to the existing facilities.

4) Utilization of Local Contractors

- There are many local contractors in Mongolia some of which have the experiences to participate in the construction under the Japanese Grant Aid as a sub-contractor. Since these contractors are considered familiar with the standard specifications and structures of the cold areas, these local contractors should be utilized for the construction of the water supply facilities in the ger areas for the smooth implementation of the construction works.

5) Capacity of Executing Agency for Operation and Maintenance

- The executing agency of the project is WSSSC. The water supply facilities of the Darkhan city was constructed around 1965 in the course of the infrastructure development of the city under the assistance of the former Soviet Union, and the water supply system was expanded around 1985, but subsequently any expansion or rehabilitation have not been conducted. Especially after turning toward democratic reform in 1990, the facilities have been used without any proper maintenance due to a fund shortage resulting in the frequent troubles and accidents caused by decrepitude. However, since a certain extent of operation and maintenance has been carried out, most of facilities are still working at present except

for some parts in spite of inadequate conditions. This situation attributed to tireless efforts of the WSSSC staff to continue the operation and maintenance of the facilities with a certain level of skills. It is, therefore, necessary to introduce the facilities and equipment under the project of which such technology level will be facilitated.

- The volumetric system of water tariff with water meters has just commenced in 2005, and the number of households having water meter installed are not many, because the fixed system with the registered number of family members has been prevailing. In the fixed system, less number of family members than actual is likely to be registered, and as a result, almost half of the residents the an apartment area is not registered in the agreement although they live there. Therefore, WSSSC claims for water charge payment with a daily consumption of 260 liter/day/capita despite the actual daily consumption of about 140 liter/day/capita, which is not considered a proper way of water charge collection. Then they started to change their collection system to commodity charge system introducing water meters. Because there are the cases that the water charge becomes cheaper actually increasing requests to install water meters, it is indispensable procure water meters under the project in order to facilitate the proper water collection by commodity charge system.
- The training of the WSSSC staff on the basic skills of operation and maintenance of the replaced facilities will be carried out at the time of commissioning of the facilities, and those for the 1st and 2nd Stations including remote control which require the overall judgment will be conducted through on-the-job training (OJT) apart from those in commissioning preparing operation manuals in order to secure the sustainability of the operation of the provided facilities. As for the chlorination system, it has been left broken more than ten (10) years, and there is no staff who knows how to operate it. Therefore, it is necessary to train the operation staff of the new chlorination facilities. These training of the operators will be carried out under the program of the technology transfer by the consultant.

6) Scope and Grade of Facilities and Equipment

- The remote and automatic control is requested for the 1st and 2nd Stations. Originally the pump units of the 1st Station were operated with the remote control system, but it was broken and the operation at site has been carried out by oral instructions from the 2nd Station through the wireless communication system at present. Therefore, operation system of the pump units to be employed under the project should be of the minimum grade adding the remote control system for the 1st Station to the present system, and the automatic control system will not be considered.
- The safest and the most effective method will be selected in the study among wireless, optical cable, and cellular phone systems for the signal transmission of the remote control system, and the transmission method by electric cable will not be adopted considering the previous experiences in the project conducted for the Ulaanbaatar water supply system.
- The intake pumps are operated in rotaation at present, and the capacity of the submersible pumps to be procured under the project will be $160m^3$/hr equivalent to existing ones.
- As for the transmission pumps in the 2nd Station, though all of four (4) pumping units are

requested to be replaced under the project, three (3) units out of four (4) units are proposed to be replaced to reserve one (1) bay for the future extension by WSSSC, and the combined pumping capacity of three (3) units will meet the water demand for 2011.

- Because the present dry-type pressurized chlorinator which has disadvantages from leakage of chlorine, inconstant injection rate and corrosion of steel pipes, the wet type vacuum chlorinator is adopted.
- The track crane (10t) and the mobile welding machine are requested to replace the present ones of decrepit condition.
- Water quality analysis devices of a spectrophotometer, a dry oven and an incubator are out of order at present. Since these devices are used for the water quality analyses of the parameters common for the regular analyses of WSSSC, their replacement with those of same grades is considered appropriate.
- The flow meters to be procured under the project should be same type as those being installed by WSSSC.
- The water supply facilities for the ger areas in the 5th and the 6th bags should be of the same grade as those constructed for the neighboring 7th bag under the finance of ADB in order for the smooth operation and maintenance by WSSC, because there has been no troubles reported on the operation of the facilities in the 7th bag so far.

7) Construction/Procurement Method and Implementation Period

- During the cold season from October to April the minimum temperature varies from -10.8^{o}C to -39.9^{o}C and the cold weather continues till the end of April, and no construction works are conducted outdoor during this period, because the concrete works require heating appliances during the cold season resulting in the poor quality of construction as well as economical inefficiency. Generally Mongolian and Russian contractors conduct outside works in the warm season and in the cold season they conduct the inside works such as utility works with heating appliances to shorten the construction period. The implementation plan should, therefore, be prepared so that the construction works continue even during the coldest period to complete the works in the limited period.
- The geology of the hilly areas surrounding the Darkhan city is composed of sandstone as the bedrock. The surface layer of weathered sand and/or sandy soils is as shallow as 50 - 100 cm, and the rock excavation will be required for the deeper parts. It was found that almost 70 % of the areas of the 5th and the 6th bag areas are composed of this type of geology. The minimum 3.5 m of depth is required for buried pipeline to avoid freeze of the water, and the depth from 2.5 to 3.0 m will be the rock excavation requiring the excavation by breakers.

2.2.2 Basic Plan

(1) Overall Plan

1) Planned Service Area

The present service area of WSSSC covers the entire Darkhan city consisting of the apartment

zone as an urban area with house connections and the ger zone as a surrounding area by water kiosks. The project area is identical to the present service area.

2) Water Demand Forecast

a. Target Year and Served Population

The target year is proposed to be set for 2011 when the project implementation will be completed. The population of the Darkhan city increases year by year because of settlement of nomads and urban migration from rural areas, but the registered population of the city increases and decreases alternately. This wide fluctuation of the registered population is caused by the movement that many residents changed the place of their registration at once depending upon various change of legal conditions; for instance many residents changed their registration to their home towns due to the establishment of land ownership law allowing private possession, though they actually live in the Darkhan city. The population data may not reflect the actual movement of the population. According to the official record of Darkhan city, the registered population is 73,457 in 2006 and 74,526 in 2007, and the data after 2006 is not affected by these phenomena. Therefore, the latest population of 74,526 in 2007 is adopted for population forecast, and the annual increase of 1.5 % is considered based on the previous population data. In addition, WSSSC estimated the increase of population based on the industrial development plan of Darkhan city and theis estimation is also considered. The population is estimated until 2015 as shown in Fig. 2.1 and the population of 91,000 is set for the target year of 2011. Out of this population, those of the ger area are estimated to increase from the latest 24,659 in 2007 to 26,150 in 2011.

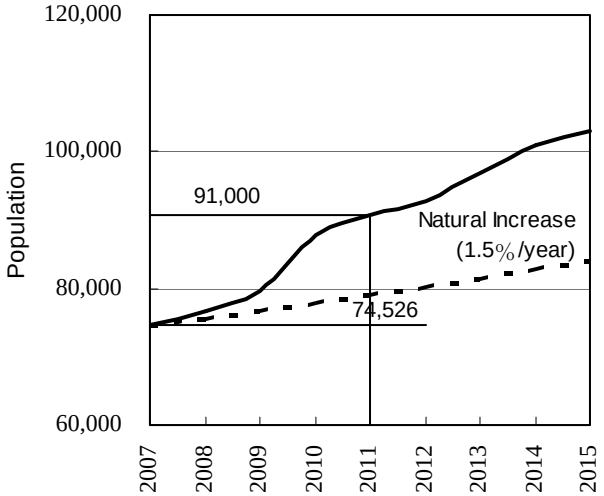


Fig. 2.1 Population Forecast of Darkhan City

The future population increase by the industrial development is estimated by WSSSC based on the migration of the workers and their family members (four (4) members per household) of the various factories planned to be constructed as shown in Table 2.3.

For 2008, the insulation factory which has commenced its operation and the International Shopping Center of which building is under construction are incorporated.

For 2009, the factories which acquired operation permits are assumed beginning of the operations. The petroleum refinery plant are planned to commence its operation in two (2) stages. The Government of Mongolia determined in 2008 to commence the operation of 1,500,000 tons of plant in 2010 as the first stage, and 20,000 workers and staff are planned to be newly employed. The second stage to be commenced in 2012 the 2,000,000 tons of plant is planned to be added and more workers and staff will be employed. The workers of 850 are considered to migrate from outside in the plan of WSSSC for the refinery plant operation.

Table 2.3 Industrial Development Plan of Darkhan City

No.	Factories	Number of Workers Considered in Population Forecast
1.	Insulation factory (2008: 40 workers, 2009: 90 workers, 2010: 60 workers)	190
2.	International Shopping Center (2008)	200
3.	Approved middle and small scale factories (2009)(canola oil factory, plate plant, car wash, sign board factory, maintenance factory, meat processing factory, food market, sheet wool processing factory)	355
4.	Petroleum refinery plant (First stage: 2010: 600 workers, Second stage: 2011: 250 workers)	850
5.	Expansion of steel plant (2010: 1,200 workers, 2011: 480 workers)	1,680
6.	Middle and small scale factories submitting applications (2013: 730 workers, 2014: 650 workers, 2015: 220 workers) (sheep wool processing factory, construction material factories (bricks and tiles), chemical products factory, flour milling factory, fixtures factory, clothing factory, food processing factory (mineral water, Jam), meet processing factory)	1,600

Further, they plan the installation of the new iron mill of 80,000 tons/year processing ironstone in addition to the existing plant of 100,000 tons/year processing steel products from scrap iron, and the commencement of plant operation is scheduled for 2010 and many workers are planned to be employed for the plant operation.

For the period after 2013, middle and small scale factories which submitted the application for operation are under contemplation, and new employment of workers of 730 for 2013, 650 for 2014 and 220 for 2015.

b. Consumption per Capita

The water consumption per capita in the apartment area is 137 liter/day/capita for 2007. According to the Mongolian standard, the target consumption per capita is set for 250 - 300 liter/day/capita, but it is not considered realistic to adopt this high range of value taking into account the present one. Therefore, 170 liter/capita/day is adopted for the target consumption per capita for the project. The WSSSC expects that the present consumption per capita of 25 liter/day/capita increases after the water supply by new system is commenced, and 35 liter/day/capita is applied in the project for the 7th bag financed by ADB. Therefore, 35 liter/capita/day is adopted for the project.

c. Non-Revenue Water (NRW)

The ratio of NRW is 36 % against the water demand in 2007, and it is not expectable to improve this value unless the distribution networks and the piping in the building are rehabilitated. It will increase to 40 % in 2008 according to WSSSC. Since any rehabilitation of distribution networks are planned and it is difficult to expect the substantial rehabilitation considering the budget size of WSSSC, the ratio will be worsen to 45 % in 2011.

d. Water Demand

The water demand in the target year of 2011 is estimated in 11,950 m^3/day as shown in the Table 2.4 considering the population of the Darkhan city of 91,000 consisting of 64,850 for the apartment areas and 26,150 for the ger areas.

Table 2.4 Estimated Water Demand in 2011

Area	Population	Consumption per Capita (liter/day/capita)	Water Demand (m^3/day)
Apartment Area	64,850	170	11,030
Ger Area	26,150	35	920
Total	91,000	-	11,950

The daily average demand is calculated to be 21,800 m^3/day considering NRW ratio of 45 % (11,950 m^3/day/(1-0.45)).

e. Daily Maximum and Hourly Factors

The daily maximum factor is set for 1.4 based on the data of WSSSC of 2006 and 2007, and the hourly factor is set for 1.5 based on the record measured in the field survey. The daily maximum and the hourly maximum demands are calculated to be 30,500 m^3/day (21,800 m^3/day x 1.4) and 45,750 m^3/day (30,500 m^3/day x 1.5), respectively.

3) Raw Water Quality

According to the results of the water quality analyses of the samples taken in the course of the pumping tests carried out in the study, it is confirmed that the raw water of all the wells in the 1st Station satisfies the Mongolian Water and Sanitation Standard as shown in Table 2.5 in Page 2 - 52.

(2) Improvement Plan of Existing Structures

1) 1st Station

a. Evaluation of Existing Well Facilities

The evaluation of priorities of renewal of the production wells were carried out based on the result of the step drawdown pumping test, the sand contents test, and the borehole TV camera survey in the field. Three indices such as specific capacity, dynamic water level, and falling objects in the wells were set, and the well are classified into three (3) grades of A, B, and C according to the following criteria.

Table 2.6 Evaluation Criteria of Existing Well

Grade	Criteria	Expected Effect of Renewal
A	Specific capacity is 100m^3/hr/m or more, dynamic water level shall be less than 10m and there is no trouble with falling objects etc. up to the bottom of the well. However, it puts it into the evaluation "A" in case when judged that it is possible easily to remove and to be collected by bailer etc. even if there is an obstacle.	It is expected to increase the specific capacity and to extend usage of wells furthermore in the future by proper rehabilitation works in the production wells of the evaluation "A".
B	Specific capacity is 100m^3/hr/m or more, dynamic water level shall be less than 10m and there is a trouble with falling object etc. up to the bottom of the well.	It is expected to increase the specific capacity and to extend usage of wells furthermore in the future by proper rehabilitation works but it is anticipated that it will be attended with some difficulty to remove and to collect of the falling objects in the hole in the production wells of the evaluation "B".
C	Specific capacity is under 100m^3/hr/m, dynamic water level is more than 10m and there is a trouble with falling object etc. up to the bottom of the well.	A great effect of the renewal (increase in the specific capacity) cannot be expected even if proper rehabilitation work is executed.

All 18 production wells were evaluated based on the criteria mentioned in Table 2.5. The result is shown in Table 2.7 in Page 2 - 53, and is summarized in Table 2.8.

Table 2.8 Results of Evaluation for Existing Wells

Grade	Wells Constructed in1965	Wells Constructed circa 1985	Total
A	4 wells	4 wells	8 wells
B	1 wells	3 wells	4 wells
C	6 wells	—	6 wells
Total	11 wells	7 wells	18 wells

b. Selection of Wells

As described later, ten (10) numbers of intake pumps are required to be replaced including those for rotation operation. The wells Nos. 1, 3, 7, 11, 12, 13, 14, 16, 17 and 18 shown in Fig. 2.3 are selected considering the following items.

- The No. 15 well is evaluated in A, but its borehole is inclined, which is not acceptable for operation and maintenance. This well will be excluded from those for replacement.
- There are three (3) lanes of pipelines conveying the intake water to the raw water transmission; the first from No. 7 to No. 11 wells, the second from No. 1 to No. 6, and the third from No. 12 to No. 18. The wells for replacement should be so selected that the load of conveyed water is distributed to these pipelines evenly.
- The wells evaluated in C will not be selected for the replacement under the project, because it is difficult to assure the stable yield for long time by the wells classified into C.

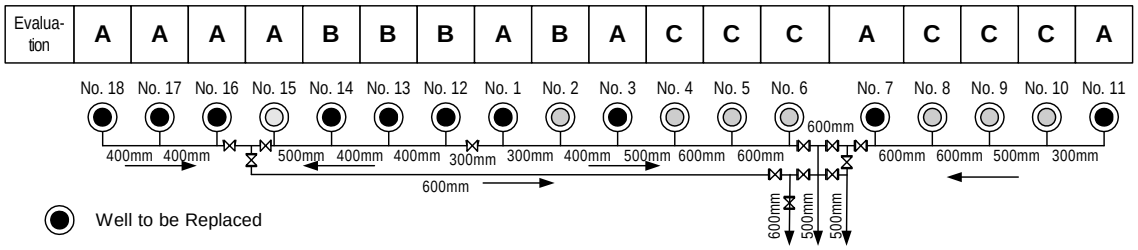


Fig. 2.3 Selected Wells for Replacement

c. Rehabilitation of Wells

The present situations of the selected ten (10) wells are summarized in Table 2.9. The wells Nos. 1, 3, 7 and 11 were constructed in 1965 with a casing diameter of 427 mm, while the wells Nos. 12, 13, 14, 16, 17 and 18 were constructed in the period from 1978 to 1984 with a casing diameter of 352 mm smaller than that constructed in 1965.

Since cracks were found on the casing pipe shallower than 2.0 m in the wells No. 1, 3, 7, 11 and 18, and there is a possibility of intrusion of polluted water and strength of poverty, the well top should be reinforced by inserting steel pipe to the depth of 5.5 m and injecting cement mortar in the annular gap between the well casing and the inserted pipes as shown in Fig. 2.4.

Most of the wells have gotten older, and iron rust and scales are found considerable in most of the wells as well as plugging of screen slots. Therefore, in order to increase the specific capacity of the well (i.e. increasing of discharge rate and decreasing of drawdown of the water level by pumping), the rehabilitation works will be executed for all the selected wells. Moreover, it is

expected to reduce the load of the submersible motor pump and cost of the repairs and maintenance of the pump by the rehabilitation of wells. The rehabilitation works of the well should apply the procedure and work item presented in Table 3.10, and the cleaning by bailing, brushing and chemical treatment will be carried out. It is possible to remove the objects dropped in the boreholes such as wire, pump strainer, etc. by this cleaning procedure.

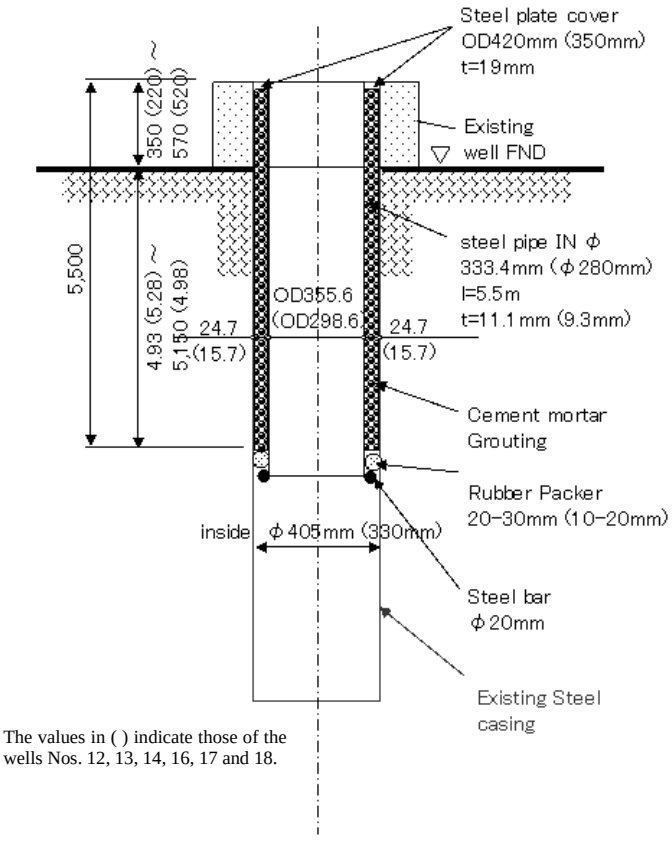


Fig. 2.4 Rehabilitation of Wells

Table 2.9 Present Situations of Selected Wells

Well No.*	Depth (m)	Damage/Crack on Casing Pipe	Degree of plugging of the creen-slot openings by incrustants	State of Iron Rust and Scales	Falling Objects
No.1 (A)	67.5	Crack at a depth of 2.23m	60 to 90% at a depth of 9 to 19m, 10 to 20% until a depth of 25m, 80% until a depth of 32m are plugged but functioned through water channel as the screen	Slots are not functioned as the screen due to large humped iron incrustation and scales deeper than 46m	Non
No.3 (A)	68.0	Crack at a depth of 1.79m is remarkable. There is a possibility that drain water flows into the well.	50 to 60% at a depth of 13 to 21m, almost 0% until a depth of 21m, 70 to 80% until a depth of 30m, 80 to 90% until a bottom are plugged but functioned through water channel as the screen	Scales become remarkable from a depth of 36m to the bottom and ratio of plugging becomes high. But slots are well-functioned through water channel as the screen.	Non
No.7 (A)	67.0	Crack at a depth of 0.99m	30 to 40% at a depth of 10 to 15m, 10 to 20% until 20m, 70% until 33m are plugged but functioned through water channel as the screen.	Iron incrustations and scales become remarkable and are overhanging deeper than 33m.	2 strainers of submersible motor pump at a depth of about 35m
No.11 (A)	68.0	Crack at a depth of 1.58m	10 to 20% at a depth of 9 to 15m, 50 to 70% until 27m, 70 to 80% until 32m, 70% to the bottom are plugged.	Scales become remarkable from a depth of 32m to the bottom and are 50 to 70% plugged. But slots are functioned through water channel as the screen.	Electric wire at a depth of 13.39m
No.12 (B)	65.0	Not observed	The slots with a depth of 8 to 23m are 30 to 50% plugged by scales but are functioned through water channel as the screen.	Iron incrustations and scales become remarkable and are overhanging deeper than 19m	Electric wire at a depth of 14.18 and 20.85m, cable of submersible motor pump at 30.78m

Table 2.9 Present Situations of Selected Wells

Well No.*	Depth (m)	Damage/Crack on Casing Pipe	Degree of plugging of the screen-slot openings by incrustants	State of Iron Rust and Scales	Falling Objects
No.13 (B)	65.0	Not observed	30 to 40% at a depth of 4 to 9m, 50% until 17m, 60 to 70% until 27m, 90 to 100% until 31m are plugged. Blind casing is between 31m and 37m.	Iron incrustations and scales become remarkable and are overhanging deeper than 38m	Electric wire at a depth of 38.84m pump at 30.78m
No.14 (B)	65.0	Not observed	50 to 70% at a depth of 8 to 14m, 30% until 19m, 30 to 50% until 24m, 50% until 31m, 60 to 80% to the bottom are plugged.	It is difficult to lower down the TV camera because iron incrustations and scales become remarkable and are overhanging deeper than 25m.	Electric wire at a depth of 36.34 and 48.75m, wire and timber-like object at 49.45m
No.16 (A)	65.0	Crack at a depth of 1.83m	30 to 50% at a depth of 8 to 13m, 10 to 20% until 26m, 30 to 50% until 31m, 20 to 30% until 35m, 50% to the bottom are plugged but slots are functioned as the screen.	Iron incrustations and scales become thick slightly but there are totally few iron rust and scales deeper than 35m	4 strainers of submersible motor pump at a depth of 13.38, 22.24, 27 and 39.26m
No.17 (A)	65.0	No damage	The slots are partially 60 to 80% plugged by scales but plugging of the screen-slot openings are few and are functioned through water channel as the screen.	Iron incrustations and scales become thick slightly but there are totally few iron rust and scales deeper than 45m	Electric wire at a depth of 58.52m
No.18 (A)	65.0	Drain water of the pump house flows into the well from the crack at a depth of 1.81m	10 to 20% until 30m, 30 to 50% to the bottom are plugged but slots are functioned through water channel as the screen.	Iron incrustations and scales become remarkable and are overhanging deeper than 30m	Non

Note ( ): Well Grade

Table 2.10 Procedures of Rehabilitation Works of Wells

Procedure	Work Item	Content of Rehabilitation Works
1	Prior Borehole Survey with TV Camera	The situation in the hole shall be checked with the borehole TV camera before commencement of the rehabilitation work.
2	Prior Pumping Test	Five steps drawdown test and recovery test
3	Bailing	To remove incrustants on the inside of the well by vertical movement of bailer (with valve)
4	Brushing	To scrape and remove incrustants on the inside of the well by wheel wire brush
5	Chemical Treatment	Stirring after pouring combinations of high polymerization phosphate, anhydrous phosphoric acid, organic acid, mineral acid, peroxide, surface-active agent, powder for bleaching, and several kinds of rust prevention medicines, etc. and leaving for 24 hours
6	Air Lifting	To dredge deposits at the bottom of well by air lifting with the double pipe consisting of lift pipe and air pipe
7	Post Borehole Survey with TV Camera	The situation in the hole shall be checked with the borehole TV camera after completion of the rehabilitation work.
8	Post Pumping Test	Five steps drawdown test and recovery test

d. Rehabilitation of Pump Houses of 1st Station

Basically the existing pump houses are planned to be used for the improvement under the project, and broken and lost facilities will be rehabilitated. As described in the previous section, the pump houses of the 1st Station were constructed in two (2) stages; those older ones constructed in 1965 (the old type: Nos. 1, 3, 7, 11) and around 1985 (the new type: Nos. 12 - 14 and 16 - 18). Since the structures and shapes are different each other, the contents and procedures of rehabilitation are also different. The works of the proposed rehabilitation are summarized in Table 2.11. (See Fig.2.5 in page 2 - 57)

Table 2.11 Rehabilitation Works of Pump Houses of 1st Station

Rehabilitation Works	Contents of Rehabilitation	
	Old Pump House Constructed in 1965 (4 Houses)	New Pump House Constructed circa 1985 (6 Houses)
1. Installation of Light Window (Fixed Window)	A fixed double window with wooden frame was installed in each pump house. These windows are sometimes broken, but some of them have not been repaired properly and were blocked by brick and block. It is necessary to repair such broken windows to save lighting expenses, the glass block windows (fixed type) will be furnished in order to avoid further breaking. - Glass block window for lighting 950 mm (w) x 1,270mm (h) x 10 nos.	
2. Replacement of Entrance Door	A single swing door is furnished at the entrance of pump houses, but they use a felt curtain to stop intrusion of cold air and to avoid the escape of warm air through the door. A double swing door will be installed in the rehabilitation work. - Inside door wood made, 900 mm (w) × 2,000 mm (h) x 10 numbers - Outside door aluminum made with urethane insulation, 900 mm (w) x 2,000mm (h) x 10 numbers Note: Only No. 1 Pump House is furnished with an entrance for pump unit and materials, but it is not used at present. Because such situation is not acceptable for the cold protection, the said door will be demolished and the opening part will be blocked off in the course of rehabilitation works. - Demolition of the existing unused door: 1,600 mm (w) x 2,400 mm (h) x one number	
3. Replacement of the existing door for the electric room	An electric room is furnished in the next room of the pump room in the old pump houses. The entrance door has gotten old, and it will be replaced with new one. - Wooden door 1,650 mm (w) x 2,200 mm (h) x 4 nos.	The transformer for the new pump house is installed outside of the house, and there is no electric room.
4. Rehabilitation of trough	There is a trough for the electric cables from the electric room, but checkered steel plates were lost. The lost checkered steel plates will be installed for safety. - Cover of trough(checkered steel plates) t=3.2mm, 300 mm (w) x 10.14 m x 4nos.	In the new pump houses, electric cables are fixed on the wall with a protection pipe.
5. Repair of pump hatch	The pumping units are normally delivered from the hatch of the roof by crane. The hatches are broken causing dangerous work conditions, these hatches will be repaired for smooth carrying in and out of the pumping units. - Pump hatch on roof Wood made, 3.47 m × 2.25 m x 4 nos. A cover made of zinc coated steel plate (914 mm x 1,829 mm x 4 nos.) Urethane insulator (t = 100 mm)	
6. Lighting	Most of the lighting facilities are out of order, and they will be replaced with new ones. - Room light: 10 sets - Entrance light: 10 nos.	
7. Heater	The heating devices were installed to avoid freeze of the water in exposed piping in the pump house, but the effect of this type of heating is poor. Therefore, this device will be demolished and the heater for the exposed piping will be furnished instead to reduce the heating expenses.	
8. Air ventila-	There is an electric room next to the pump	There is no electric room in the new pump

Table 2.11 Rehabilitation Works of Pump Houses of 1st Station

Rehabilitation Works	Contents of Rehabilitation	
	Old Pump House Constructed in 1965 (4 Houses)	New Pump House Constructed circa 1985 (6 Houses)
tion	room in the old pump house, an air ventilation will be installed on the wall between two rooms to draw the heated air to the pump room. - Installation of air ventilation (750 mm × 300 mm x 4 nos.)	house.
9. Demolish of Air Ventilation tower	In the old pump house coal-fired stove also, and an air ventilation tower is installed. However, it is not used and draws the cold air from outside. Therefore, it will be demolished.	The air ventilation tower is not installed in the new pump house.
10. Electric distribution facilities	The existing electric distribution facilities will be replaced with new ones together with lighting and heating devices.	
11. Rehabilita-tion of floor of electric room	There is a transformer in the electric room of the old pump house, and its floor has settled down due to the heavy transformer. Therefore, it will be rehabilitated casting concrete to the foundation of transformer for the smooth operation and maintenance. - Repair by floor concrete 2.0 m (w) x 2.77 m (l) x 10 cm (t)	The air ventilation tower is not installed in the new pump house.

2) 2nd Station

a. Rehabilitation and Renovation of Pump House

As shown in Fig. 3.6, the pump house of the 2nd Station consists of a transmission pump room, a control room, transformer rooms, an electric panel room and a meeting room. The tiles of the transmission pump room which have fallen off from the wall will be repaired. The floor of the pump room will also be repaired because the foundations of pump units and other related facilities have to be rebuilt. Since the pump panels will be replaced with new ones, and the meeting room will be rebuilt as the control room.

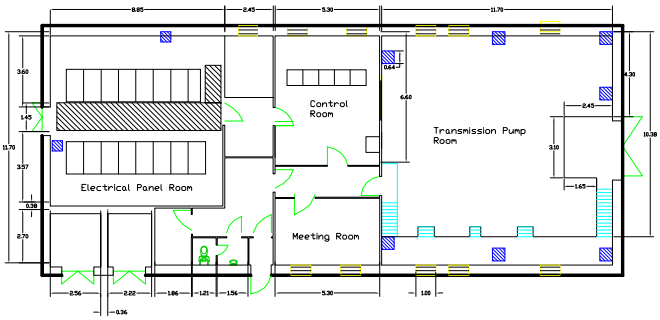


Fig. 2.6 Plan of Transmission Pump House

b. Rehabilitation of Chlorination House

The chlorination house consists of a chlorination room, a chlorine cylinder storage room and an unused storage room as shown in Fig. 2.7, and a monorail is furnished from the entrance to the chlorination room for conveying the chlorine cylinders. In the chlorination room, the exhaust equipment will be installed to

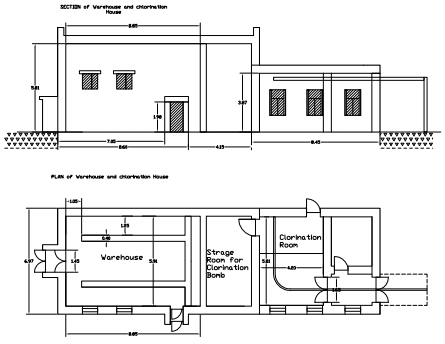


Fig. 2.7 Chlorination House

evacuate the chlorine gas at the emergent leakage. There is no damage on doors and windows in the room, but paintworks of the wall interior is found to be damaged and it will be repainted. There is no lighting fixtures in the house, they will be furnished to secure the safety and to ease operation and maintenance works.

3) Water Supply Facilities for Ger Area

a. Service Area and Water Demand

The water kiosks and the distribution pipelines are provided to the 5th and the 6th bags under the project located north and northeast of the old city area. The water demand of both areas is shown in Table 2.12.

Table 2.12 Water Demand for Ger Areas (5th and 6th Bags)

Bag No.	Served Population	Average Daily Water Demand (m^3/day)	Maximum Daily Water Demand (m^3/day)	Maximum Hourly Water Demand (m^3/day)
5	1,511	96	134	201
6	2,408	153	214	321
Total	3,919	249	348	522

- Maximum Daily Water Demand = Average Daily Water Demand x 1.4 (Rate of Loading)
- Maximum Hourly Water Demand = Maximum Daily Water Demand x 1.5 (Hourly Factor)

b. Water Kiosks

Explanatory meetings with local residents were held in the 5th and 6th bags, and it was agreed that the chief of each bag decide the locations of the kiosks to be constructed, and that the numbers of water kiosks to be constructed are 4 and 8 in the 5th and 6th bags, respectively. The locations of the water kiosks ware determined as indicated in Figs. 2.8 in page 2 - 58 and 2.9 in page 2 - 59 together with the chiefs of bags considering the expectable pressure and the locations of existing kiosks.

- 5th Bag: 4 nos.
- 6th Bag: 8 nos.
- Total: 12 nos.

Shapes, structures and finishing of the water kiosks will be same as those constructed under the finance of ADB including electrical utilities, heating system and water supply facilities. Out of 12 planned kiosks, the existing kiosk No. 5-4 will be used for the project because it was constructed two (2) years ago and its maintenance condition is found good.

The water kiosk No. 6-8 is located on the hill and it is impossible to convey the water with the pressure of the existing distribution network. Therefore, a relay pump (Head: 21 m) will be installed in the water kiosk No. 6-7 to distribute the water to the said water kiosk. A water tank of the capacity of eight (8) m^3 will be furnished in this kiosk. The water kiosks to be replaced and/or rehabilitated are listed in Table 2.13.

Table 2.13 Water Kiosks for Ger Areas

Description	Kiosk (1) Standard Type	Kiosk (2) Water Kiosk with Relay Pump (No.6-7)	Kiosk (3) Water Kiosk with Storage Tank (No.6-8)	Kiosk (4) Water Kiosk Utilizing Existing Kiosk (No.5-4)
Number	9 nos.	1 no.	1 no.	1 no.
Structure	Made of Conc. Blocks	Made of Conc. Blocks	Made of Conc. Blocks	Made of Conc. Blocks Utilizing Existing Kiosk
Shape	Flat: 4.2 m wide (center of wall), 4.2 m long (center of wall)	Flat: 4.2 m wide (center of wall), 4.2 m long (center of wall)	Flat: 4.2m wide (center of wall), 7.6m long (center of wall)	Flat: 3.9m wide (center of wall)、3.9m long(center of wall), (Utilize Existing One)
Electric Facility	Room Light	Room Light	Room Light	Use Existing One
Heating Facility	Coal briquette stove	Coal briquette stove	Coal briquette stove	Use Existing One
Water Supply Utility	Portable Wash Stand	Portable Wash Stand	Portable Wash Stand	Use Existing One
Toilet	No.	No.	No.	Use Existing One

c. Distribution Pipeline

(i) Material of Distribution Pipe

The material of pipe will be of the high density polyethylene (HDPE) which is popular in Mongolia as same as those applied for the pipelines of the neighboring 7th bag.

(ii) Diameter of Distribution Pipe

The diameter of distribution pipeline should be 160 mm as same as those of the 7th bag to avoid freeze due to smaller diameter. It was confirmed that the residual pressure head is more than 2.8 m at the locations of all the kiosks except for the kiosk No. 6-8 for which water is conveyed by the relay pump. The specifications of distribution pipes are as follows:

- Outside Diameter: 160 mm
- Thickness: 9.5 mm
- Inside Diameter: 141 mm
- Working Pressure: 1.0 MPa

(iii) Layout of Distribution Pipelines

Both ends of the distribution pipeline will be connected to the existing distribution network to maintain the maximum water flow in the pipes for preventing from freezing of water. (See Fig. 2.8 in Page 2-49 and Fig. 2.9 in Page 2-50)

(iv) Length of Distribution Pipe

The lengths of the distribution pipelines in each bag are shown below:

- 5th Bag: 2,451 m
- 6th Bag: 4,875 m
- Total: 7,326 m

d. Storage Tank of Kiosk

Out of the eight (8) kiosks in the 6th bag, the kiosk No. 6.-2 is located on the hill and a relay pump will be installed to convey the water to this kiosk. In the kiosk No. 6-8 a storage tank will be installed to store the water conveyed by the reply pump.

- Material: Made of steel plate
- Capacity: 8.0 m^3
- Shape: 1.5 m side 3.5 m long 1.5 m deep 2.0 m high
- Number: 1 tank

e. Relay Pump for Storage Tank

The relay pump will be installed in the kiosk No. 6-7 to convey the water to the storage tank of the kiosk No. 6-8 with the convey of four (4) times a day.

- Type: Inline type multiple centrifugal pump
- Capacity: 114 liter/min.
- Head: 21.0 m
- Output: 0.75 kW
- Diameter: DN = 40 mm
- Number: 1 set

(3) Improvement Plan of the Existing Equipment

1) Intake Pumps of 1st Station

a. Scope of Replacement

Intake pumps of six (6) wells are operated at present out of 18 wells. Ten (10) pumping units of which capacity is same as the existing will be replaced under the project including two (2) for the rotational operation. Valves, pipes, meters, etc. relevant to, and power supply facilities for the ten (10) pump units will also be replaced. The existing old intake pumps will be discarded.

b. Intake Pump

i) Capacity and Number of Pump Units

The capacity of the replacing pump units will be 160m^3/hr same as that of the existing pump considering the rotational operation, and the easiness in the future procurement for replacement. The number of intake pump units should be decided so as to match the number of the transmission pump units. As described later, two (2) pump units for the regular operation and one (1) unit for stand-by will be installed in the 2nd Station, and the number of the intake pump units to be installed should be even number in order to match the two (2) systems of the transmission pump units for regular operation.

The number of the replaced intake pump units is shown below, and four (4) intake pump units meet one (1) transmission pump unit in operation.

- Daily Maximum Intake 30,500 m^3/day = 1,270.8 m^3/hr
- 1,270.8 m^3/hr / 160m^3/hr = 7.9 nos. 8 nos. (even number)

ii) Type of Pump to be Replaced

The type of intake pump units to be replaced will be submersible motor pump as same as the existing pump units, and a flow sleeve will be attached to secure the cooling effect of the motor.

iii) Total Head and Output of Pump Units to be Replaced

The total pump head and the output of the replaced intake pump units are calculated based on the elevations shown in Fig. 2.10.

- Actual Pump Head

  Pump pit: HWL+717.300
  Operation level: LWL+684.000
  Actual pump head:
  Ha = 717.300 - 684.000 = 33.3 m

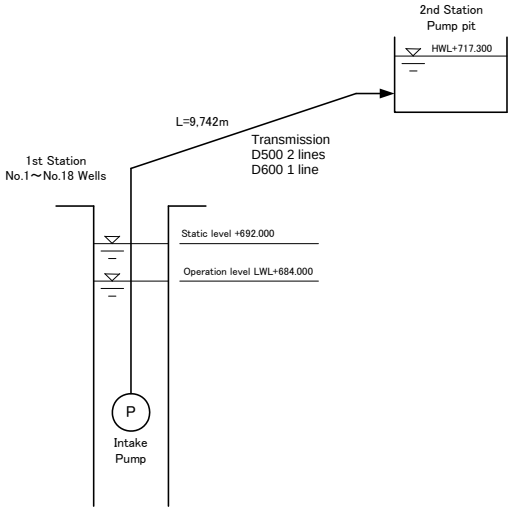


Fig. 2.10 Total Head of Intake Pump

- Head Loss in Raw Water Transmission

  Discharge coefficient: C = 84
  (The transmission consists of two (2) lines of Ductile Iron pipes (DN500) and one (1) line of steel pipe (DN600), and inner surface is not lined with mortar. The Ductile Iron and the Steel pipes are aged as old as 43 and 24 years, respectively, and the discharge coefficients are 78 and 95, respectively resulting in the compound coefficient of 84 ((78＋78＋95)/3 = 83.6 → 84)).

  Diameter of transmission: D = 822 mm
  (D = 500 mm 2 lines, D = 600 mm 1 line, Combined diameter D = 822 mm)
  $[(C_1D_1^{2.63}＋C_2D_2^{2.63}＋C_3D_3^{2.63})/\{(C_1＋C_2＋C_3)÷3\}]^{1/2.63}$
  $[(78x0.5^{2.63}＋78x0.5^{2.63}＋95x0.5^{2.63})/\{(78＋78＋95)/3\}]^{1/2.63}$ = 0.822 m = 822mm
  Distance of transmission: L = 9,742 m
  Discharge: Q = 30,720(30,500) m^3/day=1,280.0 m^3/hr
  = 21.33 m^3/min. = 0.356 m^3/sec.
  Hydraulic gradient: $I = 10.666xC^{-1.85}xD^{-4.87}xQ^{1.85}$ (Hazen Williams)
  $= 10.666x84^{-1.85}x0.822^{-4.87}x0.356^{1.85}$ = 1.13 ‰
  Head loss in transmission: Htp = LxI = 9,742x1.13 ‰=11.01 m

- Head Loss due to Relating Pipe Fittings

  Head loss due to relating pipe fittings:
  Hp = 3.0 m

- Total Pump Head

  Total pump head: H=Ha＋Htp＋Hp=33.3＋11.01＋3.0=47.3≒48 m

- Pump Output

Motor output:	P = (0.163 x γ x Q x H) / ηp × (1＋α) = (0.163 x 1 x 2.67 x 48) / 0.7 x (1＋0.10) = 32.8 = 45kW Since the transmission pump units are planned to be procured in the third countries, the Motor output is set as high as 45 kW considering the pump efficiency of the pump units expected to be procured.
Unit weight of water:	γ = 1.0 t/m^3
Discharge:	Q = 21.33m^3/min.÷8 nos. = 2.67 m^3/min.
Total pump head:	H = 48 m
Pump efficiency:	ηp = 70 ％ (Guidelines for Design of Water Supply Facilities of Japan)
Safety ratio:	α = 0.10 (Guidelines for Design of Water Supply Facilities of Japan)

- Capacity of Pump Unit

Q = 160m^3/hr (2.67 m^3/min.) H = 48 m P = 45kW

- Specification of Pump Unit

Type:	Submersible motor pump for well
Capacity:	2.67 m^3/min.
Diameter:	DN =125 mm
Pump head:	48 m
Output:	45 kW
Number:	10 nos. (two (2) for rotational operation)

c. Pipes and Fittings Relating to Pump Units

The following fittings will be installed relating to the intake pumps.

Lifting pipe:	DN = 125 mm, Flanged steel pipes, Pressure capacity 1.0 MPa
Manual gate valve:	DN = 125 mm, Pressure capacity 1.0 MPa
Check valve:	DN = 125 mm, Pressure capacity 1.0 MPa
Air valve:	DN = 25 mm
Flow meter:	DN = 100 mm, Impeller type
Combined pressure gauge:	1 set
Discharge pipe:	DN = 250 mm, Pressure capacity 1.0 MPa
Drainage pipe:	DN = 100 mm
Drain pipe:	DN = 25 mm
Well cap:	1 set

d. Power Supply System

Each pumping well of the 1st Station is supplied with 6kV, single power supply circuit. The 6kV power supply consists of two distribution line systems, both of which are coming from the 2nd

Station. Each line system has the power to feed six pumping stations for risk divergence.

After completion of the improvement work, 10 well pumps are to be replaced as illustrated in Fig. 2.11. One power line system is for six stations and the other is for four stations after the work. This means power distribution becomes out of balance to some extent, but not extremely. This does not cause serious problem. Therefore, this project does not include demand balancing of two incoming lines.

Motor starting method shall be the star delta which is commonly used for 45kW class motors.

Under-voltage relay shall be installed inside of each pump starter panel. It cuts off circuit to protect motor and cables from the damage by overheat when voltage drop occurs.

Table 2.14 shows the component of the power supply equipment in the 1st Station. Power Distribution Diagram is shown in Fig 2.11.

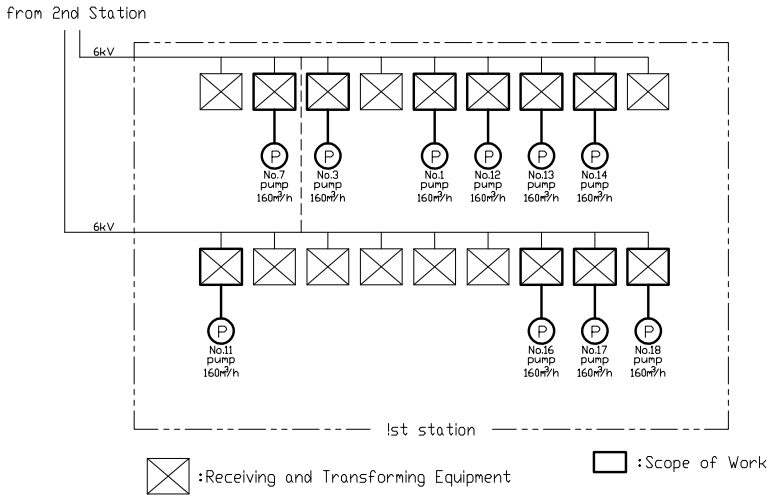


Fig 2.11 Power Distribution Diagram in 1st Station

Table 2.14 Component of The Power Supply Equipment in 1st Station

Name of Equipment	Specification	Nos
Pump Starter Panel	Indoor Wall-mounted Type 400V 45kW Star delta starter	10
Distribution Panel	Indoor Wall-mounted Type	10

e. Remote Control System

Transmitting the pump status signal is necessary to control the well pump in the 1st Station from the 2nd Station. The items to transmit shall be ON-OFF status, fault (electrical fault, mechanical fault, abnormal water level), start command and stop command. There are some alternatives for signal transmission method such as wireless private network, Global System for Mobile Communications (GSM) network, optical fiber network, etc. Table 2.15 shows a comparative study of alternative A to D. Based on the study, alternative A shall be adopted for this project considering safety to lightning surge and running costs. This alternative has been also adopted for “the Project for Improvement of Water Supply Facilities in Ulaanbaatar City” and running well at present.

Operation of well pump shall be remote and manual operation with monitoring the water supply pump status and the regulation reservoir water level. Schematic diagram of well pump operation is shown in Fig 2.12.

Table 2.15 Selection of Signal Transmission Method

	Wireless Network		Cable Network	
	Private Network (Alternative A)	GSM Network (Alternative B)	Optical Cable (Alternative C)	Metal Cable (Alternative D)
Reliability	No effect from lightning surge, no need to worry about cable cut	Same as left	No effect from lightning surge, but takes much time to repair when cable was cut	In danger of breakdown due to lightning surge
	◎	◎	○	△
Initial Cost	Lower than SGM network	Higher than private network	In addition to communication device installation, the cabling work (8km) is also necessary, total initial cost is equivalent to wireless network.	Same as left
	○	△	○	○
Communication Cost	No communication cost	Payment for communication cost every month would be heavy burden for financial management.	No communication cost	Same as left
	◎	△	◎	◎
Evaluation	Alternative A shall be adopted for this project considering safety to lightning surge and running costs. This alternative has been also adopted for "the Project for Improvement of Water Supply Facilities in Ulaanbaatar City" and running well at present.			

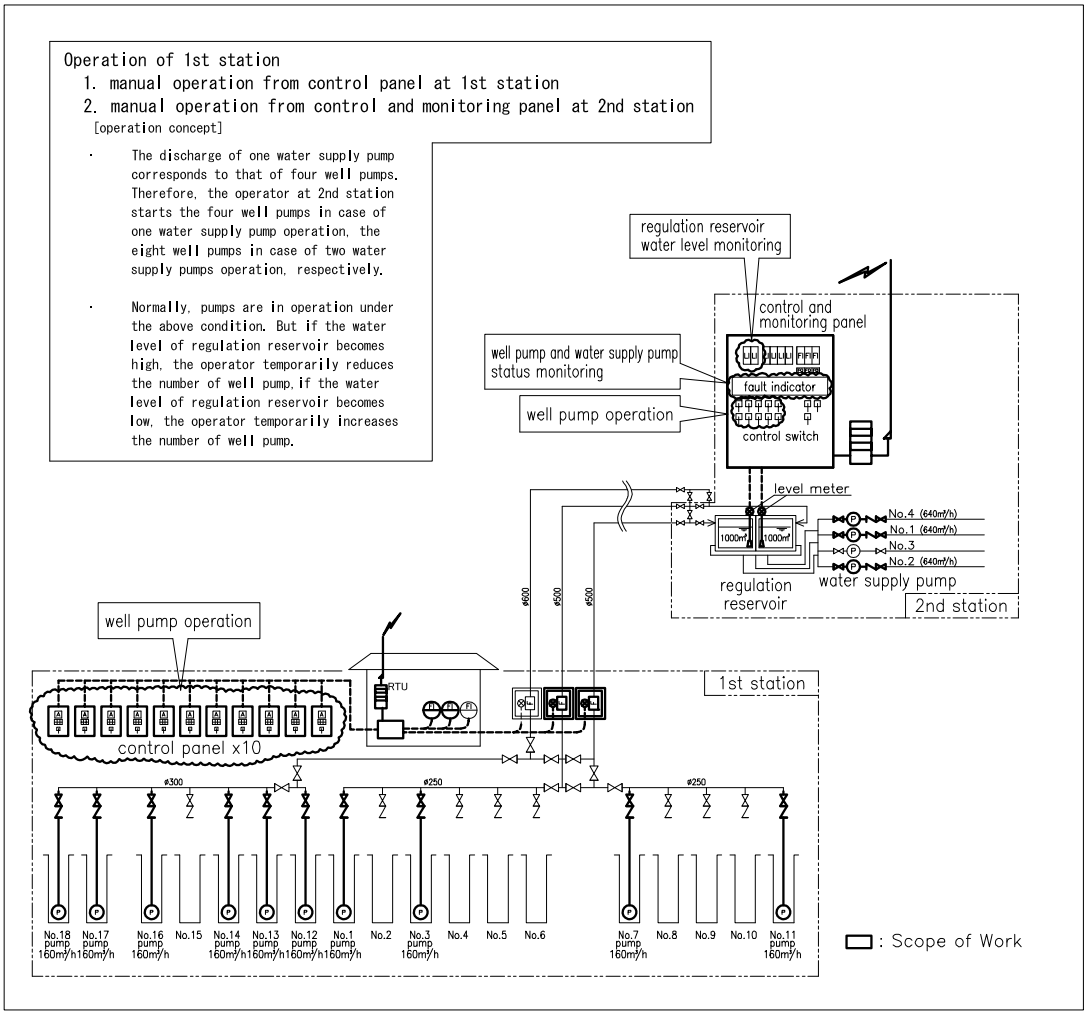


Fig 2.12 Schematic Diagram of Well Pump Operation in the 1st Station

f. Flow Meter

The Raw Water Transmission from the 1st to the 2nd Stations consists of two (2) lines of DN500 mm and one (1) line of DN600 mm pipelines. While there is one (1) set of ultra sonic flow meter on the DN600 mm pipeline, no meter is furnished on the DN500 mm pipelines, and it is impossible to grasp the total volume of intake water. Therefore, two (2) sets of flow meters will be installed on these DN500 mm pipelines to make it possible to grasp the total intake volume. The same type of ultra sonic meter as that of the existing will be installed.

- Type: Ultra sonic flow meter
- Diameter of Pipe Observed: DN500 mm
- Material of Pipe: Steel pipe
- Observed Fluid: Groundwater
- Display: LCD, 16 digits
- Items Displayed: Instantaneous discharge, Cumulative flow, Velocity
- Possible Velocity Range: 0.3 m/sec. (at minimum configurable full scale velocity)
  10 m/sec. (at maximum configurable full scale velocity)
- Accuracy: not less than 1 m/sec. of velocity, Reynolds number Re = not less than 1,000, ±20% of reading
  Velocity less than 1m/sec., Velocity error ±2cm/sec.
- Inverter: Wall mounting type
- Power Supply: AC240 V, 50 Hz
- Number: 2 sets

g. Portable Water Level Gauge

The water level gauge used for measuring water levels of wells to grasp the well condition is essential in the well management. In the 1st Station, there are two (2) resident staffs for the operation and maintenance of the 18 wells staying in operation hats located at Nos. 7 and 16 wells. They turned on and off the pump units as well as conduct the inspections of wells by the instruction of the operation room of the 2nd Station. The portable water level gauge will be provided for each operation hat.

The depth of well is about 65 m and the maximum depth of measuring by the water level gauge is 40 m in maximum considering the length of strainers and the installed position of the pump unit. The water level gauge is of the rope type with a sensor at top, simple in operation with manual tape. (See Table 2.16)

Table 2.16 Comparison of Portable Water Level Gauge

Description	Pressure Sensor Type	Manual Type (Tube Type)	Manual Type (Rope Type)
Measuring Range	0 - 100m	0 - 100m	0 - 100m
Characteristics	- Easy in measuring - Spare parts may not be easily obtained. - Continuous Observation is possible. - Expensive	- A bit complicated in measuring - Cheap	- A bit complicated in measuring - Less breaking - Cheap

h. Heating Devices for Exposed Pipes and Fittings

The fittings and pipes installed with pump units will be heated and protected by the electric coil heater to prevent freeze of the water. The materials for cold protection will be made by glass wool insulation, polyethylene film, aluminum glass cloth.

2) Transmission Pump for 2nd Station

a. Scope of Replacement

There are four (4) existing pump units in the 2nd Station, out of them two (2) pump units are out of order due to oldness, and the remaining two (2) units are operable with difficulty of troubles. Three (3) units will be replaced under the project leaving one (1) unit out of operable ones for the emergency use only. The electric power supply facilities relating to the replaced pump units will also be replaced together, and the rooms for pump installation will be rehabilitated.

b. Transmission Pumps

i) Capacity and Number of Replaced Pump Units

Since three (3) units of pumps will be replaced, two (2) units will be assigned for regular operation and another for the rotational operation. The capacity and number of the replaced transmission pumps are related to the number of pump units to be installed in the 1st Station, and are so designed to meet the number of pump units installed in the 1st Station as shown in Table 2.17.

Table 2.17 Planned Capacity and Number of Intake Pumps and Transmission Pumps

Purose	Intake Pumps			Transmission Pumps		
	Capacity per One Unit (m^3/hr)	Number	Capacity (m^3/hr)	Capacity per One Unit (m^3/hr)	Number	Capacity (m^3/hr)
Regular Operation	160	4	640	640	1	640
	160	4	640	640	1	640
Total		8	1,280		2	1,280
Rotational Operation	160	2	320	640	1	640
Total		10			3	

ii) Type of Replaced Pump

The type of the transmission pump is of the horizontal shaft type double suction volute pump as same as the existing ones considering discharge, pump head, available space, etc.

iii) Total Pump Head of Replaced Pump

The total pump head and the output of the replaced transmission pump units are calculated based on the elevations as shown in Fig. 2.13.

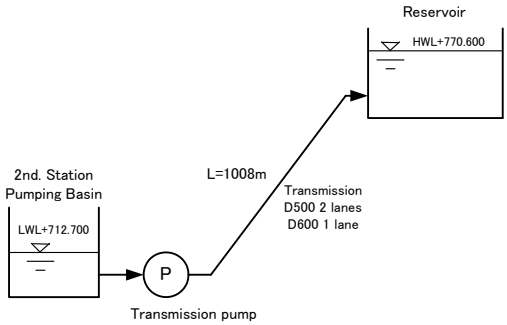


Fig. 2.13 Total Head of Transmission Pump

- Actual Pump Head

  Reservoir: HWL+770.600
  Pump pit: LWL+712.700
  Actual pump head:
  Ha = 770.600 - 712.700 = 57.9 m

・ Head Loss in Clear Water Transmission

  Diameter of transmission: D = 822 mm
  (D = 500 mm 2 lanes, D = 600 mm 1 lane,
  Compound D = 822 mm, calculated in same manners as
  the Raw Water Transmission)
  Distance of transmission: L = 1,008 m
  Discharge coefficient: C = 84 (Calculated in same manners as
  the Raw Water Transmission)
  Discharge: Q = 30,720 (30,500) m^3/day 1,280.0 m^3/hr = 21.33 m^3/min.
  = 0.356 m^3/sec.
  Hydraulic gradient: $I = 10.666 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85}$ (Hazen Williams)
  $=10.666 \times 84^{-1.85} \times 0.822^{-4.87} \times 0.356^{1.85} = 1.13$ ‰
  Head loss in transmission: Htp = L×I = 1,008×1.13 ‰ = 1.14 m

- Head Loss due to Relating Pipe Fittings

  Head loss due to relating pipe fittings:
  Hp = 3.0 m

- Total Pump Head

  Total pump head: H = Ha＋Htp＋Hp = 57.9＋1.14＋3.0 = 62 m

- Pump Output

  Motor output: $P = (0.163 \times \gamma \times Q \times H) \div \eta p \times (1 + \alpha)$
  $= (0.163 \times 1 \times 10.67 \times 62) \div 0.83 \times (1 + 0.10) = 142.9$
  = 150 kW
  Unit weight of water: $\gamma = 1.0$ t/m^3
  Discharge: Q = 21.33 m^3/min.÷2nos. = 10.67 m^3/min.
  Total pump head: H = 62 m
  Pump efficiency: $\eta p = 83$ ％ (Guidelines for Design of Water Supply
  Facilities of Japan)
  Safety ratio: $\alpha = 0.10$ (Guidelines for Design of Water Supply
  Facilities of Japan)

- Capacity of Pump Unit

  Q = 640 m^3/hr (10.67 m^3/min.) H = 62 m P = 150 kW

- Specification of Pump Unit

  Type: Horizontal shaft type double suction volute pump

Capacity:	10.67 m^3/min.
Diameter:	DN = 300 mm×DN = 200 mm
Pump head:	64 m
Output:	150 kW
Number:	3 nos. (one (1) for rotational operation)

iv) Water Hammer and Mitigation Measure

When the pump unit loses its drive power due to any accident like electric power failure, it will lose its capability to discharge water because of its reduction of rotation speed, causing the sudden pressure drop in transmission pipes. This pressure drop causes the negative pressure in the pipe, and if it reaches to about -10 m a hollow space happens to be borne resulting in a water column separation. The water columns separated in upstream and downstream of the pipe collide each other, and the water hammer is caused by the extremely high pressure at the time of recombine of water columns.

There are three (3) countermeasures against the water hammer; the fly wheel, the pressure tank (air chamber), and the surge tank methods, of which characteristics are summarized in Table 2.18.

Table 2.18 Countermeasures against Water Hammer

Fly Wheel Method	Pressure Tank (Air Chamber) Method	Surge Tank Method
To mitigate the sudden decompression of the pump discharge by the fly wheel attached to pump unit for facilitating the inertial effect. A fly wheel is necessary as a facility, but it does not require any heating measure.	The water stored in the pressure tank pushed into the pipe to prevent the decompression occurred after sudden stop of the pomp operation. A pressure tank is necessary as a facility, and it has to be installed indoor in the cold areas.	The water column downstream or the pipe is separated from the water hammer effect by the surge tank. It absorbs the increase of pressure, and prevent from negative pressure by supplying water. A surge tank is necessary as a facility, and the land acquisition is required because it has to be constructed in midstream of the transmission pipeline as well as to be constructed indoor in the cold areas.

The fly-wheel method is assured to be adopted for the water hammer analysis, because it dose not need any heating device to prevent the water from freeze. As a result of the water hammer analysis, in case that any countermeasure is not provided, the maximum pressure reaches to 1.01 MPa which is considered in safe range as shown in Table 2.19 and Fig. 2.14 (Maximum Pressure Line ①), but the minimum pressure goes down as low as -0.29 MPa (-29 m), larger negative pressure than the allowable -10 m, which causes breaking of the transmission pipeline (Minimum Pressure Line ②). In case that the fly wheel is attached to the pump unit, the minimum pressure goes down only to -0.05 MPa (-0.5 m), smaller negative pressure than the allowable -10.0 m, which is considered in the safe range without breaking of pipe (Minimum Pressure Line ④). As for the maximum pressure, the maximum pressure raises to 0.91 MPa (91 m) which is reduced for about 10 m by the fly wheel (Maximum Pressure Line ③). Longer space will be required for

Table 2.19 Results of Water Hammer Analysis

Item	Without Countermeasure	With Fly Wheel
Max. Pres.	1.01 MPa	0.91 MPa
Min. Pres.	-0.29 MPa	-0.05 MPa

pump foundation by attaching the fly wheel, but it is still possible to install pumping units with fly wheels in the present pump room. Therefore, the fly wheel method will be adopted for the transmission pumps of the project.

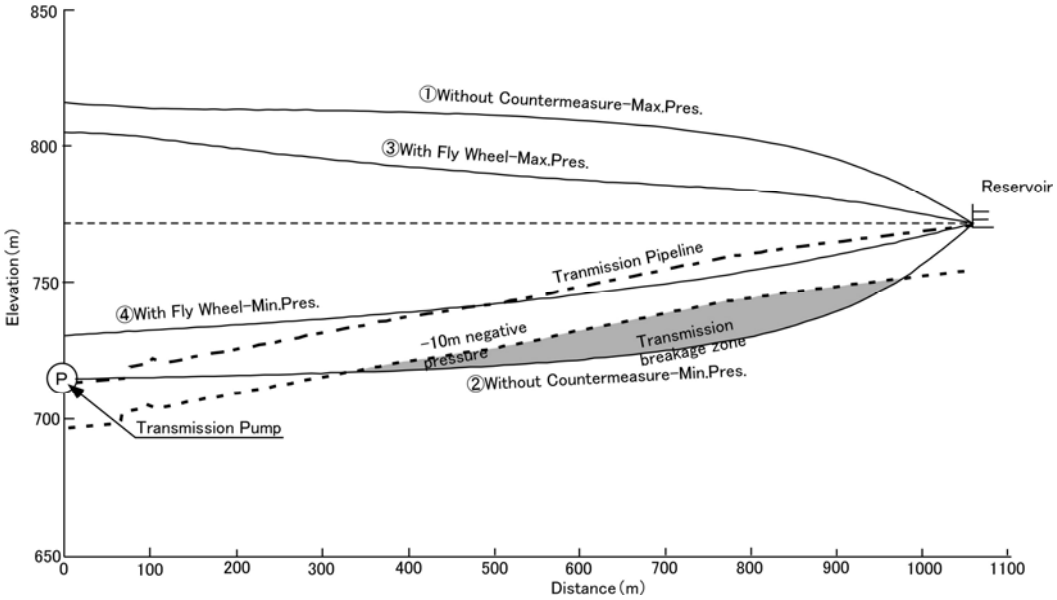


Fig. 2.14 Maximum and Minimum Pressure Lines by Water Hammer

c. Pipes and Fittings Installed with Transmission Pumps

The existring valves such as the manual gate valve on in-flow side, and the motor-operated valve and the check valve on out-flow side are old and they are found to be either out of order, broken or removed. The pipes and fittings relating to the transmission pump units will be replaced together with these valves at the time of installation of pump units. The material of pipe will be of steel for smooth adjustment of pipes because the present indoor pipe layout is considered complicated.

- Pipe Material: Steel pipe, Diameter: Suction side 500 mm, Delivery side 450 mm
- In-flow Valves: Manual gate valves, Diameter 300 mm, 3 nos.
- Out-flow Valves: Motor-operated gate valve, Diameter 200 mm, 3 nos.
- Check Valve: Diameter 200 mm, 3 nos.

d. Power Supply Equipment

The receiving voltage of the 2nd Station is 6kV, the number of receiving line to the station is two. Received power is used for the operation of the 1st Station as well as that of water supply pump in the 2nd Station. This power supply equipment was installed in 1965, the age is already over 40 years. Becoming too old, this equipment has frequent troubles such as oil leakage from circuit breaker. Besides, procuring spare parts is becoming difficult. This equipment is such vital to Darkhan city water supply system that urgent improvement is desired by WSSSC.

Under this project, pump starter panels are replaced together with water supply pump. However, there is not enough space for those new panels in electrical room. Therefore, they shall be installed using the space of existing monitoring room and meeting room. Motor starting method

shall be direct on line which is simple and cost effective. Static capacitor shall be installed for power factor correction and voltage fluctuation mitigation as the quality of electricity from substation is unstable. Under voltage relay shall be installed inside of each pump starter panel. It cuts off circuit to protect motor and cables from the damage by overheat when voltage drop occurs. Table 2.20 shows the component of the power supply equipment in the 2nd Station.

Table2.20 Component of The Power Supply Equipment in 2nd Station

Name of Equipment	Specification	Nos
HV Outgoing Panel	Indoor Self-standing Type 7.2kV 400A	1
Pump Starter Panel	Indoor Self-standing Type 6kV, 150kW direct on line start	3
Static Condenser Panel	Indoor Self-standing Type 150kVar×2	1
HV Incoming & LV Power Panel	Indoor Self-standing Type 30kVA 6.3kV/400-230V	1

e. Flow Meters

While two (2) flow meters are installed on the Clear Water Transmission and the transmitted water volume is recorded in the 2nd Station, there is no flow meter installed on the distribution pipelines and the distributed water volume is not grasped at present. The flow meters will be installed on the distribution pipelines consisting of two (2) lanes of DN500 mm and one (1) lane of DN600 mm to grasp the distributed water volume. The ultrasonic flow meters with the same specifications as those on the Clear Water Transmission.

- Type: Ultrasonic flow meter
- Diameter of Observed Pipe: DN500 mm, DN600 mm
- Pipe Materials: Ductile Iron Pipe (DN500 mm), Steel Pipe (DN600 mm)
- Observed Fluid: Drinking Water
- Display: LCD, 16 digits
- Items Displayed: Instantaneous discharge, Cumulative flow, Velocity
- Possible Velocity Range: 0.3 m/sec. (at minimum configurable full scale velocity)
  10 m/sec. (at maximum configurable full scale velocity)
- Accuracy: not less than 1 m/sec. of velocity, Reynolds number Re = not less than 1,000, ±20% of reading
  Velocity less than 1m/sec., Velocity error ±2cm/sec.
- Inverter: Wall mounting type
- Power Supply: AC240V, 50Hz
- Number: 3 sets

f. Water Level Gauge

Because there is not water level gauge installed in the pump pit and the reservoirs, the water level gauges will be installed in order for the proper operation of the intake and the transmission pumps under the project. Since the water in pits and reservoirs is not freeze, the level gauge possibly installed in the water and the immersion type with pressure sensor water level gauge which has the built-in lightning arrestor will be installed.

- Type: Immersion Type with Pressure Sensor Water Level Gauge

- Usage: Drinking Water
- Material: Resin Made
- Measured Level: 0 - 6.8 m
- Allowable Maximum Pressure: 0.2 MPa
- Measuring Accuracy: ±0.1 % (23 ^{o}C)
- Number: Pump pits: 2 nos., Reservoirs: 4 nos.

g. Control and Monitoring Panels

Control and monitoring panels for pump operation is installed in the 2nd Station. The transmission pumps will be manually operated in accordance with the water levelsof the reservoirs. Schematic diagram of water supply pump operation is shown in Fig 2.15.

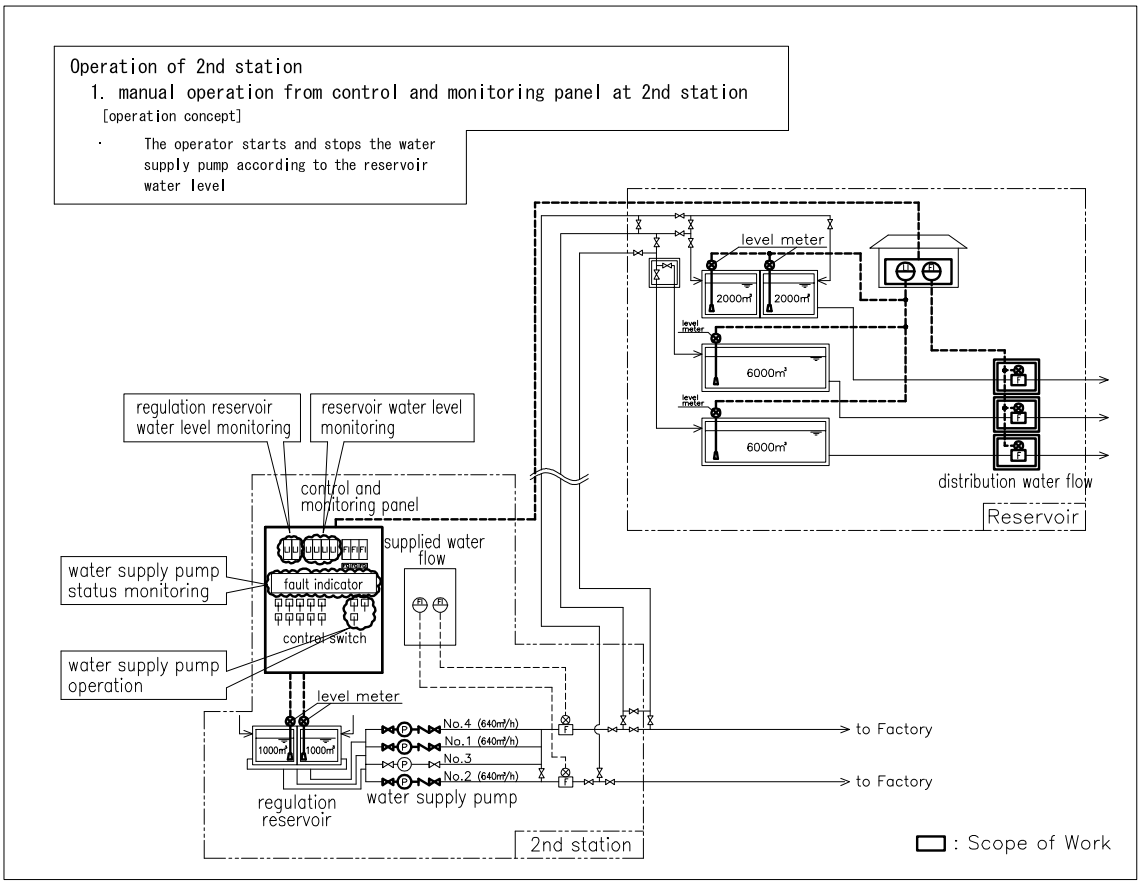


Fig 2.15 Schematic Diagram of Transmission Pump Operation in 2nd Station

3) Chlorination Facility

a. Injection Capacity

The chlorine injection will be made at the pump basin, and after the mixture the chlorinated water is transmitted to the reservoirs for distribution to the service areas. According to the Mongolian guideline for water quality, the residual chlorine should be not less than 0.3 mg/liter, and then the injection ratio and the injection volume are set as shown in Tables 2.21 and 2.22, respectively.

$Vm = Q \times R \times 10^{-3}$

Vm: Injection volume (kg/hr)

Q: Discharge for treatment (m^3/hr)

R: Injection ratio of liquid chlorine (mg/liter)

Table 2.21 Injection Ratio of Chlorine

Description	Injection Ratio
Minimum Injection Ratio	1.0 mg/liter
Average Injection Ratio	2.0 mg/liter
Maximum Injection Ratio	2.5 mg/liter

Table 2.22 Chlorine Injection Volume

Descrip-tion	Injection Ratio	Daily Average Demand 21,800 m^3/day (kg/hr)	Hourly Maximum Demand 30,500 m^3/day (kg/hr)
Min.	1.0 mg/liter	0.91	1.27
Ave.	2.0 mg/liter	1.82	2.54
Max.	2.5 mg/liter	2.27	3.18

b. Injection Method and Point

The wet and vacuum type chlorinator will be applied as the injection method. The injection point of the existing chlorinator is set at the pump basin, and the water mixed with chlorine is transmitted to the reservoirs. Since there is not any trouble reported in the existing system, the injection of chlorine will be made at the same point as the existing. The route of the injection pipeline is shown in Fig. 2.l6.

- Injection Equipment of Chlorine

  Type: Wet and vacuum type (Wall mounted type)
  Injection volume: 3.18m^3/hr
  Number: 2 nos. including 1 stand-by

- Chlorine Cylinder

  Cylinder Capacity: 50kg/cylinder
  Number of cylinder: 50kg cylinders, 10 nos.
  (Store for 10 days use)
  Daily average injection volume (kg/hr)×24 hrs×10 days÷50kg/cylinder
  = 1.82kg/hr×24hrs×10days÷50kg = 8.7 nos. ≒ 11 cylinders (Add 2 cylinders being used)

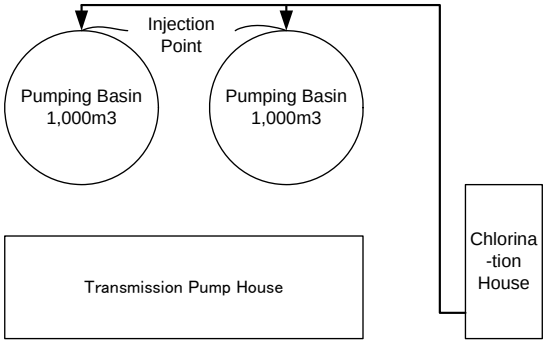


Fig. 2.16 Chlorine Injection Point

- Chlorine Injection Pipeline

  Protection pipe: DN = 160 mm, Polyethylene pipes
  Injection Pipes: DN = 40 mm, Hard PVC pipe

c. Safety Gears, Etc.

Any safety measures are not provided in the existing system, and then the following measures will be provided as a minimum measure.

- Gas Protection Mask: 2 nos.
- Protective Glasses: 2 nos.
- Protective Glove, Protective Boot (Rubber Made): Each 2 nos.
- Safety Helmet: 2 nos.
- Ammonia Water for Detecting Leakage (Density more than 28 %)
- Mouthwash
- Neutralizing Agent (Slack Lime)

4) Operation and Maintenance Equipment

a. Truck Crane

The present track crane has been used as long as 30 years so far. They face frequent breakdowns and the actual lifting capacity has become smaller, which may cause the accident. Therefore, it is necessary to replace it with new one. Especially, the track crane will be essential in operation and maintenance of the intake pumps to be replaced under the project, and its importance is quite high.

According to the dispatch record for the repair and the operation and maintenance, the average dispatch of the track crane is calculated to be 4.12 time/month as shown in Table 2.23, and its operation rate is rather high considering that a few days are necessary for one (1) event of repair though it depends upon the extent of repairs required. Most of the mobilization is considered as an emergency case, and then it is considered meaningful to replace such equipment to set up the WSSSC's organization capable to conduct the operation and maintenance of water supply facilities.

Table 2.23 Operation Ratio of Track Crane and Mobile Welder

Source	Record	Number of Dispatch		Frequency of Dispatch (time/mon.)	
		Mobile Welder	Track Crane	Mobile Welder	Track Crane
Record of Dispatch of Repair Staff (Jun. - Aug. 2006, 3 months)	Repair works done due to the breakdown of water supply facility	20	7	6.67	2.33
Record of Operation and Maintenance (Feb. 2006 - Jan. 2008, 24 months)	Regular maintenance and repair of the 1st and the 2nd Stations.	0	43	0	1.79
Total		20	50	6.67	4.12

The present crane is of mechanical-driven type, but recently only a few manufacturers produce this type of crane. Therefore, the track crane to be procured is of the hydraulic pressure type. Japanese manufactures do not have their agents in Mongolia, and they do not export their products to Mongolia at present, because any repair formation has not been established as well as the supply chain of spar parts. Therefore, the track crane will be procured in the third countries such as Russia and China.

The specifications of the track crane to be procured under the project are as follows:

- Crane: Type: Mechanical Driven or Hydraulic Pressure Type
  Lifting Capacity: Not less than 10t at boom length 8.0m and working range 4.0m
  Max. Boom Length: More than 10 m
  Max. Lifting Height: More than 20 m
- Engine: Type: Diesel Engine with water cooling
  Battery: Specified for Cold Areas

b. Mobile Welder

The welding machine is quite important in operation and maintenance of distribution networks and intake pump units, because the equipment has been used for these works frequently. The present welder has used over 30 years becoming quite older. According to the dispatch record

for the repair and the operation and maintenance, as shown in Table 2.23, the average frequency of mobilization of welding equipment is 6.67 time/mon., and it is considered quite essential equipment like track crane.

It was planned to load the welding equipment on the pick-up track in the request, but in the most case tools other than the welding equipment and repair materials are also loaded on the present welding truck. In addition, the compartment has to be furnished on the truck as same as the present truck in order to prevent theft of tools and materials, damage caused by sandy storm in spring season, intrusion of cold air during the cold period. Considering the weights of these tools and materials as well as the compartment itself exceeds the loading limit of the pick-up truck. Therefore, the truck of which loading limit is not less than three (3) tons will be used as base and compartment and generator- welder will be mounted on it.

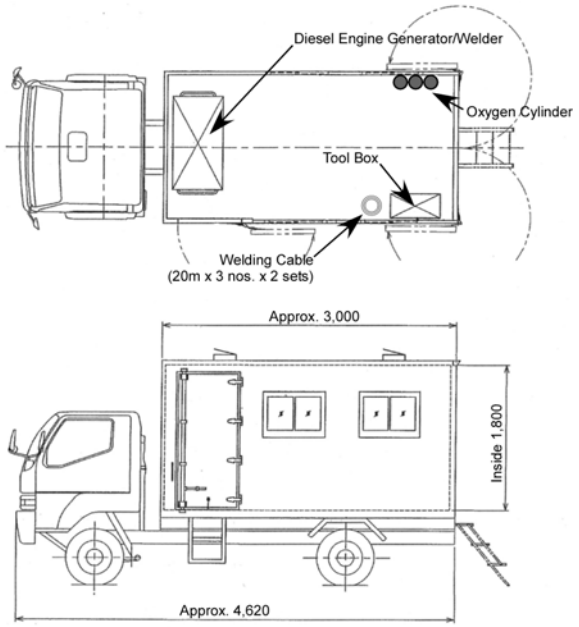


Fig. 2.17 Mobile Welder

The specifications of the mobile welder are stated below.

- Gross Vehicle Weitht: Not less than 4.3 tons
- Engine Type: Diesel engine with water cooling specified for cold areas
- Compartment: Made of aluminum plate, Internal dimensions not smaller than 1.8 m (w)×3.0 m (l)×1.8 m (h)
- Mounted Equipment: Engine welder (not less than 8 kVA), Electric welding equipment (250 A or more), Accessories for welder, Tool box, oxygen cylinders (not less than 2 nos.), Cables for welder

5) Water Quality Analysis Devices

The spectrophotometer, the incubator and the dry oven confirmed in the Preliminary Study were procured in 1990 and used over 18 years, and they are getting so older that they could be out of order. These devices are used for the analyses of the parameters which WSSSC has to analyze regularly, and are considered essential for WSSSC who should play an important roll in managing the water supply system. Therefore, one (1) no. will be procured for each of them under the project.

Table 2.24 Water Quality Analysis Devices to be Procured under the Project

	Name	Date of Procurement	Usage
a.	Spectrophotometer	Jan. 1, 1990 (Used for 18 years)	Parameters regularly analyzed such as Fe, Cl^-, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_2, NO_3, NH_4
b.	Incubator	Oct. 1, 1990 (Used for 18 years)	Always used for bacteriological analyses
c.	Dry oven	Nov. 1, 1990 (Used for 18years)	Drying apparatus for analyses

The specifications of the water quality analysis devices are as follows:

a. Spectrophotometer

- Wave Length: 340 - 900 nm
- Optical Resolution: 10 nm
- Analyzed Parameters: Fe, Cl^-, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_2, NO_3, NH_4

b. Incubator

- Temperature Range of Use: +5°C - 60°C
- Accuracy of Temperature Adjustment: ±0.2°C (Ambient temperature 37°C)
- Accuracy of Temperature Distribution: ±1.0°C (Ambient temperature 37°C)
- Operation Mode: Constant Operation, Timer Operation
- Heater Capacity: Not less than 300 W
- Inner Volume: Not less than 150 liter
- Power: AC240 V、3A

c. Dry Oven

- Operation Mode: Constant Operation, Timer Operation
- Convection Method: Fan Heater
- Temperature Range of Use: 40 - 270°C
- Accuracy of Temperature Adjustment: ±0.5°C (Ambient temperature 27°C)
- Accuracy of Temperature Distribution: ±5.0°C (Ambient temperature 27°C)
- Inner Volume: Not less than 300 liter
- Heater Capacity: Not less than 1.8 kW
- Power: AC240 V、3 A

6) Water Meter

The water meters are important in recording the consumed water volume in each household of apartment and conducting the proper water collection. Most of the households in the Darkhan city do not have the water meter, and the water charge is collected based on the number of the household members registered. However, in these household there is a tendency to register less number than those actually living in a household. In fact, the number of the registered household member is considered almost same as those who have not registered. The WSSSC collect the water charge setting the consumption per capita as large as 260 liter/day/capita. The this situation of water charge collection is not considered acceptable. Therefore, in order to carry out the proper water collection based on the consumed water volume measured with water meters, the WSSSC is promoting the installation of water meters to those of apartment areas, and about 600 of meters have been installed as of 2007. The request to install meters are increasing recently, and the WSSSC prepared the water meter installation plan as shown in Table 2.25 for the further promotion of meter installation.

Table 2.25 Water Meter Installation Plan of WSSSC-Darkhan

Description	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of Meter to be Installed	16	79	505	800	1,200	1,400	1,500	1,600	1,800	2,000	2,200
Cumulative Number of Installed Meters	16	95	600	1,400	2,600	4,000	5,500	7,100	8,900	10,900	13,100

Since there are many residents requesting the proper water charge collection in 2008, shortage of stored meter becomes one of the urgent issues to be solved and the number of meters installed grows slowly. The water meter is considered essential for the realization of the proper management and the smooth water charge collection. In order to facilitate such proper management and smooth water charge collection, the storage of water meters is considered necessary for at least one (1) year period after the completion of the project, and the water meter of 1,500 nos. planned to be installed for 2011 when the project completion is scheduled will be procured.

The specifications of water meter to be procured under the project are same as those that the WSSSC is promoting as shown below.

- Measurement Accuracy: Class B (ISO4064) - Measured Flow: 1.5 m^3/hr
- Diameter: 15 mm - Pressure Capacity: 1 MPa

The accessories such as couplings, flush filters and ball bars will also be procured together.

2.2.3 Basic Design Drawing

The basic design drawings for the installation of equipment and the construction of facilities of the project are shown in Attachment 5.

2.2.4 Construction /Procurement Plan

(1) Construction /Procurement Policy

<Project Implementation Organization>

The Project is to be implemented in accordance with the conditions stipulated in the Exchange Note agreed between Japanese and Mongolian government. WSSSC under the Ministry of Roads, Transport, Construction and Urban Development of Mongolia will be responsible for the implementation of the Project. The operation and maintenance of the facilities and equipment will be conducted by WSSSC after the project implementation. WSSSC will hire a consulting firm for engineering services such as detailed design, preparation of tender documents, support of tender, construction supervision, procurement management, software assistance, etc. Local contractors who can conduct procurement and construction work of the project will be hired by the Japanese contractor. The organizations related to the project and relationships are presented in Fig 2.18.

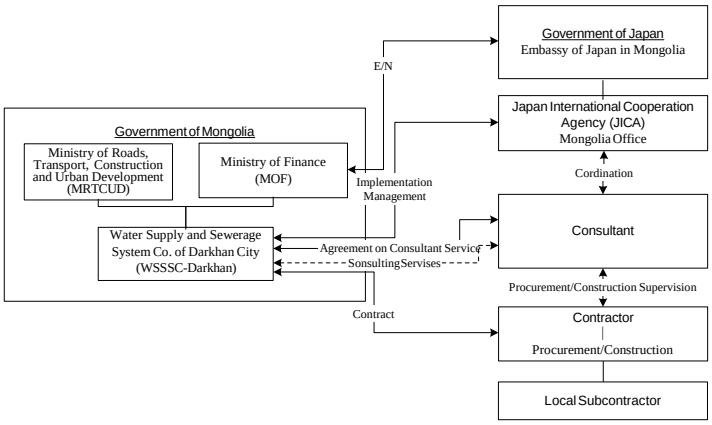


Fig.2.18 Project Implementation Organization

(2) Implementation Condition

<Construction Schedule during Coldest Period>

As shown in policy for procurement/construction method and construction schedule, generally the outside work is not conducted from October to April when it falls in the coldest period. However, this project is planed so that the construction work can be done continuously during the coldest period in order to use the limited construction period effectively. The construction schedule shall be arranged efficiently taking into account the works to be able to do during both the warm and the coldest periods as shown in Table 2.26.

Table 2.26 Work to be Done in the Warm and the Coldest Periods

Facilities	Works during the warm period (May to Sept.)	Works during the coldest period thru the worm period (Oct. to Apr.)
① 1st Station	・ Renewal work of well pump ・ Repair work of outer parts and/or insulation work for wall, window, door, roof, etc in well pump house ・ Renewal work of operation panel and transformer for No.1 ～ 11 well pump houses	・ Renewal work of piping inside the well pump house ・ Repair work of internal finish for well pump house ・ Installation work of anti-freezing pipe heater and insulation work around well pump
② 2nd Station	・ Outside piping work up to injection point of chlorination plant ・ Installation work of anti-surge device	・ Inside electrical work following renewal of transmission pump ・ Renewal work of transmission pump ・ New construction work of chlorination plant (inside house)
③ Construction of kiosk at ger area	・ Transmission pipe laying work ・ Foundation work of kiosk ・ Building work of kiosk (structure and outside finishing work)	・ Inside work of kiosk (inside finishing work and piping work)

<Unstable Power Supply>

Judging from the result of voltage measurement conducted at the power plant and the 2nd Station operation panel during the site survey, voltage of electricity supplied by Darkhan city always fluctuates (unbalance of 3-phase). It turned out that the fluctuation range was much bigger than the allowable range. As it is presumed that this fluctuation is caused by the bigger consumers like the steel company, it is considered impossible that the power supply side takes counter measure at present. Accordingly, if the power receiving side (user side) does not take any counter measure, electrical equipment will be damaged easily. Although Russian-made electrical equipment is said to be tolerant considerably against such poor quality electric power, Japanese-made electrical equipment suitable for use can not avoid damaging as far as the fluctuating electrical power exceeds allowable range. Actually two (2) intake pumps were damaged due to drastic fluctuation of voltage during the site investigation. Therefore, it is required to install AVR (automatic voltage regulator) at the power receiving facilities in the 2nd Station or it is required to take counter measure to stop the pump operation with a circuit breaker when unsafe voltage drop occurs.

<Construction of Distribution Pipeline in the 5th and the 6th Bags >

The hilly areas where the 5th and the 6th bag areas extend, is composed of the base rok of sandstone. Therefore, the excavation work for distribution pipeline is of rock almost.

Meanwhile, the route of pipeline is aligned along the road in the public land referring to the cadastar therof. As a part of the route is narrow, the construction plan of excavation for the pipeline is required to be prepared considering excavating method for the narrow road in order to make progress effectively.

<Restoration of Power Supply Facilities for the 1st Station>

The electric power for the 1st Station is supplied from two routes, but currently that for the old pump station built in year 1965 is stopped due to breaking down of the wire at the end (No.7 and No. 8 wells) and damage of the electric pole. It is required to be restored under responsibility of Mongolia side before the project implementation, if No. 8 well is used for the project.

<Implementation Plan of Rehabilitation Work for the 2nd Station>

The transmission pump house of the 2nd Station is considered narrow; approx. 12m x 12m. At present four (4) sets of pumps are installed and in addition the electrical facilities, operation panel, etc. are installed without free space. Therefore, it is required to replace the existing facilities so as not to disturb operation of these mechanical/electrical facilities. Accordingly the implementation plan should be prepared taking into account allocation of the temporary area for the existing facilities to conduct operation subsequently, demolishing schedule of the existing facilities, installation schedule of new facilities, and safety measure for operators during the rehabilitation work of the facilities, etc., in order to avoid any trouble.

(3) Scope of Works

The scope of works of Japanese and Mongolian side is shown in Table 2.27.

Table 2.27 Scope of Mongolian and Japanese Governments

Item	Japanese Sde	Mongolian Sde
(1) Acquisition of temporary area (workshop behind WSSSC head office, free area in No2. station)		X
(2) Acquisition of facilities area (including area for construction work and access road)		X
(3) Information on the location of the existing underground facilities and witness of excavation work (5th and 6th bag water distribution pipeline)		X
(4) Cooperation for connection work between the existing facilities and renewal facilities (witness during the connection work and coordination for the stop of water supply, if required)		X
(5) Water supply for performance test of equipment and hydraulic water test of water pipeline		X
(6) Tie-in of electrical power supply cable to pump house in the 1st Station (400 V)		X
(7) Tie-in of electrical power supply cable to 2nd Station (6,000V)		X
(8) Tie-in of electrical power supply cable to water kiosks in the 5th and the 6th bags (230V)		X
(9) Trial boring (confirmation of ground water level and underground facilities)	X	
(10) Procurement and construction of the facilities (planning. procurement of equipment/materials, construction)	X	
(11) Water flushing and disinfection of equipment and pipeline installed	X	
(12) Performance test of equipment and hydraulic test of pipeline installed	X	
(13) Temporary storage area and facilities for equipment and materials procured		X

(4) Consultant Supervision

The project will be implemented under Japanese Grant Aid System. The consultant will execute the detailed design study and construction supervision, including software assistance for securing the sustainable maintenance of facilities.

Detailed Design

In this phase, the detailed design, tender documents and other documents necessary for the execution of the project will be prepared.

Tendering

The consultant will assist WSSSC with tendering procedure of the project. The contract between WSSSC and the successful tenderer will be verified by the Japanese Government.

Construction Supervision

The consultant will assist WSSSC to complete the project by the scheduled date mentioned in the Exchange of Note (E/N), including meeting with contractor prior to the commencement of the construction works, witnessing the shipment of the materials and equipment for the project sites, and providing the contractor with instructions related to the construction works, equipment installation, test operations, and post installation inspection.

(5) Quality Management Plan

The consultant dispatches the resident construction supervisor for construction of water supply facilities in ger areas of the 5th and 6th bags. The construction supervisor prepares construction supervision manual based on quality control plan and conduct quality control, progress control, safety control and environment management in accordance with the said manual. The major items on field quality control are as follows;

- Foundation work: Load test, etc.
- Compaction: Material test, Density test, etc.
- Concrete work: Material test (Sand, Gravel, Cement), Mixing test, Strength test, Slump test
- Reinforcement bars: Tensile and bending strength (by factory certificate)
- Water pipeline: Hydraulic test

In addition to the above, the rate of construction progress is measured and confirmed at each stage. During commissioning stage, schedule control is made carefully so that the water supply facilities can be turned over to WSSSC timely after ensuring performance of the facilities. Meanwhile, regarding the equipment/materials to be procured, the procurement contractor carries out performance test for the well pump, the transmission pump, the chlorination facility, etc before shipment from the factory. Then the third party carries out the pre-shipment inspection. The procurement contractor prepares installation procedure and carries out the inspection required based on it as well as civil and building work. On finishing the installation work, the procurement contractor carries out performance test, ensures quality of equipment and then carries out commissioning work. The code and/or standard on inspection comply with JIS, ISO or other international codes/standards.

(6) Procurement Plan

In principle, the materials and equipment required for the project are to be procured in Mongolia, in Japan or in the third countries. China, Korea and Russia are considered as the third countries. The countries scheduled for procurement by item are as listed in Table 2.28.

Table 2.28 Scheduled Procurement Country for Main Equipment/Materials

No.	Items	Countries		
		Japan	Mongolia	Third Countries
1.	1st Station			
1.1	Submergible Motor Pump (Well Pump)	X		X
1.2	Electrical Equipment and Instrument	X		X
1.3	Remote Operation Unit		X	
1.4	Flow Meter		X	
2.	2nd Station			
2.1	Water Transmission Pump	X		X
2.2	Electrical Equipment and Instrument	X		X
2.3	Flow Meter		X	
3.	Chlorination Plant House			
3.1	Chlorination Plant	X		X
3.2	Chlorine Cylinder, etc.		X	
4.	Maintenance Equipment			
4.1	Truck Crane			X
4.2.	Truck mounted Welding Machine	X		
4.3	Water Quality Analysis Equipment	X		X
4.4.	Water Meter		X	X

The delivery place for equipment/materials procured is the workshop behind WSSSC head office. In case of equipment/materials procured in Japan, these are unloaded at Tianjin port in China, transported by railway to Zamyn Uud on the border of Mongolia via Beijing and Erenhot in China, transshipped here to change broad-gauge, and reached at Ulaanbaatar or Darkhan being at the project site. It takes about one (1) month. The equipment/materials procured in China takes the same route as those of Japan, but it takes a few weeks. Meanwhile, the equipment/materials procured in Russia are transported by railway to Darkhan via Sukhbaatar generally, where is at the entrance of north side of Mongolia. In this case, it takes about one (1) month.

The custom clearance for these equipment/materials can be made at Sukhbaatar, Zamyn Uud or Ulaanbaatar of the capital city in Mongolia. To make duty exemption for these equipment/materials, The WSSSC is required to arrange budget equivalent to import tax and valued-added tax in advance.

Materials other than the above to be used for construction of the water supply facilities at bag area are shown in Table 2.29.

Table 2.29 Scheduled Procurement Country for Construction Materials

№	Items	Countries		
		Japan	Mongolia	Third Countries
1.	Cement		X	
2.	Rebar		X	
3.	Form Materials		X	
4.	Wood for Construction		X	
5.	Fuel		X	
6.	Gravel and Sand		X	
7.	Brick and Block		X	
8.	Fixtures such as window frame, etc.			X
9.	Outside and Inside Lighting Fixtures			X
10.	Polyethylene Pipe			X

(7) Operation and Maintenance Plan

In principle, the primary operation and maintenance training for all the equipment procured and/or the facilities constructed are carried out by the procurement contractor. These trainings are carried out based on Mongolian operation and maintenance instruction manuals when the facilities are turned over to WSSSC. The training program is shown in Table 2.30.

Table 2.30 Primary Operation and Maintenance Training Program

No.	Facilities	Training Program	Duration
1.	1st Station	・ Operation for submergible motor pump (well pump) ・ Maintenance for auxiliary equipment such as pressure gauge, valve, etc. ・ Operation and maintenance for primary transformer and power distribution board ・ Operation for portable water meter ・ Reading for indicator of flow meter ・ Repair and routine inspection for submergible motor pump (well pump) including instruments	7
2.	2nd Station	・ Operation for water transmission pump ・ Maintenance for auxiliary equipment such as pressure gauge, valve, etc. ・ Maintenance for water level meter (reservoir and pond for pump) and flow meter (discharge of water reservoir),etc. ・ Operation for pump (1st Station submergible motor pump and 2nd Station water transmission pump) and how to watch indicators ・ Repair and routine inspection for submergible motor pump including instruments ・ Operation, inspection and repair for pump operation panel	15
3.	Chlorination Plant	・ Operation and maintenance for chlorine plant ・ Operation and maintenance for auxiliary facilities ・ Countermeasure for accidents and key points to avoid accidents ・ Routine inspection and repair for chlorination plant	5
4.	Water Kiosk at Ger Area	・ Inspection and maintenance for the facilities in water kiosk (well pump, meter, valve, etc.) ・ Operation for valve on water distribution pipeline ・ Routine inspection and repair for water supply system and key points for anti-freezing of water supply system during the coldest period	5

Table 2.30 Primary Operation and Maintenance Training Program

No.	Facilities	Training Program	Duration
5.	Maintenance Equipment		
5.1	Truck Crane	・ Operation for vehicle and crane ・ Routine inspection and repair for truck crane	5
5.2	Truck-mounted Welding Machine	・ Operation and maintenance for truck ・ Operation and maintenance for welding machine and generator ・ Routine inspection and repair for truck, welding machine and generator ・ key points to avoid accidents	5
5.3	Water Quality Analysis Equipment(Spectrometer, Dryer, Incubator)	・ Operation, maintenance, inspection, repair, etc for analysis equipment (contact address for service agent) ・ How to use, handle and place order for reagents, etc.(contact address for suppliers or service agent)	5
5.4	Water Meter	・ Handling, routine inspection and repair for meter ・ Setting meter	2

(8) Software Assistance

1) Background and Overview

This project to be implemented under Japanese Grant Aid System is to improve well pumps, transmission pumps, chlorination facility, operation and maintenance equipment and the related facilities for water supply system of Darkhan city (population: 75,000) which is one of the major cities in Mongolia, and to construct the water supply facilities for the 5th and the 6th bag areas. The WSSSC has conducted operation and maintenance work for water supply system of Darkhan city so far, and, therefore, they have experience for those. Meanwhile, the procurement contractor is planned to carry out operation and maintenance training for WSSC on equipment/facilities delivered during commissioning work. Accordingly it is considered that WSSSC can reach a certain level of operation and maintenance of water supply system.

At present the transmission pump makes intermittent operation due to shortage of total capacity of well pumps located at water source area, that is; the said pump is stopped when the reservoir is filled with water and started again when it is empty. Such pump operation is not preferable and not efficient hydraulically as air enters into the pipeline. Furthermore operation instruction manual is not available to make operation efficiently according to water demand.

The chlorination facility is planned to be replaced under this project. The existing one was left broken-down for ten more years. There is no WSSSC staff having know-how on operation as it was left inoperative for many years. The new chlorination plant is planned to be operated by 10 staff, that is; 8 existing staffs plus two (2) new staff (daytime four (4) staff and night time three (3) staff by shift work). Currently the said 8 existing staffs are responsible for operation of well pumps and transmission pumps of the 2nd Station. These 10 staff have no experience for operation and maintenance of chlorination plant. Furthermore it is considered that two (2) new staff assigned have no experience for operation of well pumps and transmission pumps.

Meanwhile, in the water supply facilities constructed in ger area under this project, transmission to the highest water kiosk is planned to convey water by the relay pump. However, the water sales staffs stationed at the water kiosk are not familiar with operation of machinery.

Under this situation, in order to commence operation and maintenance of all of the water supply facilities smoothly including the pumps and the chlorination system replaced, it is significant to make training required so that the operators assigned to the 2nd Station, the highest water kiosk and relay pump water kiosk can master operation technique

2) Objectives

Taking into account the above situation, software assistance which targets the following items is implemented under the project:

- The transmission pump, well pump and auxiliary facilities replaced are operated effectively and efficiently in accordance with water demand.
- The chlorination system replaced is operated efficiently and safe water is supplied.
- The relay pump installed at water kiosk is operated efficiently and sustainably.

PDM of software assistance is shown in Table 3.31 in page 3 - 50.

3) Effects

Effects of software assistance are as follows:

Effect ① The operators of the 2nd Station can master operation procedure of the pump including remote operation, prepare operation plan based on water demand and operate the pumps efficiently.

Effect ② The operators of the 2nd Station can comprehend process of the chlorination facility replaced and operate them effectively and efficiently.

Effect ③ The operators located at the water kiosk becomes familiar with operation of the pumps and can convey water to the highest water kiosk efficiently.

4) Confirmation of Effects

Index and confirmation method for achievement of effects on the above-mentioned software activities is shown in Table 2.32.

Table 2.32 Index and Verification Method for Achievement

Effect	Index	Verification Method
Effect ①	- Operation status of well pump and water transmission pump - Water distribution status from reservoir	- By operating time of well pump and water transmission pump based on operation record - By the rate of distributed water based on record of flow integrator installed on the discharge of reservoir
Effect ②	- Residual chlorine - Chlorine injection rate - Accidents	- By analysis data made from regular water quality analysis by WSSSC - By injection rate from operation record of chlorination plant and by its effect - By sustaining safety operation of chlorination plant (judging from occurrence and extent of accidents by operation record)
Effect ③	- Operation status for the relay pumps installed at water kiosk - Sales amounts by water supply at highest water kiosk	- By frequency in operation and operating time of the pump installed at water kiosk - By sales amounts from the account book of the highest water kiosk

The consultant prepares check sheets to verify skillfulness of each operator and makes verification for each operator. Finally the consultant prepares and submits the software assistance completion report to WSSSC.

5) Software Assistance Activities (Inputs)

Software assistance activities consist of lecturers on outline, process, technical specification, operation and maintenance for the equipment and/or facilities, and on-the-job training for the actual operation of the equipment/facilities. These lectures and on-the-job trainings are made for intake pumps/transmission pumps, chlorination plant and relay pumps in turn in order to carry out technical transfer successfully. Software assistance activities are carried out when commissioning work for the facilities is completed and the facilities is ready for turn-over. The outline of technical transfer activities is shown in Table 2.33.

Table 2.33 Software Assistance Activity Program

Item		Activity	Duration (Net)
1.	Well pump / water transmission pump		
1.1	Operation Control Manual	Preparation of draft of manual (in Japan) Completion of manual under cooperation of operation staff (Mongolian version)	10.0
1.2	Seminar on well pump / water transmission pump based on water demand	Basic seminar on well pump/water transmission pump operation based on water demand Seminar on well pump/water transmission pump operation based on operation instruction manual	3.0
1.3	OJT for well pump / water transmission pump operation	Confirmation for operation procedure Training by use of actual pump Preparation of operation record and daily operation report Economical operation considering electricity charges varying with time zone	10.0
2.	Chlorination plant		
2.1	Seminar on process and operation of chlorination	Seminar on process and basic operation of chlorination plant Seminar on injection rate control based on rate of water transfer Seminar on safety control	3.0
2.2	OJT for chlorination plant operation	Lecture on operation procedure by use of actual plant Countermeasure for accidents Preparation of daily control report including injection rate, etc.	7.0
3.	Relay pump (water kiosk)		
3.1	Seminar on water transfer system including relay pump	Seminar on flow scheme for water transfer system including relay pump Seminar on operation procedure for relay pump	1.0
3.2	OJT for relay pump operation	Training on operation procedure by use of actual pump Key points for operation Preparation of daily control report	3.0
Total			37.0

The actual working days (net) are 37 days (Japan: 10 days, Mongolia: 27 days) and the calendar days are 51 days (Japan: 14 days, Mongolia: 37 days). Man-months are 1.7M/M (Japan: 0.46 M/M, Mongolia: 1.24 M/M).

The above software assistance activity on seminar and OJT is carried out by a water supply control engineer mainly. However, in case that a mechanical engineer or an electrical engineer is required to support him for seminar and/or OJT, Consultant makes arrangement to dispatch

them timely in due course.

6) Implementation Formation

A water supply control engineer who takes charge of a key part of the software assistance activity is responsible for all the activities from preparation of operation control manual to implementation of seminar and OJT. Therefore, he is required to have comprehensive knowledge and know-how covering the whole part of water supply system that is; grasp of adequate water demand, operation of pump and chlorination facility, hydrogeological knowledge of well related to intake pump operation, etc. It seems to be difficult to find such engineer in Mongolia. Accordingly, the consultant dispatches a Japanese water supply control engineer who is superior on management, operation and maintenance for the water supply system. Meanwhile, a mechanical/electrical engineer who support a Japanese water supply control engineer is planed to be dispatched from the local consultant. A local interpreter (Japanese - Mongolian), who is requisite for communication with Mongolians, will be hired.

7) Implementation Schedule

The implementation schedule for software assistance activity is shown in the Table 2.34.

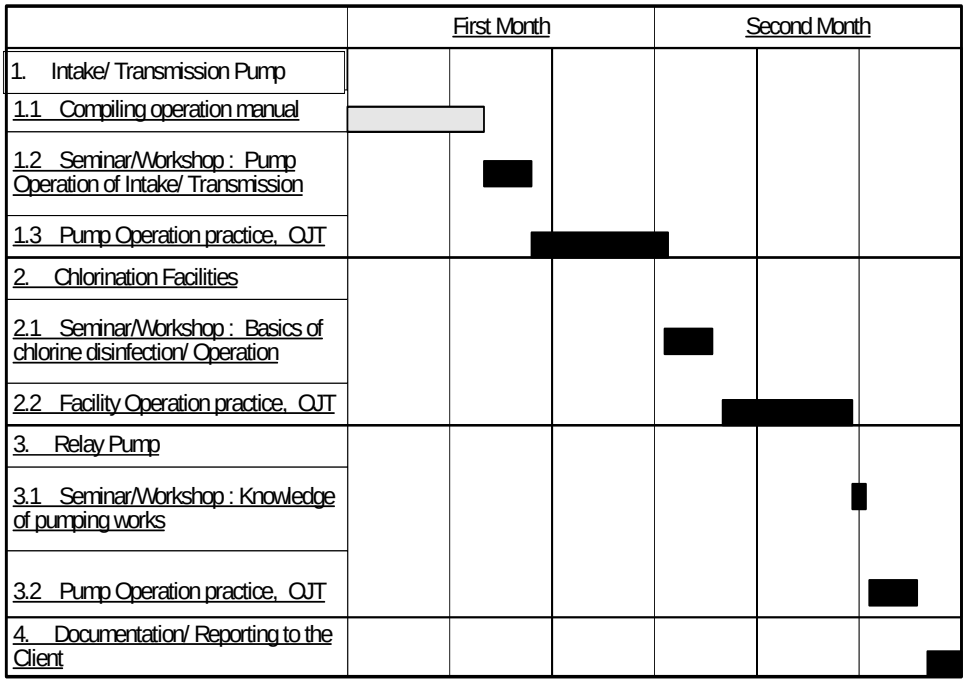


Table 2.34 Software Assistance Implementation

8) Outputs

The outputs of software assistance activity are shown in Table 2.35.

The outputs together with achievement verified are compiled in the software assistance completion report by a water supply control engineer under corporation of the local consultant and submitted to WSSSC.

Table 2.35 Software Assistance Activity and Outputs

Item	Outputs
① Well pump/Water transmission pump	Operation control manual (Mongolian)
	Seminar textbook
	Operation record during OJT
② Chlorination plant	Seminar textbook
	Operation record during OJT
③ Relay pump (water kiosk)	Seminar textbook

9) Responsibility of WSSSC

To enhance effects of software assistance activities and its sustainability and to implement software assistance activities smoothly, the following items are made under the responsibility of Mongolia side.

- To secure personnel expenses of two (2) staff employed additionally for operation control of the chlorination facility in the 2nd Station and four (4) staff employed additionally for operation of the water kiosks.
- Monitoring and follow-up to sustain operation and maintenance of the facilities.

(9) Project Implementation Schedule

This project implementation schedule is as per Fig 2.19 in page 2 - 60.

2.3 Obligations of Recipient Country

The obligations required for the Government of Mongolia for the project implementation are as follows:

(i) Provision of necessary data and materials for this project
(ii) Security at the project sites
(iii) Payment of commissions for Banking Arrangements (B/A) and Authorization to Pay (A/P)
(iv) Quick loading and unloading, and customs clearance procedures for the equipment and materials to be procured
(v) To make action of exemption from taxation for the equipment and materials to be brought in Mongolia by the Japanese personnel and taxes of subcontracts for the procurement of the equipment and materials, and the execution of services based on the approved contract
(vi) Appropriate use and maintenance of procured equipment and materials, and constructed facilities in this project
(vii) The following provisions of the human resources and the expenses for the engineers and technical staff, and the lands and spaces belonging to the WSSSC-Darkhan which will not be appropriated from the Japanese Grant Aid.

Table 2.36 Obligations to be Shouldered by Mongolian Side

Items	Remarks
(1) Provision of temporary yard (Workshop space behind the WSSSC building and vacant space in the 2nd Station)	The spaces belong to WSSSC, and they will be free of charge.
(2) Secure the lands for the project facilities including temporary yards for construction and access roads.	The land acquisition will be necessary only for the construction of water supply facilities for ger areas, but all the facilities are planned to be constructed in the public lands. It is not difficult to acquire such lands.
(3) Provision of information on the buried facilities and joint inspection on the trench excavation for the ger areas of the 5th and the 6th bags.	The engineers and technical staff will be dispatched.
(4) Cooperation at the time of connection of the existing and the replaced facilities (Joint inspection of the construction and information on shutdown of supply)	The engineers and technical staff will be dispatched.
(5) Provision of the water for pressure test for distribution pipelines to be constructed, and for performance test of the equipment.	The water of WSSSC will be used.
(6) Provision of the electric power line to the pump houses of the 1st Station (400 V)	The connection of the power lines was completed for the existing facilities, and these facilities are planned to be used. There is not any trouble happed.
(7) Provision of the electric power line to the incoming panel of the 2nd Station. (6,000 V)	
(8) Provision of the electric power lines to each water kiosk in the 5th and the 6th bags (230 V)	It is necessary to take the power line for lighting of kiosks as well as operation of relay pump. Since there are power distribution lines for consumers near the kiosks along the road, the WSSSC has to get the approval of the power supply company to connect the line as well as payment of necessary charges.
(9) Securing lands and facilities where the equipment is installed and the facilities are constructed.	These lands and facilities will be possibly secured.
(10) Personnel Assignment for Project Implementation	Increase the staff: Total 6 persons(Pump operator 2, Kiosk Salesperson 4),Provision of Software Assistance

2.4 Operation and Maintenance Plan of the Project

2.4.1 Operation and Maintenance of the Water Supply Facilities

The WSSSC conducts maintenance activities for the water supply facilities after completion of construction works. The WSSSC is the self-support accounting which has 262 staff as of 2008 and 37 are assigned in the water-supply department which conducts operation maintenance. Financial basis of WSSSC is not sound, but they have executred downsizing of the organization and applied new water tariff for improving their management. Thus, it is judged there will not be any paticular problem in WSSSC acting as a leading role on operation and maintenance for thre project implementation.

(1) 1st Station

At the 1st station, the operation of 18 wells is conducted by the operation staff stationed at two (2) operation houses located near NO. 7 and NO. 16 wells along the Haraa river. Two (2) operation staff are always stationed one at each house respectively with the rotation shift among eight (8) staff. They are conducting an operation in accordance with the instruction by the radio communication from the control room at the 2nd Station. Judging from the maintenance of the intake pumpshaving been continued in spite of the equipment and materials aged and deteriorated, it is considered that a certain level of maintenance skill is maintained. It is not

necessary to increase operation staff, since the current operation system is applicable because the remote control system from the 2nd Station is planned to be applied for operation control of the intake pumps in the facility plan of the project. There is any difficulty in maintenance of the submersible pumpnunits if the operational instruction at commissioning is sufficient, because same capacity and specifications as the current in-service pumps will be applied.

(2) 2nd Station

There are two (2) pump basins with 1, 000m^3 capacity and a transmission pump house in the 2nd Station. At present, total of eight (8) operating personnel consisting of four (4) for daytime and two (2) for night shifts are giving the operation instructions to the intake pump of the 1st station and the operation control of the transmission pumps of the 2nd Station.

The control of chlorination injection volume and replacement of chlorine cylinder for the chlorination facility having been left out of order are also operated by the responsibility of these staff after its improvement. Since the replacement of chlorine cyloinder requires careful treatment, the two (2) number of staff for night shift has to be added to the present three (3) while the daytime shift of four (4) staff is considered sufficient. The total number of the staff required will be increased to 10 due to this addition.

Depending soley on the experience of the operation staff, the intermittent operations have been made for the intake and the transmission pumps so far. Though operation procedures are almost same as the existing ones, it is required to furnish an operation manual to realize the efficient operation to match to the water demand because the pumping capacity will be increased to a large extent. Primary operational training will be made at the commissioning stage on the chlorination facility. Additional trainings for safty control, etc. are necessary. Such training will be conducted as activities of the software asistance.

(3) Water Supply Facilities in Ger Areas

Water supply facilities which consist of distribution pipelines and water kiosks (12 places) for the ger areas of the 5th and 6th bags will be constructed. The water-supply department of WSSSC will be in charge of this maintenance of the water supply facilities as well as the facilities that have been already constructed in the neighboring 7th bag. Judging from the situations of maintenance and management of the existing ones, there will not be any problem.

At present, there are water kiosks in eight (8) places in these two (2) bag areas, and water is distributed by the tank lorry to these kiosks for retail sales. The number of the water kiosks is increased to 12 by the project, it is necessary to increase the number of kiosk operators from eight (8) to 12. WSSSC implements necessary training on collection of water charges, and, therefore, commissioning training on the valve operation such as opening and closing valves at the water kiosks seems to be enough. However, one kiosk is located in the elevated land in the 6th bag, it is planned to distribute the water by a relay pump from another water kiosk nearby. It is, therefore, necessary to train salespersons on the pump operation as a part of the technical assistance activities.

From the above description, the number of operating staff will be increased as shown in Table 2.37.

Table 2.37 Increase of Operating Staff of 1st of and 2nd Stations and Salesperson of Water Kiosks

Facilities	Present	After Project Completion	Increase in Personnel
1st Station Intake pump	8 (It is always two in the shift). (It operates by the instruction from the 2nd Station operation room).	8 (Always two in each shift). - Not operating the intake pump except the emergency case-	-
2nd Station Transmission-pump	8 (Daytime shift : 4, night shift: 2) - Instruction to the 1st Station operation member by wireless communication-	10 (Daytime shift : 4, night shift: 3) - The intake pump at the 1st Station is operated by the remote maneuvering device-	2
Chlorination Facilities	-		
5th and 6th Bags, Ger Area Water Facilities	8(Only daytime)	12 (Only daytime)	4

2.4.2 Maintenance of the Equipment

In order to supply safe water continuously, appropriate maintenance for the equipment is necessary. Approximately 20 senior member and regular employees of the university graduation level belong to WSSSC excluding an administrative department. They did maintenance works of the old water supply facilities with insufficient repair/inspection tools and equipment. Moreover, it is considered to introduce the facilities with similar specifications to the current system as far as possible in accordance to their request and easiness for switching over to the new facilities based on the current maintenance level. Therefore, there is not any problem on the maintenance of the crane-track and the mobile welding machineries.

The water quality analysis devices will belong to the water analysis laboratory. Any particular technical transfer nor additional staff assignment are not necessary for required water quality analysis at the implementation stage of the project because past slacken water analysis was merely caused by hardware failures.

2.5 Project Cost Estimation

2.5.1 Initial Cost Estimation

(1) Costs Covered by Mongolian Side

The costs covered by Mongolian side are listed below.

Table 2.38 Costs Covered by Mongolian Side

(Unit: Million MNT)

Items	Costs	Remarks
(1) Provision of temporary yard (Workshop space behind the WSSSC building and vacant space in the 2nd Station)	-	The spaces belong to WSSSC, and they will be free of charge.
(2) Secure the lands for the project facilities including temporary yards for construction and access roads.	-	The land acquisition will be necessary only for the construction of water supply facilities for ger areas, but all the facilities are planned to be constructed in the public lands. It is not difficult to acquire such lands.
(3) Provision of information on the buried facilities and joint inspection on the trench excavation for the ger areas of the 5th and the 6th bags.	-	The engineers and technical staff will be dispatched.
(4) Cooperation at the time of connection of the existing and the replaced facilities (Joint inspection of the construction and information on water stop)	-	The engineers and technical staff will be dispatched.
(5) Provision of the water for pressure test for distribution pipelines to be constructed, and for performance test of the equipment.	-	The water of WSSSC will be used.
(6) Provision of the electric power line to the pump houses of the 1st Station (400 V)	-	The connection of the power lines was completed for the existing facilities, and these facilities are planned to be used. There is any trouble happed.
(7) Provision of the electric power line to the incoming panel of the 2nd Station. (6,000 V)	-	
(8) Provision of the electric power lines to each water kiosk in the 5th and the 6th bags (230 V)	13.2	It is necessary to take the power line for lighting of kiosks as well as operation of relay pump. Since there are power supply lines for consumers near the kiosks along the road, the WSSSC has to get the approval of the power supply company to connect the line as well as payment of necessary charges.
(9) Securement of lands and facilities where the equipment are installed.	-	These lands and facilities will be possibly secured.
(10) Personnel Assignment for Project Implementation	14.5	Calculation on staff increase (6 persons) based on WSSSC salary scale
Total	27.7	-

According to the Mongolian tax system, equipment and materials procured by grant aid are exempted from tax on value added (VAT) and import customs, etc.

(2) Conditions of Cost Estimate

<Time of Cost Estimate>

The project cost estimate is based on prices and exchange rates as of June 2008.

<Exchange Rates>

The exchange rate of the average from December 2007 to May 2008 is applied for the cost estimate.

- 1 USD = 106.73 JPY
- 1 USD = 1,168.77 MNT
- 1 MNT = 0.091 JPY

2.5.2 Operation and Maintenance Cost

(1) Production and Operation and Maintenance Costs

1) Personnel Expenses

As described in the previous section, the following staff increase is necessary for the operation and maintenance of the replaced and the constructed facilities.

- 2nd Station: Operation staff 2 persons
- Water kiosks: Kiosk operator 4 persons

As for the personnel expenses for the above staff, the annual salaries of operation staff of the 2nd Station and kiosk operators are set at 2,301,783 MNT/year and 1,904,040 MNT/year in average based on the salary table of WSSSC, and 19 % of social insurance fee is added as shown below.

- Operation Staff: 2,301,783 MNT/head/year x 119 %×2 persons = 5,478,243 MNT
- Kiosk Operator: 1,904,040 MNT/head/year x 119 %×4 persons = 9,063,230 MNT
- Total: 14,541,473 MNT

2) Power Expense

The power expense is estimated comparing the annual power consumptions of the existing and the replaced pumps. The intake pumps of the 1st Station, the transmission pumps of the 2nd Station and the relay pump of water kiosk are considered, and the results of calculation are presented in Table 5.2. The electricity tariff was revised in July 2008 increasing the price to 68 MNT/kW (298 % increase), and this revision is considered in the calculation for the power expense of the replaced pump.

Table 2.39 Power Expenses of Existing and Replaced Pumps

Facilities		Annual Power Consumption (kW)	Unit Price of Power Supply (MNT/kW)	Power Expense (MNT/year)	Increase of Annual Power Expense (①－②)
1st Station	① Replaced Pump	2,227,960	68	151,501,280	45,985,523
	② Existing pump	1,990,863	53	105,515,757	
2nd Station	① Replaced Pump	1,830,110	68	124,447,480	54,714,055
	② Existing pump	1,315,725	53	69,733,425	
Relay Pump of Water Kiosk	① New Pump (4 hr Operation/day)	1,095	68	74,460	74,460
				Total	100,774,038

Total increase of the annual power expenses of the intake pumps of the 1st Station, transmission pumps of the 2nd Station, and the relay pump of water kiosk are calculated to be 100,774,038 MNT/year.

3) Chemical Expense

The annual expense for Chlorine is calculated based on the planned annual injection volume.

- Injection ratio of chlorine: 2 mg/liter
- Unit price of chlorine: 1,000 MNT/kg

- Water supply volume to be treated: 21,800 m^3/day
- Annual chlorine expense: 21,800 m^3/day x 2 mg/liter x 365 days x 1,000 MNT/kg
  = 15,914,000 MNT/year

4) Fuel Expense

The water transportation by tank lorry will not be made for the 5th and the 6th bags, because all the water kiosks will receive the water through the constructed distribution pipelines. Tank lorries will be used for the other areas where the distribution pipelines have not yet been constructed, and those kiosks will be reduced from present 22 to 14 only. Therefore, one (1) lorry will be enough to serve such remaining areas, and then one (1) driver of the lorry will be reduced. The expenditure to be reduced is calculated below.

- Water transportation by tank lorry (present): 22 kiosks by 2 lorries
- Water kiosks to be constructed under the project: 8 kiosks
- Share of water transportation by lorry for 5th and 6th bags considering the transportation distance and frequency of water service: 64.21%
- Decrease of fuel expense:
  29,160 MNT/day x 64.21 % x 365 days x 5/7 = -4,881,519 MNT
  (Effect to decrease fuel expense)

5) Operation and Maintenance Cost

The increase of annual operation and maintenance cost is calculated to be 126,347,992 MNT as shown in Table 2.40.

Table 2.40 Increase of Annual Operation and Maintenance Cost

(Unit: MNT/year)

Expenses	Personnel Expense	Power Expense	Chemical Expense	Fuel Expense	Total
Amount	14,541,473	100,774,038	15,914,000	-4,881,519	126,347,992

The total of annual expense is calculated to be 905,030,900 MNT adding the estimated increase of expenses to the actual expenses for 2011 as shown in Table 2.41.

Table 2.41 Calculation of Total Expense of WSSSC

(Unit: 1,000 MNT)

Expense Item	Expenses in 2007 (Water Supply Section)	Estimated Increase of Annual Expenses	Estimated Annual Expenses for 2011
Personnel Expense	276,350.1	14,541.4	290,891.5
Power Expense	177,839.8	100,774.0	278,613.8
Fuel Expense	52,553.7	-4,881.5	3,672.2
Repair Expense Including Water Quality Tests	118,149.6	15,914.0	134,063.6
Depreciation	70,404.4	-	70,404.4
Other Expense	83,385.4	0	83,385.4
Total	778,682.9	126,347.9	905,030.9

(Note) The expenses for industrial water supply are excluded.

(2) Revenue

The population of the Darkhan city in the target year of 2011 is set for 91,000, and the WSSSC is expected to reach the management level to cover the expenses necessary for operation and

maintenance of the water supply facilities. The ratio of installation of water meter will be increased from 7 % to about 20 %, and the revenue of WSSSC will be increased due to the population growth.

Table 2.42 Estimated Revenue of WSSSC for 2011

(Unit: 1,000 MNT)

Description	Apartment Area	Bag Area	Total
Population in 2011	64,850	26,150	91,000
Revenue from Water Supply in 2011	925,868.5	503,500.0	1,429,668.5

(Note) Water tariff of 2007 is applied.

(3) Cost and Revenue Balance

The cost and revenue balance of WSSSC in 2011 will be improved by the project and the necessary operation and maintenance cost will also be covered by the expected revenue. As shown in the Table 2.43, in case that the water charge collection is decreased, the revenue still expected to cover the expenses. The costs are increasing recently due to recent price inflation, and in case that the cost is increased due to such inflation the cost is still covered by the revenue. However, the water tariff should be revised when the rise of prices is so sharp that the cost of operation and maintenance exceeds the revenue.

Table 2.43 Cost and Revenue Balance of WSSSC in 2011

(Unit:1,000MNT)

			Operation and Maintenance Costs (ii)			
			100%	110%	115%	120%
Balance ((i)-(ii))₩			905,030.8	995,533.9	1,040,785.5	1,086,037.0
Revenue (i)	100%	1,429,668.5	524,637.7	434,134.6	388,883.0	343,631.5
	90%	1,337,071.6	432,040.8	341,537.7	296,286.1	251,034.6
	80%	1,244,474.8	339,444.0	248,940.9	203,689.3	158,437.8
	70%	1,151,877.9	246,847.1	156,344.0	111,092.4	65,840.9

2.6 Other Relevant Issues

This project is mainly to replace the pump units and the relating facilities on operation, and it has to be avoided to stop the operation of such facilities long time because it is impossible to suspend the water supply to the city area. Therefore, it is necessary to implement the construction and installation works so as to avoid the difficulties in the people's lives. It is also important to establish the implementation plans which make possible to shift from the old facilities by commencing the services as soon as the replacement is completed one by one.

The implementation schedule of the project is established considering these issues, but it is necessary to take into account the following items during the implementation of the project.

(i) Before approving the contractor's implementation plan, such proposed plan should be examined in detail to confirm that any unnecessary suspension of the existing facilities in operation is not occurred. In case that any suspension of operation is considered unavoidable, it is necessary to direct the contractor to minimize such suspension and to schedule it for night time when the water demand becomes minimum. Especially for the renovation of the 2nd Station pump house, the relocation of the existing electric facilities have to be considered, and then it is necessary to pay careful attention to avoid the unexpected accidents and damages.

(ii) It is important to remove and relocate the existing facilities in the presence of the staff incharge of WSSSC confirming the existing conditions among the contractor, the consultant and WSSSC. When any work which needs susmension of the facility operation is carried out, it is necessary for the consultant to coordinate between the contractor and WSSSC to confirm the effect of such suspension before commencement.

(iii) In case that any suspension of water supply service is compelled, it is necessary to inform the population of such suspension through the public relations of WSSSC, and to take best effort to minimize the effects to be caused by such suspension.

Table 2.5 Results of Water Quality Analyses

No.	Parameter	Unit	Guideline		Well Number								
			Mongolia	WHO (Ref.)	1	2	3	4	5	6	7	8	9
1	Color	TCU	20	15	<20	<20	<20	<20	<20	<20	<20	<20	<20
2	Odour	-	2	-	<2	<2	<2	<2	<2	<2	<2	<2	<2
5	Taste	-	2	-	<2	<2	<2	<2	<2	<2	<2	<2	<2
6	Calcium (Ca++)	mg/L	100	-	36.1	38.9	37.1	36.3	38.2	37.1	36.2	38.1	37.1
7	Magnesium (Mg++)	mg/L	30	-	13.00	15.90	16.10	15.10	14.96	17.00	14.30	14.10	19.40
8	Hardness	mg/L	-	-	3.25	3.45	3.55	3.50	3.30	3.40	3.51	3.10	3.50
9	Chlorine (Cl-)	mg/L	350	250	8.518	8.585	9.393	8.753	8.669	8.997	8.478	9.191	8.672
10	Nitrogen-Ammonia (NH4)	mg/L	-	1.5	0.12	0.11	0.14	0.13	0.11	0.14	0.14	0.13	0.12
11	Nitrous acid Ion Concentration (NO2)	mg/L	-	3	0.05	0	0	0.05	0	0.05	0	0.02	0.05
12	Nitrate Ion Concentration (NO3)	mg/L	10	50	6.45	6.6	5.66	6.85	7.96	6.95	6.8	7.25	6.35
13	Hydrogen-Ion Density (pH)	mg/L	6.5-8.5	-	7.61	7.03	7.64	7.10	7.00	7.04	7.02	7.56	6.92
14	Iron (Fe)	mg/L	0.3	0.3	0.165	0.178	0.173	0.175	0.189	0.182	0.191	0.151	0.158
15	Sulfuric Acid Ion (So4)	mg/L	500	250	21.85	24.54	23.53	24.76	21.69	24.36	22.87	23.09	24.91
16	Evaporation Residue (TDS)	mg/L	1,000	1,000	498	534	452	322	368	504	496	472	476
17	Manganese (Mn)	mg/L	0.1	0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
18	Copper (Cu)	mg/L	1	1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
19	Lead (Pb)	mg/L	0.03	0.01	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
20	Fluoride (F)	mg/L	0.7-1.5	1.5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
21	Sodium (Na)	mg/L	-	-	155.5	165.4	158.3	166.7	165.9	159.5	156.3	163.5	164.2
22	Zinc (Zn)	mg/L	5	3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
23	Coliform	Number/L	3	Non/100mg	Non	Non	Non	Non	Non	Non	-	Non	Non
24	Cadmium (Cd)	mg/L	0.01	0.003	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
25	Chromium (Cr)	mg/L	0.05	0.05	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
26	Arsenic (As)	mg/L	0.05	0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
27	Turbidity	NTU	-	5	<5	<5	<5	<5	<5	<5	<5	<5	<5
28	Temperature	deg	-	-	5.5deg	6.0deg	5.8deg	5.2deg	5.5deg	5.5deg	6.0deg	6deg	6.0deg
29	Molybdenum (Mo)	mg/L	0.25	0.07	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
30	Aluminium (Al)	mg/L	0.5	0.2	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025

No.	Parameter	Unit	Guideline		Well Number								
			Mongolia	WHO	10	11	12	13	14	15	16	17	18
1	Color	TCU	20	15	<20	<20	<20	<20	<20	<20	<20	<20	<20
2	Odour	-	2	-	<2	<2	<2	<2	<2	<2	<2	<2	<2
5	Taste	-	2	-	<2	<2	<2	<2	<2	<2	<2	<2	<2
6	Calcium (Ca++)	mg/L	100	-	37.0	37.1	37.1	36.5	36.1	37.1	38.0	37.0	38.1
7	Magnesium (Mg++)	mg/L	30	-	16.66	17.66	17.00	13.21	14.72	16.45	15.54	15.80	15.66
8	Hardness	mg/L	-	-	3.35	3.55	3.56	3.55	3.40	3.25	3.45	3.30	3.46
9	Chlorine (Cl-)	mg/L	350	250	9.287	9.197	9.393	9.107	8.797	8.950	8.916	9.287	9.388
10	Nitrogen-Ammonia (NH4)	mg/L	-	1.5	0.11	0.14	0.13	0.12	0.13	0.14	0.12	0.14	0.13
11	Nitrous acid Ion Concentration (NO2)	mg/L	-	3	0.10	0.02	0	0	0.06	0	0	0.05	0.15
12	Nitrate Ion Concentration (NO3)	mg/L	10	50	5.45	5.55	6.85	7.98	6.25	5.36	7.5	6.05	6.95
13	Hydrogen-Ion Density (pH)	mg/L	6.5-8.5	-	6.98	6.99	7.18	7.01	6.92	7.60	7.05	7.23	6.55
14	Iron (Fe)	mg/L	0.3	0.3	0.173	0.155	0.158	0.162	0.168	0.159	0.171	0.182	0.165
15	Sulfuric Acid Ion (So4)	mg/L	500	250	23.03	21.63	20.35	24.2	21.33	21.75	20.71	21.68	24.83
16	Evaporation Residue (TDS)	mg/L	1,000	1,000	382	348	452	492	336	496	324	464	372
17	Manganese (Mn)	mg/L	0.1	0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
18	Copper (Cu)	mg/L	1	1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
19	Lead (Pb)	mg/L	0.03	0.01	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
20	Fluoride (F)	mg/L	0.7-1.5	1.5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
21	Sodium (Na)	mg/L	-	-	149.7	149.0	149.8	154.8	158.7	156.1	161.9	173.3	168.4
22	Zinc (Zn)	mg/L	5	3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
23	Coliform	Number/L	3	Non/100mg	Non	Non	Non	Non	Non	Non	Non	Non	Non
24	Cadmium (Cd)	mg/L	0.01	0.003	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
25	Chromium (Cr)	mg/L	0.05	0.05	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
26	Arsenic (As)	mg/L	0.05	0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
27	Turbidity	NTU	-	5	<5	<5	<5	<5	<5	<5	<5	<5	<5
28	Temperature	deg	-	-	6.0deg	5.5deg	6.0deg	6.0deg	5.5deg	6.0deg	5.2deg	5.5deg	5.6deg
29	Molybdenum (Mo)	mg/L	0.25	0.07	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
30	Aluminium (Al)	mg/L	0.5	0.2	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025

Table 2.7 Priority Evaluation for Rehabilitation of Existing Water Wells

Well No.	Year of Construction	Well Depth (m)	Casing Diameter (mm)	Result of Pumping Test and Sand Contents Test (*: Number indicates figures at the final step.)								Result of Borehole TV Camera Survey									Evaluation
				Date of Test	Position of Test Pump (GL -m)	Pumping Rate (m^3/h)	Static Water Level (GL -m)	Dynamic Water Level (GL -m)*	Drawdown (m)	Specific Capacity ($m^3/h/m$)	Sand Content *(mg/l)	Date of Survey	Damage/Crack on Casing Pipe	Sand Drain Accumulation of Sand	Degree of plugging of the screen-slot openings by incrustants	State of Iron Rust and Scales	Condition of Pipe Joints	Galvanic Corrosion	Falling Objects	Depth of Observation	
No.1	1965	67.5	427	2008/6/19	25.0	230	4.71	6.68	1.97	116.8	0.1	2008/6/19	Crack at a depth of 2.23m	Sand drain at a lower part of slots	60 to 90% at a depth of 9 to 19m, 10 to 20% until a depth of 25m, 80% until a depth of 32m are plugged but functioned through water channel as the screen	Slots are not functioned as the screen due to large humped iron incrustation and scales deeper than 46m	No damage	Non	Non	Landed at a bottom buried by incrustations, scales and sand at a depth of 60.66m	A
No.2	1965	68.0	427	2008/6/2	25.2	350	4.22	7.35	3.13	111.8	1.2	2008/6/3	No damage	Not observed	70 to 80% at a depth of 11.5 to 13m, 60 to 70% until a depth of 21m are plugged but functioned through water channel as the screen	Shape of slot is not clear and slots are not functioned as the screen due to large humped iron incrustation and scales deeper than 21m	No damage	Non	Strainer of submersible motor pump at a depth of 35.85m	It is not possible to lower TV camera due to falling object (the 4th pump strainer). (depth: 35.85m)	B
No.3	1965	68.0	427	2008/6/4	25.1	250	4.24	6.32	2.08	120.2	2.1	2008/6/5	Crack at a depth of 1.79m is remarkable. There is a possibility that drain water flows into the well.	Not observed	50 to 60% at a depth of 13 to 21m, almost 0% until a depth of 21m, 70 to 80% until a depth of 30m, 80 to 90% until a bottom are plugged but functioned through water channel as the screen	Scales become remarkable from a depth of 36m to the bottom and ratio of plugging becomes high. But slots are well-functioned through water channel as the screen.	No damage	Non	Non	Landed at a bottom buried by incrustations, scales and sand at a depth of 65.20m	A
No.4	1965	67.0	427	2008/6/7	31.4	140	4.08	28.52	24.44	5.7	Nil	2008/6/8	Crack at a depth of 1.52m	Not observed	10 to 20% at a depth of 10 to 20m, 70 to 80% at a depth of 23 to 29m, 100% from 32m to the bottom are plugged.	Slots are almost 100% plugged and not functioned as the screen due to large humped iron incrustation and scales deeper than 32m.	No damage	Non	Strainer of submersible motor pump at a depth of 58.01m and 58.16m	It is not possible to lower TV camera due to falling object (pump strainer). (depth: 58.16m)	C
No.5	1965	68.0	427	2008/6/9	31.3	190	3.98	11.74	7.76	24.5	3.2	2008/6/9	No damage	Not observed	10 to 30% at a depth of 9.5 to 21m, 50% until 23m, 70 to 80% until 25m, 90 to 100% from 25m to the bottom are plugged.	Slots are almost 100% plugged and not functioned as the screen due to large humped iron incrustation and scales deeper than 32m.	No damage	Non	Cables of submersible motor pump at a depth of 47.19m and 50.52m	It is not possible to lower TV camera due to falling object (pump cables). (depth: 50.52m)	C
No.6	1965	67.0	427	2008/6/9	30.8	150	3.87	14.38	10.51	14.3	0.3	2008/6/10	Hole at a depth of 0.26m, cracks at a depth of 1.20 and 2.54m	Not observed	30 to 50% at a depth of 8 to 11m, almost 0% until 12m, 30 to 70% until 21m, 70 to 80% until 30m, 90 to 100% to the bottom are plugged.	Slots are almost 100% plugged and not functioned as the screen due to large humped iron incrustation and scales deeper than 32m.	No damage	Non	Non	Landed at a bottom buried by incrustations, scales and sand at a depth of 61.71m	C
No.7	1965	67.0	427	2008/6/17	25.2	260	3.89	5.43	1.54	168.8	0.2	2008/6/17	Crack at a depth of 0.99m	Sand drain at a lower part of slots	30 to 40% at a depth of 10 to 15m, 10 to 20% until 20m, 70% until 33m are plugged but functioned through water channel as the screen.	Iron incrustations and scales become remarkable and are overhanging deeper than 33m.	No damage	Non	2 strainers of submersible motor pump at a depth of about 35m	It is not possible to lower TV camera due to falling objects (2 pump strainers). (depth: about 35m)	A
No.8	1965	67.5	427	2008/6/15	25.2	250	3.90	11.27	7.37	33.9	2.1	2008/6/16	No damage	Not observed	70 to 90% at a depth of 11 to 17m, 40 to 50% until 23m, 60 to 70% until 30m, 70 to 90% to the bottom are plugged.	The iron rust and scale become remarkable from a depth of 31m to the bottom and there is a possibility that corrosion is in progress in the casing pipe. Slots are not functioned as the screen.	No damage	Non	A round object at a depth of 47.76m	It is not possible to lower TV camera due to a round falling object. (depth: 47.76m)	C
No.9	1965	68.0	427	2008/6/15	25.1	225	3.64	11.69	8.05	28.0	Nil	2008/6/17	Crack at a depth of 1.75m	Not observed	The slots with a depth of 11 to 22m are 10 to 20% plugged by scales but are functioned totally as the screen.	The iron rust and scale become remarkable from a depth of 22m to the bottom and slots are almost 100% plugged.	No damage	Non	2 strainers of submersible motor pump at a depth of 24.01 and 30.69m	It is not possible to lower TV camera due to falling object (pump strainer). (depth: 30.69m)	C

Table 2.7 Priority Evaluation for Rehabilitation of Existing Water Wells

Well No.	Year of Construction	Well Depth (m)	Casing Diameter (mm)	Result of Pumping Test and Sand Contents Test (*: Number indicates figures at the final step.)								Result of Borehole TV Camera Survey									Evaluation
				Date of Test	Position of Test Pump (GL -m)	Pumping Rate (m^3/h)	Static Water Level (GL -m)	Dynamic Water Level (GL -m)*	Drawdown (m)	Specific Capacity (m^3/h/m)	Sand Content *(mg/l)	Date of Survey	Damage/Crack on Casing Pipe	Sand Drain Accumulation of Sand	Degree of plugging of the screen-slot openings by incrustants	State of Iron Rust and Scales	Condition of Pipe Joints	Galvanic Corrosion	Falling Objects	Depth of Observation	
No.10	1965	68.5	427	2008/6/16	31.3	180	3.81	16.97	13.16	13.7	0.7	2008/6/15	Crack at a depth of 1.28m	Not observed	30 to 80% at a depth of 10 to 17m, 10% until 20m, 30 to 40% until 23m, 70 to 80% until 31m, 80 to 90% to the bottom are plugged.	Slots are 80 to 90% plugged and not functioned as the screen due to large humped iron incrustation and scales deeper than 31m	No damage	Non	Cable of submersible motor pump at a depth of 51.47 and 60.59m, electric wire at 58.39m	It is not possible to lower TV camera due to falling object (pump cable). (depth: 60.59m)	C
No.11	1965	68.0	427	2008/6/10	25.3	260	3.87	5.96	2.12	122.6	Nil	2008/6/11	Crack at a depth of 1.58m	Sand drain at a lower part of slots	10 to 20% at a depth of 9 to 15m, 50 to 70% until 27m, 70 to 80% until 32m, 70% to the bottom are plugged.	Scales become remarkable from a depth of 32m to the bottom and are 50 to 70% plugged. But slots are functioned through water channel as the screen.	No damage	Non	Electric wire at a depth of 13.39m	Landed at a bottom buried by incrustations, scales and sand at a depth of 62.50m	A
No.12	1978 ～ 1984	65.0	352	2008/6/1	25.7	390	3.88	5.84	1.96	199.0	2.0	2008/6/2	No damage	Not observed	The slots with a depth of 8 to 23m are 30 to 50% plugged by scales but are functioned through water channel as the screen.	Iron incrustations and scales become remarkable and are overhanging deeper than 19m	No damage	Non	Electric wire at a depth of 14.18 and 20.85m, cable of submersible motor pump at 30.78m	It is not possible to lower TV camera due to falling object (pump cable). (depth: 30.78m)	B
No.13	1978 ～ 1984	65.0	352	2008/5/27	26.0	400	3.55	6.43	2.88	138.9	2.6	2008/5/28 & 2008/6/20	No damage	Not observed	30 to 40% at a depth of 4 to 9m, 50% until 17m, 60 to 70% until 27m, 90 to 100% until 31m are plugged. Blind casing is between 31m and 37m.	Iron incrustations and scales become remarkable and are overhanging deeper than 38m	No damage	Non	Electric wire at a depth of 38.84m pump at 30.78m	t is not possible to lower TV camera due to overhanging of large humped iron incrustations and scales (depth: 42.68m)	B
No.14	1978 ～ 1984	65.0	352	2008/5/26	26.1	400	3.65	5.76	2.11	189.6	3.5	2008/5/27	No damage	Sand drain at a lower part of slots	50 to 70% at a depth of 8 to 14m, 30% until 19m, 30 to 50% until 24m, 50% until 31m, 60 to 80% to the bottom are plugged.	It is difficult to lower down the TV camera because iron incrustations and scales become remarkable and are overhanging deeper than 25m.	No damage	Non	Electric wire at a depth of 36.34 and 48.75m, wire and timber-like object at 49.45m	It is not possible to lower TV camera due to a lot of falling objects (Wires and timber-like object). (depth: about 49.5m)	B
No.15	1978 ～ 1984	65.0	352	2008/6/21	25.7	250	3.31	4.74	1.43	174.8	1.0	2008/6/22	No damage	Sand drain at a lower part of slots	The screen-slot openings are slightly plugged by scales but these slots are well-functioned through water channel as the screen.	Iron incrustations and scales become thick slightly but there are totally few iron rust and scales deeper than 22m	No damage	Non	Strainer of submersible motor pump at a depth of 17.02m	Landed at a bottom buried by incrustations, scales and sand at a depth of 61.13m	A
No.16	1978 ～ 1984	65.0	352	2008/5/28	25.6	400	3.40	5.28	1.88	212.8	3.9	2008/6/20	Crack at a depth of 1.83m	Sand drain at a lower part of slots	30 to 50% at a depth of 8 to 13m, 10 to 20% until 26m, 30 to 50% until 31m, 20 to 30% until 35m, 50% to the bottom are plugged but slots are functioned as the screen.	Iron incrustations and scales become thick slightly but there are totally few iron rust and scales deeper than 35m	No damage	Non	4 strainers of submersible motor pump at a depth of 13.38, 22.24, 27 and 39.26m	It is not possible to lower TV camera due to 4th falling object (Pump strainer). (depth: 39.26m)	A
No.17	1978 ～ 1984	65.0	352	2008/5/29	25.6	400	3.62	5.83	2.21	181.0	3.9	2008/5/30	No damage	Sand drain at a lower part of slots	The slots are partially 60 to 80% plugged by scales but plugging of the screen-slot openings are few and are functioned through water channel as the screen.	Iron incrustations and scales become thick slightly but there are totally few iron rust and scales deeper than 45m	No damage	Non	Electric wire at a depth of 58.52m	Landed at a bottom where buried by incrustations and scales and where spanner and wires are observed at a depth of 60m	A
No.18	1978 ～ 1984	65.0	352	2008/5/30	25.6	400	3.67	6.41	2.74	146.0	3.3	2008/5/31	Drain water of the pump house flows into the well from the crack at a depth of 1.81m	Not observed	10 to 20% until 30m, 30 to 50% to the bottom are plugged but slots are functioned through water channel as the screen.	Iron incrustations and scales become remarkable and are overhanging deeper than 30m	No damage	Non	Non	Landed at a bottom buried by incrustations, scales and sand at a depth of 57.26m	A

Criteria of Evaluation:
Evaluation A: The specific capacity is 100m3/h/m or more, the dynamic water level shall be less than 10m and there is no trouble with the falling objects etc. up to the bottom of the well. However, it puts it into the evaluation “A” in case when judged that it is possible easily to remove and to be collected by bailer etc. even if there is an obstacle.
Evaluation B: The specific capacity is 100m3/h/m or more, the dynamic water level shall be less than 10m and there is a trouble with the falling object etc. up to the bottom of the well.
Evaluation C: The specific capacity is under 100m3/h/m, the dynamic water level is more than 10m and there is a trouble with the falling object etc. up to the bottom of the well.

Table 2.31 PDM of Software Assistance

Project Name: The Project for Improvement of Water Supply Facilities at Darkhan City
Country: Mongolia
Period:
Target Group: Operation Staff of Intake and Transmission Pumps
Operation Staff of Chlorination Facility
Operation Staff of Relay Pump (Water Kiosk)
Prepared: September 2008

Narrative Summary	Verifiable Indicators	Names of Verification	Important Assumptions
Overall Goal - The replaced facilities are operated, and maintained smoothly, and used on sustainable condition.	- Volume of supplied water and sales amount of WSSSC - Operation conditions of facilities and equipment	- Annual report of WSSSC - Repair record of equipment	The policy of Mongolia on water supply is not changed.
Purpose of Software Assistance - The replaced intake and transmission pumps are operated efficiently in accordance with the water demand including the relating facilities. - The replaced chlorinator is operated efficiently, and safe water is distributed. - The relay pump installed in the water kiosk is operated efficiently and sustainably.	- Operation conditions of intake and transmission pumps, chlorinator and relay pump - Sold amount of water - Water quality of supplied water - Occurred accidents	- Operation record of pumps and chlorinator - Sales book of water kiosk - Results of water quality analyses - Repair record of equipment	WSSSC conducts the operation and maintenance of the replaced and constructed facilities on sustainable basis.
Output 1 The operation staff of the 2nd Station understands the operation of control system including remote control, establish the operation plan in accordance with water demand, and enable to operate the pumps efficiently.	Operation hours of intake and transmission pumps Variation of distributed water	Operation record of intake and transmission pumps Distributed water volume recorded by the flow meters installed on the distribution pipelines.	The staff who finished the training under this assistance continues to work for the same purpose.
2 The operation staff of the 2nd Station understands the mechanism of the replaced chlorinator, and enables to operate the system efficiently.	Residual Chlorine Injected volume of chlorine Occurred accidents	Results of water quality analyses carried out regularly by WSSSC. Operation record of Chlorinator Operation record of Chlorinator	
3 The staff assigned for the constructed water kiosk understands well on the operation of the relay pump, and enable to convey the water to the kiosk on elevated hill efficiently.	Operation conditions of intake pumps (Frequency and duration of operation) Sold amount of water	Operation record of intake pumps Sales book of water kiosk	

Activities
- Technical Assistance to the operation staff of WSSSC for the followings.
  - Intake and transmission pumps including remote control system
  - Chlorination Facility
  - Relay pump in water kiosk
	Input
	(Japanese Side)
	- Dispatch of Japanese Consultant (Water Supply Management Engineer).
	- Fund for Local Consultant (Electric and Mechanical Engineer)
		(Mongolian Side)
		- Fund for the operation staff of intake and transmission pumps as well as chlorination facility (10 staff), and water kiosks (2 staff).
			The staff who finished the training under this assistance continues to work for the same purpose.
			Pre-conditions
			The necessary numbers of operation staff of WSSSC are assigned properly.

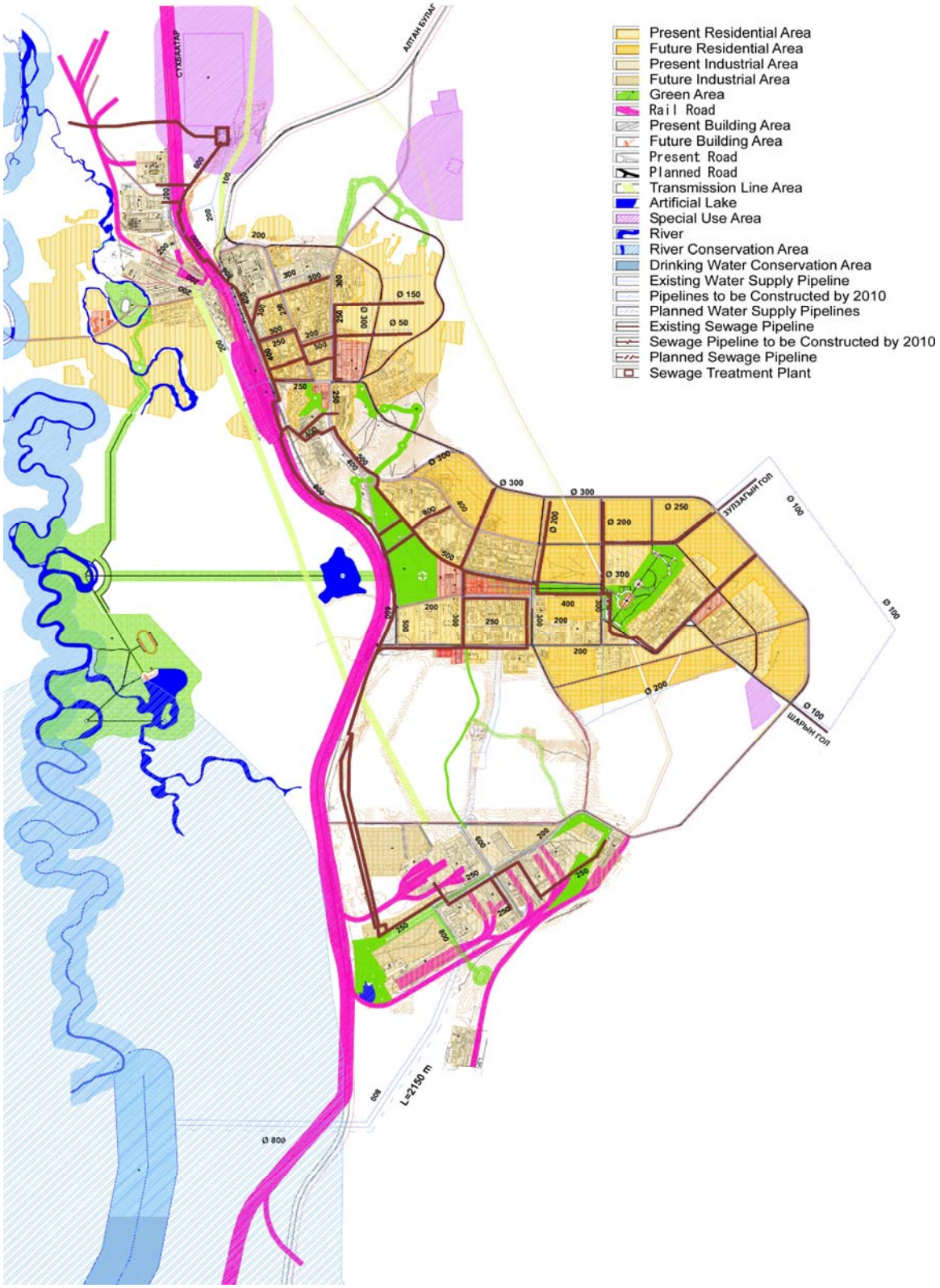
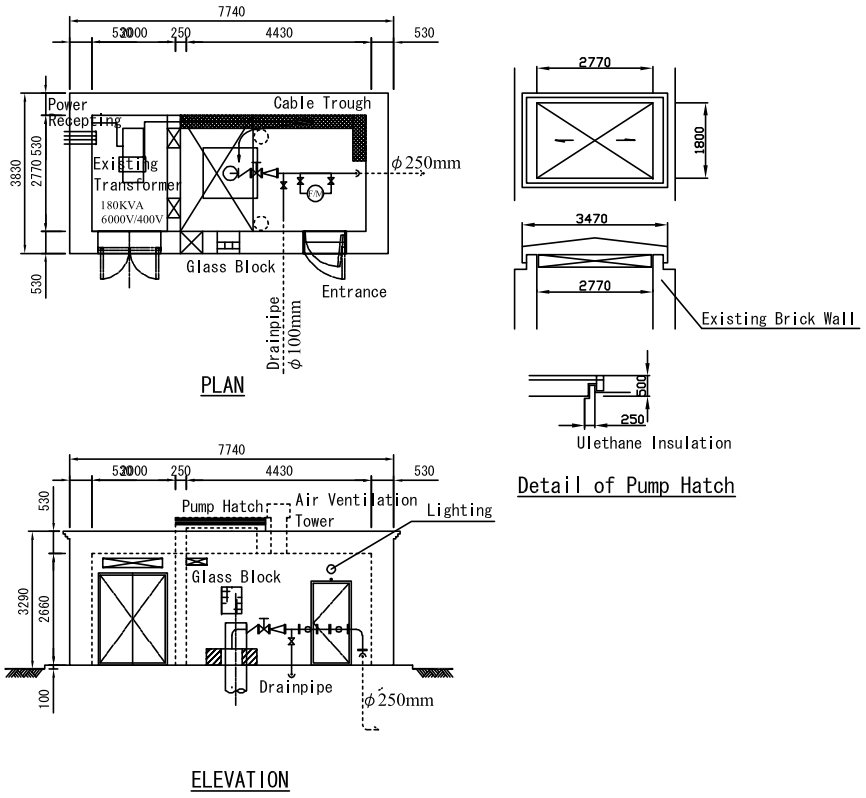


Fig. 2.2 LAND USE PLAN OF DARKHAN CITY

Rehabilitation of Existing Tubewell
(No. 1, 3, 7, 11)



Rehabilitation of Existing Tubewell
(No. 12, 13, 14, 16, 17, 18)

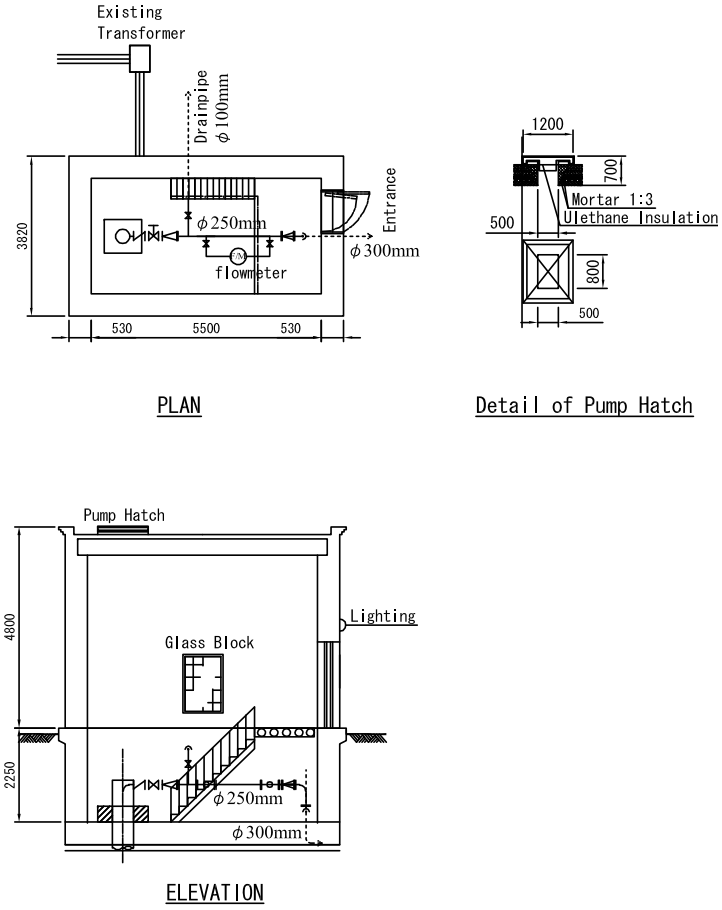
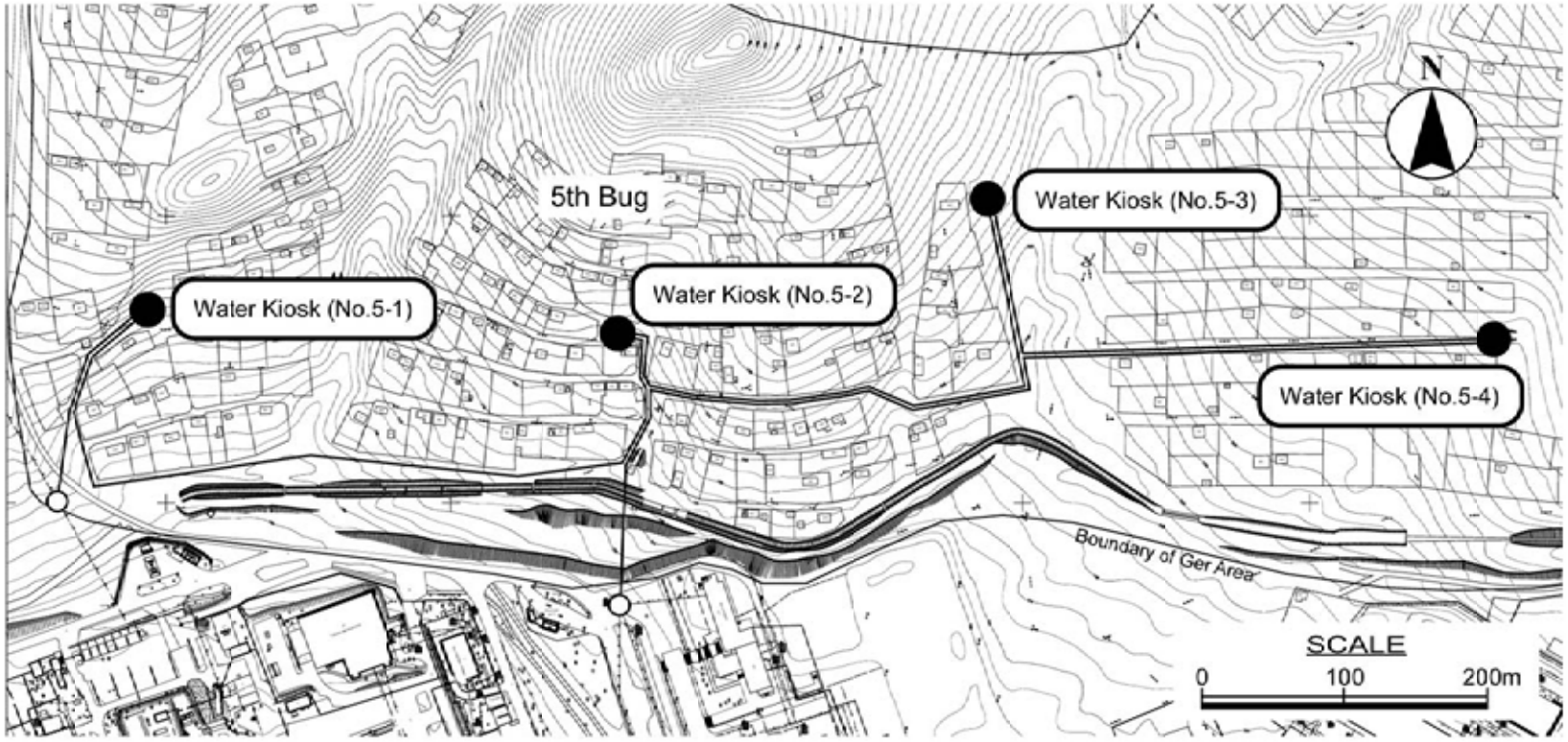


Fig 2.5 Rehabilitation of Pump House



LEGEND

- Water Kiosk
- Distribution Pipeline
- Connection to Existing Distribution Pipeline

Fig. 2.8 Water Supply Facilities for Ger Areas (The 5th Bag)

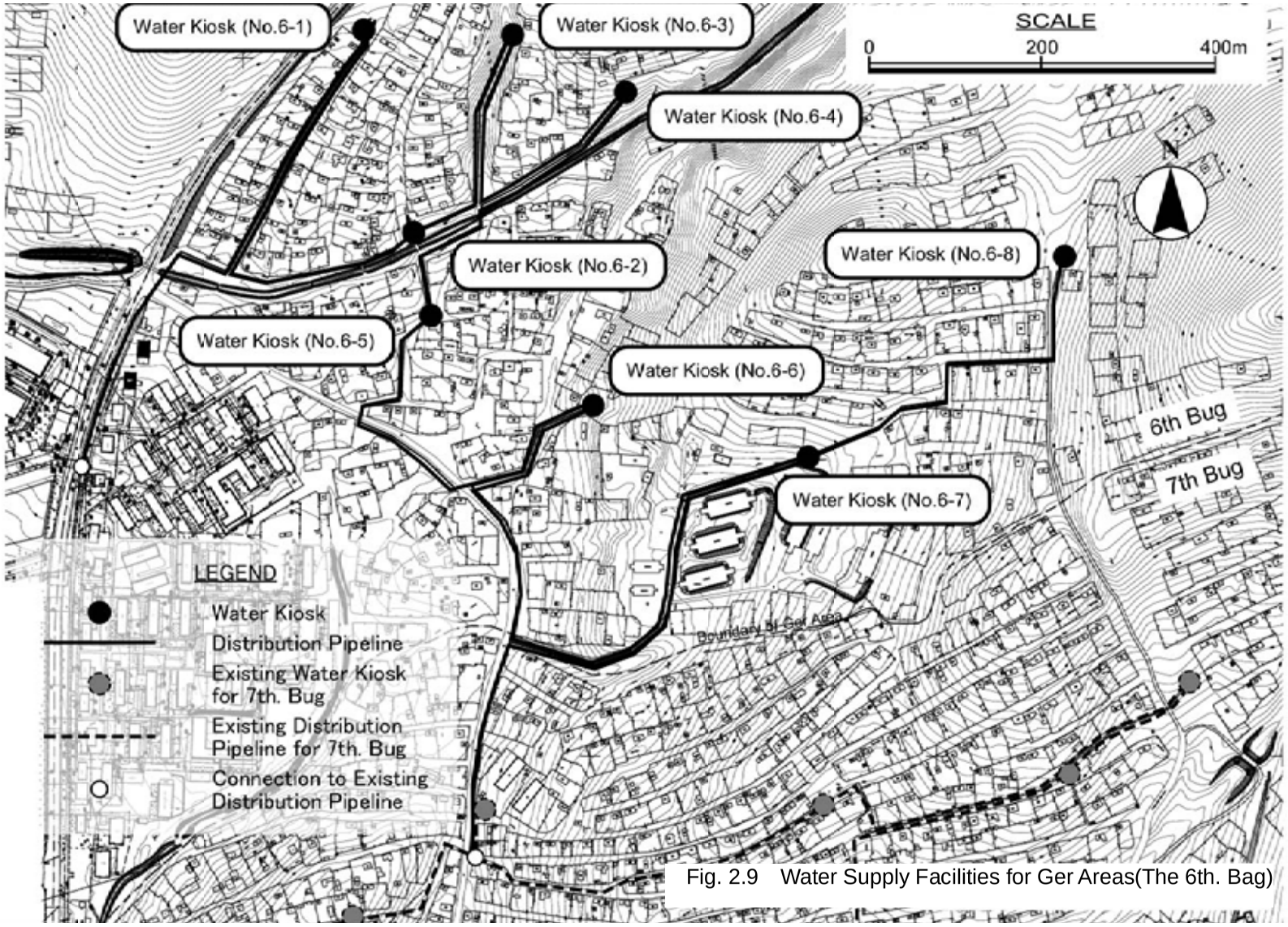


Fig. 2.9 Water Supply Facilities for Ger Areas(The 6th. Bag)

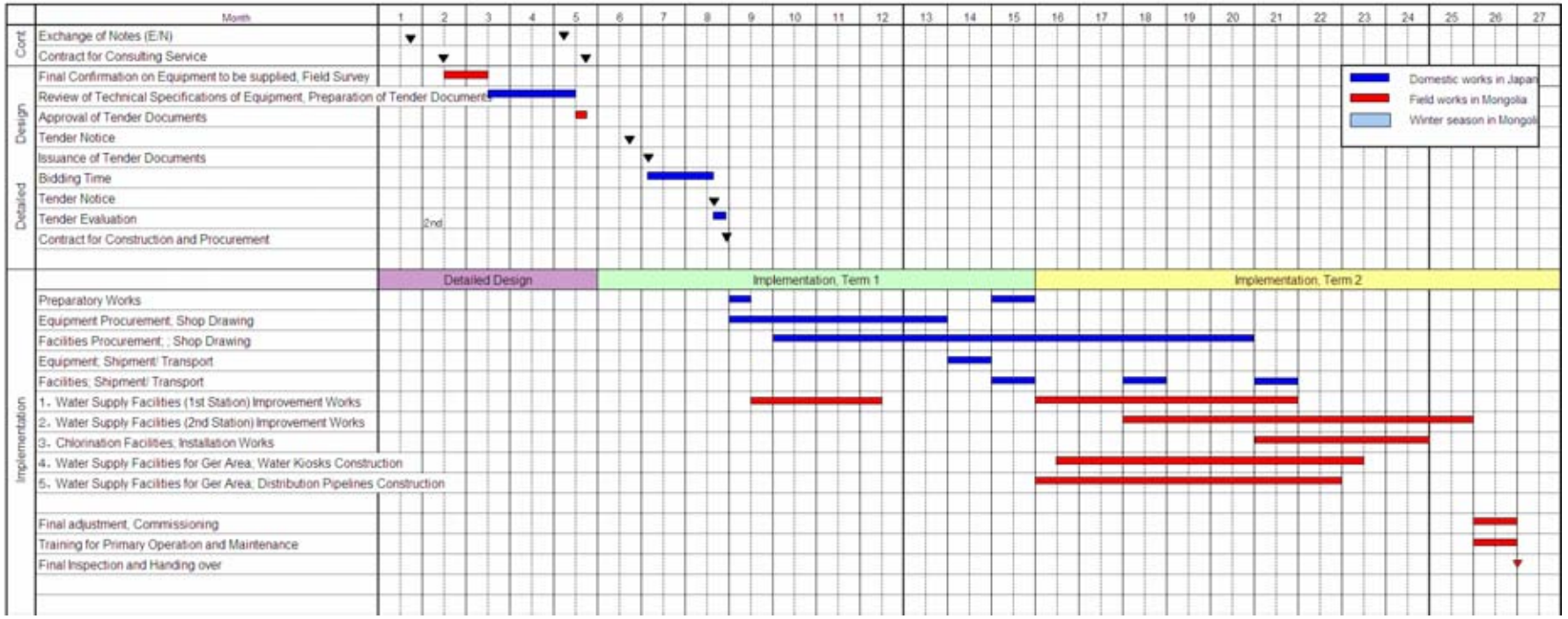


Fig. 2.19 PROJECT IMPLEMENTAION SCHEDULE

CHAPTER 3 PROJECT EVALUATION AND RECOMMENDATIONS

CHAPTER 3 PROJECT EVALUATION AND RECOMMENDATIONS

3.1 Project Effect

Present situations and constraints and direct and indirect impacts of the project are summarized in the following table.

Table 3.1 Project Effects and Extent of Improvement by the Project

	Present Situations and Constraints	Measure Taken by the Project (Project Components)	Project Effects and Extent of Improvement
Direct Effects			
1.	- The water supply system of Darkhan is getting older and their functions have been declined. The risks of decrease of water production and suspension of water supply service is high, and then the rehabilitation of basic water facilities is considered to be the issue to be solved urgently. - The water production of the city is decreased with a rate of 8 % as the number of operated pump units decrease, and the production decreased to 13,600 m^3/day in 2007. If the water production decreases more, water supply volume may be short. - The Darkhan city is considered to be the core city as the 3rd potential city after Ulaanbaatar and Erdenet. Many factories are planned to be established, and the migration of workers and their families to the city is planned, but it is difficult to increase the water production with the existing old water facilities in accordance with the population increase.	- The intake pump units of the 1st Station and the relating facilities (10 nos.) will be replaced, and the remote control system from the 2nd Station will be provided. - The transmission pump units (3 nos.) and the relating facilities will be replaced. - The water supply facilities will be provided for the ger areas of the 5th and the 6th bags.	- The present water production of 13,575 m^3/day will be increased to 21,800 m^3/day - The risks of decrease of water production and suspension of water supply service will be mitigated, and the necessary water production will be secured in accordance with the population increase (75,000 in 2007 will be increased to 91,000 in 2011). - The present water consumption per capita will be increased; the present 140 litter/capita/day will be increased to 170 litter/capita/day in the apartment area and the present 25 litter/capita/day will be to 35 litter/capita/day in the ger area.
2.	- Since no chlorination has been applied because the existing chlorinator was left out of order, the risk of water borne diseases is considered high.	- The existing chlorinator in the 2nd Station will be replaced.	- The effect of the disinfections is expected due to the replacement of chlorinator, the present residual chlorine of 1 mg/litter will be improved more than 0.3 mg/littler as presented in the Mongolian guidelines。
Indirect Effects			
1.	- Since old and ineffective water facilities are used for producing water, operation costs of the intake and transmission pumps especially that for electricity weigh on the financial balance of WSSSC.	- The operation of the pump units becomes effective due to the replacement of pump units and renovation of pump houses.	- The pump operation costs especially electricity cost will be improved resulting in the improvement of the financial standing of WSSSC. - The electricity cost per unit water production will be decreased from the present 49.64 MNT/m^3 to34.68 MNT/m^3.
2.	- Because the track crane and the mobile welder which are considered indispensable for repairing the pump units and pipelines are old and get troubles frequently, the operation and maintenance works of the water supply facilities are not smooth. - Since the water quality analysis devices such as	- The operation and maintenance vehicles such as track crane and mobile welder, and the water quality analysis devices such as spectrophotometer, incubator and dry oven will be procured.	- It becomes possible for WSSSC to dispatch the own vehicles to most of the repair works, which will make the operation and maintenance services more flexible and will reduce the repairing costs。 Further, it will be possible to cut the rental cost of the operation and maintenance vehicles which may be necessary when their own

Table 3.1 Project Effects and Extent of Improvement by the Project

Present Situations and Constraints	Measure Taken by the Project (Project Components)	Project Effects and Extent of Improvement
spectrophotometer, incubator and dry oven are out of order, it is impossible for WSSSC to analyze the water quality parameters which have to be analyzed periodically.		vehicles are on repair. - It becomes possible to analyze the parameters to be analyzed periodically.

3.2 Recommendations

In order to continue the sustainable and smooth operation and maintenance of the water supply facilities to be replaced and constructed and the operation and maintenance equipment to be procured under the project as well as the water supply of the Darkhan city even after the project completion, the following items should be particularly considered by the Mongolian side.

(1) Facilitation of Flow Meter Installation toward Improvement of Financial Balance of WSSSC

As discussed in the previous chapter, the financial balance of WSSSC will be sound in 2011 on condition that the water charge is collected in good condition in the apartment area. However, unexpected situations have to be considered as follows:

- Decrease of the rate of water collection
- Increase of operation costs due to price inflation
- Improper timing of revision of water tariff

In case that these situations may become serious, it will be impossible to keep proper financial balance and the improvement of financial condition of WSSSC will be disrupted.

The WSSSC takes its effort to promote the activities to facilitate the installation of flow meters in each household to shift from the present fixed charge system with the registered number of household members to the volumetric system with the used water volume which is considered fairer. This activity was commenced in 2005, and the demand of the meter installation is increased as the installation of the meters is progressed. The WSSSC is required to extend the installation activity using the 1,500 flow meters provided under the project in order to establish the fair water charge system as soon as possible. To improve the financial conditions and to manage the WSSSC on stable conditions, it is important to establish the fair and effective water charge system keeping the good rate of water charge collection.

(2) Improvement of Water Distribution Networks in the City Area

The replacement and construction works in the 1st Station (intake pump units), the 2nd Station (transmission pump units and chlorinator) and the ger area for the water supply system will be implemented under the project. According to WSSSC, the transmission pipelines are old but in good condition without any trouble. However, the distribution networks in the city area were constructed when the Darkhan city was constructed, and have passed long time since its construction. Any substantial replacement and repair has not been made for the distribution networks, and ruptures and leakage of pipes are found frequently. Especially those occurred in the winter season cause freeze of the supplied water, and in case that the repairing of pipes is

failed the water supply service may not be continued until the next spring. Therefore, it is essential to replace the old and broken pipes in the networks in order to utilize the water supply facilities on the sustainable and effective conditions. It is important to replace such old and deteriorated pipes systematically by the WSSSC's self effort.

(3) Improvement of Power Source Quality

By the hearing at power plant and the voltage measuring at the 2nd Station, it was found that the power source voltage from the substation to Darkhan city is always fluctuating (voltage drop, voltage imbalance), and those fluctuations are way exceeding the allowable range. It is estimated that these fluctuations are originated in the operation of large consumers such as metallurgical plant, and impossible to take measure at other consumer side at present. If the substation does not take any measure, the equipment will break down easily. The equipment made in Russia has some tolerance against this kind of voltage, but the equipment made in this country, even manufactured in accordance with standard, it may break down as long as using the fluctuating power which is always exceeding the allowable range. Therefore, in this project, (1) Application of Russian pump, and (2) Trip of the circuit breaker in the event of an undervoltage by installing undervoltage relay in the pump panel are considered to protect the pump motor and cable from low quality power source. According to the development plan of manufacturing plants, the metallurgical plant, etc. will be expanded in the future. After that, the power problem may become more serious for neighboring consumers. Therefore, it is supposed necessary to take measure against the voltage fluctuation under the leadership of the electric power company at earlier stage. Countermeasures such as increasing the substation capacity, installing an auto voltage regulator, etc. can be considered as examples.